THE SEVENTH INTERNATIONAL SYMPOSIUM ON ENVIRONMENTAL CONCERNS IN RIGHTS-OF-WAY MANAGEMENT

The Seventh International Symposium on Environmental Concerns in Rights-of-Way Management

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Edited by:
John W. Goodrich-Mahoney
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Colin A. Guild

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Preface

The Seventh International Symposium on Environmental Concerns in Rights-of-Way Management follows a series begun at Mississippi State University, Mississippi in 1976 and subsequently held at Ann Arbor, Michigan in 1979; San Diego, California in 1982; Indianapolis, Indiana in 1987; Montreal, Quebec, in 1993; and New Orleans, Louisiana in 1997. The Symposium was organized by a steering committee composed of representatives from industries, agencies and universities concerned with research and management of electric, pipeline, railroad, and highway rights-of-way.

The purpose of this Symposium was to achieve a better understanding of the current and emerging environmental issues related to rights-of-way management by sharing environmental research and practical experience throughout the world. The symposium attracted 460 registrants from 22 countries, giving it a truly international favor. The symposium consisted of two introductory addresses one by Chief Roy Whitney of the Tsuu T'ina people, a part of the Dene Nations and one by Dr. Dale Arner, Professor Emeritus at Mississippi State University and Honorary Chairman of this Symposium who started this series of symposia in 1976. Dr. Brain Bietz, Director of the Energy Counsel of Canada, gave a keynote address. Following Dr. Bietz's address a lively panel discussion was held on the "Corridor Concept Revisited: Multiple Rights-of-Way." Symposium sessions focused on Vegetation Management; Project Management; Cultural; Wildlife; Biodiversity; Geographic Information Systems; Wetlands; Soils; Aquatic Life; Public Participation; and Regulatory Compliance where 110 papers were given, of which 100 peer-reviewed papers appear in this proceedings.

The Eight International Symposium on Environmental Concerns in Rights-of-Way Management will be held in Saratoga Springs, New York, during September 12–16, 2004. See the Symposium web site at www.rights-of-way-env.com for updates and information on prior Symposia.

Acknowledgments

This Symposium could not have taken place without the dedicated efforts of many individuals. The editors would like to acknowledge the contributions of the steering committee whose tireless efforts again proved invaluable. The steering committee members are: Larry Abrahamson, Paul Anderson, Grete Bridgewater, Edward Colson, Allen Crabtree, James Crinklaw, G. Jean Doucet, James Evans, Kenneth Farrish, John Goodrich-Mahoney, Colin Guild, Harvey Holt, Stuard Lunn, Dean Mutrie, Wayne Marshall, Kevin McLoughlin, Peter Prier, Richard Revel, Jorge Roig Soles, Ian Scott, Glen Singleton, Richard Skarie, Gus Tillman, and James R. (Randy) Williams. We acknowledge the authors of the papers and posters for their efforts and the quality of their contributions, as well as the individuals who served as technical reviewers of the papers.

We acknowledge the main sponsors, TransCanada, Tera Environmental Consultants LTD, and the Electric Power Research Institute, and significant support from Alliance Pipeline, ATCO Electric, BC Hydro, Canadian Pacific Railway, ESG International, Gas Research Institute, National Resources Group, Inc., PanCanadian, and Westcoast Energy.

We also acknowledge the host organizing committee, Eric Mohun, Susan Austen and Michelle Richard whose efforts contributed significantly to the success of this Symposium. Finally, we appreciate the flawless efforts of the staff at the Calgary Westin Hotel.

Responsible Management through the Ages

The Calgary 2000 logo was designed specifically for this Symposium to convey the message that environmental management is a spatial and temporal responsibility. The indigenous theme suggests that environmental management has coincident with the evolution of man. We are the managers within a specific time and place. Overseeing two straight lines representing parallel rights-of-way, the top half of the logo signifies man as the steward of his environment. The images below represent the biophysical components, including tracks of the grizzly bear, an international icon for wildlife and wilderness and a key species of concern for right-of-way managers in the Province of Alberta.

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Part I
Symposium Plenary Session

Plenary Session Opening Remarks and Presentations

Dean Mutrie and Colin Guild

THE FOLLOWING IS A TRANSCRIPT OF THE PLENARY SESSION OPENING REMARKS AND PRESENTATIONS

Good morning, everybody, my name is Dean Mutrie, and I am co-chairman of this symposium, along with Colin Guild, whom I'll introduce in a moment.

We are honored to be your host for this, the 7th in a series of leading edge symposia on environmental concerns on rights-of-way management. The purpose of this symposium is to achieve a better understanding of current and emerging environmental issues related to rights-of-way management by sharing environmental research and practical experience throughout the world.

We have assembled an excellent collection of papers from all around the globe. This symposium is the only forum where people from different utilities, countries and environmental disciplines meet to share information and ideas from their respective fields of expertise. We hope you come away with new ideas that you can apply to your own work back home, and that the social and business contacts that you make here will stand you in good stead the rest of your professional life.

As of this morning, I am pleased to announce that we have 460 registrants from 22 countries registered at the symposium. At this time I would like to take a few moments to thank our sponsors and acknowledge that their sponsorship of this is the only way that we could hold the symposium. It's taken a huge amount of work, which I have learned over the past months and particularly the last few days. There's past chairmen sitting in this audience and they will attest to the amount of work that it takes to pull one of these together. So with that, the following sponsors have provided both financial support and a lot of dedicated, talented people to help us pull this off. Our major sponsor is TransCanada, as well as the Electric Power Research Institute or EPRI, John Goodrich-Mahoney will be up later on. Our other sponsors, include TERA Environmental Consultants, BC Hydro, Alliance Pipeline, ATCO Electric, the Canadian Pacific Railway, ESG International, GRI, NRG, PanCanadian, and Westcoast Energy. We would like to thank our sponsors because they made this possible.

I would like to introduce my co-chairman Colin Guild from TransCanada.

Colin Guild

Thank you Dean. I would like to extend my welcome to everyone, and now I would like to introduce Brian McConaghy, vice president of TransCanada.

Brian McConaghy

Good morning, everyone. Welcome to Calgary and welcome to the symposium. I hope you're going to continue to be able to take in some of the sights in and around Calgary. We believe it's a beautiful setting, and we're quite proud of it. On behalf of TransCanada, I want to say that we are pleased to act as a major sponsor for the 7th in this series of quality symposiums.

The bringing together of experts like yourselves and the sharing of ideas, new procedures and new technologies will help us all meet the commitments that are expected in our communities, our companies and in the eyes of the general public as they view our industry. The oil and gas industry in North America and around the world has hundreds of thousands of kilometers of right-of-way, and for the most part, we just borrow the land from the landowners for our construction activities and ongoing operations.

We have the obligation to return the land to the landowner in such a condition as the owner can continue with past land management practices. This obligation has its challenges, but it's through your ideas that practices will continue to improve, and we, as an industry, can be proud of our efforts in caring for the environment. Thank you very much. Enjoy and learn. Thanks.

MR. DEAN MUTRIE INTRODUCES CHIEF ROY WHITNEY OF THE TSUU T'INA NATION

Chief Roy Whitney

Good morning. It's a pleasure to be here this morning with such a group of distinguished people that

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really assist in determining how the next seven generations will endure or support the world environmental concerns. Thank you for that kind introduction and greetings from our elders, the Counsel and the citizens of the Tsuu T'ina First Nation.

Many of you may know that the Tsuu T'ina people are part of the Dene Nations of northern Canada. We settled in southern Alberta years ago as we followed the Dene migration trail from northern Canada as far into Mexico. Our Dene cousins, the Navajo and the Apache of the America southwest migrated there about the same time.

Tsuu T'ina lands are located very close to Calgary. In fact, if you cross 37th Street, South West, you will be standing on Tsuu T'ina lands, 69,000 acres south and southwest of the City of Calgary. Many of you will also know that we at Tsuu T'ina have been preparing for the past decade to take our place in the economy of this province. Through economic development, we believe our project plans will provide prosperity to our people and a level of financial independence unknown to us since the European settlement.

It is a pleasure to have an opportunity to address a gathering of this kind and to exchange ideas. We at Tsuu T'ina have some challenges ahead as we begin our negotiations with the City of Calgary and the Province of Alberta this fall regarding our largest project, a transportation corridor linking the southern extremity of Calgary with the northwest through Tsuu T'ina lands. We will have some major decisions to make regarding that project, particularly since there will be major environmental challenges.

We have already had questions raised by the citizens of Calgary regarding our plans for development along the corridor at off ramps and intersections with Calgary communities. Although the challenges are substantial, we have no doubt that we will be able to find a proper balance that will permit the kind of development we need while limiting the extent of intrusion to the neighboring communities. In addition, we will be searching for ways to create the least intrusion to the environment.

Since the transportation corridor will pass through areas of our land, which are a habitat of many species of wildlife, those of you have or will be involved in projects involving pipeline utility corridors and the likes should know and realize that when aboriginal lands and communities are involved, the perspective is very different. The considerations are not totally economic in nature, although there are economic considerations.

We in First Nations community have a strong relationship with the land that we occupy and live on. When our land is considered in a development context, consultations regarding our traditions and our direct participation are very important. First Nations community will always want to have an opportunity to participate in environmental screening and the work being done. It is critical from your point of view, as potential developers, to recognize that aboriginal environmental companies should be utilized particularly because of their special knowledge of the land others may not have. First Nations will want to make sure that something remains in their community of benefit from a project and, again, those are not simply economic in nature.

We at First Nations will also watch very carefully the reclamation of lands after a utility corridor or a pipeline is installed. It is important for you to know that First Nations' view of the standard of reclamation will not necessarily be the same as government standards. Because First Nations and the land itself are bound together in so many traditional ways, the standard may be dramatically higher. This is particularly so if the land has been used for traditional purposes at any time in the past. We, as aboriginal people, are acutely aware of our need to protect those things in nature that we value.

We believe that we have a duty to our future generations to use our land in a way that will not diminish their right to use the land later on. In our culture, all of our decisions are carefully measured because of the impact of the next seven generations. We take that duty very seriously. In fact, we at Tsuu T'ina have set aside 25,000 acres of our land as untouched wilderness for the use of future generations. I know that in the larger society there have been times when environmental concerns were given very little attention. Impacts on nearby villages, towns and communities were not always considered. We at Tsuu T'ina have watched as Calgary's development has appeared on our doorstep almost overnight.

Right now, we are becoming gradually surrounded by the suburbs of Calgary. Before the turn of the last century, one of our leaders had a dream. He dreamed one day that Tsuu T'ina people or Sarcee people, as we were then called, would be surrounded by boxes. Our people were puzzled about this and the dream was pondered many times.

Now, more than a century later, we know what the dream meant. As we watch Calgary grow, we note how little we have been consulted. We note that in many cases development improperly straddles the right-of-ways between our nation and Calgary. Regulatory agencies should be supervising this kind of development better. On that note, we have recently assured worried Calgarians that because of our sense of neighborliness, we will not be building a pig farm along the transportation corridor. We believe that human creativity and imagination is such that good solutions to development issues can be found. We know that it is important to consider others and to listen to others. Cooperation and consultation are all important in this process.

As I have mentioned, we as First Nations have much more than a passing interest in maintaining a proper balance between modern development and to meet our present needs while ensuring that the way of life that we value in nature remains very much a part of our lives and our enthusiasm to obtain those things that we need to live well in a modern society. We must take great care not to sacrifice what is most sacred of all things in any native community, the land, itself, and our nature.

We do not intend to depart from our commitment to nature. We will continue to protect the sensitive environmental areas located on our lands at the western end of the Glenmore reservoir. We intend to ensure that the natural habitat of the wildlife is disturbed as little as possible. We will consider designs for the transportation corridor that will give meaning to this approach. We have attempted to diminish the fears of those people who oppose us in our development plans by helping them to have a clear picture of who we are and what we hope to accomplish.

I was elected chief of the Tsuu T'ina nation 16 years ago. Back then the issues facing our people were very different from what we now face. But we continue to ask ourselves the same questions year after year; questions which are very fundamental to us; questions about who we are as a people and a nation; what direction do we want to move towards; how will our decisions affect our children or our grandchildren.

Are our goals right for our people? We believe that we must ask ourselves these questions again and again as we consider what development to allow and what the next steps are to take. We know that our value system is different from that of our partners in the transportation corridor project. Our partners, the City of Calgary and the Province of Alberta know that in doing project work with Tsuu T'ina, it must be the value system of our people which stays at the forefront.

It is realistic to assume that many Calgarians will move on to other communities in the future and in time. We at Tsuu T'ina have lived here for thousands of years. Our lands have been reduced to a small reserve with the making of Treaty No. 7 in 1877, and the establishment of our reserve in 1883. Our people will be here for centuries to come, that is why we must be very careful how we develop our lands. We will continue, however, to rely on the collective wisdom of our elders and our spiritual leaders within our community to guide us as we move ahead in this new developmental period.

We look forward to developing strong working relationships with the people of this city and southern Alberta. We ask our friends to pray for us as we seek the guidance of our creator to make good decisions, not only for our people, but as well for all Albertans. We at Tsuu T'ina continue to pray that each and every individual around the world will one day come to realize that all of the land which makes up this planet earth is as a precious living thing, a breathing thing, which deserves as much respect and protection as every pair of human hands can offer.

May I wish each and every one of you an excellent and wonderful symposium. Thank you very much for inviting me here.

DEAN MUTRIE INTRODUCES DR. DALE ARNER

Dean Mutrie

Dr. Arner is the department head and Professor Emeritus of the Department of Wildlife and Fisheries of Mississippi State University, and Dale is the fellow who founded the symposium series back in 1976. He also chaired the second one at Ann Arbor in 1979, and he's been on the steering committee for all subsequent symposia. At the 4th symposium in Indianapolis, Dr. Arner was presented with an award for foresight and dedication in fostering understanding of environmental concerns in rights-of-way management.

Dr. Arner has received many other awards during his illustrious 60-year career, including Wildlife Conservationist of the Year Award in 1970 from the Mississippi Wildlife Federation, and the Sears & Rowbuck Foundation; the CW Watson award in 1985 for significant contributions to fish and game conservation; and being nominated in 1973 by the School of Forest Resources for a listing in Outstanding Educators of America. Dr. Arner is still active in teaching wildlife management at MSU, and has written more than 70 peer reviewed or invited papers on wildlife and vegetation management with focus on black bear, beaver, wild turkey, ducks, bobwhite quail and the use of fire in vegetation management.

My personal favorite is a 1980 paper presented at the worldwide fur bearer conference at the University of Maryland entitled, "The Practicality of Reducing a Beaver Population Through the Release of Alligators." I don't know why we never thought of that in Alberta! Anyway, I could go on singing Dr. Arner's praises, but we'll just leave it! That the man is a pioneer in the application of environmental sciences to rights-of-way management, and we're lucky to have him with us today. Please join me in giving a warm Calgary welcome to our honorary chairman, Dr. Arner.

Dr. Dale Arner

I must say in defense of the beaver/alligator deal, that we found in Mississippi there were a lot more cotton mouths and a lot more other critters for the alligators than the beavers, so it wasn't too successful.

I appreciate the invitation to participate in the 7th International Symposium. It's been a very pleasant 24 years involved with the symposia. It started, as you mentioned Dean, back in 1976. And in case you might be wondering how that first symposium was started, many of us were concerned about the plethora of papers that were submitted in the mid 1960s and 70s concerning rights-of-way, and a lot of these papers were beginning to discuss the environment through the use of deer as an indicator of how old a particular treatment was in their rights-of-way maintenance program. If the deer ate it or just sniffed at it, they would call it a choice deer food plan. And we were concerned about all of the people that were trying herbicides, bulldozing and seeding, and their use of deer was an indicator of the success of these types of treatments on the environment.

I talked to a number of my colleagues back in the late 60s and 70s about their concerns with the papers being presented and their content. Dr. Eggler, you might know, was a big proponent of the U shaped right-of-way. You would use selective herbicide in developing low shrubs in the center of the right-of-way. This was beginning to be developed as the solution to right-of-way maintenance. I didn't quite see it that way, and Dr. Frank Egler didn't like what I saw, so he called me the smorgasbord man, somebody who was trying to develop a lot of high quality food for deer. That was unnecessary.

Anyway, this was the typical things that we were facing back in those days in all the papers that were being presented, and after talking to a number of people at the time we thought it would be good to start our own symposium, and have a question and answer session. We could talk to people who have different ideas than we had, and have a discussion of ideas. And it evolved, and in 1976 we held the first one at Mississippi State University, and there are several folks in the room here who participated in that first one, Kevin McLoughlin was one of the ones participating. Let me see, I might have some other names here. Gus Tillman, Ed Colson, and Allen Crabtree, those were the ones that participated in the first symposium. We had about 180 some people registered. We had 36 presented papers, and that covered 330 pages of the proceedings.

Now, we — I think we had a stroke of good luck with this thing because we were able to get some sponsors from the power and utility companies down there to host a happy hour, and then we found some other donors that would grant us all the bob white quail that we needed for the dinner. So we had all the quail you could eat and all the bourbon you could drink, and this was at $25 a head. So it went over so well that Gus Tillman, the next day at a critique, volunteered immediately to chair the next one in Ann Arbor. I think if we hadn't had this happy hour, we would have had very few volunteers, but as they were all anticipating another happy hour in Ann Arbor, the meeting was a success. We had some really good papers and we had some really good comments and arguments back and forth, and I think that's what it's all about to try to put our cards on the table and discuss the pros and cons of the different treatments that we are going to use and its impact on the environment.

I think one of the things that was lacking at that one, and the next one or two was we did not have papers about endangered plant species. Also, we did not talk very much about songbirds. It was mainly deer and a little bit about wild turkey. But I think those things are being considered now, and I feel very good about the rights-of-way symposia as they have been evolved.

I do have one concern that perhaps we are not getting enough input from people in the different state resource management groups, like the game and fish departments. At first we had more input from them and as the symposia went on, we seemed to have less and less input. And they are the people with the resources to all the different treatments, like fertilizer and lawn seed and so forth for any over seeding or any of other procedures, and I think we should make an effort to have them more a part of our symposia. I don't know how to do it or what it takes, but I think this is a challenge for us to try to influence them to attend and participate.

I believe that's it — I'll wind up my little discussion here. I just want to express my gratitude again for the invitation and the hospitality and kindness that has been shown to my wife and myself at this meeting and I hope I'll be able to attend the next one. I know darn well if Gus Tillman can make it, I can. I'm looking forward to that. Thank you.

Dean Mutrie

Thank you, Dr. Arner, that was great. It's good to know that you're part of a bigger movement and there's a history here.

Now I would like to introduce our keynote speaker this morning who is Dr. Brian Bietz. Dr. Bietz has been a member of the Alberta Energy and Utilities Board for close to 10 years. He has over 20 years of professional experience in environmental health and safety issues in the public and private sector, including Director of Environment and Technology for our Western Canadian Waste Management firm, and as an environmental consultant to government and industrial clients.

Dr. Bietz is a director of the Energy Counsel of Canada and serves on the Environmental Advisory Committee of the Calgary Airport Authority. He is also a member of the Public Advisory Committee for the Canadian Electricity Association's Environmental Commitment and Responsibility Program and is Registrar for the Alberta Society of Professional Biologists. Brian is also a home grown product. He is a rare commodity in these parts. He is actually a native of Calgary. From his perspective as a member of one of the most respected energy regulatory boards in the world, ruling on controversial pipeline, power line and energy projects, Brian will share his insights into the environmental and public issues associated with energy corridors. Please join me in welcoming Dr. Brian Bietz.

Dr. Brian Bietz

Thank you very much, Dean. That's going to be a difficult introduction to live up to.

Good morning, ladies and gentlemen. It's certainly an honor to be asked to address you at this prestigious conference. As a native Calgarian, I'm certainly proud of the Province of Alberta, and I hope that all of you that are visiting here will be able to find some time to also enjoy some of Alberta's natural beauty. And please don't be lured just by the siren call of the Rocky Mountains. Alberta has a vast number of special places that range from boreal forest, Aspen parkland through the wetlands, native prairie and all of these have a unique beauty and all are tremendous places to visit.

Now, the citizens of this province have long valued these wild areas and at the same time, the province has been blessed with these ecological treasures, Alberta has also been endowed with other natural resources. These include significant deposits of oil, gas, coal and oil sands. And in combination with the province's strong agricultural roots, both Alberta's economy and its population have been growing steadily over a number of decades. And of course, with this growth has come the age-old conflict in trying to balance the protection of one set of resources for the development of the other.

Now, the decisions and the ever growing economic resources perhaps make Alberta in many ways the perfect place for the 7th International Symposium on Environmental Concerns in Rights-of-Way Management. In Alberta there is an ongoing struggle to find the balance between environmental protection on the one hand and economic development on the other.

Clearly, though, Alberta has in no way a monopoly on sensitive natural environments with the now 400 plus delegates at this conference. With over 20 countries represented, every one of you has in this room in some fashion or another been directly involved, likely on an almost daily basis, in trying to find that balance between protection of a natural environment and enhancing the efficient and economic delivery of resources to the public, whether through pipelines, power lines, by road or by rail.

I also expect that every one of you has, at some time or another in your professional careers, struggled with the trade-offs that, on occasion, must be made to achieve that balance and to protect the public interest. And the fact is these aren't simple decisions. The value that the public may place on environmental protection versus economics is often anything but clear. And furthermore, just by following the rules can be less than satisfactory since the regulations themselves that we work under are often dated relative to current societal values. And finally, societal values themselves are not static but are evolving steadily over time. Even these values are subject to a number of both short and long-term pressures. A strong economy, an acute shortage of a resource can often lead to very different views on the relative value of environmental resources.

Now, the purpose of this conference is, of course, to consider the advances that have been made in addressing the environmental issues that are associated with the development and maintenance of rights-of-ways. And looking at the conference agenda, one cannot help but be struck by the level of sophistication that is now being brought to this subject. Sometimes, however, it is also important to take a step back from the details and to re-examine some of our most basic assumptions, and that is the goal of this, the first session of the conference.

The issue that we intend to address this morning, both in my opening remarks and later in the session that will be after the coffee break is the corridor concept. And corridors, for the purpose of this session, have been widely defined. They are rights-of-ways containing more than a single linear development. Therefore, they may include two similar systems such as two transmission lines of equal size, or alternatively several pipelines of different sizes carrying different materials. Finally, they could contain different forms of linear development.

Now, historically the development of corridors has been one of the most widely accepted approaches to addressing the environmental and social issues associated with rights-of-way. It is intuitively obvious that the use of corridors for linear developments is a potentially extremely useful tool for reducing environmental impacts. By focusing development within a single restricted area, it's clear that in turn other areas can be left unaffected. And if you happen to be one of those lucky species or people that lives in those other areas, then your needs have clearly been met.

But like any other form of conventional wisdom, it's also very important that these concepts on occasion be challenged. We need to do so, not only because we continue to gather more information about their performance, but also because sometimes we find that some of the basic truths underlying our earlier views have changed. Unfortunately this is not something that we, as a society, commonly do. Therefore, I find that it is particularly impressive that the organizers of this conference have made this the subject of the plenary session. I think it's fair to say that few disciplines are willing to make sure that the emperor really does have his clothes on. So my goal this morning is to introduce some of the issues that may cause us to begin to reconsider when and how the corridor concept should be applied.

As Dean said, I'm a board member with the Alberta Energy and Utilities Board, and although Dean said some nice things, in Alberta, all energy development is regulated by the EUB, or as we are often affectionately referred to by industry, "those bastards at the board." The latter comment is usually followed by a spitting noise.

Now, the EUB's regulatory authority is extensive and it includes approvals for all new oil and gas wells in Alberta, which this year will be approximately be 10,000 to 12,000 wells, and the associated pipelines, batteries, compressors and processing plants. It also includes approvals for new power plants and power lines. In Alberta, the board regulates a little more than 20,000 kilometers of transmission power lines and 275,000 kilometers of pipelines of which 170,000 kilometers are of four-inch diameter or greater. The EUB processes in the neighborhood of 25,000 applications a year.

Now, the EUB has a rather interesting structure. A virtual army of very dedicated and very professional staff handles these thousands of applications. Because they worked hard to develop a good, working relationship with the industry, and because the industry generally has an excellent understanding of Alberta's regulatory requirements, the vast majority of the applications they receive can be routinely processed and approved. However, for a very tiny minority of these applications, less than a hundred a year, routine approval is not possible. And for energy development applications in particular, the most common issue that prevents the EUB staff from processing the application is a concern raised by an affected landowner.

Now, in Alberta, any individual whose rights may be adversely affected by a decision of the EUB has the right to a public hearing, and I think it's a tribute to the excellent relationship between the industry and the public that there are, in fact, so few hearings a year. However, when a hearing is required, this is the point where my colleagues of the board and I come into the picture. Our mandate is set out in legislation. We are tasked with ensuring that the orderly and efficient development of the energy resources of Alberta takes place in the public interest. However, the legislation does not define that term in the public interest.

Now, the legislation does require that when we make our decisions, we take into account the environmental, social and economic impacts of the proposed project. Clearly, however, it is also expected the board can consider all of the relevant factors when determining whether proposed development is in the best interests of Albertans. The hearing process, while far from perfect, does provide the board with an excellent opportunity to better understand the concerns of the public. It also provides us with a unique opportunity to watch as those concerns change over time, and while many issues have remained the same, others appear to be changing, and some of those changes, I would suggest, may be particularly relevant to our consideration today of the corridor concept. And it is those changing conditions that I would like to just focus the remainder of my comments to you.

First of all, it is clear that the Alberta public still places significant importance on environmental protection. I think it would be fair to say that on public land in particular, and in Alberta, that is a significant amount of land, this continues to be one of the public's most important objectives; however, it is very noticeable that other issues begin to take on additional importance as the proposed development approaches privately owned lands. These issues quite naturally tend to revolve around the potential direct impacts of the development on the concerned individuals. What perhaps is most interesting, however, is how the public's view of some of these issues seems to be shifting, and I would like to address three of those.

I think one of the most interesting things that we have seen in recent years has been a negative reaction from the public regarding new development in areas where there has already been a long history of industrial activity. While objections to development in relatively undisturbed regions wouldn't be surprising, this recent rising concern from areas that already have significant development is somewhat unexpected.

Now, for example, and I think this is probably true across North America, but it's certainly true in Alberta, with the current restructuring of Alberta's energy industries, we are seeing a number of older fields and facilities, particularly gas plants being purchased, refurbished and often expanded by new and smaller and more aggressive companies. This has led in turn to increased drilling, plant upgrades and often-expansive new pipeline developments where there has already been previous development.

Now, the board has had a number of objections from landowners in these areas of expanded development, and this is what's — it's an interesting argument. What they argue is that they don't oppose energy development, and furthermore, they recognize the value that is brought to all Albertans. However, they also argue that they have directly borne the impacts of oil and gas activity for the last 20 years or more, and they are not prepared to do so for another 20.

Now, the first time I heard this argument, I must admit that I was just a little bit surprised. Again, conventional wisdom would seem to suggest that it should be easier to get public agreement to the expansion of energy development in an area where it was already common. But the landowners point out that they have always been led to believe that the fields and the region would decline usually over a 20 to 25-year period. However, just when they believed that the field, the associated facilities were approaching the end of their economic life, they suddenly find themselves being asked to agree to a significant life extension or even a major expansion. This, they argue, simply isn't fair. They shouldn't, as individuals, have to shoulder in perpetuity, all the impacts from developments that are designed to benefit the general public as a whole.

Now, one might have a little less sympathy for this argument if the landowners had moved into the area after the plant or the pipeline had been built. Often, though, the fact is that they were there first and, furthermore, hadn't been particularly happy with the development in the first place. And even if they had moved into the region after the development had started, most did so with the same information that they could expect activity to decline within two to three decades. In their minds, when the company told them that this new development would have a 20 to 25-year life span, this was a commitment, and in rural Alberta in particular, such commitments are expected to be honored.

Now, a second area that we are seeing of public concern appears to be arising around safety issues in general. Despite ongoing efforts by regulators and industry alike, public concern with the posed risk seems to be growing. Again, this is somewhat surprising since at the same time that same public seems to be-coming much more knowledgeable about the actual relative risks of the various forms of energy development, including the risks of transporting that energy. The use of corridors is clearly one area where the directly affected public is raising safety concerns more frequently, and this is particularly true when it is proposed to transport new substances or commodities within the right-of-way. When this occurs, safety concerns often become a key issue that the public brings to the board for resolution. In Alberta, a common example is the addition of a sour gas pipeline with its potentially lethal hydrogen sulfide content into what was until then sweet gas rights-of-way.

Now, again, it is difficult for the board to easily dismiss these concerns. While it would seem unlikely that there would be anything greater than an additive increase in risks from such developments, the fact is that the database needed to confirm in this case is often not well established. For example, is the risk of failure in any one line increased or decreased? And if one line does fail, what are the new risks of sequential failure in another? Now, for a land owner living in proximity to a proposed rights-of-way to a proposed corridor, these are very serious questions, and it's a question I wouldn't mind leaving with this room because it's certainly one that in the future we believe has to be addressed in a more fulsome manner.

A third area of change in public attitudes is with the long-term economic impact of urban development. For example, the expansion of a right-of-way may raise significant economic questions. Again, this is particularly true when a change in the commodity being transported such as sour gas leads to a substantive increase in development setbacks.

Now, it's very rare anymore that an objection to development does not include a reference to likely negative effects on land values and our future development options. Again, this is a change from the past where many of your developments were primarily on agricultural land with little prospect in the future of being much more than agricultural land. In Alberta, certainly that scenario is changing.

Now, one could argue that economic impact should be irrelevant in protecting the broader public interest. For example, using corridors to reduce environmental or social impacts should outweigh any individual economic effects. And to a certain degree this is true, provided that society is prepared to offer fair compensation to the affected individual. However, since these public concerns lead to significant resistance to development, and we ultimately believe — that if we ultimately believe that corridors are environmentally and socially the best option in the region, we need to address the issue of appropriate compensation for affected individuals. But again, setting that fair economic value seems to also becoming increasingly difficult.

Now, what I would like to do is conclude very briefly and say that the benefits of right-of-way corridors to help manage environmental impacts are numerous. But it is important as you work towards that and examine that issue that we look for balance in the things that we do, and to remember that in serving the public interest, which ultimately is all of our goals, that many competing interests need to be addressed in arising at the best solution. I would like to invite your active participation in this morning's discussion after the coffee break because I think that will be a significant step in helping all of us to achieve that goal. Thank you very much.

MR. MUTRIE INTRODUCES MR. GOODRICH-MAHONEY

Dean Mutrie

Our next speaker is John Goodrich-Mahoney from the Electric Power Research Institute (EPRI). He is a program manager in EPRI's Environmental Department. He produced the proceedings from the sixth right-of-way sixth symposium in New Orleans, and we prevailed upon him to do it again. So he is our senior editor, and he is going to come up and make his editor's remarks.

Mr. Goodrich-Mahoney

Before I make a few comments about the editorial process for the proceedings, I would like to offer my congratulations to Dean and Colin. As many of you know, Randy Williams, from Entergy, and I co-chaired the last one, and I know intimately what it takes to do this. So a big hand to these fellows.

As Dean mentioned, EPRI will be funding the proceedings for this symposium, and I would just like to take a few minutes to comment about how this is going to happen. We have approximately 110 papers, and this is a tremendous turnout for this symposium. I would like to thank all the authors for their hard work, and also those individuals who developed posters, some of which will be submitted later as papers.

Your papers have been submitted for peer review, as we did for the first time after the New Orleans symposium. I will work with you to resolve any comments on your papers. After this process is completed the papers will be submitted to Elsevier Science Ltd. for publication. EPRI will mail a copy of the proceedings to everyone who attended this symposium.

Dean, I think that's pretty much what I wanted to cover. Enjoy the rest of the symposium and we look forward to seeing you at the next one. Thank you very much.

Corridor Concept Revisited: Multiple Rights-of-Way

Allen F. Crabtree III

A panel of five representatives from government, academia, private citizen groups, and landowners was assembled to discuss the pros and cons of the routing of multiple utilities in common rights-of-way corridors. The common wisdom for the last 30 years has been that "shared rights-of-way are good and green fields are bad." Many corridors, however, are now reaching saturation, carrying multiple utilities, transportation systems and other linear facilities. The question of "how much is enough" is a very germane topic for discussion. Routing has always been a balancing process, and there is not one easy solution. In the last 30 years, construction techniques and requirements have changed, societal values have changed, development has sprung up around corridors, and consequently developers of new lines will have to face significant environmental, engineering, safety, and land use issues. The panel discussion was an attempt to review the concept of how much is enough, when shared corridors are good and when they are not, when a green field corridor is preferable and when it is not.

Keywords: Common corridors, shared rights-of-way, utility corridors, transportation corridors

DISCUSSION

The traditional wisdom has been to route linear projects in corridors whenever possible, to consolidate impacts, to minimize land required for individual rights-of-way, and to better fit within regional and area planning efforts. Utility corridors have been established by Federal, state/provincial, and local governments in an effort to concentrate linear rights-of-way in common areas whenever possible. Regulatory agencies have issued policies and regulations that encourage the use of common rights-of-way.

This concept has proven itself in terms of reducing local impacts from construction, since shared rights-of-way allow for savings in the amount of required right-of-way. Over the years, the corridor approach has reduced the amount of new right-of-way acreage required, reduced impacts to wetlands, prime agricultural lands and wildlife habitat. However, too much of a good thing can be bad. When too many (and that is not defined) utilities are placed in common corridors, there are problems if maintenance must be done on one of these lines. The increasingly wide right-of-way affects wildlife use and travel. Landowners find that use of their property is constrained, and their ability to develop or sell is diminished. The potential for sympathetic explosions from gas and petroleum lines in common rights-of-way is increased, as is the potential for terrorism. When the number of shared lines expands beyond two or three together, questions have been raised about increased fragmentation of wildlife habitat, land use and property value impacts, potential safety issues, and aesthetic impacts. The base question is "how much corridor sharing is too much?"

A panel of experts in the field was assembled for a plenary session to discuss the pros and cons of linear facility corridors. They included the following:

- Dr. Brian F. Bietz, Board Member of the Alberta Energy and Utilities Board;
- Robert Arvedlund, Chief of the Environmental Review and Compliance Branch I for the Federal Energy Regulatory Commission (FERC) in Washington, DC;
- John Kobasa, Vice President of Engineering, Operations and Construction for CMS Energy Corporation's international gas pipeline unit, CMS Gas Transmission and Storage Company, in Detroit, Michigan;

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- James Irving, a rancher and farmer with a lifetime involvement on the family grain and cattle farm near Regina, Saskatchewan;
- Dr. David S. Maehr, Assistant Professor at the Department of Forestry, University of Kentucky, in Lexington, Kentucky; and
- Michael Sawyer, landscape ecologist with the Citizen's Oil & Gas Commission in Alberta.

The panel discussed the range of potential impacts from locating utilities in common corridors, both positive and negative. Anecdotal examples were provided, including the areas where problems have been identified, solutions, species affected, etc. There were discussions in the following topical areas related to the corridor concept:

- Regulatory issues and policies;
- Construction, maintenance, engineering and safety issues;
- Wildlife impacts and habitat fragmentation issues;
- Land use, property values, and landowner concerns; and
- Impacts to natural resources and environmental concerns.

These questions were posed to the panel for discussion:

- What is a utility or transportation corridor, and what constitutes a shared right-of-way?
- When is a corridor too full?
- Can (or cannot) the maximum number of utilities in a corridor be determined?
- What is a compatible mix of utilities in a shared right-of-way?
- When is a green field corridor the best solution?
- What are the benefits of a third-party pipeline?
- What are the impacts on the future use of land from corridors?
- Do shared corridors have a greater impact on wildlife habitat fragmentation than green field corridors?
- How have the perceptions of people changed regarding shared corridors? and
- What is the trade-off of issues that should be dealt with in utility routing?

This is a many-faceted subject, and the panel concluded that there is no one simple solution. Clearly a balancing of resource values, environmental values, social and engineering values, all need to be considered in cases where multiple utility corridors are designated, and also when additional lines are proposed for addition in common with others in shared rights-of-way.

THE FOLLOWING IS AN EDITED TRANSCRIPT OF THE PANEL DISCUSSION

Mr. Allen Crabtree

I would like to welcome you all to the continuing plenary session. We will be having a panel session the rest of the morning on which we will be following up on the excellent introductory comments that Dr. Bietz provided in his keynote address. Sort of priming the pump as it were. If you anticipate walking away from this panel discussion with a lot of concrete answers and fast and hard rules, you probably ought to go back into the poster session.

One of the delightful things about us old hands having been around the right-of-way planning and the routing process for years is that there are no set rules. The business changes over the years. The variables change that we have to deal with, whether we are a regulator or a consultant or an applicant or any of the other individuals who are involved, particularly landowners. Brian brought out that many of us have had, for the last 30 years, the Animal Farm mantra that "shared rights-of-way are good, green fields are bad" doesn't work. It works sometimes and sometimes it doesn't work.

Since the 70s, the emphasis has really been on the co-location of utilities. And as Dr. Bietz pointed out, it's not just pipelines, it's not just electric transmission lines, it's all linear types of facilities, and sometimes they are by themselves and sometimes it's co-located with other types. Routing has always been a balancing process and we have all discovered that there isn't one easy solution. The construction techniques and requirements have changed, societal values have changed. Development has strung up around corridors and future lines have significant problems.

The toughest thing that all of us have to face, whether we're a regulator or a planner is when a land owner comes up and they say, I've got five pipelines on my property, how much is enough? You're proposing another pipeline, how much is enough?

What I would like to do with this group today is to throw around some of the concepts of how much is enough. When are shared corridors good; when are they not good; when is a green field corridor preferable; and when is it not preferable. We have some slides to illustrate some case studies that will help you get a feeling for some specific instances that the members of the panel have had to face, and we'll be throwing it open for questions to the audience toward the end of the session.

But let me first ask the panel, "What constitutes a shared right-of-way versus a single purpose one?"

Mr. Kobasa

In my mind, a shared corridor occurs once you have two companies in a corridor. I think to the extent that a pipeline company or overhead transmission power company puts an overhead transmission line, and they put a second one in there in my definition, I would say that's a shared corridor. I think it's called locating with your own facilities. So in my own definition, a shared corridor starts to occur when other companies come into that corridor.

Mr. Crabtree
When is a corridor too full then?

Mr. Kobasa
Let me first set out what I think is the basic premise for considering the routing of any utility. The preferred route eventually selected should have been based on a balance of its environmental impacts, constructibility, and operating and maintenance issues, and land owner and community impacts.

That said, I believe our topical question, "When is a corridor too full?" is best answered as follows: A corridor is certainly too full when an alternative green field routing exists which has fewer environmental impacts than would the corridor routing, and it also ameliorates, if not eliminates, any constructibility and operational and maintenance issues posed by the corridor. And while the green field route probably raises new land owner nimby (i.e., not in my back yard) issues, it certainly avoids affecting land owners who have previously been affected several times as a corridor was being developed over the years. The correct selection must be based on a carefully weighed balance of the issues identified.

And since generally all involved parties in these deliberations will have their own biases, it is vitally important that a proper and balanced perspective be taken so that the route finally selected has the best chance of getting by all the parties. Let me illustrate how I believe this — the issues I just raised would come into play in an example, which replicates the situation my company has been involved in.

In the recent route selection of a 130 mile long 36 inch pipeline through a Midwest region replete with pipelines, we, like all good pipe liners, looked at the routes of other pipelines in the area who are generally headed in the direction we need to go. In effect, fully embracing the corridor concept. As we went about our routing study, we saw opportunities to parallel other pipelines without any adverse consequences that couldn't be reasonably dealt with. However, we came into a segment of the route where paralleling other pipelines started to pose some very undesirable constructibility and operational and maintenance issues.

What we found is that existing corridor in this segment occupied by two different companies with as many as three to four pipelines of large diameter already in place, what requires some 16 crossovers, actually cross unders, because of the congested residential and commercial development that already encroached on the existing corridor. We were looking at diagonal crossings some 460 feet long by 250 feet across, and at least 12 feet deep.

With the construction related issues associated with working around multiple loaded pipelines in this way and concerns it raised for future safe operational and maintenance activities, we asked ourselves, is there a better alternative for routing our pipeline through this segment, and went looking. And what we found was a better alternative routing, some four to six miles to the west of the corridor. A green field routing which affirmatively addressed those issues I identified earlier as answering the question, "When is a corridor too full?"

This new routing affected less of the environment, since it is two and a half miles shorter than the corridor route affecting fewer overall lands. It affects fewer wetlands, 3200 feet versus 7800 feet crossed by the corridor route affects fewer forested areas, 13 acres versus 39 acres of the corridor, and the new route affects some 14 percent fewer landowners.

Mr. Crabtree
If an applicant came to you, Brian, with this logical process of going through the various variables and said, "this is what we recommend", what would your answer be or your challenge to it?

Dr. Bietz
I don't know that we would — I guess under our system, the first question that we would ask is, "Do you have the same sort of sign-off by those land owners?" That would be the key question from our perspective. If the design makes economic sense, economics would probably be the last question, but if it makes sense from a safety perspective and it makes sense from an environmental perspective, it meets the current rules and procedures, and then finally, the company had been able, through effective consultation, to get the land owner to buy into this, then from our perspective, we really wouldn't have a concern.

Mr. Arvedlund
I'm not going to comment on the specific project. It is obviously before FERC, a draft EIS has been put out, so I think staff's position is kind of well known. It was one — not the first time we were faced with this. We have a couple of others in-house that we're facing the same question of when is enough enough.

In the particular EIS that I'm speaking of, we did, in fact, embrace leaving the corridor for a variety of environmental and safety reasons. I don't know that we focused on the landowner issue for this particular one, but that's becoming more and more important.

It is obvious that if somebody comes in with a route that landowners have signed of on, that makes life a whole lot easier for everybody, and we probably would embrace it. But for this particular project, it just seemed to make sense to leave the corridor and go with a green field route. What you've got to kind of recognize is the minute that you do that you might actually be inventing another corridor, because once one comes in, then a lot more comes in, although, most companies don't want to admit that up front, but that is, in fact, a reality. So you do have to kind of keep that in mind. You're creating more than just one pipeline down the road.

To get most other federal agencies, particularly the land management agencies, to sign off on leaving a corridor could be one tough nut to crack. They don't normally embrace that very well, but — and it's rare that they do that, but in this particular instance, FERC is willing to embrace that particular end of the project, but it does make sense in this case.

Mr. Kobasa

And one issue I raised and one that Bob raised I think in our 140 miles, we do collocate with other utility corridors for about 40 miles. For instance, the forestry division in one of the States wanted us to parallel the pipeline through the forest, and we had to go a little bit out of our way to achieve that balance with them.

But one of the issues we did take a look at, Brian, was landowner acceptance. And we have a little bit of history because there was another project proposed several years earlier that perhaps was going to come through the same region, though it started from a different direction, the public record was replete with land owner concerns that went into the FERC that says, "Why me again?" And we saw a significant amount of land owner letters into the FERC with that earlier project and what we realized again that we may be bringing new land owners into play, it seemed like there could have been so much opposition to coming back in, especially trying to get through some of the congested areas that, coupled with the issues that seemed to favor going out of the quarter for that segment, unbalanced to us seemed like it made sense.

Mr. Crabtree

Well, let me ask Dave and Michael, what questions would you pose for John's company; or has he given an approach that would satisfy you?

Dr. Maehr

When I think of corridor concepts, it's totally opposite, in fact, 90 degrees different than what you all are talking about here.

My concept of corridor is a landscape system that provides movement of bioduct or ecological processes from one point to another. And more often than not, the types of corridors that we're discussing here are at 90 degrees to the processes, and they cause problems in terms of the movement of wildlife, the movement of water, the movement of fire, other natural processes, and it would be those kinds of concerns that I would raise, what's being done to mitigate or reduce or eliminate the problems that those utilities are going to cause. I guess my first question to that would be, do you really need it? Is it absolutely necessary to put this thing in?

Mr. Crabtree

Okay. Thank you. All right, John, you've had the resource agency staring you in the face asking you these hard questions.

Mr. Kobasa

Well, fortunately we didn't have difficult issues to face. I don't want to minimize the impacts to farmers on going through their agricultural lands, but virtually this entire 90-mile alternative section was through agricultural land. So it wasn't an issue of affecting perhaps some local ground life, I would guess, but it wasn't an issue of going through forested wood lots or going through endangered species territories. And on the basis that we had to do all the cultural resources investigations, and we do have some phase II digs that we have to do and follow through on. It becomes the balance that we talked about.

Mr. Crabtree

Michael, how about you? If you were representing landowners on either the corridor or on the green field, what are the hard questions you would be asking?

Mr. Sawyer

Well, obviously the selection of the route is a site specific case, and I'm not familiar with all of the details, but my concern would be that it appears just on the face of it that some of the routing issues here are primarily based on engineering questions.

And one of the questions that I would raise is notwithstanding the arguments that have been put forward about the lesser amount of force, the lesser amount of wetlands, it's still new wetlands, I would assume, that are being disturbed. So it would be with the specifics in the case, we would weigh up whether disturbing those new smaller amount of wetlands are actually better than keeping that development in an existing wetlands, and it depends on the site specific. But my concern would be that some of those considerations would be overwhelmed by the economic and engineering considerations that the pipeline component would be most focusing on.

Mr. Crabtree

Is there a maximum number of utilities that can be determined for a corridor? Is there a hard and fast number?

Mr. Iving

I'm here representing some of the concerns and issues that I have as a landowner. I'm going to start off trying to introduce the topic by giving just a brief history of our situation as landowners and how corridor development has affected us.

I grew up on a grain farm, a cattle farm in south central Saskatchewan about 40 miles west of Regina. Our farm was homesteaded in 1898. In the last 50 years we've experienced corridor development on our farm. And that's resulted in seven major oil pipelines occurring on our property in two distinct corridors. The inner section of these two corridors is roughly 240 m from our farmyard. The bulk of our property as a square, basically these corridors make a big X across our property.

So, what I want to get into first is kind of outline how these corridors were developed. In 1950, the first major pipeline goes through our land. It's a 20-inch line. Today that transports NGL, natural gas in liquid form, and light crude.

In 1954, the second line goes through, this is a 24-inch heavy crude. And also with that line, a tank farm is developed about a quarter of a mile from our property for storing heavy crude which is then transported by a branch line to a Moosejaw based asphalt company.

In 1967, a 34-inch, and this is still in the first corridor, a 34-inch pipeline is then put through. This is now transporting light and medium crude. In 1977, we see the development of the second corridor on our land, and the initial line there is a 12-inch ethylene/ethane propane line.

In 1994, in the initial corridor we have another 20-inch line going through, and this is refined products and heavy crude — or just refined products. In 1998, another line going through on the initial corridor, this is a 36-inch line. This is transporting heavy crude. In 1999, in the second corridor, we have a 36-inch line going through, and this is transporting natural gas. That's the latest line being developed.

So those are the two major corridors as far as pipelines goes. And along with that we have other smaller corridors and things like overhead power lines, underground power lines, fiber-optic cable lines and things like that. So, as you can see, we have a number of pipelines, a great variety of different ages, different sizes, volumes, products being carried, pumping pressures and critical locations, as I pointed out, the intersection of those two corridors.

So what does this mean to us as landowners? Well, as far as safety is concerned, we see more lines means an increase in safety risk to us and there is concern about the different ages of pipelines. Disruption of topsoil is an excellent example of how these corridors, in the last seven years, have affected us. There's construction, and reclamation, but really, the reclamation never gets to go into effect because by the time it's initiated, you're starting on another project.

Agriculture, is another area of concern. During the construction process, you have fragmentation of pastures, fields, again, soil degradation and disruption. Life-style, this is a major one for us. This is one — especially this summer, it just really hit home for us. Constant disturbances, it's basically like living in an industrial area or a construction area.

So where do we see a future as far as landowners? One of the major things I see is that there's a very high probability with these two corridors that there's going to be more lines, and again, that's going to affect us in a variety of negative ways with the natural gas exploration of the high Arctic, Northwest Territories and with the large demand for natural gas in the Chicago area in the US Midwest. We feel as landowners, these lines are here, but there's definitely going to be more. So that, again, is going to cause an accumulation of more negative stress on us.

So our attitude has changed, I guess, as a family as land owners from let's say from 1950 when my grandfather — when the first line went through, it was kind of a — he looked at it as acceptance, basically accepting the project of compliance. He felt like it was almost his patriotic duty in developing the west. And now it seems for us that we've just seen the impacts of it so many years after years, that, for us, we've kind of entered a stage of formal objection. We don't want any more lines. The carrying capacity of the land in relation to safety, environment, agricultural productivity, disturbance to life-style for further corridor development has been reach or exceeded. We, as landowners, believe it has. However, pipeline authorities and government regulating bodies do not. Thus, there is a definite gap between what we, as landowners, feel comfortable to live with, and what pipeline and government regulators see as feasible.

So here's the million dollar question: Is it possible to develop a system or guidelines to determine when enough is enough; and if so, how should this be accomplished?

Mr. Kobasa

May I ask a question? How many different companies are involved in those pipelines?

Mr. Irving

With the pipelines, we have three.

Mr. Sawyer

What's your sense, as a landowner, of the job that the regulator, which in this case would be the National Energy Board, has been doing?

Do you feel like they're representing the public interest, representing your interest in this case?

Mr. Irving

Definitely, from the experience we've had and especially in the last couple of years going to formal objections, I don't see the regulating body as an independent body. I don't see them as looking at both issues from a nonbiased point of view. It seems to me that when they regard the issues that we bring up, it seems like they only address the trivial. For instance, from our latest formal objection hearing, the only thing we really got out of it as a positive sign was a bit of dust control, things like that. Things that are really trivial to us. I almost see the regulating body and the pipeline companies, like a buddy buddy system where they're working together and they don't really have perspective of the landowner's concern.

Mr. Sawyer

I want to follow up on that from our perspective, as an environmental group that deals with a lot of landowners. We often get the question raised about the issue of benefits and costs, and who's benefiting from this pipeline? Is it the private interest, particularly the pipeline owners or the shippers on that line? Is it the government or is it broader society? But then the question is, "Who is actually bearing the cost?" And our sense is, that as a rule of thumb, that these individual landowners who are burdened by these developments are bearing a disapportionate amount of the burden in terms of the broader public interest, but there isn't, in our view, a reasonable mechanism to compensate them. And then the other question is, even if compensation was addressed in a satisfactory way, some of those landowners simply don't want those activities to occur on their land.

Mr. Irving

Exactly.

Mr. Sawyer

And there's an imbalance here and that's what we have to address.

Mr. Irving

That's what I, as a land owner, find the most frustrating part is that while you're being compensated in monetary ways, but the reality of the situation for us is that, we don't want any more pipelines going through. If the question is, "Can we pay you more money if you put more lines in?", no, that's not addressing our concerns. We simply don't want any more pipelines. And I think it's almost unfair to say that you're being compensated for that. A lot of land owners realize that even once you get past the issue of this pipeline is going through anyway what else do we have left to restore some kind of value for this project going through? And I guess that's where we look at compensation.

Mr. Kobasa

I would like to make a comment. I think I'm always putting myself in regulator's shoes, I guess. The answer to your question of when should somebody say "enough is enough" probably establish a policy, I think goes to the point of saying, what is the alternative? You know, are we really not going to use the natural resources we have where we need them? So, again, it becomes a balance. It becomes an issue of what are the alternatives, and what's the impact of those alternatives.

Mr. Irving

Yes, I definitely see that. For obviously as far as costs go, developing more pipelines in the original right-of-way is probably the most cost efficient way of developing a pipeline. And then as far as developing a pipeline somewhere else, again, you're going to have to go through a whole different group of land owners, and it's going to be more trouble that way, too. So, again, I don't have the solution, but I do know that we have to establish some kind of limits to how many you can allow a landowner to have on his land. For us, I think that limit was six, maybe even less than that. Definitely not seven.

Mr. Crabtree

A lot of times when a company comes in with a pipeline, they will actually acquire a right-of-way for a second or third line as part of it, so when they come in with a future pipeline, they already have the easement secured. Is that the case here with any of these three companies?

Mr. Irving

In the initial pipeline, it was. In this last corridor, it was actually developed beside the initial right-of-way. There's two different companies involved with the second corridor, so it was developed beside that other company's right-of-way already in place. So now they don't have room for development of another line as we speak. But again, really, what does it matter? If they want to put another line through, if the government accepts that proposal, they'll build that right-of-way. They'll take that right-of-way. So, really, as far as their purchasing, you know, a tract of easement for two or three more pipelines, I don't think it really matters. Maybe it's just more paperwork when the time comes.

Mr. Crabtree

Brian, Bob, any comments on the situation that James has?

Dr. Bietz

I might make one. James, I understand what you're talking about in terms of our compensation system. When that first pipeline came through, there was a formula and it was based on, "we'll be disturbing your farmland one time," "it will be a certain amount of soil mixing and reclamation," and it was based on that. I really don't think our current system of compensation recognizes this ongoing and continuous impact on not only your livelihood, but also your quality of life. We're not supposed to deal with compensation when we address an issue, but you turn it on it's head in the sense that if somebody came to me and said, "Well, I'll give you $5,000 if you let me put an oil well on your front lawn in front of your bungalow in Calgary." I would say, "Forget it." But if they said, "I'll give you half a million dollars if you let me put an oil well on."

and I would say, "Well, put one in the backyard, too." I mean suddenly, you know, everything is relative.

Maybe what the companies need to have, and certainly it would make your decision-making a little more straightforward, is an economic formula that would allow them to make some of those decisions such that at some point in time, they own your farm. But maybe at the end of the day you don't mind because you've got enough money in the bank. You'll buy the next half dozen quarters to the west or to the east.

Mr. Irving

Yes, you see, that's definitely the point I agree on. The way the regulating bodies, the pipeline companies deal now is, it's property value, and the amounts of land in that easement that they are taking with the right-of-way. So I don't think the issue now is establishing compensation based on that. I think it's establishing compensation based on loss of rights. And I don't know how you put a dollar value on that, and when I say "loss of rights," I mean a loss of quiet enjoyment of our land. I don't know how you put a dollar value on that, but I know that that's what we feel is being taken by developing a right-of-way is our rights rather than our actual property, if that makes any sense.

Mr. Crabtree

At what point should the applicant or should the regulator back up and take a look at an alternate major corridor approach rather than going down the same old path?

Mr. Arvedlund

Well, I would say up to about a year or two ago, we never got to that point. I think the Federal Government, and particularly the land management agencies, absolutely made you stay in corridors. They didn't entertain ideas like leaving the corridor, or if they did, they definitely were going to put you through some hoops. You would not, for example, leave a corridor and probably get an environmental assessment. You would absolutely get environmental impact at the same time. So, leaving the corridor means a process of one or two years or maybe more instead of eight or nine months. It's an environmental decision, but it's also a very economic one to the company, because time is money. A gas pipeline, and I suspect with oil pipelines, the applicants are in a hurry. They want it now. And they can't afford a year's delay, so the route will be in the corridor one way or the other.

Now, particularly with landowners becoming more vocal, more aware and having more access to the government, I think, you better listening to them. We don't consider compensation in the formula of how we make decisions. Compensation is dealt with between landowner and an applicant or in the courts. You know sometimes I think certain regulatory people think that their landowner is using it to get a better price, and that's unfortunate. That's a crappy attitude to have, but people do have it, you know. I don't and my staff doesn't, but I can assure you in terms of routing, I can't think of a case where we thought about compensation being the answer. I'll leave it at that.

Dr. Maehr

I work as a consultant and as a scientist. I am a troubleshooter and have development issues, and it sure seems to me that we're doing our best here on the panel so far to skirt the issue of the environment. We are talking about economics. We are talking about legal issues and about quality of life issues, which I think are very important.

I would ask, how serious is the environment being considered by these big organizations? Is the environment truly a serious part of the process? How important is the environment? We find ourselves talking about these more practical human issues. Where does the environment fit in?

Mr. Kobasa

Well, I think the human species has taken the back seat to those environmental considerations regarding pipelines. I've been involved with two major corporations and started my construction activities on-shore and offshore back in 1968. Working for two major corporations and being an officer since 1980, I would say that, at least in my company, environmental considerations were always in the forefront of anything we did.

Mr. Sawyer

I would like to follow up on that and make a point that I think is relevant. If you look at the legislative and regulatory concepts of the United States versus Canada, there are some significant differences. For example, a lot of Americans make some assumptions about regulatory process. You know, you've got the Species Act, you've got the Clean Air and Water Act, and you've got others. In the Canadian context, there are no equivalents. When a person from an America company makes statements that those issues are forefront, it's probably because they have to be forefront because there is some specific legal requirements to address those issues.

In Canada, unless Brian significantly disagrees with me, I think it's a fair statement to say we don't have most of those laws and regulatory infrastructure. I think that's worth considering in the broad discussion of corridors in North America.

Dr. Bietz

Well, I think to some degree that Mike is correct. Specific laws are only as good as they are implemented, and the best law in the world doesn't necessarily accomplish things that you want to do if there are a ton of exemptions.

Just to get back to your question of the environmental issue, it is an interesting one. In my own particular position, my job is to not be an advocate for anything, which, if you know me very well, has always been a pretty uncomfortable position for me to be in, and I've learned to quell at least some of my impulses. But when I try to make these decisions, I am looking for others to argue those positions, so what tends to happen is, on public lands versus private lands you get into a different advocacy type of situation. When I'm dealing with an issue on public lands, I have a company coming forward with its position and it's got a bias, there's no question. I'm looking to the land managers to present that second position, and then quite often Mike and others present a position where, you know, that's quite a bit stronger with regards to environmental protection.

I'm actually limited in a sense. I can only address what I hear, and if those arguments aren't made in front of me in those cases, then I work with the evidence that I have. And it's an interesting process, and as a scientist I find very frustrating at times. The lawyers, however, will tell you it's the only way it can work. I guess the bottom line is, balance. If next to James, is 25 square miles of unbroken prairie, while James has half a dozen pipelines on his land, that's a really tough trade-off between green field corridor through native prairie and the existing corridor. I know personally that I would struggle with trying to find the balance.

Mr. Irving

Yes, I find that interesting, and John brought that up, too, about how the environment takes precedence or what seems to take precedence, over, I guess, human issues, land owner issues. I'll just give you a quick example with the latest pipeline that's gone through our property. One of our major concerns, is the intersection being so close to our farm yard, our house, things like that. And just down the way, the pipeline had actually been shifted in order to move around, I think it was peppered frogs, in a valley area.

And then when it came to our intersection, first of all, we didn't want the pipeline, and second of all, if it was going to go through, we wanted it farther away from where we live. And the kind of reaction we got out of it was, "Well, you'll move that pipeline for these frogs, but then for us, you know, you won't move it." So it is frustrating.

Mr. Crabtree

I can understand where you are. Let me ask, when is a green field corridor the best solution?

Mr. Sawyer

In the context of these proceedings we're talking about utility corridors, power lines, right-of-ways, highways, transportation infrastructure. But when I look at this question of green fields, I tend to fall on Dave's side of the equation. I look at it from a conservation/biologist's point of view. A corridor is a route that allows movement of individuals or species across the landscape. And there is a gap between those two things, and they're important to consider.

I want to propose a different definition of corridors from a utilitarian point of view — corridors are a linear tract of land used for human purposes that fragments natural landscapes and creates barriers to the movement of individuals or species across that landscape. Now, that may have different intensities depending on the context of any given project, but you know, I think that's true about all corridors, whether they are green field or not.

And the issue here is habitat fragmentation. The reason it's an issue is because we are entering into a significant period of extinction. To what extent do you consider that in making any individual decision?

It's reasonably well documented in the US, that there are over 750 species that are listed as threatened or endangered, and another three or 4000 that are potentially listed. Worldwide habitat fragmentation and habitat loss are the biggest single factor in putting the species at risk.

How do corridors affect landscapes and fragment lands?

I'm going to use an Alberta boreal forest example. The boreal forest occupies about 50% of the province, over 300,000 square km. This is a photograph taken from the late 1940s, an aerial photograph in the Swan Hills area of the boreal forest, and it shows a relatively pristine landscape without any linear features. This is what the same area looked like 12 years later. There was a significant oil pool discovered there. We have well sites. We have roads, pipelines, seismic lines and the landscape becomes more fractured. By the early 1980s, the forest industry had recognized that now that we have access to this landscape, we can actually go in and log. In addition, there's additional oil and gas development, and the landscape, in a very short period of time, is progressively becoming more and more fragmented.

Here's what the area looked like in the early 1990s. In a 40-year period, the area went from a pristine landscape to a landscape that is highly fractured and has really caused a lot of problem from a wildlife point of view. Now, some might suggest that this is just a nice little example for the sake of making a point. In fact, it's not that isolated an example. Let me show you some numbers.

In the boreal forest in Alberta, we have over 660,000 km of seismic lines since 1986 alone. Those seismic lines occupy a physical footprint of over 5000 square km. We've got over 100,000 wells with a physical footprint of over 2500 square km; 160,000 km of well access roads alone; with a 2400 km square footprint; 95,000 km of pipeline right-of-way, and an unknown amount of power line right-of-way, and these add up to over a 98 million km of linear disturbance or corridors which have a 12,000 square km physical footprint on that landscape. And that doesn't include the forest fragmentation from forest harvesting, agricultural conversion, utilities or other public transportation infrastructure.

When we look at this, we now have 74% of this landscape that has fragmented linear disturbance densities greater than one kilometer per kilometer square, that's about 74% of that landscape. Only 12% of that landscape remains roadless or uncorridored. Of course, these all have serious implications for wildlife species — wolves, grizzly bears, and others. The bottom line here is that, whether you call it the tragedy of small decisions or just simply call it the accumulative effects question, we have failed as a society to control the proliferation of corridors, for whatever purposes they are, and that, at the end of the day, is going to really exacerbate the extinction crisis and associated issues.

And I think what this screams out for, and I'm using an Alberta example here, but I'm sure we can find other examples where other people operate, what it says about corridors and neglected management in general is that we have to come up with scientifically and socially defensible thresholds that we determine in advance of any particular project. So that when a developer comes forward, he says, "this landscape is already full" or "it has some additional capacity," or "alternatively, I would have to free up some capacity by doing some restoration work in some way."

But in the absence of defined defensible scientifically and socially embedded thresholds, it's just going to be development, ad hoc development, every incremental proposal gets approved and we end up with landscapes that look like this, which are essentially void of any natural functioning. So I think the question, "When is it appropriate to have a green field versus an existing right-of-way?" I think it's a site specific, a landscape specific question. Obviously in a landscape like that, the corridor questions are irrelevant. It's already trashed and it doesn't really matter where you go.

If you have a relatively pristine landscape and you want to manage it, obviously it makes sense. Corridors make sense in other situations. At the end of the day, if we pay attention to managing the environmental aspects on a landscape scale, it really comes down to site-specific factors that decide between the two options.

Mr. Crabtree

When is a corridor too full?

Mr. Sawyer

Well, I think the solution to that is to work with the best available science to actually identify what the various biological thresholds that need to be applied and use that as the planning context to make the decisions about corridor routing and corridor proliferation.

Mr. Arvedlund

Yes, I don't think Brian would agree with you.

Mr. Sawyer

That wouldn't be a surprise.

Mr. Arvedlund

I feel the frustration of the landowners more so in the last couple of years than before. I just don't totally believe that there's an instant answer to, "When is enough enough?" because unless you can straighten somewhat by the width, you would just keep extending the width until you just physically ran out of room. So what might start out as a 200-foot corridor suddenly is a one-mile or two-mile corridor. And, if you're focusing on fragmentation issues, I don't think the average land owner could give a damn about that issue versus "I've got too much," you know, put it on somebody else's, let them go share the misery. Unfortunately, when you get to the new landowner, he or she feels the same way. You know, put it on Brian's land.

They're both legitimate comments, but I don't think the Federal Government has that answer. I don't have the answer, I know that.

Mr. Kobasa

Allen, I would like throw out an example, if I may. This situation might not apply because of site-specific things, but about 1967, I believe it was Shell Oil Company found the first Niagarin gas reef in the State of Michigan. This reef was defined several years later as running diagonally across the north central part of the State, from the Lake Huron coast line to the Lake Michigan coast line maybe some 300 miles overall. The State of Michigan, in concert with the producers, required one pipeline, one large gathering header that would carry both the condensates and natural gas that would be built along the trend, and then the producers would have to get transportation rights.

As the reefs were developed, there were over 200 reefs discovered, those then fed into that central header, so now you have each individual line, so to speak, coming in from the reservoirs. There was recognition back than what this pipe was going to look like overall in some master plan development, and eventually that master plan was pretty well followed.

Mr. Crabtree

You may also remember the Pigeon River saga. Here's a case where Shell and Amoco and some other developers as well wanted to develop the area. Pigeon River is state forest, and there was a lot of concern about fragmentation and what development is going to do to the elk habitat. It wasn't just the drilling of wells and the access roads. It was the treatment facilities and the gathering lines as well.

Ultimately, the field was developed, put under production and the elk herd has prospered, but that's kind of the exception rather than the rule. And it took an awful lot of work, and I'm not sure how applicable it is everywhere, but — Brian, you were shaking your head a moment ago.

Dr. Bietz

I was going to say, actually, I don't disagree with a thing that Mike is saying. I think he raises some very, very good points.

If I'm addressing a corridor in public lands, for example, and one of my major issues is environmental, then absolutely. If I have a threshold that I can measure that expansion, that corridor against, it makes my job infinitely easier. Mike is absolutely right. Then you look at the trade-offs between a new line versus expanding an existing corridor. If I can see evidence that says, well, look, I can make that corridor another 40 m wider, suddenly a whole group of species that normally was to go across 10 m, that won't go across 50 m, then my decisions become a little easier in terms of, well, maybe a green field corridor makes some sense.

I think the issue of compensation in terms of companies offering to do other things to balance off some of the new impacts, that's an area I don't think that has really been explored very well. I think some of the stuff that's been done so far is — it's not a lip service, but I don't think it's been all that practical. You know, I think as regulators, we've asked companies to do things, in my mind, they're much more effective types of compensation than we have asked for in the past. I find those are all very, very positive suggestions.

In terms of the coordination development, you're right, oil and gas companies are very difficult to get to coordinate. They're a competitive business by nature. The only real way in my mind that you do that is you tie future approvals to the success of the coordination, so that companies, when they go back to the boardrooms and they explain why they're now cooperating with what used to be their corporate enemy out there, they can go back and say again, "those bastards at the board" are making us do it. Future approvals are going to be tied to success. So there's a lot of opportunities out there for us to move forward with some new models.

Dr. Maehr

I think you're hinting at another issue and that is a development of what we want the future to look like, and environmental issues are very emotional ones in the US and I assume they're becoming increasingly so in Canada.

I think you can have more development as long as it's in keeping with some accepted vision by all parties. The compensation idea is something I'm involved in more and more in the consulting work I do in Florida. I encourage the developers and regulators to look at ways to compensate for losses of natural resources, wildlife species habitat in recreating it or promoting mitigation that actually makes things better once that development project is over with.

Mr. Crabtree

David, could you share with us what your corridors have on green field?

Dr. Maehr

In 1970, it was not even believed that the Florida panther still existed in the State of Florida, let alone in the southeast where it once raced around the southeast coastal plain. And over the course of 30 years, the panther became very popular with the public. School children designated it as the State mammal for the State of Florida and research on the panther continues today.

The Florida panther was a phoenix rising out of the ashes on its own accord as researchers studied where they were and what their problems were. And the basic problem was the panther does not have sufficient space. We can talk about genetics and problems associated with small populations, which are exacerbated by highways and utility corridors, but in fact, the problem is space. As an example, consider the movement of a single male panther moving away from its natural range, the place where it was born, in seeking a new home range for itself. And in this case the panther went from the big cypress swamp in south Florida and made it to within about four miles of the Epcot Centre in Orlando, a tremendous dispersal of over 200 km.

It was a very frustrated dispersal for him because he went to a place where there were no other panthers. There's highways, there's canals in here, there's all kinds of problems, but the animals are demonstrating the biological potential to commonize habitat. What we need to do is retrofit the landscaping in such a way that we could get females to move across these obstacles and barriers and filters that were created by humans.

One of the problems we have to overcome as the conservation biologist is not appearing too radical in our thinking. We can't move too quickly or we're shot down immediately. But one of the things that might sound strange to you is this whole idea of the park paradigm. I'm talking about the wonderful system of parks that now surface the globe, which started at the Yellowstone National Park. The Yellowstone, Yosemite, this idea of being able to capture by diversity and beautiful landscapes and postage stamp areas around the country, representatives of what we had, before our various countries were settled.

Conservation biologists now realize that parks in and of themselves were not enough. There is not a single national park in North America that in and of itself is capable of supporting all the native mammal species that were there originally. And so this begs the question of connecting or reconnecting those landscapes in such a way that regions can maintain those species that otherwise would be lost if all we had left were the parks.

Some of you may be aware of a great effort, you may hear about it later in the conference, the wild lands project would connect existing reserves with corridors and buffer zones in promoting large carnivores in recreating movement between these areas. And utility corridors, highways are a problem. They're still barriers. And from a strictly conservation/biologist's view, piggybacking as many of these corridors on top of each other, I think, is a benefit for diversity in minimizing the impacts of such a development on processes, such as, water flow, fire, parasitism, these sorts of things that are all natural processes that are interrupted by utility corridors, highways.

So I think my answer is pretty clear on new green field utility corridors. They are something to be avoided because they promote habitat fragmentation. It's being completely cold and mean to the other human issues that I think are also important. But strictly by a diversity concept, I think multiple utilities in a single corridor is the way to go.

I would challenge all of you in the room to think of ways that this process connection promotes that diversity. Are there other ways that landscapes can be retrofit by putting in new corridors? Can there be certain attributes in the landscape that can be restored and forests be planted in association with a new corridor? And I think as we see the wild lands project take off and become more accepted by the public, and this is an international effort now, we'll see it as possibilities increase.

Mr. Crabtree

Are there instances where a utility corridor can also function as a transportation corridor for wildlife?

Dr. Maehr

Where you create early successional habitats, you may encourage things like tortoises and sparrows and things that might otherwise be rare, as agriculture creates problems. You also invite exotic colonization; exotic species moving in, weedy species and you create edge effects that make it more difficult, more area sensitive than interior for species to survive.

But certainly I think it makes great sense to me to have power line corridors associated with highways, pipelines as well in those systems. You may have tremendous impacts in that particular corridor, but I think you're minimizing the overall sprawl of the various footprints of those types of utilities.

Mr. Crabtree

Do we have the right tools to answer the problem; or what tools do we need?

Mr. Arvedlund

Well, I don't think we have the right tools. I don't even think the Federal Government; the various agencies are talking among themselves about this problem. What needs to be fixed is recognizing the problem and even just sitting down and seeing if there's some common ground. I have a feeling there's not a common ground. You've got to go down to the local state agencies, and then how do you fit the landowner into the equation?

I think if you put all of those people in the same room, they would all walk out mad. So, I don't have the solution, and I didn't come here to try and say there was a solution. I certainly see the problem. I'm glad that this is one of the first conferences that I've come to that is at least openly airing to the subject. I think it's discussed behind closed doors or maybe, you know, on phone calls, but never quite open like this, so maybe this is a good start. In the Federal Government, I know there's a difference of opinion among the land agencies and the regulatory groups on this issue. I think, somewhere along the line we're just going to have to bring it out more and more. Maybe in future conferences like this we can get some of the land management agencies and maybe some state agencies as well, because I suspect they may even have more points than I have.

Dr. Maehr

In reference to tools, they're out there and available to us, to address potential problems.

This is a photograph of a wildlife underpass that was constructed when alligator alley was replaced with I-75, and it now connects Naples with the southern part of Florida. There were 30 of these things installed and it cost them about $800,000 apiece and they were heralded as a wonderful success. Panthers use them, at least six or seven out of 30, and so one could argue that indeed maybe they're not much of a success, but that all has to do more with landscaping configuration where the forest is than anything else.

The fact is, the underpass has reduced highway mortality on the Florida panther and other wildlife, and it may well be a very useful solution in some situations. The problem with having tools like this is I think it eases our guard — it allows us to lower our guard with some of the overall bigger arching —

overarching effects that new highway construction can bring.

Can we really solve the problems of fragmentation by putting in underpasses like this? I would say we can solve some of them, but we can't solve all of them. We might be able to fix problems with existing roads by retrofitting them with underpasses, but we need to be careful in avoiding looking at underpasses and overpasses as a panacea, but it definitely is one of the many tools that is out there.

Mr. Sawyer

I want to go back to the question of thresholds and I think until we, as a society, are able to step back and do some broad landscape scale planning so that we can decide on what that vision is and what the criteria to measure whether they were being successful or not. We always get bogged down in projects specific, get into the regulatory process, my sense is that that is, until we break out of this pattern, we are doomed to make small incremental decisions.

And even if a project is well planned and well implemented, there is always some incremental loss of habitat or fragmentation. And so the end result after years of ad hoc decisions, we end up with some serious problems. So I think we need a fundamental reshaping of how we think about resource development and what kind of planning context.

I wanted to raise one other point, which is fundamental, do we need these facilities? This is a broad topic. We could talk about this for a long time, but one of the things we don't talk about is demand for energy. And there's a lot of potential benefits from looking at how do we manage the demand for energy on the consumptive end, and does that trickle back up stream.

So, no, maybe we don't need that extra pipeline, and I imagine it can apply to transportation or any type of utility. And I think this needs to be considered in that big picture view that we need to adopt.

Mr. Arvedlund

It also applies, actually, to other resources as well. Do you build a new reservoir or do you have water conservation? We're focusing very hard on the regulated utilities, and yet, we have as many effects on wildlife habitat, on societal problems, on growth and development from what essentially are not federally and not provincially regulated type of problems, such as housing, for example, and some of the other items. So, I think we need to put this in the whole context.

Mr. Sawyer

And the approach that I would envision would capture those small decisions.

Mr. Kobasa

In the US, those of us in our industry have developed a good working relationship with our regulators as new issues have come up, and we've tried to sit down and tried to resolve them. But you know, in the US industry, the corridor concept was kind of no brainer up until about the mid 80s. We were regulated monopolies on the pipeline side and we all had our markets that we served, and nobody else went into those markets. You added capacity, you looped your existing systems and you stayed right along that corridor, so to speak, unless you had some other kind of deviation that was admissible.

The industry started to get deregulated with pipe to pipe competition in the late 80s. The pipes started going to other regions, connecting to different sources of supply, so this started to bring in new routing issues. Not every utility starts at the same place and goes to the same place, not even for incremental addition. So you have to say, "when can you use the corridor and when can't you use the corridor" and in the example I illustrated, there are areas where we are using corridors because it didn't pose any objectionable consequences that could be dealt with.

Mr. Irving

I think technology and a massive change of life-style into the future is going to provide the change, which is going to fix our situation. A change of life-style, where we have people trying to find other ways like solar power where you won't need a corridor with pipelines transporting natural gas to provide that energy. The answer is turning to other ways of providing that energy, and I think that will help the environment, too.

Mr. Crabtree

There are a lot of things, frankly, about corridors that we haven't talked about yet, and we could probably go on all day. There's a problem of putting two pipelines together. Are you reducing the risk of synergistic explosions? If one goes up, how far away does the other have to be? The problems of future maintenance in crossing over pipelines or working under a power line. The problems of different types of utilities running together.

Let open up the session for comments from the audience, and see if there's anything you would like to direct it to the panel as a whole or to any member of the panel.

Mr. Gartman

Well, let me give a comment as a recently retired environmental person from Columbia Energy or Columbia Gas Transmission. As far as compensation, this was addressed quite a bit, and the implication generally of eminent domain is sacrifices for the benefit of many, and maybe it's time we rethink that in terms of maybe some sacrifices of the people who are receiving this benefit for the benefit of the few that can be in terms of dollars, significant amounts, double trouble, whatever, but eminent domain has to be reconsidered.

Regarding technology, I don't know if directional drilling would have made a big difference for James's farm, but it certainly could have eliminated a lot of the surface disturbance, and so we've got methods now to go under the frog habitat and put the pipeline there if you didn't want it through your wheat field, and so those are things we can deal with. And one of the things also, all of this, the Swan Hills implications, habitat loss and such, of course, gets into the sticky issue which we won't get into, the growth in population. If you look at the population of North America when James's grandfather had his farm there, established the farm, compared to the population of North America today, I think you'll see that curve reflect just about all the problems that we're going to be talking about during this seminar. So that's my comment.

Mr. Crabtree
Would anybody on the panel like to comment?

Mr. Kobasa
Yes, I would be imposing a viewpoint on eminent domain in reconsidering eminent domain as related I think to gas pipelines. Non-regulated people like the oil companies certainly don't have federal protection, aren't under the Natural Gas Act, they can charge anything they want for their product. They have to go out and negotiate without the power of eminent domain as a rule.

I think as long as the gas pipeline industry has its rights regulated, there has to be a provision that allows us to say, what is fair and just compensation that I might have to pay for for my rights-of-way as I planned and execute projects? I can't go out and make a deal with a company to provide some service for them at some guaranteed rate without going into cases every year without having some basis for a fair pricing of the land I'm using relative to saying, I don't have the rights of eminent domain. Therefore, the last guy that wants to hold me up to keep my project from happening is the guy that's going to get the most money. There needs to be the balance that we talked about, and I think as long as our rates are regulated, I think we need the ability to have eminent domain as well as many other industries.

Mr. Crabtree
Anyone else on the panel want to comment?

Dr. Maehr
Well, look at the endangered species in the United States, and we, as citizens, voted for these types of legislation, and then we need to pay. If the landowner is losing some rights to develop his or her land, that person needs to be compensated from us, citizens of a country that voted for and supported that legislation.

So while I'm a proponent of saying I think eminent domain laws should be available to us in the gas industry, I'm just as firmly a proponent that land owners ought to be fairly compensated for what they're giving up as we build facilities across their land. I think we need imminent domain to be successful in the business. On the other hand, landowners should be fairly compensated for what they're giving up as a part of having that utility constructed. They're not mutually exclusive.

Mr. Crabtree
Another question, please?

Mr. Lind
My name is David Lind with the Land and Forest Service here in Alberta. I would to direct a comment to Brian.

One of the concerns we have as land managers is that there doesn't seem to be much of a concern, about the management of the right-of-way. No one has ever sat back and thought, well, what about when they committed that right-of-way we asked them to put in two pipelines of a certain size, one now being available for future use. When you move that right-of-way over five miles, now you've just created a problem down the road five miles over. If we could get some of the companies to work together and work on larger, Brian, are there any restraints right now, at least from the Alberta standpoint, in allowing that to happen?

Dr. Bietz
Yes, probably the fundamental restraint in terms of oil and gas development, and that's probably true for others, is your ability to predict into the future. I think it would be pretty hard to convince somebody to put parallel 36-inch pipeline into a corridor today on the anticipation of future gas, because that assumes that we will need to develop all those wells eventually to fill that pipeline. I think we really are starting to move to some degree in that direction in terms of asking companies to take these broader perspectives. How successful we're going to be is really yet to be seen.

Mr. Arvedlund
Well, that's the problem, you have to pay arbitrarily say twice the amount for another pipe and that's very hard to justify at a rate hearing. We have had some companies actually build larger diameter pipelines, which might be a little bit better answer than a wider corridor.

I like that idea, but you do have to convince not only regulators, but the people ultimately paying for the pipe that their costs are going to be higher today, but may be lower down the road. But I would rather see something like that in terms of bigger pipes, you know, that you can then expand later and maybe even higher pressure pipe so that you can expand later.

Mr. Sawyer
I just wanted to pick up on the comment from the gentleman from the Alberta Forest Service and point out the irony of the question, because we have Brian who is with the Alberta Energy Utility Board whose jurisdiction is to regulate energy projects, but they have no jurisdiction over the land. On the other hand, we have the forest service, which has the legislative jurisdiction to manage the land, but they have no jurisdiction over the activities.

It's that dysfunctional delegation of jurisdictions which results in those kinds of landscapes. So I thought it was kind of interesting, you know, that they don't talk. As a general rule they don't talk about how they're going to manage these things. So I wanted to point that out, it just struck me as an ironic situation.

But I also wanted to raise something particularly about costs and our — particularly in North America — our almost religious infatuation with this so-called market place and using the market as the determining factor. The problem with the marketplace is that it doesn't really exist and it doesn't really work, and there's all sorts of infractions with it. The point is, that when you get down to dealing with issues like quality of life, air issues, wildlife issues, fisheries issues, all these sort of things that the market doesn't capture.

So if we're using the marketplace as our decision-making of goal posts, but it doesn't consider most of the things that we want to consider, then clearly we have a problem. And I think that is one of the underlying root causes of many of our problems here is the over reliance on a marketplace that doesn't work.

Mr. Colson
I suggest that the marketplace did truly work, and perhaps it could in relation to another industry like the communications industry where they have to bid on building a particular project or a bid for an airway. What if the government was in a position to suggest that a particular developer wants to propose a pipeline project from point A to point B that it goes after a competitive bid. All these aspects will certainly arise, and then perhaps the issues would be deliberated with a greater forum. We would all wish that the best project would be built, not just one favored by a particular industry or a particular company.

Mr. Crabtree
And what would be the context for that? Would there be some type of new regulatory process?

Mr. Colson
It involves more government intervention, which is certainly something the capital, markets don't desire. Similar to what was going on in California with the Public Utility Commission. They decided what was in the best interest of Californians, and they sat and decided on who was going to build what route where.

Mr. Crabtree
And as I recall it was popular, too.

Mr. Colson
Yes, it was until they built too many projects.

Mr. Crabtree
Yes. Anyone have any comments to Ed's question? Interesting concept.

Mr. Bietz
It is, but in my mind it raises even a more fundamental question for me. I think that it goes back to the vision question. I don't think we even have a real good vision, what we believe is good environmental protection. But I suspect a grain farmer in Saskatchewan has quite a different vision than an oilman in Calgary or a forester in Grande Prairie in terms of what does the public really want in terms of environmental protection?

Some of you might know that we've got a real good berry crop this year and we've got a lot of grizzly bears coming down to the low country in Kananaskis. If you drive up there on the weekend, you're going to see a lot of yellow tape. It looks like somebody got murdered up there, but what it is is, they're just keeping you off the trails because they're trying to avoid conflict with the bears.

The interesting thing, there are two letters to the Herald, and let me add, we have had three maulings, no deaths, and interestingly, the people that were actually hurt, their reaction was, "well, we shouldn't have been there in the first place, it really isn't the bear's fault." When you read the newspaper articles there is a little bit of a dynamic. Well, the two letters were great, because they just show you how wide we are in this, and really still today. One letter said very clearly, "look, it's time the human beings stayed out of these areas, this is where bears live." The other letter was the exact opposite. "There's 10 to 15,000 bears in northern BC and Alaska, why in the world are we putting up with these wild savage animals when we're trying to enjoy our recreation?"

The problem that I have is, I don't know for sure just how widely those two positions really are held by the general public. And so that goes back to this whole vision question. I would like to think that we really put value on Florida panthers. I would love to believe that as a society. If there was a major gas shortage in the US, how long do you think it would be before we developed offshore fields in Florida? That's a question I'm not sure we really have the answers to in terms of our vision. I kind of digressed, but it sort of goes back to the economic model. Maybe we were prepared to pay for that, but I'm not sure as a society we really answered that. I'm not sure that I could ask a guy on the street, "How much are you prepared to really protect James's life-style?" and I don't know what answer I would get.

Dr. Maehr

Perhaps if I had more practicality or application if we controlled our own human population growth, I mean, that's the big wild card, and that's one thing we really can't address here.

Mr. McLoughlin

I used to be involved in routing transmission lines back in the 70s, and then in the early 80s, I was a project manager for a project entitled Environmental Externalities in New York State. I think that's what you've been talking about. Along with deregulation, energy conservation, demand side planing, environmental externalities have been cast aside in favor of direct market costs. I think what a lot of people are trying to get at here is the contingent valuation concept in economics, looking at those non-market values, willingness to pay, how much is something worth to us; willingness to be compensated for certain impacts. It's not a pure science. It's very subjective. As we said, the man on the street said, where do you go to get that information? It's a very subjective type of evaluation.

But looking back at all the impacts, in New York we're looking at natural gas as the fuel of choice. But you look back at the up stream costs of all the impacts that are occurring to get that natural gas to New York, this is where environmental externalities analysis can play a role, and unfortunately it is not conducted in New York.

Mr. Sawyer

I like what I hear there, and I would just like to point out one thing. This discussion that a lot of the energy use in the States is shifting to gas is because gas has been sold as a green fuel. If you look just at the burner tip, at the emissions and the cost, that's probably a true statement. But when you do a full cycle analysis and look at all of the upstream costs, both direct and externalities cost, that argument isn't as clear as it could be.

One of the things that I've been trying to get to are regulators, and people here in Alberta at the National Energy Board is to start considering the whole picture, and so far we haven't done that. The reality is, when we're talking about energy and energy management on a continental basis, if we actually start looking at full cycle costs and benefits we would be surprised at how inefficient we are using our resources. I think that doing a full cycle analysis would show us some real startling pictures, which would change how we treat energy in our society.

Mr. Goodrich-Mahoney

I would like to take a pessimistic viewpoint about what we're discussing today. I think one of the keys that I think Bob brought up earlier on that has not been discussed in full is fragmentation of the environment and its potential impact on the land and species. But there also the continual disruption of the land by energy projects, which may be more important. I suspect that if James had those six pipelines put in at the same time, he would not have the same level of objection that he does today. He is faced with a continual process of development, which impedes his use and enjoyment of his land.

We need better metrics for assessing and analyzing costs and we need to integrate the public and regulatory process so that more individuals are talking to each other to reach a consensus on energy projects. I also think we need a longer term vision somewhat a kin to what Chief Whitney said about the next seven generations earlier today.

Mr. Crabtree

Anyone on the panel want to comment?

Mr. Kobasa

I don't know how we get a long-term vision. It certainly seems like something you can't be against, but how you get to that is a mind-boggling issue. It's hard enough to see a year down the road in the business with all the changes that are going on, let alone with somebody with the wisdom to say, "here is what we see 500 years up."

I mean, those are nice concepts. The reality is you're faced with it today, you're faced with it tomorrow and the next day, and to try to say "where are we." I've been through months of five-year planning programs, 10-year planning programs at corporations, and after the plan is reviewed and put to print, a month later it was almost useless.

Things are changing so fast in our society, but it's not that we shouldn't be thinking about those things. Certainly we need people thinking about, "where are we going in the future?" But we also have to say this has to be living and breathing thing and it's going to change, and we realize it's going to change. We should be thinking about the future, no question. But to think somehow we're going to predict 500 years from now or a hundred years from now or even 20 years from now is a major assumption, I think. We need to be thinking about the future, but we need to be making sure we're flexible enough in our plans to be able to direct them the right way, and the conditions change because change is inevitable.

Mr. Sawyer

Well, this may be a perverse sense of optimism. If we get into a hard winter this year, with our gas supply problems and lack of storage and the tying of electricity costs to gas now, we can expect to see dramatically increasing consumer costs for energy. That might take the North American population out of their assumption that they're being taken care of, everything is fine, and it might be that shift in public perception of energy that helps us move to this longer term vision.

So even though the energy — the looming winter energy crisis is maybe upon us any day, I think it's a good thing and it will help us move in the right direction.

Mr. Crabtree

Well, we're just about out of time, and I just want to thank, first of all, the panel for your comments and your insights, and I want to thank all of you who asked questions. And I have a charge for all of you. I started out by saying we didn't have the answers for you, and it's clear from listening to all of us talk up here that we sure don't have the answers. More over there isn't one answer that fits all situations.

I am optimistic, however, I've seen when we didn't have a lot of the knowledge and the tools that we have now. But, I'm also frustrated as a former of state and federal bureaucrat that a lot of times we don't have the tools, a lot of times we hamper ourselves with our own making, our own regulations, and certainly the communication is not as good as it could be. I would like to think we're making progress.

I would like to ask each of you to please send your comments in, because this is an area that deserves a closer look in the future. Your suggestions would be most welcome.

At that, I would like to thank all of you for spending time with us this morning.

Mr. Mutrie

I didn't quite know what to expect this morning. We wanted a lively debate and we got one, and I think that's great. So, anyway, on behalf of Colin, the steering committee, and myself I would really like to thank Allen and the entire panel for just a wonderful job. Thank you very much.

BIOGRAPHICAL SKETCH

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Part II
Vegetation Management

Integrated Vegetation Management The Exploration of a Concept to Application

Kevin McLoughlin

With the seminal "Position Paper" issued (first released as an internal working paper format in the early 1990s) by the member utilities of the New York Power Pool entitled "Application of Integrated Pest Management to Electric Utility Right-of-Way Vegetation Management in New York State" the phrase Integrated Vegetation Management (IVM) was utilized, defined, and described in detail as being a more functional term. This IPM/IVM Position Paper described how many commonly accepted Integrated Pest Management (IPM) precepts (tactics and program elements) are incorporated into contemporary electric transmission right-of-way (ROW) vegetation management programs in New York State. As a result, the acronym IVM has since become synonymous with ROW vegetation management and is now used throughout the industry as an ambiguous descriptive term for virtually all ROW vegetation management activities. Unfortunately, the term IVM means different things to different people. The deployment of herbicides to achieve many of the goals and objectives of an authentic IVM program needs to be based upon the appropriate principles and practices of the much more rigorously established IPM body of knowledge. In order to gain scientific credibility and regulatory and public acceptance the entire concept of IVM (as a distinct subset of IPM) needs to be thoroughly "thought out" so that all it's various assumptions and premises are easily recognized and the benefits to be derived from the application of IVM are transparent to all. This paper will attempt to evaluate the original IPM/IVM Position Paper and focus on the rationale for the changes that have been made (and those that haven't) in the revised 2000 edition of this IPM/IVM Position Paper. The concepts espoused in this IPM/IVM Position Paper have now been subject to nearly 10 years of application experience and thus a more detailed understanding of how well the various ROW vegetation management practices qualify under the rubric of commonly accepted IPM (IVM) principles is needed.

Keywords: Rights-of-way, ROW, vegetation management, integrated pest management, IPM, integrated vegetation management, IVM, herbicides, pesticides

INTRODUCTION

The phrase Integrated Vegetation Management, IVM, has in a few short years become the expression of choice when referring to the management of right-of-way (ROW) vegetation, particularly when herbicides are the primary method of controlling the unwanted plant growth. More specifically, for the management of vegetation on electric transmission line ROW, the term IVM is now ubiquitous used and is virtually synonymous with these efforts. Practically every electric utility, contractor, chemical company, and consulting firm involved with ROW vegetation management espouse an adherence to all IVM principals and practices. This is especially true for those employing the various designated techniques commonly recognized in the industry as "best management practices" (BMPs), as determined by almost anything that is deemed appropriate and applicable within the burgeoning field of endeavor labeled IVM. This new moniker of IVM also allows one to embrace a generally well accepted concept that is recognized, by most, as a quite legitimate equivalent surrogate for the much more widely

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acknowledged pest control strategy, Integrated Pest Management (IPM). Moreover, the term IVM is actually more descriptive in respect to the field of ROW vegetation management than the much better known and historically well developed and mature term IPM. Let's face it, no one really likes to refer to a tree (well at least most trees) as a pest!

BACKGROUND

In the mid 1980s a major regulatory push for IPM occurred in New York State. Many of the definitions proposed during this period[1] by those desiring to discourage pesticide usage included such items as only using the least toxic alternatives and that pesticides should be used only as a last resort if nothing else will control the pest. At this point in time, if one were a pesticide user, a close acquaintance with the more commonly recognized basic tenets of IPM and how one's use of pesticides adhered to the more generally accepted scientific precepts of IPM was the latest, nearly obligatory, procedure to follow. The question being asked by state pesticide regulators was "how does your use of pesticides adhere to IPM dictates?"

Thus when explaining to various audiences during the mid 1980s how the NYS electric utility industry responsibly managed vegetation on ROW by using IPM, the many skeptics seeking ways to discredit this appeal would invariably clamor, "how can you legitimately call a tree a pest." During one such confrontational address before an environmental group, the snickers and chortles caused by this disclosure, (i.e., one of the "pests" being obliquely referring to was actually the NYS official Tree, the Sugar Maple) spoiled the entire message. Too often, this interspersion of the terms "tree" and "pest" while speaking to IPM concerns in regards to ROW vegetation management usurped the message the New York State electric utility industry was attempting to communicate. Hence, it was quite logical to conclude that if the word "pest" is the red flag utterance, lets simply move around it by inserting the more appropriate term "vegetation" and call the phenomena we are describing Integrated Vegetation Management. It was at this moment, in 1986, that the term IVM was born out of necessity to avoid the recurrence of this issue of calling one of the most beloved groups of plants, i.e., trees, a pest. Since many of the practitioners of the art and adherents of the science of ROW vegetation management are by academic training Professional Foresters this juxtaposing of terms was an easy path to follow and acceptance by professional Utility Arborists was akin to osmotic.

The first known use of the expression "Integrated Vegetation Management" as a descriptive term for ROW vegetation management along with it's derivation from IPM was in formal comments submitted by the eight electric utilities members of the New York Power Pool to the New York State Department of Environmental Conservation in regards to proposed new pesticide notification regulations in late 1987. This same document was then used again in a legal deposition in a successful court case as part of an Article 78 complaint by the New York electric utilities against the NYS Department of Environmental Conservation in regards to their issuance of new "arbitrary and capricious" rules for pesticide notification.

With this deposition as a starting point, the New York electric utilities began in 1992 to assemble an in-house working document that more suitably and thoroughly described how ROW vegetation management met the qualifications of a genuine IPM program. This in-house working paper evolved into a "IPM/IVM Position Paper" using the classical IPM tactics and IPM program elements as the framework for showcasing how ROW vegetation as practiced in New York State meets all applicable IPM standards. This IPM/IVM Position Paper was released for extensive industry review and comments were solicited from the regulatory community, academia and noted experts in the field of ROW vegetation management beginning in 1993. With the reception of approvals from over 50 reviewers and inclusion of comments where appropriate, the IPM/IVM Position Paper was finalized and finally approved by the Executive Committee of the eight member systems of the New York Power Pool for general distribution in 1995. This paper was then probably given its widest audience when it was also published in the proceedings of the Sixth International Symposium on Environmental Concerns in Rights-of-Way Management held in New Orleans in February of 1997. As a result of this relatively broad distribution for a regional electric industry "Position Paper" many new adherents to IVM and others involved with IPM took the opportunity to further express their views. With the acceptability of the IVM concept by the environmental regulatory personnel in New York State, the electrical utilities practicing IVM on their ROW were also subject to the increased scrutiny of the practical aspects of implementing the IVM concept and the various interpretations of what constituted an appropriate application of IVM.

With the movement to a deregulated electric utility industry and an unbundling of generation assets, the face of the NYS electric utility industry has changed dramatically. For instance, the New York Power Pool is now the NYS Independent System Operator, i.e., an ISO. With the demise of the NYPP, the handling of collective NYS environmental regulatory affairs by the state's electric utilities is now being arranged by the Environmental Energy Alliance of New York (EEANY). The former NYPP IPM/IVM Position Paper

1 Such efforts persist to this day.

is currently being updated and revised by the members of the Alliance to incorporate some of the latest terms and concepts in the ever changing field of IPM. This latest venture is attached as Appendix A. Over the eight-year existence of this IPM/IVM Position Paper numerous comments concerning the contents were received, mainly from entities outside of New York State, that questioned some of the substantive subject matter and points of view expressed. New information, updating of data, revised definitions, and experience in applying IVM have all contributed to the need for a fresh look at this IPM/IVM Position Paper that is approaching nearly a decade of existence. Thus, a reevaluation of some of these past comments and how best to understand and properly interpret the current rendition of this "IPM/IVM Position Paper" are in order. It is the purpose of this paper to provide some of the rationale behind these statements and explain the concerns that generated this IPM/IVM Position Paper in the first place. The following fourteen points provide a framework for discussion of most of the macro issues brought forth by various reviewers over the years since the NYS IPM/IVM Position Paper was first released.

IPM is generally misunderstood

Unfortunately, what is imprecisely grasped or even poorly comprehended by many well-meaning IVM practitioners and adherents is that not all "so called" BMPs are really all that good and some are quite noticeably better than others. Allowing and condoning virtually any and all ROW vegetation management activities, treatment procedures, application techniques, etc. as simply various commensurate IVM alternative methods to be prescribed on a site specific manner without reliable qualifiers and adequate safeguards can be an invitation to disaster and a golden opportunity for the antipesticide zealots to chip away at the Holy Grail of ROW vegetation management.

This fact was dramatized to the author by two distinct episodes in the mid 1990s that occurred while addressing utility audiences about this relatively new term, IVM, as embodied in the New York Power Pool seminal "Position Paper" entitled "Application of Integrated Pest Management to Electric Utility Rights-of-Way Vegetation Management in New York State." A couple of astute attendees brought home clearly this message; this reappraisal of current ROW vegetation management practices emphasizing, for the most part, the selective use of herbicides and announcing it as "IVM" is really just calling a rose by a different name. In other words, really nothing has changed in the ROW vegetation arena as a result of adopting this IVM nomenclature. What has actually occurred is only the insertion of a new phrase, "Integrated Vegetation Management" and it's acronym (IVM) has been brought on the scene and this new descriptive term has caught the fancy of the ROW vegetation management community and is now a highly popular expression. As more succinctly put by another seasoned and well-credentialed ROW observer, it was simply "adding a new term to a term rich field." These observations, although seemingly belittling the concept of IVM to some ROW Managers, are basically true. However, IVM is a more comprehensive descriptor than the formerly popular phrase "selective ROW vegetation management."

The second episode of concern was when a well meaning ROW Manager from the audience volunteered the observation "My company use's two kinds of IVM, ground broadcast and aerial applications and we let the contractor make the decision as to which technique to use." Other comparable comments along a similar vein (i.e., a very narrow assortment of available ROW vegetation management techniques) have been submitted over the years as an acceptable electric utility ROW IVM program. It seems that some ROW programs are still adhering to the "Silver Bullet" concept that "one size fits all" and are enamored by the possibility that one single technique or chemical (tank mix) combination will solve all their ROW vegetation management problems across the spectrum of vegetation conditions they find on their respective systems. Unfortunately, some chemical company advertising efforts seemingly promote this type of myopic viewpoint.

When taken collectively these two observations do not bode well for the long term health and well being of IVM on electric utility ROW. The proper application of IVM, as a direct offshoot of IPM, should usher into use a sophisticated system of decision making based upon all principals and tenets of applicable IPM science. This is the main thrust of the former and current NYS IPM/IVM Position Paper on this subject. In this IPM/IVM Position Paper we try to answer the question, in a point by point evaluation, of how contemporary ROW vegetation management as practiced by the NYS electric utility industry achieves or even exceeds all applicable IPM fundamental principles.

This somewhat strict adherence to the body of knowledge referred to as IPM may be due in some part to the unique regulatory nature of New York State. The NYS Department of Public Service may be the only regulatory body in the nation requiring the submission, review and eventual approval of System-Wide ROW Vegetation Management Plans under Part 84 of the Public Service Law. This set of regulations also requires annual updates of ROW vegetation work completed, as well as anticipated efforts for the forthcoming work season, which are then monitored through field inspections by the PSC staff. Closely coupled to this unique regulatory system is the complementary degree of involvement by the NYS Department of Environmental Conservation in the use of pesticides for the ROW Category under Part 325 of the Environmental Conservation Law. Personnel from both state agencies routinely inspect electric utility ROW vegetation management activities and are on call for any and all public complaints. The NYS IIPM/IVM Position Paper is thus used as by these regulators as yet another "yardstick" to measure the competence of the company ROW vegetation management programs. Consequently, due to these "checks and balances" the deployment of an IPM systematic approach to electric utility ROW vegetation management has become common place in New York State and thus some of the aforementioned concerns seemingly do not apply.

Thus, one of the most common errors or misinterpretations occurring by readers of the "IPM/IVM Position Paper" is a lack of understanding of IPM. Although, this concept (IPM) has been around in agriculture for about 50 years it is just emerging for many other sues of pesticides. Rudimentary IPM definitions and predecessor concepts were being generated back in the late 1940s. Literally hundreds of legitimate definitions of IPM have been created over the intervening five decades. As a relative upstart in the field of IPM application, we ROW Managers must, by necessity, borrow heavily from the body of literature and systematic approach that have been developed and so successfully applied by the agricultural sciences and industry. As IPM is now being applied to virtually all pesticide usage, the head start gained by agriculture is amply evident in the IPM literature and encountering solid information and examples outside the agricultural experience is a relatively recent event. In fact, when one thoroughly checks the IPM literature the ROW category for IPM is usually found under "Urban IPM" or another relatively new terminology of "Community IPM." Although we may think we are closer to the forestry type use of pesticides, the IPM literature has placed us as an extension of other manmade environments as in the "turf and ornamental" and "landscaping" pesticide use category.

IVM is a subset of ROW management

Another macro misinterpretation of IVM in general, is that this single concept is the all-inclusive phrase to cover all aspects of the broader field of endeavor that comes with the territory expressed by the term "ROW Management." Many activities performed on the ROW have little to do with IVM and among the foremost with an environmental orientation are some proactive wildlife management actions that do not directly have a bearing on the manipulation of the ROW vegetation. For instance, placement of blue bird boxes and the installation of raptor nesting platforms in towers are just two of many wildlife related actions taken in conjunction with ROW management that have little if any direct bearing on IVM. In fact the entire field of "avian interactions" as they relate to electric transmission support structures is not directly linked to the use of IVM on the ROW. Although mentioned peripherally in the New York IPM/IVM Position Paper, the building and maintaining of access roads, particularly across streams and through wetlands, is an important environmental aspect of ROW maintenance that is not directly linked to the IVM program. Certainly, better ROW access roads and routes will undoubtedly aid and abet the IVM program but it is not in the normal sense a direct part of it. In many northern States and Canada the opening of ROW to snowmobile use in winter with trail marking and grooming are popular activities that are in the ROW multiple use category not at all related to IVM. However, in those ROW programs that employ the use of herbicides to curtail the growth of trees, IVM is an appropriate and applicable moniker to describe this effort. However, if the ROW vegetation management program is completely mechanical, e.g., mowing, and/or manual, e.g., hand cutting, and no herbicides are used, then the term IVM would not technically apply and thus need not be used. Direct oversight and overt interest by environmental organizations and regulatory agencies[2] virtually disappears when pesticide use goes to zero and with it the need to use the term or even talk about IPM/IVM.

The utility IVM program could easily be subsumed under these broader more inclusive ROW undertakings be they entitled ROW Resource Management, Integrated Resource Management, Line Clearance Program, or ROW Environmental Management or whatever other descriptive title best fits the situation.

No herbicides, no IVM: Does IVM overemphasize herbicide use?

Another major complaint by some reviewers (usually not utility) was the emphasis on herbicide use in the original "NYPP IPM/IVM Position Paper" to achieve the benefits of IVM. This again was quite purposeful. When first developing the IPM/IVM Position Paper in the early 1990s, several IPM "Experts" were contacted for their ideas about the subject as it related to the control of ROW vegetation. One almost universal warning received from this bevy of IPM practitioners and specialists was that we (the electric utility industry) always have a quite viable non-chemical option available to us when the pest population reaches that predetermined threshold of economic harm. In other words, we (the utility industry) have the distinct advantage (unlike many other pesticide users) of being able to remove the pest threat from the ROW by exercising mechanical/manual/physical means to rid the system of the pest. For most other IPM practitioners, once the pest has reached a certain threshold level the action that must be taken is the application of a pesticide. In many agricultural situations, no other

2 This is not the case in New York State. The PSC looks at the costs, risks and total environmental compatibility of the ROW vegetation management program and thus encourages the judicious use of herbicides to create low growing relatively stable ROW plant communities requiring less long-term maintenance.

non-chemical approach is even possible. We, the electric utility industry, on the other hand always have a non-chemical option available to us that can be put to use right up to the last moment. Thus, to adequately address this real concern, the paper goes into repeated exacting detail about the myriad long-term advantages of employing herbicides in an ever more discreet and selective applications each treatment cycle resulting in less material being used over time.

Waiting (or not) for economic thresholds to be exceeded

An offshoot of the above discussion and another potential IPM problem for IVM is the timing of application based upon classical IPM dictates of waiting until one has reached the economic damage threshold of an intolerable pest level. It is inherently much more difficult to determine acceptable injury level for a ROW situation since the incremental damage done by growing trees is not easily computed. Complete adherence to this IPM prescription would have ROW Managers literally running around their system always "hot spotting" trees that are just ready to enter the wire security zone. This would actually be the antithesis of a proper IVM procedure that has as its concurrent goal the fostering of all the low growing desirable vegetation. Waiting until the trees on the ROW are so tall that they are encroaching on the wire security zone is foolish from an economic, system reliability and overall environmental viewpoint. With such tall trees allowed to remain on the ROW so long, the shading effects on the desirable vegetation would virtually eliminate these assets from the ROW. Since the promotion of all lower growing vegetation is touted as the equivalent of the well established IPM "biological control" tactic in the application of IVM to ROW vegetation management, this threshold concept if incorrectly applied as "just in time" maintenance could lead to serious long term problems, i.e., the reduction or even elimination of many low growing species, and is a complete misapplication of the IVM concept.

Preventive measures are not the same as treatment methods

One of the most common problems encountered with various well meaning reviewers and some IPM/IVM practitioners as well is understanding the differences between "preventive measures" on the one hand and the three classical IPM tactics of cultural, biological and chemical control methods on the other. Preventive measures in and of themselves are not a control tactic although they can sometimes be confused with the implementation of cultural control practices. Another ROW (albeit roadway) example might help. Expanding the road pavement out beyond the normal point of guardrails placement and then installing the guardrails through the pavement will eliminate the need for future under guardrail vegetation control. This procedure is customarily designated as an IPM preventive measure not as an IPM cultural pest control tactic. In other words, it is "changing the design of the facility to completely avoid the need for pest control." As for electric transmission line ROW, preventive measures usually are all those other "multiple uses" of the ROW that preclude the growth of trees. These range from parking lots to pastures.

One interesting preventive measure enhancement program recently instituted by a New York Sate transmission owner (and member of EEANY) is a cost sharing effort with the underlying ROW landowner. In ROW areas that are now "wildlands" and the ROW vegetation management is performed by the utility, if the underlying landowner has an opportunity to transform the ROW into a productive use, the company will cost share the work to be done (50/50) to convert the ROW to a landuse condition that will preclude the establishment of trees. So far, this effort has created pastures for sheep, cows, and horses. Deer food plots were a goal of another ROW landowner and grass cover to be mowed adjacent to a campground is another conversion project. The key to the success to date of this endeavor is the willingness of the landowner to match the monetary contribution of the electric utility so that the landowner has from the onset a vested interest in the success of the ROW land use conversion project.

Another quite unique ROW multiple use that has emerged recently is the use of the ROW in the production of raw materials for the increasingly popular rustic Adirondack stick and twig furniture. Large twigs (branches) and young sapling size boles of certain common tree species are the "feedstock" for this unique furniture form. Adirondack style furniture and other such rustic embellishments (e.g., picture and mirror frames) in the folk art tradition are becoming quite trendy for interior design and decoration in the mode of a "casual elegance." This means that such traditional tall growing target tree species as yellow birch, gray birch, white birch, pin cherry, black cherry, and hickory are now being purposefully grown on the ROW and carefully harvested (to prevent damage to the bark) in the sapling stage for eventual production of this unique, currently in vogue, primitive style furniture. The future of this stick and twig market for rustic furniture designs is being watched closely as any let up in harvesting of these tree saplings will leave the ROW in a situation requiring immediate attention.

IPM (IVM) control tactics: Cultural

The traditional "big three" IPM tactics of cultural, biological, and chemical were relatively easy to differentiate for IVM applications. Cultural tactics in an agricultural context stem from various "cultivating" practices like plowing the soil just prior to seeding to turn over the weeds and put under residues of last years crop. Both these outcomes, due to tillage, reduce the pest populations. Other classical agricultural

cultural tactics include strip cropping and crop rotation. These agricultural applications of cultural tactics involved various mechanical, physical, and manual methods and combinations of all three to produce the desired pest control effect. Thus, IVM cultural methods, considered in this context, could be regarded as *mechanical* tree removal by mowing or *manual* by hand-cutting with a chainsaw with either of them resulting in the *physical* removal of the tree(s) from the ROW environs.

IPM (IVM) control tactics: Biological

The biological controls in traditional IPM usage refer to the employment of other organisms that are usually a disease, predator or parasite to the target pest. These predators or natural enemies of the target pest are purposefully manipulated or applied as beneficial biological controls. For ROW IVM, the deliberate introduction of such tree pests to kill off such ecologically desirable and economically important plants is virtually impossible. Even giving members of the public the erroneous thought that this could occur would be cause for immediate serious concern. Nonetheless, currently under development is the first true biological control for application on ROW. A naturally occurring fungus is being commercially tested for application to the freshly cut stumps of red alder in the Pacific Northwest. It seems that this fungus will begin to infect the cut surface and spread far enough to thwart any forthcoming vegetative reproduction, i.e., stump sprouts, without infecting the healthy uncut trees just off the ROW. There are exceptions to every rule and this seems to be one of them, but it may become more prevalent as such biotechnology applications keep advancing.

Overall, the term biological control as used in an IVM context can also mean natural controls or ecological controls, which are also sometimes referred to in the IPM literature, and this is where the low growing desirable vegetation found on ROW fits so nicely into the picture. It is the wide assortment of lower growing species that are fostered and promoted by IVM practices and these become the assets (credits) of the ROW IVM program much as the tall growing target trees are the liabilities (debits). This "simple" objective of IVM is to increase the assets (percent vegetative cover occupied by desirable low growing vegetation) and simultaneously decrease the liabilities (the number of trees stems capable of eventually reaching the wire security zone). The ecological consequences of such tree removal actions and the fostering of all lower growing vegetation are well stated in the IPM/IVM Position Paper. The down-to-earth fact remains that two things, i.e., plants, cannot occupy the same space at the same time. All the IVM activities that degrade the presence of ROW trees and thus concurrently foster the establishment and growth of all the other low growing species will aid and abet this IPM biological control tactic.

IPM (IVM) control tactics: Chemical

The deployment of chemicals on ROW for IVM is not a last resort type of operation, but a very deliberate and focused approach to achieve a highly desirable end-point. This message is the primary focus of the NY IPM/IVM Position Paper. We wanted to make it abundantly clear, to friend and foe alike, that without the judicious selective use of herbicides the relatively stable ROW plant community composed of an assortment of low growing shrubs, vines, herbs, grasses, sedges, reeds, ferns, etc. cannot be created let alone maintained. One of the basic IPM tenets repeatedly depicted in the literature is the statement that IPM is a system designed to provide long term management of pests, not temporary eradication of them. This is certainly the goal of IVM and by promoting the existence of all low growing plants on the ROW (by minimizing our treatment effects upon them) while focusing our efforts on the selective removal of target tree species, the long term maintenance of the ROW is always given a top priority.

IPM (IVM) control tactics: Physical

The newest official entry into the classical lists of IPM tactics is "physical." This forth IPM tactic was added to the latest EPA IPM definition back in 1994 (after the first drafting of the NYS IPM/IVM Position Paper) and is also the definition used by the NYS DEC in its latest set of pesticide regulations officially adopted this past January 2000. Thus both Federal EPA and State DEC definitions of IPM previously included only the three classical tactics; cultural, biological, chemical and now include physical as a forth. As a distinctly new set of pest control tactics encompassed by the addition of this new term, physical, the examples for IVM seemingly are overlain by the various cultural tactics of mechanical and manual that are also by nature physical. However, in the IPM literature physical means such things as the application of heat and steam as well as use of physical barriers and various other similar control methods such as hand picking, sticky traps and other trapping techniques. Hence in the latest version of the IPM/IVM Paper (Appendix A) the terms of cultural and physical are now purposefully used in an interrelated fashion. These other physical efforts (e.g., heat) are not addressed in the revised IPM/IVM Position Paper as they have yet to find a niche in the ROW manager's toolbox.

IPM (IVM) control tactics: Others

Other commonly used terms for multiple IPM tactics, otherwise referred to as methods of control, control measures or even tools, found in various IPM definitions also include such designations as legal, educational, pest resistance, sanitation, habitat modification, natural enemies, natural mortality, weather, and finally no action. None of these secondary IPM tactics are dealt with in the NYS IPM/IVM Position Paper.

Why isn't the popular term "brush control" used?

The long commonly used electric utility industry expression "brush control"[3] should now be considered almost an oxymoron when used in connection to IVM, since by the very definition of "brush" (actually the plural of bush or dense growth of bushes) meaning shrubby vegetation, i.e., shrubs, vines, and small trees, it gives an erroneous picture of what we are now trying to achieve with a balanced IVM approach to ROW vegetation management. A "balanced" IVM approach means that the eradication and subsequent decline of target tall growing trees on the ROW will be done in a manner that has the propensity to preserve, to the extent practical, all the existing desirable low growing plants (including many woody shrubs) that are compatible with the goals of long term ROW vegetation management. This is what is truly meant, in part, by the term "integrated" as used in the expression IVM. IVM is also an integration of techniques that will allow, nay, even promote and foster, the existence of one set of green plants while quite selectively discriminating against another set of green plants so that over time a conversion of the ROW plant community occurs resulting in a minimum maintenance situation. If a utility is constantly resorting to repeated indiscriminate broadcast applications (from the ground or air) of herbicides or is constantly mowing, this is not truly an IVM program but a ROW maintenance or "brush control" effort that will virtually never cease nor wane.

Isn't high volume foliar spraying the same as broadcast applications of herbicides?

In regards to the declaration in the IPM/IVM Position Paper that NYS electric utilities never use aerial spraying or indiscriminate ground broadcast applications of herbicides, the simple fact is that by definition and practice no utility has to resort to this type of ROW application anymore in New York State. However, many companies still routinely use high volume ground foliar applications albeit in a selective manner. In the conventional high volume foliar application of herbicides, each target tree species, i.e., the foliage and stem, is thoroughly wetted to the point of runoff. At the same time patches of desirable lower growing vegetation remain untreated. Whereas the definition of broadcast spraying requires a uniform coverage of an entire area with a predetermined rate of application, so that every square foot of surface receives a specified dosage. Although uniform high-density stands of trees selectively treated by the high volume technique will, admittedly, end up looking a lot like the same density of trees treated by a broadcast application under some circumstances, the general trend is noticeably different. Due to the inherent patchiness of ROW vegetation rarely is an entire span, let alone a sizable segment of ROW, so uniformly filled with a dense 100% coverage of target tree species. Another reason for emphasizing this difference is that the definition of the term and usage of "broadcast application" of herbicides has quite important legal meanings and connotations aside from those depicted on the pesticide labels directions (although the label is the law). A case in point, the state of Vermont has banned certain *ground broadcast applications* of herbicides. Another example, the new amended label for one herbicide allows the selective and spot applications of the product in active pasture situations while posing restrictions and other rate limitations on broadcast applications under the same circumstances.

Notwithstanding these nominal (so far) strictures on broadcast herbicide applications, some ROW situations elsewhere in the country (or world) may actually lend themselves to a broadcast treatment with certain qualifying factors. For example, tall high-density stands of trees can first be mowed to immediately gain control (reclamation) of the ROW and reduce the amount of aerial biomass needing treatment. Immediately following the mowing, a broadcast application with a radiarc type spray unit of a soil active residual herbicide (perhaps selective to dicots or legumes) can be performed that will leave some vegetation unharmed while effectively taking out all the woody vegetation prior to resprouting from the severed stem and untouched roots systems. Unfortunately, this type of control approach has been severely limited of late due to new label restrictions of the preferred selective herbicide for this application technique. Also, in remote regions with dense stands of trees occupying the ROW, the only feasible method to the control the growth of trees may be aerial application of herbicides.

Update and/or add new definitions of IPM

Many comments received over the years had to do with proposing new definitions for IPM and/or IVM that better fit the ROW circumstance. The IPM/IVM Position Paper used and still uses the most basic generic expressions found throughout the literature for describing IPM. There are literally hundreds of legitimate definitions of IPM found in the literature. One of these almost made it into the new IPM/IVM Position paper. This definition is probably the "best" existing definition of IPM found befitting the usage of IVM. This definition came into being in 1994 and J.R. Cate and M. K. Hinkle of the Audubon Society are credited for this unique succinct definition of IPM as follows.

3 Another similarity that is drawn from the field of Forestry is the demise of the term "fire control" in preference for "fire management." Fire control was the popular term used to describe the entire fire program when it consisted only of fire prevention, detection and suppression. Now with the advent of allowing wild fires to burn if they meet predetermined conditions and the use of prescribed burning the term fire management is now the preferred term.

"Integrated Pest Management is the judicious use and integration of various pest control tactics in the context of the associated environment of the pest *in ways that complement and facilitate the biological and other natural controls* of pests to meet economic, public health, and environmental goals."

Point of comparison: No-till agriculture and IVM

Two items previously mentioned, i.e., the notable agricultural background for all things IPM and the fact that utilities always have a non-chemical option, brings us to another important point of comparison not mentioned in the IPM/IVM Position Paper or elsewhere. This comparison came while discussing IVM with some agricultural IPM practitioners. We may be able to draw some interesting similarities in the use of herbicides on ROW by the electric utility industry to achieve certain desirable environmental endpoints and the relatively new agricultural efforts to establish "no-till" farming practices to achieve the noble goal of sustainable agriculture.

The deployment of no-till agriculture is depicted as an environmental success story (and rightfully so) in progress. Its primary purpose is to minimize soil erosion (by water and wind) and the concurrent nutrient loss resulting in sedimentation and other water quality impairments by suspended solids and nutrient enrichment. By reducing soil and nutrient loss, less fertilizer is likewise needed as an added benefit. Long-term soil productivity is thus ensured. Improved soil moisture management is enhanced and reduced fuel costs are also results of no-till cropping systems. However, in order to control weeds and reduce the chance of pest buildups in the crop residuals a combination of increased chemical (herbicide) usage and cultural tactics must be used for this unique agricultural system to be successful. In a no-till cropping system, herbicides replace tillage for weed control. It is also important to rotate the crops in this system and avoid planting the same crop back into its own residue.

In many recent agricultural IPM scenarios, the no-till system is always mentioned as an anomaly, whereby herbicide usage in this instance is actually greater and more needed than previously with tillage. Without herbicides, the no-till system is a no-go. Without the judicious application of herbicides to selectively remove only the target tall growing tree species from the ROW while purposefully fostering all the desirable low growing species, the goals of IVM are likewise virtually impossible to achieve. We (both the electric utility industry and the agricultural industry) have individual success stories here to be proud of, but we must get our stories straight and strictly adhere to the basic tenets and principles of our respective sciences and not allow ourselves to be lulled into complacency with clever verbiage and adroit postulations. Unfortunately, there is simply no easy way to add this distinctive comparison into an already too lengthy NYS IPM/IVM Position Paper.

SUMMARY

Although not a lot has changed from the original IPM/IVM Position Paper first written as a New York Power Pool in-house document circa 1992–1993, released in 1995, widely published in 1997 and finally to the new slightly amended 2000–2001 version to be released under the Environmental Energy Alliance of New York banner. The many comments and suggestions, questions and inquires, interpretations and citations received over the years necessitated a hard new look at the original thesis in respect to both the changing times and all the new IPM/IVM information becoming available. The numerous well meaning observations and opinions proffered over the existence of this document demanded a public explanation as to why certain positions were taken and things said. Differences of opinion and emphasis will remain as to ascribing the low growing desirable ROW vegetation as a "biological" control or using the newer term, an "ecological" control or even "natural" controls. Moreover, some common IPM preventive measures as applied to the ROW situation may overlap with someone's perception of cultural control tactics. Irrespective of these minor semantic skirmishes, the overall message is now clear and the passage of time has now imbedded the term IVM firmly into the rubric of ROW vegetation management. So much so that now others are borrowing the same term (IVM) for their particular application of IPM to a solely vegetational situation, e.g., the control of alien invasive species in natural environments.

CONCLUDING REMARKS: IVM IN RESPECT TO HERBICIDE USAGE

It is still a long regulatory road ahead for all pesticide users, as the public perception (read social intolerance) of pesticide risk in general is still very high. Even though the herbicides in common IVM use on ROW today have very low toxicity, particularly as applied diluted in various carriers, and the mixing and delivery methods are substantially better than ever, the environmental and human health concerns over all pesticide usage are ever present. The fear and loathing still generated by the word "pesticide" by the vocal majority of Americans today may seem like an irrational response to those of us that have taken the time to thoroughly review the risks. However, it is these very same irrational and most often emotional fears that when taken collectively drive government policy, create the laws, and make the regulations that can jeopardize the continued use of pesticides. As an industry, as pesticide users, we must strive to continue to improve our performance, and use these valued tools in a manner consistent with the esteemed principles of IVM, which we all so highly tout and so emphatically espouse. Overuse, misuse or otherwise overtly harmful uses of these valuable materials must not be tolerated. We all have a lot to gain if these miracles of modern chemistry are allowed to do the job intended, we all have a lot to lose if these products are banished from our custodianship.

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BIOGRAPHICAL SKETCH

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APPENDIX A

APPLICATIONS OF INTEGRATED PEST MANAGEMENT TO ELECTRIC UTILITY RIGHTS-OF-WAY VEGETATION MANAGEMENT IN NEW YORK STATE

Environmental Energy Alliance of New York Land Use Subcommittee Committee Position Paper

The Environmental Energy Alliance of New York is an association of electric and gas Transmission and Distribution (T&D) companies and electric generating companies that provide energy services in the State of New York. This position paper was prepared by the Land Use Subcommittee of the T&D Committee, which currently represents the following members: Central Hudson Gas & Electric Corporation, Consolidated Edison Company of New York, Long Island Power Authority, New York Power Authority, New York State Electric & Gas Corporation, Niagara Mohawk, Orange & Rockland Utilities, and Rochester Gas & Electric Corporation. For more information about this Position Paper please contact Kevin T. McLoughlin, the System Forester for the New York Power Authority at P.O. Box 200, Gilboa, New York 12076. Tel. (607) 588-6061 ext. 6903, Fax (607) 588-9826 or e-mail: Kevin.Mcloughlin@nypa.gov.

EXECUTIVE SUMMARY

As a matter of public safety and system reliability, electric utility rights-of-way (ROW) vegetation managers have a continuing need to preclude the establishment and subsequent growth of tree species that are capable of growing up into or even close to overhead electric lines. The members systems of the Environmental Energy Alliance of New York (EEANY) Transmission & Distribution (T&D) Committee employ the process of Integrated Pest Management (IPM) to ensure that tall growing trees do not interfere with these critically important electric power transmission facilities. IPM balances the use of cultural, biological, physical and chemical procedures for controlling undesirable tree species on utility ROW. These IPM procedures, as practiced by the New York State electric utility industry, can be more appropriately referred to as an Integrated Vegetation Management (IVM) strategy. One of the important components of the IPM/IVM process is the selective use of herbicides to curtail the growth of undesirable tall growing tree species while preserving, to the extent practical, the lower growing vegetation on the ROW to act as a biological deterrent to the future re-establishment of trees.

The EEANY Land Use Subcommittee members have been practicing IVM policies and programs for over two decades on those portions of the approximately ten thousand circuit miles of overhead transmission line ROW that require the vegetation to be managed.

IVM is an environmentally compatible activity that is cost effective and has all the elements of a conscientiously applied IPM strategy. This paper discusses the application of IPM to contemporary electric utility ROW vegetation management practices in New York State today.

Integrated Pest Management (IPM) is a process that balances the use of cultural, biological, physical and chemical procedures for reducing pest populations to tolerable levels. Rather than relying solely on chemicals (or eliminating chemicals completely) IPM seeks to produce a combination of pest control options that are compatible with the environment, economically feasible and socially tolerable. The control of vegetation, i.e., the contemporary management of vegetation, on electric utility line rights-of-way (ROW)[4] readily accommodates itself to an IPM process. This paper describes how the member electric systems of EEANY T&D Committee have been actually practicing an IPM strategy for about two decades. However, that strategy can be more appropriately referred to as an Integrated Vegetation Management (IVM) strategy.

BACKGROUND

In New York State after a forested landscape is cleared, or when a cultivated field is abandoned, the natural vegetation type that will ultimately re-occupy the site and dominate the area will be tall growing trees. When the cleared area is an electric utility ROW, these resurgent trees can grow too close to the overhead electric lines. When this occurs, there is the potential for an electrical discharge from the electric line through the air to the tree and then to the ground. This is known as a "line to ground fault" or "flash-over." The result of a line to ground fault is an instantaneous break in electric service and a potentially very dangerous situation on the ground in the immediate vicinity of the high voltage discharge. Therefore, as a matter of public safety and system reliability, utility ROW vegetation managers have a continuing need to preclude the establishment and subsequent growth of those tree species that are capable of growing into or even close to the electrical lines.[5] Utilities ensure that tall growing trees do not interfere with electric lines by committing to a long-term ROW vegetation management program.

4 Electric utility ROW are strips of land, from 30 yards to over 300 yards in width, that are used by electric utilities as corridors for the transmission of electric energy.

5 The electrical facilities being discussed herein are for the most part high voltage transmission lines and only those lower voltage distribution lines that have a discernible cleared ROW. There are more than 10,000 circuit miles of overhead transmission lines at or above 34.5 kV belonging to the member systems of EEANY. ROW vegetation management under these electric transmission facilities is quite distinct from roadside tree trimming around distribution lines and these street tree-pruning operations are not the subject of this paper.

INTEGRATED VEGETATION MANAGEMENT AS AN IPM STRATEGY

IPM has been described as a system of resource management that attempts to minimize the interaction between the pest and the management system through the integrated use of cultural, biological, physical and chemical controls. Implementation of an IVM program utilizing modern ROW vegetation management techniques meets this definition completely; IVM is a system of resource (vegetation) management that minimizes interaction between the pest (tall growing trees) and the management-system (safe and reliable electric service) through the integrated use of *cultural* (mechanical and manual methods that *physically* remove tree stems), *biological* (low growing plants and herbivory), and *chemical* (herbicides) controls.

Utilities use three general routine procedures for removing tall growing trees from the ROW: (1) mechanical methods such as mowing with large machines and hand cutting with chainsaws, (2) chemical treatments, i.e., the selective application of herbicides, and (3) combinations of both mechanical and chemical methods.

Mechanical methods of tree removal alone will clear the ROW of tree stems temporarily. However, employment of these mechanical methods allows trees to physiologically respond by regenerating quickly from the energy reserves contained in their undisturbed root systems. This tree regrowth occurs through such mechanisms as "stump sprouting" and/or in some species "root suckering." This regenerative capacity is characteristic of virtually all hardwoods,[6] e.g., maple, beech, birch, aspen, oak, ash, cherry, etc. and is particularly pronounced in the juvenile or sapling stage of tree maturation resulting in the eventual production of many more stems than were originally cut. By drawing upon the food reserves in their undisturbed root systems and through a series of complex compensatory physiological plant responses, the resurgent growth from the remaining portions of the tree (stump and/or roots) is actually enhanced when a tree stem is severed. It is through the production within the plant of naturally occurring stimulatory substances together with the loss of growth inhibitors (caused by the removal of the above ground growth centers) which then exert their influence on the remaining vegetative structure to promote excessive new tree growth. These new, more numerous stems, growing much faster than when left uncut, (e.g., five to ten feet or more the first year after cutting) makes subsequent tree removal from the ROW more frequent, laborious, hazardous and costly.

6 Hardwood is a conventional term for all deciduous (broad-leaved) trees belonging to the botanical class "Angiosperm." Softwoods, also commonly referred to as evergreens and conifers, belong to the botanical class "Gymnospermae" (and are practically confined to the order "Coniferae") do not posses this regenerative trait (with one lone partial exception in the northeast — young pitch pine), and once cut below the lowest whorl of live branches will not resprout.

The selective application of herbicides to only the tall growing target tree species can in most instances eliminate completely the resurgent tree growth problem because the herbicide when properly deposited on the target species translocates throughout the tree (including the root system) and arrests all future growth and development, i.e., killing the entire target plant not just temporarily removing the above ground portion. Selective herbicide application involves two general techniques:[7] a basal application to the lower stem of the tree and a foliar application to the leaves. Selective application of herbicides only to the target tree species allows retention of nearly all the desirable low growing vegetation on the ROW. The elimination of the tall growing trees from the ROW will also encourage the further growth and development of all the indigenous low growing woody shrubs, herbs (forbs and grasses), ferns, etc. by removing the trees that would otherwise begin to directly compete with and eventually "crowd out" the low growing species over time. With effective minimally disruptive tree removal, these lower growing desirable plant species will expand into the ROW areas formerly occupied by trees and produce a thick dense plant cover that will discourage the invasion of new tree seedlings and/or the future growth of any remaining tree seedlings. These desirable low growing plant communities act as the "biological controls" in this IPM/IVM scenario. The establishment and the preservation of these low growing plant communities on ROW serve to reduce over time the amount of work required and cost incurred by the utility to maintain the ROW each treatment cycle while coincidentally diminishing the amount of herbicide necessary for adequate coverage of the target species.

Mechanical and chemical controls are often used together with favorable synergistic results. For instance, a tree is manually cut with a chain saw and the resulting freshly severed stump is treated with a herbicide formulation to prevent resprouting. This procedure removes the immediate physical threat to the overhead electrical line as well as the future tree growth with little disruption to the surrounding desirable plant cover while requiring very limited use of herbicides in a highly efficacious spot application.

ESSENTIAL ELEMENTS OF AN IPM STRATEGY — ILLUSTRATIONS & EXAMPLES

Traditional IPM programs consist of five basic elements: (1) preventive measures, (2) biological controls, (3) monitoring, (4) assessment, and (5) control measures. These essential elements of a sound IPM/IVM program are illustrated in the following examples.

7 Many variations of these two techniques exist.

Preventive measures

When the land use of a ROW is altered to preclude the establishment and growth of trees, the utility has little, if any, ROW vegetation management activities to perform. This advantageous situation occurs when a ROW fee owner or adjacent land owner productively uses the ROW in a manner compatible with the electrical facilities, and this use usurps the potential development of tall growing trees. The most common ROW multiple uses often involve various types of agricultural[8] activities, i.e., crop production, pastures for grazing livestock, and within certain height limitations even Christmas tree plantations and some types of orchards. Those agrarian activities, as well as many other types of allowable industrial, commercial and residential multiple uses, which effectively curtail the opportunity for any tall growing vegetation to become established can thus eliminate completely the burden for any ROW vegetation management by the utility. However, any use of the ROW that allows even one tree capable of growing up into the electrical lines, e.g., hedgerows between cultivated fields, requires due diligence by the utility to prevent an electrical discharge.

Biological controls

One of the principle goals of ROW vegetation management is to promote low growing relatively stable (long lived) plant communities, which consist of numerous species of woody shrubs, herbs (forbs and grasses), ferns, etc. on the ROW. These low growing plant communities are a very desirable ROW accessory in that they inhibit both tree establishment and their subsequent growth by directly competing with the tall growing species for the available site resources (sunlight, water, and nutrients). Thick low-growing plant communities, which hinder tree seed germination and the early development of the undesirable tree seedlings and small tree saplings, act as the biological control agents in this IPM/IVM strategy.

There may even be some indirect biochemical interactions, called allelopathy, occurring among various plants that result in a chemical competition of sorts between certain lower growing desirable ROW species and some of the tall growing tree species. Allelopathy has been defined as the influence of one plant on another via the production of natural growth inhibitors. Currently there exists only a limited understanding of this ability of plants to produce and release phytotoxic substances that can then be translocated to other plants and used to curtail certain critical physiological plant functions such as growth and reproduction.

8 It should be noted that most agricultural pursuits require the use of significant amounts of various pesticides, e.g., insecticides, fungicides, herbicides, etc. on an annual basis. Thus, the total quantities of pesticide applications will often dramatically increase on those ROW areas converted to farmland as compared to the spot treatments of herbicides every four to seven years by the utility.

These naturally occurring "herbicides" offer yet another potential beneficial aspect of the biological controls in assisting the ROW vegetation manager to curb the spread of the undesirable tall growing trees.

In addition to their immediate benefits to the utility of reducing the undesirable tree population, these low growing plant communities offer an assemblage of plant species that provide diverse and productive habitat conditions for a wide variety of wildlife, e.g., birds and mammals. Managed ROW creates habitats that provide wildlife food and cover values that are remarkably different, and oftentimes surpassing, those of the neighboring forest. Also, this juxtaposition of two different, but complementary plant communities (one perpetually kept in a low growing condition and the other usually a forest) produces what is known as the "edge effect." This effect enhances wildlife profusion, i.e., abundance and diversity, in the boundary area transition zone (ecotone) between these two distinct habitat types. Some of the new and more numerous wildlife species attracted to these enhanced ROW created habitats provide yet another beneficial function of further reducing tree establishment and growth through their collective herbivory, e.g., browsing by deer and rabbits on young trees, girdling of tree seedlings by voles, and tree seed predation by mice.

Monitoring

As explicitly called for in an IPM program, monitoring of the pest population involves the following items:
- Regularly checking the area
- Early detection of pests
- Proper identification of pests
- Noting the effectiveness of biological controls.

The ROW vegetation managers of the EEANY member systems routinely carry out all of these monitoring activities as an integral part of their electric utility ROW vegetation management programs. Monitoring procedures have been integrated into the NYS Public Service Commission approved "Long Term ROW Management Plans" developed by each member system. Monitoring activities include an evaluation of the previous treatments to determine overall program effectiveness as well as the current condition of the ROW so as to ascertain when the next treatment should occur and by what means. All of these procedures are part of a sound IPM/IVM strategy. ROW throughout New York State are regularly inspected to determine the height and density of the tall growing target tree species as well as the condition of the lower growing vegetation. Inspection results help determine, to a large extent, the timing and type of ROW vegetation treatment that the utility implements.

These field inspections also serve another important function, i.e., the fulfillment of a quality assurance/quality control (QA/QC) program. This QA/QC component of the ROW vegetation management program provides feedback as to the conduct of the field crews regarding their adherence to the work specifications as well as to determine the longer-term efficacy of the treatments. In addition to the routine utility monitoring, the Department of Public Service staff annually inspects the results of the company ROW vegetation management programs to insure compliance with all applicable regulatory mandates.

Identifying the undesirable tree species is a critical component of an IPM/IVM program. With hundreds of species present on a ROW, all vegetation treatment personnel must be sufficiently knowledgeable of plant species to enable them to readily distinguish between target trees to be treated, and all non-target desirable low-growing species to be left as undisturbed as possible. Based upon field inspections, the type of vegetation treatment will also be determined in large part by the distribution and abundance of the lower growing species. For instance, when thickets of shrubs, such as viburnums or dogwoods, are present together with only a few target tree stems, the highly selective stem specific application of herbicides would produce the most acceptable results. The extensive use of mowing for example over such a ROW segment containing only a few target species would be quite disruptive to the existing desirable low growing vegetative cover. Such an ecological disturbance would unnecessarily leave the ROW in a much more open and vulnerable condition thereby actually enhancing the ROW site conditions for the eventual re-establishment of undesirable trees as well as significantly reduce its aesthetic and wildlife values.

Assessment

Assessment is the process of determining the potential for pest populations (target trees) to reach an intolerable level. For ROW vegetation managers, the most opportune time to eradicate target trees is well before they reach the height of the overhead electrical lines. From an assessment perspective, an effective IPM/IVM strategy needs to: (a) prevent any interruption of electrical service and avoid risk of injury to the public, (b) treat the target species at their optimum height range of five to ten feet or as they emerge from the lower growing plant cover (at this stage they can be conveniently treated with limited amounts of herbicide so as to achieve the highest degree of control possible), (c) cause the removal of the target tree species before they become tall and dense enough to begin to crowd out and adversely alter the composition, structure and density of the desirable lower growing vegetative cover, and (d) minimize any direct disruption by the treatments themselves to the existing desirable ROW plants so they continue to occupy the ROW and function as biological controls.

Control measures

IPM strategy dictates that once a pest population has reached the intolerable level action should be taken.

Typically, under an IPM program, chemical pesticides are used as a control measure when no other strategies will bring the pest population back under the economic threshold. In fact, the success of IPM often occurs by waiting until a pest population reaches this threshold and then often hinges on the availability of a pesticide to bring the pest population back under control quickly. For ROW vegetation management the pest population consists of only the target tree species that meet certain critical height[9] characteristics. Only those trees that have emerged from the lower growing plant "canopy" need to be selectively removed; thus many very small tree seedlings may remain untreated, submerged within the low-growing plant community on the ROW. Most of these small tree seedlings, left fully submerged within the dense low growing understory vegetation, will never fully develop into trees as they will succumb to the surrounding competitive pressures of the lower growing desirable vegetation and its associated biotic agents, e.g., animal herbivory. An additional positive attribute of this biological control feature occurs when those few remaining target trees that finally "escape" from the low growing plant communities only do so after a considerably longer time period than would normally happen under relatively (open) unencumbered circumstances. This helps to extend the duration between ROW vegetation treatments.

The choice of treatment technique as well as the explicit mode of application to ensure adequate control of the target tree species are also important aspects of selective ROW vegetation management that uniquely qualifies IVM as an IPM approach. As part of an IPM/IVM program, herbicides are used only to treat individual tree stems or groups of target trees, and no aerial or indiscriminate ground broadcast (blanket) applications (uniformly spraying the entire ROW) are used in New York State today. Herbicides that are used on ROW are matched to site-specific characteristics and target species, and the products are selected from dozens of commercially available materials based upon various attributes such as efficacy, toxicity, cost, etc. Furthermore, once a specific herbicide(s) is selected for application, its efficacy can be further enhanced (and its environmental impact minimized) by proper timing and selection of the most suitable method(s) of treatment (including integration with mechanical controls) together with choosing the most appropriate formulation and dosage rate.

The option of non-chemical mechanical clearing of the ROW; by hand cutting with chainsaws, mowing with large machines like a hydro-ax or even using massive earth moving equipment in a stump/soil shearing operation, is most always an available alternative. These physical methods of tree species removal are used for those ROW segments occupied by or located close to sensitive land uses or containing special resources that have been determined to be vulnerable to the application of herbicides. These designated ROW locations can be granted this extra protection through the judicious use of "no spray zones" or "set back distances" which are often referred to as "buffer zones" where herbicide use is not allowed. The determination not to use herbicides can be made by the ROW manager on a site-specific basis or through general company policy even when law, regulation, and label conditions allow such herbicide use. The discretion to employ buffer zones as well as the selection of the appropriate set back distances, must be made in a prudent manner since all the mechanical alternatives will inevitably cause an increase in the number and vigor of incompatible tree species on those portions of the ROW so treated. However, the opportunity to employ mechanical clearing of the ROW is an available option for the ROW manager on specifically chosen ROW segments with certain predetermined characteristics that warrant this treatment. Herbicide usage can be restricted in deference to specific notable ROW resources or as a consideration to particularly sensitive land use conditions while still maintaining the overall goals of a sound, long term, and effective IVM program when viewed from a system-wide perspective.

Even in certain ecologically sensitive areas, the selective use of herbicides may be apropos provided the appropriate precautions are taken. For instance, when treating vegetation in or adjacent to designated wetlands, a herbicide with the appropriate characteristics, e.g., an aquatic or wetland label could be selected. However, to assure that virtually no surface water contamination occurs (irrespective of any allowable label statements) buffer zones can be prescribed around streams, lakes, wetlands, and other sensitive water resources. Studies have shown that buffer zones of only 5–25 feet can effectively curtail the deposition of airborne spray particles and the movement of the herbicide by runoff into surface water resources. A dense stand of vegetation in the buffer zone will

9 This "critical tree height" is determined "electrically" by the distance between the tip of the tree and the overhead electric line with consideration for the voltage of the transmission facility, at any given point on the ROW. The higher the line voltage the more clearance that is necessary around the conductors which is often referred to as the wire security zone. For instance, a 765 kV line requires about 25 feet whereas a 345 kV line needs about a 15-foot wire security zone. Also, as the voltage of the transmission facility increases the minimum wire distance from the ground likewise increases. The minimum conductor sag at mid-span allowed for a 765 kV line is about 50 feet from the ground whereas a 345 kV line only requires a height of around 30 feet from the ground. Finally, the location of the tree on the ROW will determine the distance to the conductors and the resulting allowable maximum tree height that can be tolerated at that particular point. Trees located near the edge of the ROW or close to tall towers can be allowed to grow taller than their compatriots located in the center portions of the ROW near conductor mid-span which is within the area of maximum line sag, i.e., where the line is closest to the ground.

further reduce the linear distance of buffer zone necessary, as will very stem specific treatment techniques. Conversely, sparse vegetation in the buffer zone and high volume treatments will increase the distance of the buffer zone required to insure abatement of any herbicide movement. All established EEANY member system specifications for their buffer zones meet or exceed these threshold conditions.

ROW CONVERSION

One quite unique aspect of IPM, as applied to the management of ROW vegetation, is the relative long-term nature of the desired effects and the timeframe required to assess the consequences of actions taken. Although, mechanical removal of the tall growing trees will physically eliminate the immediate threat to electrical reliability and public safety, this method only serves to perpetuate the long-term tree problem and exacerbate future ROW maintenance requirements. Typically, mechanical tree removal will result in the need for more cutting as frequently as every two or at most about four years. After several mechanical treatments, i.e., over a number of ROW treatment cycles, the collection of tree stems requiring control can readily increase to over 20,000 stems per acre. Similarly, when a new ROW is cleared and all vegetation is allowed to grow back naturally, the target tree densities will likewise increase to very high levels in only a few years after the initial tree removal operations and prior to any herbicide application. In fact the term "ROW Reclamation" is customarily used to describe the extreme actions that must often occur to treat very high tree stem densities that are frequently found on a routinely mechanically treated ROW.

When herbicides are used over several treatment cycles, the period of time between treatments can usually be elongated from three or four to six or seven or even more years and concurrently the number of stems to treat each cycle becomes fewer. Herein lies the truly unique aspect of ROW vegetation management from an IPM/IVM perspective; the treatment of vegetation with herbicides must be viewed over the long term to fully grasp the significance of this system in reducing the target tree population that will also reduce the use of chemicals and concurrently increase the effectiveness of the biological controls, i.e., all the lower growing plants that volunteer to occupy the ROW. For example, when a new ROW (or an older ROW that has received only mechanical treatments) is first treated the amount of herbicide needed for proper coverage of the numerous target trees may be in the order of about two to four gallons of concentrate per acre. The following treatment, three to five years later, may require about half that amount because the number of target species has been reduced and the lower growing desirable vegetation is beginning to exert it's influence on the ROW vegetation dynamics. The next treatment, in four to six years, will continue this downward trend in herbicide usage until subsequent treatments produce "nearly" a tree-free ROW requiring a minimum of judiciously applied herbicide to produce the desired effect. At this stage the low growing vegetation is firmly established and offers a relatively stable condition that effectively inhibits the rapid resurgence of trees. However, in order to perpetuate this highly desirable minimum maintenance ROW condition, when new trees begin to emerge (as they most certainly will from the tree seed sources off the ROW) these target trees must still be controlled through the diligent efforts of the ROW vegetation manager to preclude their full development and ultimate dominance over their lower growing associates.

This process of "conversion" from a ROW that is literally filled with trees to one that is dominated by lower growing vegetation with only a few remaining tree stems capable of growing into the overhead electric lines is not a simple one step process, but requires an extended program commitment and adherence to a long range vegetation management plan. Each phase in the ROW conversion process can be quite complex depending in large part upon the target species mix coupled with tree height and density together with the abundance and distribution of the low growing vegetation as well as other site specific characteristics. As the stem density of the target species is reduced with each passing treatment cycle, the type of treatment chosen can then become more selective. Finally, after several treatment cycles when the ROW is occupied by a low density of target trees and the conversion process virtually completed some continuing herbicide use will still be required, but the focus at this stage shifts to selecting techniques which offer the minimum amount of disturbance to the desirable lower growing vegetation, i.e., the biological controls.

General considerations

The use of herbicides by the EEANY member systems is subject to regulation under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) administered by the US Environmental Protection Agency (EPA) and Article 33 of the New York Environmental Conservation Law (ECL) administered by the Department of Environmental Conservation (DEC). Pursuant to FIFRA regulations, no herbicide may be marketed, distributed, sold or advertised until the EPA registers it. After many years of product development, advanced toxicology studies and field testing, the pesticide manufacturers submit to EPA thousands of pages of research data that are compiled into a registration application. From this voluminous registration package, the manufacturer develops a proposed product label that identifies the pest or pests that the product will be effective in controlling and provides complete instructions for correct use, handling, and disposal of the product as well as other information required by FIFRA. In New York State, the DEC has the responsibility for establishing regulations and standards for the registration of pesticides, the certification of pesticides applicators, and all other matters pertaining to pesticide use as well as the responsibility for enforcement of all it's regulations and standards.

Other Federal, State and even local laws and their resulting regulations may impinge on the manner in which ROW vegetation management activities will occur. As mentioned previously, wetland protection requirements can have a pronounced effect on the types of vegetation management techniques chosen. Considerations for the protection of endangered or threatened species and their habitats can similarly become a dominant concern on some ROW. For instance, the nurturing of the endangered Karner blue butterfly and its requisite host plant, the blue lupine, has resulted in considerable evaluation of selected ROW herbicide use in the preservation and enhancement of the habitat conditions necessary for the survival of this endangered species of butterfly. Even the State requirements for management of river corridors under the Wild and Scenic Rivers Act provide definitions and requirements for IPM. Local ordinances, zoning mandates, as well as property owner concerns may sometimes play a critical role in the selection of ROW vegetation management techniques, e.g., the control of poisonous plants, invasive weeds, and allergy producing pollinators. In some instances voluntary compliance with provisions of the Federal Noxious Weed Act may require action on the part of utility ROW vegetation managers to prevent the spread of listed deleterious weeds and other alien invasive species. For example, the control of infestations of the introduced weed, purple loosestrife, which threatens the biological integrity of North American wetland ecosystems by displacing native vegetation is a goal shared by the electric utility industry with both state and federal environmental agencies.

Prevention of non-point sources of pollution & storm water discharge requirements

Another important regulatory program that can directly affect the choice of ROW vegetation management practices available under IPM/IVM is found within the authority of the Clean Water Act as amended by the Water Quality Act of 1987 and involves the control of non-point sources of water pollution along with some aspects of the permit requirements for stormwater discharges for point sources resulting from construction activities. These regulatory programs focus on water quality issues, i.e., the prevention and control of water pollution. In both programs, as they apply to the ROW maintenance situation, the focus is on using management practices to prevent, reduce, minimize or otherwise control the availability, release, or transport of substances that adversely affect surface and ground waters. They both act generally to diminish the generation of potential water pollution emanating from sources on the ROW.

The control of non-point sources of pollution is accomplished through the identification of "best management practices" (BMP's) and their implementation on a site-specific basis using best professional judgment and experience. The control of stormwater discharges which can be considered as point sources due to their collection of runoff into a single outlet, e.g., a culvert or ditch, are similarly treated by the requirement to prepare a "Stormwater Pollution Plan" under the auspices of a SPDES (State Pollutant Discharge Elimination System) General Permit. This plan essentially enumerates the BMP's that will be used to prevent and/or control polluted runoff from occurring. Neither of these programs imposes effluent limits for specific substances, rather they provide for an effective means of reducing or preventing the impact of pollution generated from land management activities. In addition to the ROW managers primary concern of minimizing pesticide related impacts within the context of an IPM strategy, these two somewhat interrelated regulatory programs broaden the environmental concerns arising from IVM to encompass other pollution control objectives. Thus, both of these clean water related programs could directly influence the decision-making process of the ROW vegetation manager and in some cases virtually dictate the menu of treatment choices available.

The most common potential source of pollution arising from a ROW is erosion and the resulting generation of sediment causing siltation in streams and other waterbodies. Sedimentation from all sources is a major water quality degradation issue in New York State. Also, the loss of soil nutrients and their entryway into surface watercourses or groundwater by excessive leaching or as attached to sediment particles is likewise an important water quality concern. Both of these major sources of water pollution can be generated from ROW if bare soils are present or insufficient plant cover occurs. Therefore, in choosing ROW vegetation management techniques, particularly on steep slopes or other areas of high erosive potential, e.g., riparian zones, the ROW vegetation manager must be concerned with their effects on the local hydrology. Vegetative disturbances resulting in bare surfaces or exposed soils and the degree to which vehicular traffic movement occurs causing rutting can become limiting factors in the selection of target tree control methods. For instance, mowing with a hydro-ax on a steep slope or along a streambank could cause erosion by vehicular rutting as well as through denuding the site by excessive removal of vegetation.

The imposition of these regulatory programs to prevent and/or control sources of potential degradation of water resources arising from ROW vegetation management activities results in the following two general precepts: (1) maintain as complete a vegetative cover as possible at all times, and (2) keep exposed soil and any soil disturbance/compaction operations to a minimum especially in critical areas. By keeping these two relatively simple fundamental principles a host of positive attributes can be ascribed to the ROW vegetation management program including: (1) dense low growing vegetation on the ROW will act as filter strips for the surrounding area thereby decreasing overland flow, increasing soil water percolation and removing pollutants, (2) complete vegetative cover on the ROW will stabilize soils and prevent erosion and sediment transfer, (3) minimizing soil compaction by restricting heavy vehicular traffic on the ROW decreases the amount of surface water generated on a given area and thus reduces the volume of stormwater runoff, and (4) avoidance of any soil disturbance on the ROW will reduce or eliminate the need for amelioration activities that would otherwise be required under these clean water programs to restore the disturbed area to its original slope, soil compaction, ground cover, and hydrologic condition.

ROW management research

IPM is never a finished or static process. As fresh data become accessible and new knowledge is obtained about the pests in question and the various control treatments available, the specifics and details of the currently acceptable IPM strategies will naturally be altered and thus subject to constant modification. IPM practitioners can aid and abet this dynamic adaptation and improvement process through conducting basic ecological research on the pests in question as well as applied research in new and promising control strategies. Also needed is the constant reappraisal of existing techniques in order to modify them to produce even more efficacious results. The member systems of the EEANY have individually conducted research into IPM related ROW management matters but even more so collectively, through the auspices of the former Empire State Electric Energy Research Corporation (ESEERCO),[10] have collaborated on numerous research projects over a 25 year span of time involving many diverse aspects of ROW vegetation management. These studies were conducted on a wide range of subjects and a host of issues important to utility ROW managers in their execution of ecologically sound and cost effective IPM/IVM programs.

Beginning with a literature review in 1973, this extended ESEERCO ROW management research program has included projects on ROW treatment cost comparisons, long term effectiveness, ROW treatment cycles, herbicide fate and mobility, allelopathy, ROW multiple uses, buffer zones, soil compaction and mitigation, repeated mechanical cutting effects on vegetation and costs and the effects of ROW treatments on wildlife. Two of the more recent multi-year studies have recently been published in the mid 1990s; *ROW Vegetation Dynamics* conducted by the Institute of Ecosystem Studies and *ROW Stability* by the State University of New York College of Environmental Science and Forestry. The final ROW research product to come out of ESEERCO program in 2000 involves a risk assessment and environmental evaluation of the use of tree growth regulators. These numerous and diverse research projects have greatly assisted the New York State electric utility industry to focus their ROW Vegetation Management Programs on the most cost effective and least disruptive techniques while also allowing them to tailor the research results to their own individual company circumstances. The latest ROW research efforts currently being undertaken by the electric utility industry are now found within the bailiwick of the Electric Power Research Institute (EPRI). EPRI has picked up where ESEERCO left off and has created a new research target, "ROW Environmental Management & Development" which is currently being subscribed to by 44 electric utilities across the nation.

SUMMARY

The overall goal of a utility ROW vegetation management program is to provide for the safe and reliable transmission of electric power in an economic and environmentally compatible manner. This lofty goal translates "on the ground" into the vegetative conversion of a strip of land, i.e., the ROW, often initially found filled with tree saplings to a ROW corridor that harbors mainly a profusion of lower growing species. This goal is currently being achieved in New York State by the implementation of sound IPM/IVM programs at each of the electric transmission and distribution systems of the EEANY members. To paraphrase applicable IPM terminology; ROW vegetation managers use multiple tactics to prevent pest (tree) buildups that could endanger electric system reliability and public safety by: monitoring pest (tree) populations, assessing the potential for damage (system reliability, public safety, preservation of the biological controls), and making professional management and control decisions, considering that all pesticides (herbicides) should be used judiciously. ROW management decisions depend in large part upon the mix of target species, the height and density of the dominate individual stems, and the abundance and distribution of the low growing desirable species. As the number of different target species is reduced and their stem density decreases with each passing treatment cycle, the type of vegetation treatment performed can become more selective with the attendant benefit of reducing

10 ESEERCO ceased to exist in 1999 due to the increased economic pressures of a deregulated competitive electric market.

the amount of herbicide needed to maintain the ROW. Thus, after several treatment cycles, when the ROW is occupied by a greatly reduced number of target trees, some minimum herbicide use will still be required but the focus now shifts to selecting techniques with the least amount of disturbance to the lower growing vegetation.

It should be stressed in closing that these ideal ROW conditions of a "minimum maintenance" ROW (composed almost entirely of low growing plants) to be achieved through the attentive implementation of an IPM/IVM program, is simply just that, minimum not zero maintenance. Although the low growing plants will help immensely in precluding the growth of trees, due to the pressures of natural plant community succession that ultimately will occur, these voluntary biological controls can never be expected to fully exclude trees over long periods of time from invading the ROW and exploiting their well defined ecological niches. Even after many treatment cycles using herbicides, when the ideal ROW condition is seemingly achieved, if the ROW is left untreated or if mechanical methods are resorted to, the ROW will revert rather quickly to a tree dominated landscape and all the attendant benefits of a stable low growing mosaic of desirable ROW vegetation will be lost. These attendant benefits include species diversity in an aesthetically pleasing setting with increased wildlife abundance while protecting soil and water quality values.

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Integrated Vegetation Management on Electrical Transmission Rights-of-Way Using Herbicides: Treatment Effects Over Time

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The goal of vegetation management on electric transmission rights-of-way (ROWs) is to ensure safe, reliable transmission of power. A common, ecological approach to managing vegetation on ROWs — Integrated Vegetation Management (IVM) — is to promote desirable, stable, low-growing communities that will resist invasion by undesirable, tall-growing tree species. Vegetation management studies consistent with IVM took place on a 25-km section of Niagara Mohawk Power Corporation's Volney–Marcy 765 kV electric transmission ROW in upstate New York. Initial clearing treatments for establishment of the ROW occurred in 1983. Vegetation management treatments for the first and second conversion cycles were applied in 1984 and 1988, respectively. Selective and non-selective applications of stem-foliar and basal herbicide treatments were applied to replicated study areas during the second conversion cycle. Woody stem data from initial clearing to present (1999) were used to evaluate the effects of the herbicide treatments on stem densities of undesirable and desirable woody species over time. It was hypothesized that stem density of undesirable woody plants would continue to decrease over time and stem density of desirable species would increase or remain the same over time, thus, moving towards a more stable community of woody desirable species and a maintenance phase of management. Undesirable species densities were maintained and desirable densities increased over 11-years using an IVM approach. A stable community of woody desirable species (i.e., maintenance phase of management, as defined in this paper) has not been reached and may need another 10–20 years before it develops on the powerline. Shrub abundance needs to be increased to attain maintenance levels.

Keywords: Powerline corridor, shrub dynamics, stem-foliar herbicide, basal herbicide, herbicide, undesirable and desirable vegetation

INTRODUCTION

The goal of vegetation management on electric transmission rights-of-way (ROW) is to ensure safe, reliable transmission of power. A common, ecological approach to managing vegetation on ROW — Integrated Vegetation Management (IVM) — is to promote desirable, stable, low-growing communities that will resist invasion by undesirable, tall-growing tree species (McLoughlin, 1997). The impact that IVM has on both desirable and undesirable species dynamics over time is critical to its success. Establishing a stable, low-growing community is necessary to enter the maintenance phase of management (Nowak et al., 1992); therefore, an important purpose of this study is to determine whether the vegetation has reached the maintenance level. Research initiated during the establishment of a powerline corridor in New York State — the Volney–Marcy (V–M) powerline, established in 1983 — offers an opportunity to study the effects of nearly two decades of IVM and to determine how successfully low-growing communities have resisted tree invasion on the powerline corridor.

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OBJECTIVE

The objective of the study was to describe the dynamics of woody vegetation over time on the V–M powerline corridor using selective and non-selective herbicide treatments with a focus on the establishment and ability of low-growing communities to resist tree invasion. The hypotheses to be tested were: (1) stem density of undesirable woody plants would continue to decrease over time and (2) stem density of desirable species would increase or remain the same over time.

MATERIALS AND METHODS

Study area description

The study took place on the 17-yr-old (1999 age) V–M powerline corridor, a 765 kV transmission line ROW in the Towns of Lee, Western, and Floyd in Oneida County, New York (43°21′N, 75°32′W–43°15′N, 75°17′W) (described previously by Nowak et al., 1992; paraphrased as follows). The corridor passes through the Interlobal Highland Region, between the Tug Hill Plateau and the Mohawk Valley; it is covered by northern hardwood forest with a predominance of red maple (*Acer rubrum* L.) and eastern hemlock (*Tsuga canadensis* [L.] Carr.), although there was a mixture of both abandoned and active agricultural and forest land on and surrounding the study area. The V–M ROW is 68.6 m wide. The study area is approximately 25-km in length, generally running east-west in direction. On the south side of the V–M powerline is the 28-yr-old (1999 age) New York Power Authority Fitzpatrick–Edic 345 kV transmission line; its ROW width is 45.7 m.

Soils of the study area are silt and sand loams, including a variety of Fragiaquepts, Eutrochrepts, and Haplaquepts of varied drainage; the dominant soil series encountered were Camroden, Pickney, Pyrities, Katurah, and Malone. Many of the soils have fragipans, which cause the sites to be wet with a perched water table. Most of the sites have mesic or hydric moisture regimes.

Experimental design and treatments

A randomized incomplete block factorial design (three to six replications, $n = 19$) was used to test second conversion cycle mode (non-selective and selective) and method (basal and stem-foliar) treatment effects on undesirable and desirable woody plant species density. Treatment plots ranged in size from 0.23 to 0.75 ha, extending from edge to edge of the ROW. Treatment plots were systematically assigned within randomly chosen areas located across the study site and treated in mid-summer 1988.

The four study treatments were composed of two basal and two stem-foliar herbicide treatments applied selectively and non-selectively at the beginning of the first conversion cycle (1984) and repeated at the beginning of the second conversion cycle (1988). The four treatments were applied during late July–August.

Selective basal

Treatment of undesirable vegetation (trees that can grow more than 6 m in height) during late July–August 1988 with a herbicide mixture consisting of 7.6 L of triclopyr at 0.480 kg ai ha^{-1} and 371 L of No. 2 fuel oil; it was targeted at the lower 0.3 to 0.6 m of individual stems, saturating the base of the stem and all exposed roots to the point of rundown and puddling around the root collar zone.

Nonselective basal

Treatment of all woody vegetation with a herbicide mixture and application method the same as that for the selective basal treatment. Herbaceous vegetation was not treated.

Selective stem-foliar

Treatment of undesirable vegetation with a herbicide consisting of a mixture of 1.4 L of triclopyr at 0.480 kg ai ha^{-1}, 1.9 L of a formulation of picloram at 0.060 kg ai ha^{-1} plus 2,4 D at 0.240 kg ai ha^{-1}, 0.95 L of adjuvant (crop oil concentrate) and 375 L of water, applied to leaves, branches and stems to a point of wetness.

Nonselective stem-foliar

Treatment of all woody vegetation with a herbicide mixture and application method the same as that for the selective stem-foliar treatment. Herbaceous vegetation was not treated.

Data collection

Vegetation was measured in 1999 using a series of systematic 1.8-m wide strip transects and 1.13-m radius regeneration plots located with a random starting point. Transects and regeneration plots started and ended at a minimum of 7.6 m from the plot edge. Transects and regeneration plots covered 6 to 16% and 1 to 2% of the treatment plot area, respectively.

Desirable and undesirable vegetation densities (number of stems per hectare as shoot sprouts, root sprouts, and seedlings) were measured by species and height in 1999. Stems 1.27 cm diameter at breast height (dbh; 1.37 m along stem above ground) or greater were tallied on strip transects, while stems less than 1.27 cm dbh were tallied on regeneration plots. Historic stem density data — 1987 and 1990 — for stems >0.9 m height were used from Nowak (1993) for comparisons through time.

Desirable woody plants were defined as those that attain maximum heights of less than 6.1 m, undesirable woody plants as those that can attain a maximum height growth greater than or equal to 6.1 m (Tables 1 and 2). Serviceberry was included with desirable species, but is also recognized as an undesirable species depending on specific site and transmission line conditions (Nowak, 1993).

Table 1. List of "undesirable" woody plant species[1] present on the Volney–Marcy study area

Common name	Scientific name
American basswood	*Tilia americana* L.
American beech	*Fagus grandifolia* Ehrh.
American hornbeam	*Carpinus caroliniana* Walt.
balsam fir	*Abies balsamea* (L.) Mill.
bigtooth aspen	*Populus grandindentata* Michx.
black cherry	*Prunus serotina* Ehrh.
butternut	*Juglans cinerea* L.
common chokecherry	*Prunus virginiana* L.
Eastern hemlock	*Tsuga canadensis* (L.) Carr.
Eastern hophornbeam	*Ostrya virginiana* (Miller) Koch
Eastern larch	*Larix laricina* (Duroi) Koch
Eastern white pine	*Pinus strobus* L.
elm	*Ulmus* spp. L.
gray birch	*Betula populifolia* Marsh.
hickory	*Carya* spp. Nutt.
pin cherry	*Prunus pensylvanica* L.f.
poplar	*Populus* spp. L.
quaking aspen	*Populus tremuloides* Michx.
red maple	*Acer rubrum* L.
red pine	*Pinus resinosa* Ait.
red spruce	*Picea rubens* Sarg.
scotch pine	*Pinus sylvestris* L.
striped maple	*Acer pensylvanicum* L.
sugar maple	*Acer saccharum* Marsh.
white ash	*Fraxinus americana* L.
white spruce	*Picae glauca* (Moench) Voss
yellow birch	*Betula alleghaniensis* Britt.

[1]Nomenclature follows Gleason and Cronquist (1991).

Table 2. List of "desirable" woody plant species[1] present on the Volney–Marcy study area

Common name	Scientific name
alder	*Alnus* spp. Mill.
alternate-leaved dogwood	*Cornus alternifolia* L.f.
apple	*Malus* spp. P. Mill.
arrow-wood	*Viburnum dentatum* var. *lucidum* Aiton
black chokeberry	*Aronia melanocarpa* (Michx.) Ell.
common buckthorn	*Rhamnus cathartica* L.
common elderberry	*Sambucus canadensis* L.
common mountain holly	*Nemopanthus mucronatus* (L.) Loes.
dogwood	*Cornus* spp. L.
hawthorn	*Crataegus* spp. L.
hazel	*Corylus* spp. L.
highbush blueberry	*Vaccinium corymbosum* L.
holly	*Ilex* spp. L.
honeysuckle	*Lonicera* spp. L.
low sweet blueberry	*Vaccinium angustifolium* Ait.
meadowsweet	*Spiraea alba* Duroi.
nannyberry	*Viburnum lentago* L.
red elderberry	*Sambucus racemosa* L.
ribes	*Ribes* spp. L.
rose	*Rosa* spp. L.
serviceberry[2]	*Amelanchier* spp. Medik.
skunk currant	*Ribes glandulosum* Grauer
spicebush	*Lindera benzoin* (L.) Blume
steeple-bush	*Spiraea tomentosa* L.
sumac	*Rhus* spp. L.
wild black current	*Ribes americanum* Mill.
wild raisin	*Viburnum nudum* var. *cassinoides* (L.) T.G.
willow	*Salix* spp. L.
winterberry	*Ilex verticillata* var. *verticillata* (L.) A. Gray
witch hazel	*Hamamelis virginiana* L.
witch-hobble	*Viburnum alnifolium* Marsh.

[1]Nomenclature follows Gleason and Cronquist (1991).
[2]Serviceberry was included with desirable species, but is also recognized as an undesirable species depending on specific site and transmission line conditions.

Herbaceous plants are considered desirable species. Percent cover of all species was tallied in 1999 using the 1.13-m radius regeneration plots (by height strata: <0.3, 0.3–0.9, 0.9–1.5, and >1.5 m). Relative percent of total cover by desirable and undesirable woody species and herbaceous (i.e., all non-woody) species was used in this study.

Data analysis and hypothesis testing

Paired t-tests were used for comparison of second conversion cycle changes in stem density for desirable and undesirable woody plant species between 1990 and 1999.

Analysis of variance and analysis of covariance were used to test treatment mode and method effects on undesirable and desirable woody plant density in 1999. An alpha level of 0.10 was used as the critical value for significance testing, though significance levels (P values) up to 0.20 were considered potentially meaningful.

Analysis of covariance was used to adjust for non-homogeneous pre-treatment stem densities, only if the correlation between the concomitant variable was greater than $r = 0.30$ (Cochran, 1957); the concomitant variable was pre-treatment (1987) stem densities for both desirable and undesirable woody plant density.

An unbalanced approach was taken to examine treatment mode and method effects on vegetation because not all treatments were represented in all blocks; Type III hypotheses were tested (Milliken and Johnson, 1984).

Significant interaction effects were examined by graphing treatment means. Simple effects were analyzed when the slope of lines connecting means differed markedly, as interaction would affect interpretation of mode and method effects.

All statistical analyses were done using SAS computer software package (SAS Institute, 1998).

RESULTS AND DISCUSSION

Undesirable species

There was no significant difference in density of undesirable woody stems (0.9 m and above) in 1990–1999 ($P = 0.22$, paired t-test, $n = 19$). Density has not decreased over time as hypothesized; however, stem density of undesirables has been maintained with IVM even over a long treatment cycle (11 years; Fig. 1).

There was a significant mode *x* method interaction ($P = 0.15$) for 1999 density of undesirable stems over 0.9 m height (ANOVA with a covariate). Analysis of simple effects indicated that the selective treatment had higher densities than the non-selective mode for basal methods ($P = 0.06$), but not for stem-foliar methods ($P = 0.76$). The basal treatment had a higher undesirable stem density than the stem-foliar treatment method in the selective mode ($P = 0.05$), but not in non-selective mode ($P = 0.96$). It may be more difficult to successfully locate and treat undesirable stems in the selective mode for basal treatments than the other three treatments, resulting in more missed trees. Nowak (1992) found no difference by mode of treatment, but did find that basal methods had more undesirables than stem-foliar methods, which is not inconsistent with these findings.

In the study area there are 2.0 to 4.1 times more seedlings under 0.9 m than there are over (Table 3). There are large numbers of small undesirable seedlings below 0.9 m height in 1999 in all treatments (2913–7486 stems ha^{-1}), but the selective basal treatment had more than twice as many small seedlings than the other treatments (Table 3). These results may indicate a potentially problematic future for selective basal treatments, particularly when considering smaller seedlings. Trees less than 0.9 m will likely be hidden in the understory and missed during the next treatment cycle.

Large numbers of small seedlings with decreasing density for larger trees would be expected in hardwood forests. The same could be said for densities on powerline ROW. The high densities in the small height classes on the V–M may indicate that the desirable communities are not successfully resisting tree invasion; the density of desirable species required to effec-

Table 3. Undesirable woody stem density for treatments by height class in 1999

Treatment (mode/method)	Stem density (stems ha^{-1}) Under 0.9 m height	Over 0.9 m height	n	Ratio under/over
Non-selective/ stem-foliar	3230 (995)[1]	1215 (202)	6	2.7
Non-selective/ basal	3462 (1569)	843 (128)	3	4.1
Selective/ stem-foliar	2913 (1032)	1484 (623)	6	2.0
Selective/ basal	7486 (940)	2723 (586)	4	2.7

[1] Values in parentheses are standard errors.

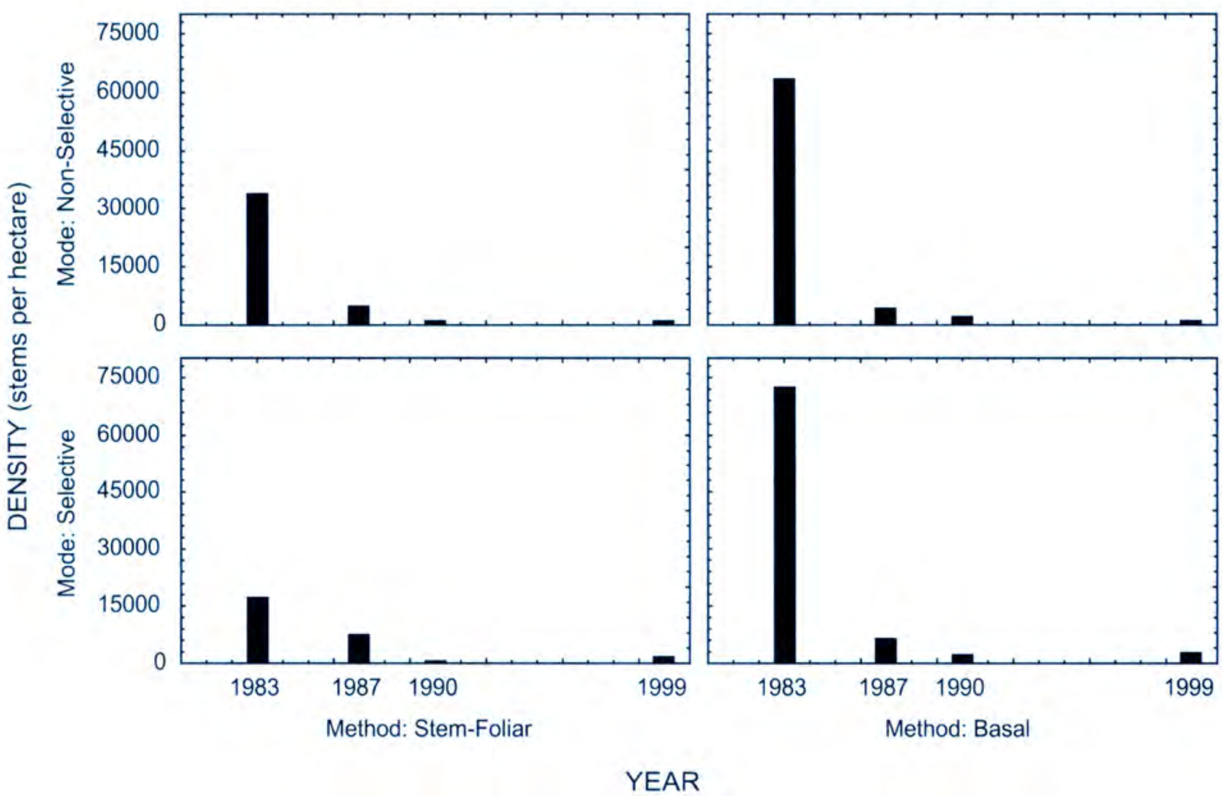

Fig. 1. Undesirable stem density since clearing[1] on the Volney–Marcy powerline for selective and non-selective modes of basal and stem–foliar herbicide treatment methods.

1 Initial clearing (1983), first treatment cycle (1984), second treatment cycle (1988).

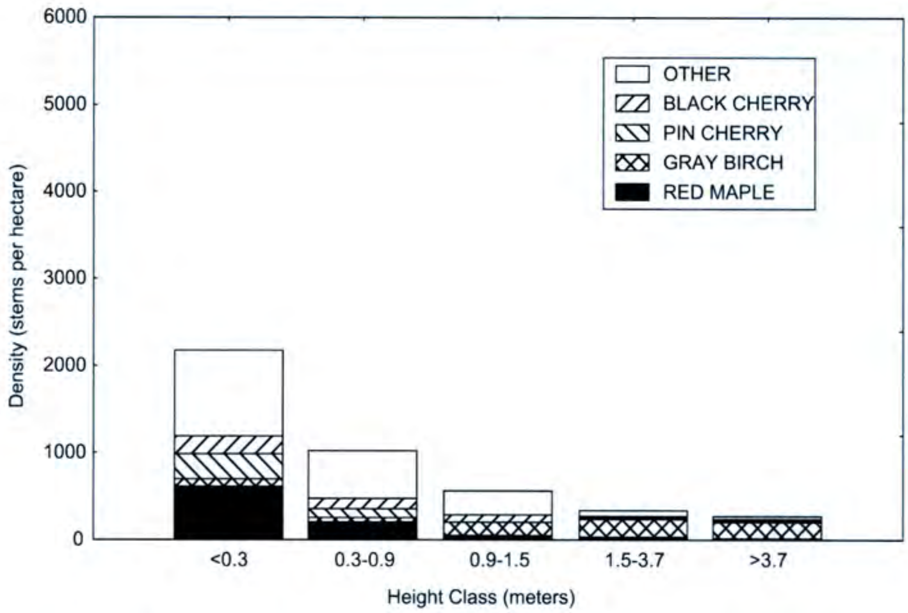

Fig. 2. Undesirable species[1] density distribution by species and size class for all treatments except selective basal in 1999.

1 Initial clearing (1983), first treatment cycle (1984), second treatment cycle (1988).

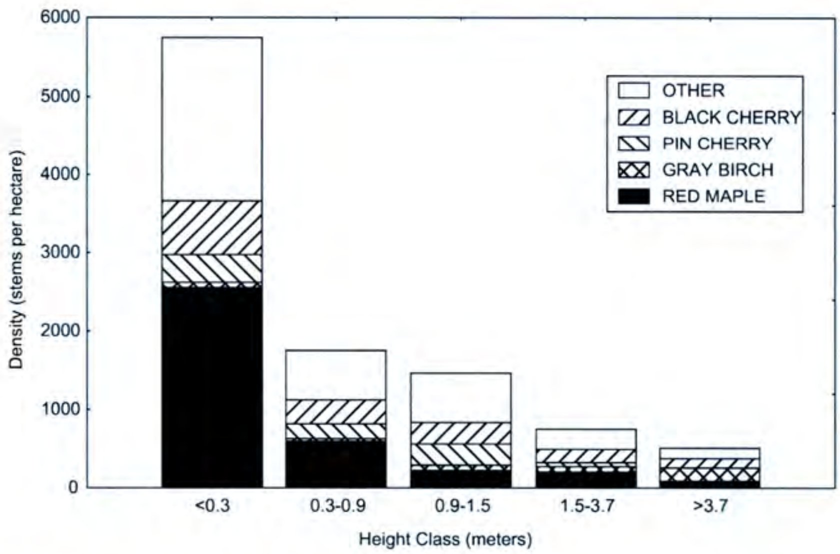

Fig. 3. Undesirable species density distribution by species and size class for the selective basal treatment in 1999.

tively resist tree invasion may not exist yet. Comparisons of shrub abundance (unpublished data) on the V–M and the Fitzpatrick–Edick powerline — the adjacent, older line — indicated that shrubs were less developed (lower abundance) on the V–M. It may take longer for the desirable communities to fully occupy the corridor and adequately resist tree invasion.

Small seedlings in the study area were dominated by red maple, black cherry, and pin cherry (Figs. 2 and 3), among a variety of other species (e.g., sugar maple, quaking aspen, white ash, and choke cherry; see Table 1 for scientific names). The larger trees in the study area had a much higher proportion of gray birch than the smaller classes. There appears to be a species shift through time from pioneer to later successional species. This shift is important because it indicates that the vegetation on the ROW is not yet stable.

Desirable species

There was a significantly higher density of desirable stems (0.9 m and above) in 1999 compared to 1990 ($P = 0.02$, paired t-test, $n = 19$; also see Fig. 4). Interpretation of this result must be tempered due to differences in methods for desirable woody plant inventories. Data collected in 1999 were more detailed than those collected previously; therefore, a more accurate accounting of stems by height classes might have falsely indicated an increase in desirable density. To minimize this possibility, only stems over 0.9 m height were used for comparison with 1990 data. The dominant desirable species included meadowsweet, steeple-bush, willow, and arrow-wood.

Analysis of 1999 data (ANOVA with a covariate) indicated that the selective modes had a marginally higher stem density than the non-selective modes ($P = 0.13$). There were no method-related differences ($P = 0.68$). These results are consistent with Nowak et al. (1992) for 1990 desirable densities.

Desirable woody species over 0.9 m height accounted for only a fraction of the total number of desirable stems present. It is important to consider the number of small stems (<0.9 m) that may indicate continued growth and proliferation of desirables. The smaller height class was 1.6 to 4.8 times larger than all desirable stems over 0.9 m (Table 4). Desirable woody species appear to be increasing in number in the study area and are more abundant than small undesirable species (13,769 compared to 4061 stems ha^{-1}; $P < 0.01$, paired t-test, $n = 19$). These results, collectively, give evidence to suggest that our hypothesis is true; desirable stem density is increasing over time with an IVM approach.

Woody desirable plants, with advantages of height and longevity, are not the only desirable species that are important in resisting tree invasion on powerline corridors [e.g., *Rubus*, ferns, goldenrod/asters; Bramble and Byrnes (1983), Bramble et al. (1990), Hill et al. (1995), Horsely (1993)]. Desirable woody species comprise only a fraction of the total relative cover on the powerline corridor (from <1 to 8%; Fig. 5). Herbaceous species (including *Rubus*) account for 73–91% of the total relative cover, and undesirable woody species account for 9–19% of the total relative cover. Clearly, woody desirable species can only tell a portion of the story; herbaceous communities will be an important factor in the future management of the ROW.

Table 4. Desirable woody stem density for treatments by height class in 1999.

Treatment (mode/method)	Stem Density (stems ha^{-1}) Under 0.9 m height	Over 0.9 m height	n	Ratio under/over
Non-selective/ stem-foliar	12,762 (4616)[1]	3932 (1759)	6	3.2
Non-selective/ basal	10,380 (7834)	2186 (1142)	3	4.8
Selective/ stem-foliar	13,036 (5526)	6588 (2229)	6	2.0
Selective/ basal	18,923 (11,424)	11,986 (10,069)	4	1.6

[1] Values in parentheses are standard errors.

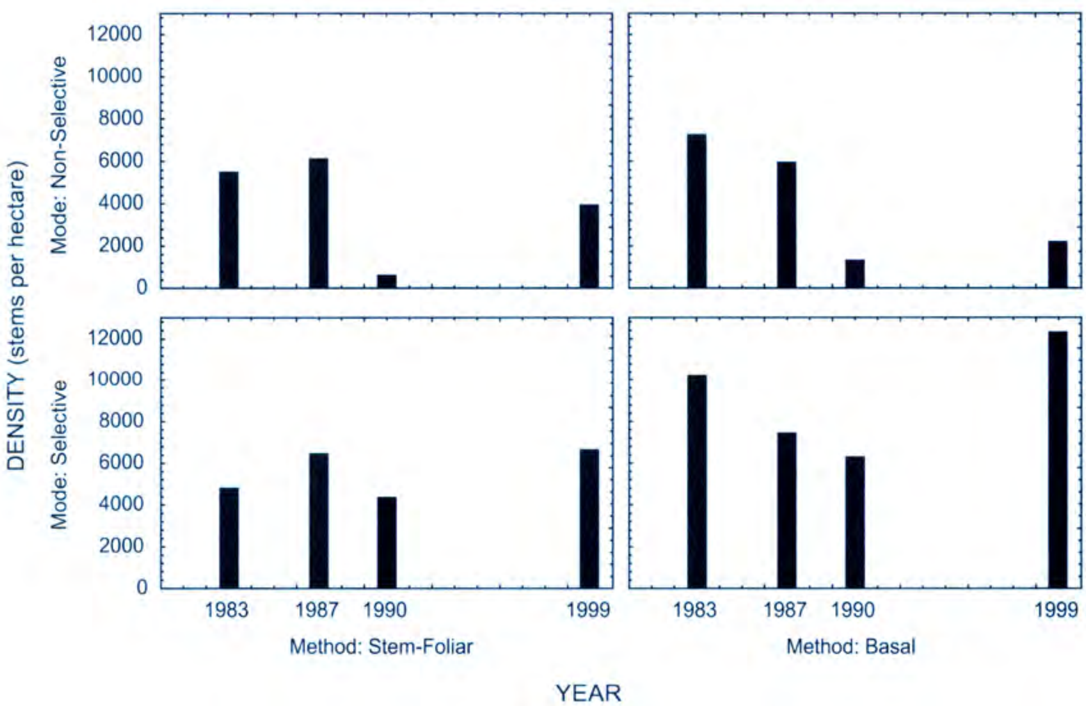

Fig. 4. Desirable stem density since clearing[1] on the Volney–Marcy powerline for selective and non-selective modes of basal and stem-foliar herbicide treatment methods.

1 Initial clearing (1983), first treatment cycle (1984), second treatment cycle (1988).

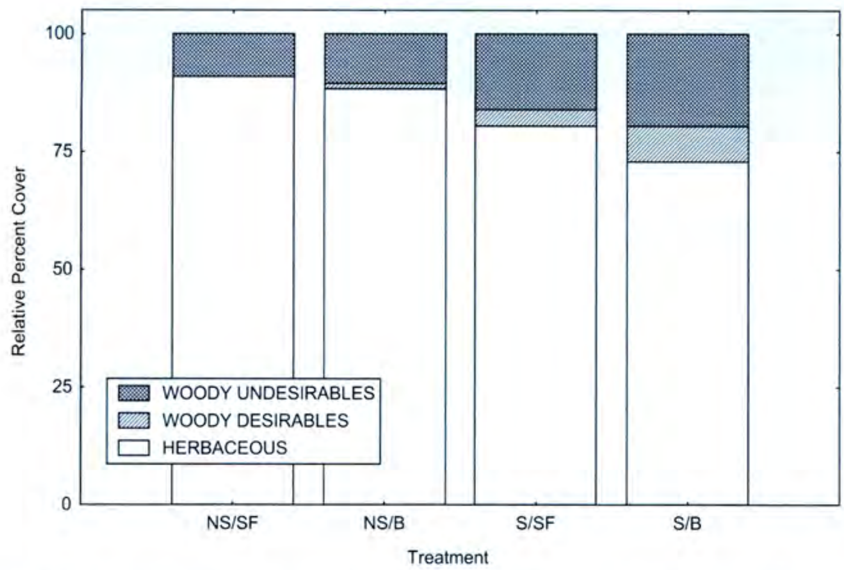

Fig. 5. Relative percent cover of undesirable and desirable woody plants and other herbaceous plants (including *Rubus*) by treatment[1] in 1999.

1 NS/SF — non-selective/stem-foliar, NS/B — non-selective/basal, S/SF — selective/stem-foliar, and S/B — selective/basal.

SUMMARY AND CONCLUSIONS

The 1999 treatment effect results are similar to those found by Nowak et al. (1992). The potentially important differences found here were that woody desirable species density has increased in abundance, while undesirable woody species density was maintained on the V–M ROW. The selective basal treatment had some potentially problematic symptoms. Not only were undesirable stem densities for the selective basal treatment high for all stems over 0.9 m in height, but more importantly, there were many stems in the smaller height classes (<0.9 m). All treatments had high densities of small seedlings, which indicate resistance to tree invasion can still be improved. Management of herbaceous communities may play a role here, but establishment of stable shrub communities will be crucial.

Interestingly, the species composition of the various height classes indicates a shift from gray birch in the taller (and older) classes to red maple and a variety of other species (e.g., cherries, sugar maple, white ash, quaking aspen) in the smaller height classes. The ability of these small seedlings to persist in the understory until the next treatment cycle poses another challenge to managers, as many of these trees will be misses and may escape from a predominantly herbaceous community.

There is sufficient evidence to suggest that the V–M ROW has not yet reached a maintenance phase of management due to the persistence of undesirable seedlings and increasing numbers of woody desirables. The dominant cover is herbaceous, and conversion to a stable, low-growing, woody community may require another 10 to 20 years.

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Versatile Plant for Multiple Use on Rights-of-Way

Dr. Dale H. Arner and Dr. Jeanne C. Jones

Today's rights-of-way (ROW) manager must be concerned more than ever before with multiple-use aspects of plant communities that resist invasion of woody plants, are aesthetically pleasing, provide food and cover for wildlife, and can be economically maintained. One plant species which has these and other desirable traits in the southeastern United States is partridge pea (*Chamaecrista fasciculata*). The purpose of this paper is to review field trial results of establishing partridge pea in different ecosystems by using different techniques, such as overseeding in herbicide treated, disked, and burned plots. The maintenance, as well as ecological aspects, of this plant in ROW management, are reviewed and discussed.

Keywords: Partridge pea, ROW, overseeding, herbicide, disking, burning, legume

INTRODUCTION

Today, right-of-way (ROW) managers must be concerned more than ever before with multiple use aspect of ROW management. Multiple use concerns necessitate the development of plant communities that resist invasion of woody plants, are aesthetically pleasing, provide food and/or cover for wildlife and can be economically established and maintained.

A plant species that exhibits these desirable traits is partridge pea (PP) (*Chamaecrista fasciculata*). This species is an annual legume native to the southeastern United States. PP is a noduled legume that is capable of nitrogen fixation (Allen and Allen, 1981). It generally grows in colony-like clusters and produces large yellow flowers from late summer into early fall (Radford et al., 1987). The profusion of blooms during this time of year is visually pleasing. Stoddard (1932) wrote "when the large flowering species (*Chamaecrista fasciculata*) blossom, areas miles in extent take on a bright yellow hue." The flowers produce nectar and pollen that are used by a variety of insect pollinators, including native bees and wasps, butterflies, and European honeybees (Martin et al., 1961). The use of the seed of PP by bobwhite quail (*Colinus virginianus*) for food is well documented. Stoddard (1931) reported that PP seeds are taken by bobwhite quail every month of the year with maximum consumption occurring during the winter months. He reported that nearly 80% of the quail crops examined during late winter contained PP. Rosene (1969) noted that PP seed was found in over 35% of the quail crop collected in Alabama. Brazil (1993) analyzed the contents of nearly 6,000 quail crops collected in Mississippi over a 2-year period. He reported that PP ranked 9th and 7th in importance. Seed of PP was utilized during winter months by northern bobwhite quail inhabiting upland disposal areas of the Tennessee Tombigbee Waterway in Mississippi. Warren and Hurst (1981) rated utilization of PP forage by white-tailed deer (*Odocoileus virginianus*) as high in the spring and moderate in summer.

Stoddard (1931) reported that PP developed dense stands of vegetation with very little herbaceous understory, creating conditions that are excellent for quail feeding and loafing. Although no pertinent references were found in a literature review it is believed that allelopathic properties of PP may be a major factor in the paucity of ground cover found growing beneath PP. The lack of understory vegetation creates conditions unfavorable for fire; this condition is an impediment to prescribed burning but is a desirable aspect for fire lane development.

PP has a tough impermeable seed coat that is capable of maintaining dormancy for extended periods of time. Rosene (1969) reported that PP seed can remain viable for 60 years or more. Dormancy is apparently broken by exposing the seed to sunlight

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or heat. Sunlight has been reported as an important catalyst in the germination of many herbaceous weed species (Duke 1944). Seed impermeability and long term viability of seed have management implications for the renovation of PP stands on ROW. If PP seed occur in the seedbank of a ROW, germination of PP could be stimulated by conducting soil disturbances, such as disking, fire, or the use of herbicide. This renovation of residual seedbanks into PP stands can produce valuable food and cover for wildlife and enhance soil quality due to plants' fixation of nitrogen-in root nodules.

The purpose of this paper is to report the results of field trials establishment and maintenance of PP in several different ecosystems of the southeastern United States.

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FIELD TRIAL STUDIES

Farmland (temporarily out of cultivation)
Location
Mississippi Agricultural and Forestry Experiment Station (MAFES) Holly Springs, MS.

Soil type
Loess with good inherent fertility with a soil pH 6.0–6.5.

Dominant vegetation
Broom sedge (*Andropogon virginicus*).

Treatment
3 plots each (0.10 ha) in area were disked in late summer, two of the plots were sowed with ryegrass (*Lolium perenne*). One of the disked plots was unseeded. In January all 3 plots were overseeded with PP.

Results
Examination of the plots in late summer of the following year revealed little difference in PP coverage between the overseeded ryegrass plots and the fallow plot overseeded with PP. Examination during the following summer revealed an excellent stand of PP in all 3 plots; one year later examination in late summer showed invasion of native grasses and forbs, however PP was still common.

Renovation
The following August one of the ryegrass/PP plots was disked; the following August a dense stand of PP was evident while in the 2 remaining plots PP was declining.

Discussion
Utility ROW located on Loess soils have good inherent fertility quite sufficient for the development of good stands of PP without the additions of any soil amendments. Those ROW which have been maintained by herbicide will usually have a plant coverage dominated by grass frequently of the genus Andropogon. If these ROW are located in forested areas where deer, turkey, and/or quail are featured game species, annual ryegrass can be sowed one fall followed by overseeding of PP the 2nd fall, and disked after the 2nd year of establishment.

Location
Mississippi Agricultural and Forestry Experiment Station, Brooksville, MS.

Soil type
Brooksville Clay, developed from Selma Chalk. Soil is high in calcium and fertility (Pers. comm. Dr. David Pettry, Soil Scientist).

Dominant vegetation
Goldenrod (*Solidago altissima*).

Treatment
In early fall of 1993, three 4 m × 20 m plots were mowed in a field dominated by goldenrod (GR). In February, the mowed plots were sowed with PP at rates of 13.44 kg/ha.

Results
A good (>50% coverage) to excellent (>90% coverage) of PP developed beneath a moderate canopy of GR by the summer of 1994. By the summer of 1995, PP had declined to less than 50% coverage. By 1996, GR had spread through rhizome development and become dominant (>50% coverage) in all three plots. Although declines in PP occurred, the plant was still evident within the GR canopy.

Renovation
During the winter of 1996, an attempt was made to burn the GR/PP plots. Burning proved unsuccessful due to inadequate fuel in the understory. This paucity of understory plants may be due, in part, to allelopathy of both GR and PP to other plants found in abandoned agricultural fields. Bramble et al. (1990) reported that two species of GR were considered to be highly resistant to tree invasion. Duke (1985) reported that GR is one of the species that produces toxins which inhibit

black cherry (*Prunus serotina*) establishment. Field observation suggests that the scarcity of understory vegetation in fields dominated by PP may also be due to allelopathy.

To increase available fuel, hay was distributed on field trial plots. The increased fuel resulted in a fire sufficient for the regeneration of PP. The following summer PP was the dominant ground cover (>80% coverage) within plots and had spread to adjacent areas covering an estimated 0.5 ha. PP assumed dominance or codominance (90 to 45% percent coverage) within plots in 1997 and 1998. By the spring of 1999, GR canopy was increasing and in 1999, renovation of PP stands was undertaken. Within the 0.5 ha area, seven 3 m × 30 m plots were established to test renovation techniques. Three plots were disked with one pass of the disk over the plot to roughen the ground surface and expose GR rhizomes to the atmosphere while minimizing the severing and covering the rhizomes. Two plots received herbicide application with glyphosate at a rate of 3 pints per 40 gallons of water in late summer, 1999. Two plots received no treatment. By early summer of 2000, PP seedlings were evident in both herbicide and disking plots, but were scarce in control plots. In June, 2000, six hoops (51 cm in diameter) were randomly tossed and sampled for percent ground cover in each plot. Fifty-four percent of the disked plot hoops and 50% of the herbicide hoops exhibited PP seedlings. Brome grass (*Bromus japonicus*) was commonly found in herbicide plots, but was limited in disked plots. Brome grass has been reported to have chemical substances that depress growth of corn, wheat, and sorghum (Rice, 1974). Control plots where no renovation treatment had occurred exhibited less than 10% of hoops with PP seedlings. These plots were dominated by GR.

Dominant vegetation
Giant Ragweed (*Ambrosia trifida*), Brome grass, and Johnson grass (*Sorghum halapense*).

Treatment
In August 1998, six 4 m × 20 m plots were disked and sowed with hairy vetch (*Vicia villosa*). During winter 1999, frequent examination of vetch plots revealed limited germination of vetch. In late winter, 1999, PP was sowed at rate of 13 kg/ha over vetch plots with no soil preparation.

Results
Field examination of the plot in May and June, 2000 revealed very little PP germination and establishment. Poor germination of vetch and PP may have been due, in part, to inhibitive effects of the plants that dominated the site prior to disking. Root and top extract of brome grass have been shown to be inhibiting to all legumes except ladino clover (*Trifolium* sp.) (Rice, 1974). Duke (1985) listed giant ragweed as having alleged allelopathic activity in agroecosystems.

Location
Gasline ROW.

Soil Type
Impoverished soil — Boswell-Susquehanna. Texture — gravelly sandy loam complex. Soil low in calcium, phosphorous, and potash.

Dominant Vegetation
Broomsedge, Three-awned grass *(Aristida* spp.), Poor Joe (*Diodia teres*) was co-dominant.

Treatment
Four 20 m × 10 m plots were burned in mid-March and sowed with PP at the rate of 1.2 kg/ha. Two plots were fertilized at the rate of 11.2 kg/ha with nitrate of soda (16% N), 30 kg/ha of superphosphate (P_2O_2 18%), 9 kg/ha muriate potash (60% K_2O), and 224 kg/ha of lime.

Results
The two unfertilized plots had few PP seedlings the following summer, the fertilized plots moderate coverage of PP. During the second growing season, PP seedlings were common to plentiful in both fertilized and unfertilized plots; however, the PP in the unfertilized plots were spindly with a wilted appearance, while in the fertilized plots the PP were approximately twice the height of those in the unfertilized plots and were robust in appearance.

Discussion
Impoverished soils of the Lower Coastal Plain will require the use of soil amendment in order to develop a dominant or co-dominant stand of PP. It appears that once PP becomes established, no additional fertilizer is needed (Arner, 1959). Renovation by burning or disking appears to be all that is needed for rejuvenation of PP. PP stands established on some of the poor soil areas have been rejuvenated 10 years after establishment. Such areas revert to native grasses or forbs, but PP is easily rejuvenated by burning or disking. Burninig is more successful if sufficient understory herbaceous plant exist to provide adequate fuel for fire spread.

Location
DeSoto National Forest, Camp Shelby, MS. This south Mississippi land base is a training site for the Mississippi Army National Guard. Over 100,000 troops train annually for artillery, aircraft, tracked vehicle, and bivouacking preparedness. Located in the original range of the longleaf pine ecosystems, the indigenous plants and animals are adapted to fire. Military training results in high fire frequency in each year.

Soil type
Deep sands of Troup, Agala, and Eustis series with Susquehanna series intermixed. Soil pH levels ranged from 5.0 to 5.6 prior to soil amendment application.

Dominant vegetation
Bluestems (*Andropogon* spp.), Grease grass (*Tridens* spp.), three-awned grass, and genera of the family Asteraceae (*Solidago, Eupatorium, Erigeron* spp.).

Treatment
Eight, 20 m × 30 m plots were established within herbaceous plant communities on artillery firing points that surround the 2900-ha artillery impact area. Sites were prepared by disking to create a well-prepared seedbed. Lime was applied at a rate of 2200 kg/ha. Approximately 340 kg/ha of 0-14-14 fertilizer was applied to each plot. Scarified PP seed was planted at a rate of 17 kg/ha during March, 1991. Seed was not covered following seeding. Twenty, randomly established, 1 m^2 quadrats were surveyed in each plot during June–July, 1991 and 1992. Ocular estimate of percent coverages of PP and naturally colonizing plants was conducted in each quadrat using methods described by Hays et al. (1981).

Results
Coverage of PP ranged from 78% (SE = 8.0) to 100% in seven of the seeded plots during 1991. Grass and forb coverage within PP plots ranged from 4% (SE = 2.5) to 35% (SE = 10.5). A mean coverage of 45% (SE = 12.0) was observed in one plot which had been disrupted by tracked vehicle maneuvers. Coverage of PP did not differ in 1992 ($P > 0.10$) in seven of the eight plots. The plot that had been disturbed by tracked vehicle maneuvers in 1991 exhibited an increase in 1992, with percent coverage of PP averaging 67% (SE = 4.0) by 1992.

Renovation
Renovation was not conducted as part of this study; however, fire resulting from artillery ignitions occurred on all plots by 1992. Coverage of PP appeared to respond positively to fires, with coverages spreading outside of original plot perimeters on six of the eight experimental plots.

Discussion
Seeding of PP was judged successful due to observed coverages following seeding. Although sandy soils were droughty in nature and could be expected to limit PP growth during drought years, the years of 1991 and 1992 exhibited greater than normal rainfall (>8 cm/growing season). PP responded well to artillery-ignited fires. These fires generally occurred in late summer or fall during dry weather conditions. Spreading of PP was observed in the two years following the study although plots were not monitored through surveys. PP is considered an excellent native plant for establishment on the military reservations where fire and soil disturbance is eminent and upland game birds are featured wildlife species.

Location
Upland Disposal Sites of the Tennessee-Tombigbee Waterway, Tishomingo, Mississippi (TTW). This area is classified as a severely disturbed land base. Disposal area substrate is comprised of spoil material that was excavated from up to 54 m in depth. The spoil material contained acid overburden from the Eutaw and Cretaceous Layer Formations and therefore, exhibited high soil acidities (pH < 5.0) prior to reclamation (Jones et al., 1996, Ammons et al., 1983). Disposal areas were reclaimed through application of soil amendments and planting of agronomic grasses and legumes. Following reclamation, most disposal areas exhibited pH levels of 5.5 or greater in the upper 10 cm. Soil pH levels were more acidic in the >10 cm substrate depths reaching as low as 2.9 on site where acid overburden was within 35 cm of the soil surface (Jones et al., 1996). Sand content of spoil texture ranged from 47 to 90%, with most soils being classified as sandy to sandy loam (Jones, 1995).

Dominant vegetation
Experimental plantings were conducted in two vegetation cover types that were seeded for erosion control and reclamation: (1) sites exhibiting >60% coverage of sericea lespedeza *Lespedeza cuneata* and (2) sites exhibiting >60% seeded grasses [Kentucky 31 Fescue *Festuca elatior arundinacea*, common Bermudagrass *Cynodon dactylon*, and Weeping lovegrass *Eragrostis curvula*].

Treatment
Six disposal sites were selected through stratified sampling within the two cover types. All sites exhibited sandy substrates and pH levels ranging from 5.8 to 6.5 in the upper 10 cm of soil. Three 2 m^2 quadrats were sown with a mixture of kobe lespedeza (*Lespedeza striata*) and partridge pea at seeding rates of 22.4 kg/ha and 11.2 kg/ha, respectively. Inoculated, scarified seed were distributed over existing vegetation with no soil preparation during February, 1984. Percent coverage of PP within 2 m^2 quadrats was monitored during July, 1984 through 1988 using gridded ocular estimate methods described in Hayes et al. (1981). Percent coverage of PP was compared between the two cover types using the Ranked-sign Wilcoxon Test (Daniel, 1990).

Results
Coverage of PP averaged 90% (SE = 11.4) in quadrats that were dominated by seeded grass during the summer of 1984. Coverage of PP was significantly lower in quadrats located in the sericea lespedeza cover type ($P < 0.05$), averaging 15% (SE = 3.2). Coverage of PP increased in 1985 in both cover types, with coverage averaging 100% in the seeded grasses cover type and 33% (SE = 12.0) in the sericea lespedeza cover type. High rainfall during June through September of

1985 (>9 cm/4 months) was a probable reason for increases in coverage during this year. Percent coverage remained high on 2 of the grass cover type sites from 1986 through 1988, with mean ranging from 90% in 1987 to 100% in 1986 and 1987. A decline was detected on one of the grass cover type sites, with PP coverage dropping from 5% coverage in 1986 to less than 1% coverage by 1988. Colonization of this site by sericea lespedeza was recorded in 1986 through 1988 with percent coverage of this exceeding 60% in these years. Reduced PP coverage on this site was due, in part, to competition from this perennial lespedeza in drought conditions of these years (<4 cm rainfall/4 months). PP coverage in quadrats of sericea lespedeza cover types were averaged less than 1% coverage during 1986–1988.

Discussion

Seeding of partridge pea over existing grass cover types with no soil preparation was considered a success. Seeded grass cover types had at least 10% bare soil exposure which allowed seed contact with mineral soil. Seeding of PP over existing sericea lespedeza exhibited marginal success during the first two years; however, declines in PP coverage was observed during the last three study years. Competition from dense stands of sericea lespedeza, deep litter depths (>5.0 cm), and low rainfall are possible reasons for the observed declines. Renovation of dense stands of perennial agronomic cover may be necessary for retaining PP coverage over time. Disking, prescribed fire, or selective herbicide may be used to limit coverage of undesirable vegetation that may compete with PP. However, disking on drastically-disturbed sites that contain acid overburden, such as TTW disposal areas, may cause increased soil acidification and loss of all vegetation.

SUMMARY AND RECOMMENDATIONS

PP has been successfully established by overseeding or burned, mowed, disked, and herbicided old field plant communities. The native plant communities involved were goldenrod growing on prairie soils, broomsedge and annual ryegrass on loess soils, and three-awned grass and broomsedge on lower coastal plain gravely soils. Only the impoverished soil of the Lower Coastal Plain required fertilizer for establishment of PP. It is recommended that soil analysis be conducted before any management plans are developed. PP will grow in many different soil types even those of low fertility; however, application of lime will be required on soils with pH levels of 4.5 or less. ROW preparation for overseeding of PP may be accomplished as follows: disking in the late summer or early winter, treatment with a herbicide of low residual toxicity for legumes, ie glyphosate, in late summer, and mowing in late summer. Mowing and overseeding of PP was effective only in the GR and broomsedge communities; whereas, mowing was not effective in giant ragweed, brome grass, or Johnson grass communities. Mowing is not recommended for aggressive plants, such as tall fescue that spreads by underground stolons that may increase after mowing or grazing.

Burning is not applicable for renovation of PP communities where poor fuel conditions exist due to lack of understory herbaceous plants. This condition is often encountered in dense GR stands where ample fuel for fire does not exist beneath the GR cover. Adequate fuel loading is essential for successful burning that scarifies existing partridge pea seed and enhances PP stand development conditions.

PP is a noduled legume which improves impoverished soils, it provides both food and cover for quail and cottontail rabbits and appears allelopathic to many invading old field plant species. PP establishment should be given serious consideration in ROW management in the Southeastern United States.

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Reducing Maintenance Costs using Integrated Vegetation Management on Electric Utility Transmission Lines in British Columbia

Thomas C. Wells, Kevin D. Dalgarno, and Ray Read

BC Hydro maintains over 17,800 km of electric transmission lines in British Columbia spanning biogeoclimatic zones from desert grasslands to alpine tundra. The primary goals of the vegetation program are to maintain public safety and system reliability at reasonable cost while balancing environmental and social resources. These goals are accomplished within a process-based organization using Integrated Vegetation Management principles. LapMap, a mapping and database program, was developed to collect a wide array of data including civil, environmental, and social attributes. Vegetation inventories define the growth rates and stand densities of key target species, as well as identifying competitive ground cover, to determine action thresholds for treatment. Conductor-to-ground clearance models combined with target species growth rates permit treatment cycle optimization and identification of off-cycle problem areas. A prescriptive approach is taken to select the appropriate combination of manual, mechanical, chemical, and natural control methods to establish short and long-term site objectives. Results from transmission corridors in the Southern Interior and Vancouver Island indicate that selective approaches to right-of-way maintenance allow long-term site objectives to be met at reduced costs. This is achieved by optimizing treatment cycle lengths or reducing maintenance by clearing only what is necessary to establish compatible plant communities. With these programs, resources are used more efficiently while protecting key riparian and wildlife habitats as well as promoting opportunities for compatible use.

Keywords: Transmission, rights-of-way, balancing resources, inventories, prescriptive maintenance

INTRODUCTION

The primary objective of most rights-of-way vegetation maintenance programs is to ensure the safe and reliable transmission of power. There are many ways to achieve this objective. Historically most utilities, including BC Hydro, treated vegetation on their rights-of-way using non-selective methods of manual, mechanical, or chemical controls on a calendar cycle basis. After annual field patrols of rights-of-way, a list of areas requiring work were compiled along with cost estimates. When funding was confirmed, contracts were prepared using non-scaled mapping with little information being conveyed to contractors. Often the result was an uneven mix of different vegetation management cycles and treatments with frequently higher maintenance costs. This approach is giving way to site-specific maintenance based on Integrated Pest Management principles (Bramble and Byrnes, 1983; Finch and Shupe, 1997; McLoughlin, 1997). There are several drivers for this move at BC Hydro including public and regulatory expectations, the need for efficient use of financial and human resources, and the changing face of the electric industry across North America.

BC Hydro has adopted a triple bottom line approach to reflect the integration of environmental, social, and economic values in its business activities (BC Hydro, 1999). This has impacts across all business units including vegetation management. It is no longer sufficient merely to remove tall-growing vegetation under the

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lines by whatever means necessary. Today, management practices are designed to minimize impacts on natural resources. This has led to significant changes in the way business is done. For example, Transmission and Distribution at BC Hydro is a process-based organization (Hammer, 1996) in part to focus on streamlining and standardizing maintenance practices. These changes have not occurred overnight but rather are a work in progress.

Vegetation maintenance at BC Hydro has evolved into a selective, prescriptive based approach to optimize treatment cycles and provide more diverse long-term benefits. The core strategy has been the implementation of Integrated Vegetation Management (IVM) which includes the following steps:

- Completion of inventories to assess current right-of-way conditions;
- Development of action thresholds to manage risk and determine optimum timing for work;
- Preparation of prescriptions and work plans using best practices to provide value added solutions and balancing of resources;
- Monitoring and evaluation of programs to create a cycle of continuous improvement.

The base model is rooted in Integrated Pest Management (IPM) principles but is increasingly incorporating Integrated Resource Management (IRM) aspects as well. To achieve this, a full spectrum of treatment options is employed including manual, mechanical, chemical, cultural, and biological controls to promote low growing, stable plant communities on rights-of-way (Morrow, 1997). This minimizes safety hazards and virtually eliminates line outages from tall growing species. Additional benefits are now incorporated, where feasible, into the regular maintenance program. The natural regeneration of selective plant communities results in an increase of available fish and wildlife habitat (Harriman, 1999). Compatible use opportunities include modifying rights-of-way as green spaces for public recreation or growing non-timber forest products to reduce the maintenance base, enhance social and economic value and contribute to the ongoing consent to operate the system. This paper outlines three examples of the application of IVM at BC Hydro. Changes to maintenance strategies will be discussed with emphasis on benefits that have been achieved and difficulties that have been encountered along the way.

METHODS

Three sites were chosen to implement IVM protocols on BC Hydro rights-of-way in the Southern Interior and Vancouver Island of British Columbia (Fig. 1). The sites chosen had detailed mapping available including as-built photogrammetric maps at 1:2500 scale and BC Terrain Resource Inventory Maps (TRIM) at 1:20,000 scale. The maps included the location of transmission

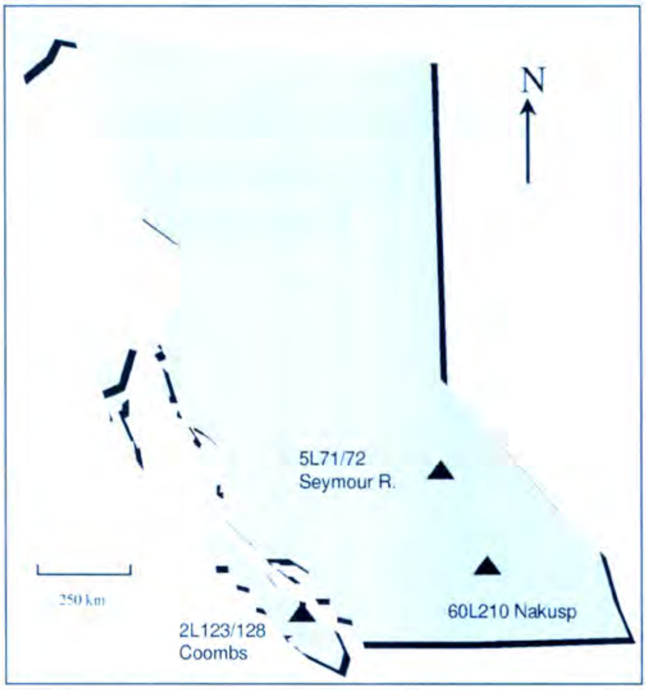

Fig. 1. Study sites on three BC Hydro transmission rights-of-way in British Columbia.

structures, conductor to ground clearance models displayed as isolines, riparian areas, access, topographic, and cadastral information. Data were entered into LapMap, a portable mapping and database system developed by BC Hydro that embodies many features of a Geographic Information System (GIS), but is not true GIS. Using LapMap, a variety of right-of-way data were documented from field surveys, including vegetation, wildlife, recreation, compatible use, and heritage attributes.

A number of parameters were used to describe right-of-way vegetation communities (Table 1) to define the type and scope of maintenance work required and to create a baseline for monitoring the efficacy of prescribed treatments. These data were entered into LapMap by creating work management area polygons on the map base. New boundaries were set when distinct changes in vegetation type or target species densities were noted or where changes in slope, riparian drainages or available access would dictate the use of different treatment options. Polygons were also defined on the basis of compatible right-of-way usage such as the presence of Christmas tree farms, agricultural land, or park boundaries.

Site descriptions and estimation of percentage cover abundance for deciduous and coniferous target species as well as competitive ground cover were based on standard methods (Mueller-Dombois and Ellenberg, 1974; Luttmerding et al., 1990). Conifer and deciduous target species densities were estimated in stems per hectare using a rapid plot method (Hide, 1974). Target and ground cover species recorded in LapMap are listed in Table 2. Within sample plots, growth rates for

Table 1. Vegetation site descriptors used in LapMap

Span information
Circuit Name
From Structure–To Structure
Limit of Approach (automatically calculated based on voltage class)
Minimum Conductor to Ground Clearance in polygon (m)
Polygon Area (ha)
Site Description
major topographic features, terrain, slope, aspect, target vegetation, and ground cover
Special Considerations
hazards, special land use concerns
Target Species
Deciduous/Coniferous Species
Percent Cover of Deciduous/Coniferous Species
Height of Deciduous/Coniferous Species (m)
Age of Deciduous/Coniferous Species (years)
Growth Rate (m yr^{-1})
Alpha Deciduous/Coniferous Target Species — most problematical target species on site
Alpha Deciduous/Coniferous Target Height (m)
Alpha Deciduous/Coniferous Target Age (yr)
Average Deciduous/Coniferous Density (stems ha^{-1})
Percent Cover of Deciduous/Conifer Layer
Control Cycle (calculated in years)
Next Work Timing (estimated date of next work)
Maximum Allowable Tree Height (m)
Ground Cover
Species
Cover Abundance
Comments (on ground cover present)
Competing Vegetation Complex
Prescription
Last Treatment Year (date)
Compatible ROW Use
Biogeoclimatic Subzone
Treatment Type: recommended methods to be used
Treatment Targets: target vegetation to be treated
Scheduled Treatment (date)
Treatment Comments: detailed prescription for work site
Work Completed (year)
Evaluation Date
Evaluation Comments

target species were determined by felling the tallest stem of an individual or coppice and measuring the stem length and recording its age by counting growth rings. Previous year's growth was also recorded by measuring the length between the end bud scars of the current and previous year.

Other data collected included determining the biogeoclimatic subzone for the site (Meidinger and Pojar, 1991) as well as the competing vegetation complexes present (Newton and Comeau, 1990). Treatment options based on field observations were also recorded. Estimates for the timing of work were automatically calculated in LapMap based on limits of approach or the maximum allowable tree height defined as acceptable for a section of circuit, and the height and growth rates of the target vegetation observed. The voltage class of the circuit determines limits of approach. This forms the action threshold by which work must be done although usually a further margin of safety is built in.

These data were then used to develop site specific prescriptions to meet both near-term and long-term maintenance objectives. Prescriptions formed the basis for creating work contracts. Lump sum contracts were employed for the majority of work with time and materials contracts used for clearing off-cycle problem areas. Contracts were based on open competition and awarded on price and contractor experience. After work was completed, the sites were reviewed to determine whether maintenance objectives had been met and to determine any necessary follow-up work. Before another work cycle commences, current site conditions are evaluated to refine the prescription. This is important to ensure a continuous cycle of improvement.

Cost analyses for these trials were based on calculating the cost per hectare of the various treatments employed or considered. These costs were derived from historical treatment records at the three sites as well as current contract pricing. Costs for collecting site information and prescription development were estimated from loaded staff time rates. All estimates were adjusted to 1999 present value costs using the Consumer Price Index Annual Averages (for all items), obtained from the BC Hydro accounting office.

RESULTS AND DISCUSSION

5L71/72 Seymour River to Celista Creek

This site is a 16 km long by 122 m wide section of dual 500 kV corridor approximately 184 ha in size situated in the Southern Interior (SI) from the Seymour River to Celista Creek. The area lies within the Thompson Moist Warm Interior Cedar–Hemlock (ICHmw3) biogeoclimatic variant and has cool, wet winters and warm, moderately dry summers (Lloyd et al., 1990). The ICH has the most suitable climate for tree growth in the Interior with climax stands of Western red-cedar and Western hemlock. Seral stands include Douglas-fir, lodgepole pine, trembling aspen, and birch. Growth rates of the deciduous target species on the right-of-way (typically birch, cottonwood, or aspen) ranged from 0.9–1.2 m yr^{-1} with conifers growing at 0.4–0.5 m yr^{-1}. Stem densities ranged from 2350 stems ha^{-1} to 103,460 stems ha^{-1} with an average of 26,487 stems ha^{-1}. Ranchers use sections of the right-of-way for grazing cattle.

Treatment history and costs were collected from archived files (Table 3). Most treatments involved manual slashing but the right-of-way was treated with Tordon 101 (picloram and 2,4-D) in 1978/79 and selected sections were mowed in 1992. The total cost for these treatments was calculated to be $241,965 CDN. Costs of vegetation maintenance over the next 20 years for this area are predicted to be even greater

Table 2. Target and cover species encountered at the study sites

Common name	Scientific name	Distribution in sites	
		VI	SI
Deciduous Target Species			
vine maple	*Acer circinatum*	X	
Douglas maple	*Acer glabrum* ssp. *douglasii*		X
bigleaf maple	*Acer macrophyllum*	X	
Sitka alder	*Alnus crispa* ssp. *sinuata*		X
mountain alder	*Alnus incana* ssp. *tenuifolia*		X
red alder	*Alnus rubra*	X	
arbutus	*Arbutus menziesii*	X	
paper birch	*Betula papyrifera*	X	X
black cottonwood	*Populus balsamifera* ssp. *trichocarpa*	X	X
trembling aspen	*Populus tremuloides*		X
bitter cherry	*Prunus emarginata*	X	X
Coniferous Target Species			
grand fir	*Abies grandis*	X	
hybrid white spruce	*Picea glauca x engelmannii*		X
lodgepole pine	*Pinus contorta*	X	X
Western white pine	*Pinus monticola*	X	X
Douglas-fir	*Pseudotsuga menziesii*	X	X
Western red-cedar	*Thuja plicata*	X	X
Western hemlock	*Tsuga heterophylla*	X	X
Competitive Ground Cover			
Saskatoon	*Amelanchier alnifolia*	X	X
hairy manzanita	*Arctostaphylos columbiana*	X	
kinnikinnick	*Arctostaphylos uva-ursi*	X	X
snowbrush	*Ceanothus* spp.		X
red osier dogwood	*Cornus stolonifera*	X	X
beaked hazelnut	*Corylus cornuta*	X	X
broom	*Cytisus scoparius*	X	
common horsetail	*Equisetum arvense*	X	X
salal	*Gaultheria shallon*	X	
ocean spray	*Holodiscus discolor*	X	X
common juniper	*Juniperus communis*		X
Utah honeysuckle	*Lonicera utahensis*		X
black twinberry	*Lonicera involucrata*	X	X
Oregon-grape	*Mahonia* spp.	X	X
Indian plum	*Oemleria cerasiformis*	X	
falsebox	*Paxistima myrsinites*		X
reed canary grass	*Phalaris arundinacea*	X	X
ninebark	*Physocarpus* spp.	X	X
bracken fern	*Pteridium aquilinum*	X	X
currents	*Ribes* spp.	X	X
roses	*Rosa* spp.	X	X
Himalayan blackberry	*Rubus discolor*	X	
thimbleberry	*Rubus parviflorus*	X	X
salmonberry	*Rubus spectabilis*	X	
willows	*Salix* spp.	X	X
blue elderberry	*Sambucus caerulea*		X
red elderberry	*Sambucus racemosa*	X	X
soopolallie	*Shepherdia canadensis*		X
hardhack	*Spiraea douglasii*	X	X
common snowberry	*Symphoricarpos albus*	X	X
blueberries	*Vaccinium* spp.	X	X

because continual slashing of deciduous coppices has resulted in increased stem densities. This poses a problem for the use of the area by ranchers.

Inventory data collected in 1997 coupled with Lap-Map analysis of conductor to ground clearances for this circuit were used to develop selective treatment prescriptions. Areas of less than 14 m conductor to ground clearance can only sustain vegetation to a maximum height of 8 m before violating the 6 m limit of approach required on 500 kV circuits. However, these areas represent only 6.5% of the right-of-way (Table 4). The prescribed treatment for areas with less than 14 m conductor to ground clearance is to slash and spot herbicide treat all vegetation except shrubs

Table 3. Treatment history and costs for 5L71/72 structure 68/1-77/1 from 1978–1999

Year	Spans treated	Treatment type	Total treatment cost (1999 dollars CDN)
1978/1979	68/1-73/2	Chemical (Tordon 101)	89,858
1988	68/1-73/2	Slash	3,552
	73/2-77/1	Slash	31,412
1989	68/1-73/1	Slash	36,814
1992	68/1-72/1	Slash	28,152
	72/1-73/2	Mower head	28,676
	73/2-77/1	Slash	23,501
Total			241,965

Table 4. Total area in each treatment zone for 5L71/72 structure 68/1-77/1

Conductor to ground clearance	Number of hectares	Treatment area (%)
<11 m	2.5	1.4
11–14 m	9.4	5.1
14–20 m	58.4	31.8
20–33 m	102.1	55.5
>33 m	11.4	6.2
Total hectares	183.8	100.0

which at maturity would be less than 3 m tall. In areas with 14–33 m conductor to ground clearance, only target species capable of growing within the limits of approach would be removed. This allows Sitka alder and many willow species to be retained since they do not exceed 6 to 8 m in height at maturity. Areas with more than 33 m clearance would not have to be treated on a regular basis except for removal of danger trees that could fall within limits of approach. Such vegetation would only have to be treated on a 10–20 year cycle basis.

Past treatments on this circuit were not selective with periodic clearing of the entire right-of-way from edge to edge. The treatment cycles were quite variable and appeared to be the result of available budgets in certain fiscal years. The comparative costs for some common treatment methods used in the SI are listed in Table 5. To predict future costs, three scenarios were developed (Table 6) the use of repeated, non-selective slashing based on a six year cycle, selective slashing, and selective slashing with herbicide treatments of low line clearances less than 14 m. Conductor to ground clearance areas (Table 4) and treatment costs (Table 5) were used to develop budget estimates for the three treatment scenarios, with figures adjusted to 1999 dollars (Table 6). The estimates made are conservative but with the integrated management approach, cost savings were projected to be as much as $225,000 CDN over a twenty year period while maintaining line security and public safety. This does not take into account

Table 5. Treatment techniques and the related costs per hectare for the Southern Interior in 1999

Treatment technique	Cost per ha ($CDN)
Hand Slashing	450
Treat with Herbicide (thin line)	600
Mechanical Mowing (track)	750
Mechanical Mowing (tire)	600
Cut and Treat with Herbicide	800

that selective approaches maintain biodiversity on the right-of-way and are favored by the public and regulatory agencies. Greater long-term savings are projected when spot herbicide treatments are used because target species densities are lowered further. Even with up front costs of $20,500 CDN to do the inventory and prescription for this section of corridor, the cost benefits of IVM are apparent.

60L210 Fauquier to Nakusp

This study site is a 46 km section of 69 kV transmission right-of-way running along the eastern side of the Arrow Lakes in southern British Columbia from the lake crossing 6 km north of Fauquier to the substation at Nakusp. The right-of-way is of varying width but in total encompasses approximately 150 ha. The southern end near Fauquier is predominantly Crown land and is situated on steep west facing slopes with poor accessibility. Toward Nakusp the right-of-way is situated on level or rolling terrain which is privately owned and often used for pasture. The area lies within the Dry Warm Interior Cedar–Hemlock (ICHdw) biogeoclimatic subzone and Columbia-Shuswap Moist Warm Interior Cedar–Hemlock (ICHmw2) variant (Braumandl and Curran, 1992). Western red-cedar and Western hemlock are climax species. On disturbed sites, birch dominates with mountain alder and cottonwood occurring on wet soils. Growth rates of birch ranged from 0.65–1.8 $m\,yr^{-1}$ with a median of 1.3 $m\,yr^{-1}$. Densities varied from 5000–108,000 stems ha^{-1} with a mean density of 45,550 stems ha^{-1}.

The circuit is important because it is a radial feed to Nakusp and New Denver and when it fails power goes out in the entire valley. Poor accessibility to the line owing to the rugged terrain renders the corridor difficult to maintain. Because of historical community resistance to herbicide treatments, the right-of-way had been repeatedly slashed on a four-year cycle from 1984 up to 1996. Near Nakusp, some sections on even ground were machine groomed and seeded and this achieved good control of target species. However, mechanical grooming is precluded on much of the corridor because of the steep terrain. In the hand-slashed sections, increasing stem densities from birch coppices made the right-of-way an impenetrable thicket. In addition, there was an accumulation of slash debris on the ground up to 2 m thick. This made it difficult for

Table 6. Predicted treatment cycle and costs in 1999 dollars CDN for three treatment options on 5L71/72 str. 68/1-77/1

Scenario 1				Scenario 2			Scenario 3		
Year	6 year cycle of non-selective slashing	ha	$000s	Using selective slashing only	ha	$000s	Selective with the use of herbicides	ha	$000s
1998	Slash all vegetation that can grow into limits of approach	172	77.6	Slash all vegetation in <11 m areas	70	31.6	Cut and use herbicides in <11 m areas	2.5	2
				Slash targets only in <14 and <20 m areas			Slash targets only in <14 m areas (use selective herbicides)	9	7.5
							Slash targets only in <20 m areas	58	26.3
2002							Control vegetation growth in <11 m areas	2.5	1.5
2003				Slash all vegetation in <11 m areas	114	51.3			
				Slash targets only in <14 and 20–33 m areas					
2004	Slash all vegetation that can grow into limits of approach	172	77.6						
2006							Cut and use herbicides in <11 m areas	2.5	2
							Slash targets only in <14 m areas (use selective herbicides)	9	7.5
2008				Slash all vegetation in <11 m areas	12	5.3			
				Slash targets only in <14 m areas					
2010	Slash all vegetation that can grow into limits of approach	172	77.6				Control vegetation growth in <11 m areas	2.5	1.5
2013				Slash all vegetation in <11 m areas	70	31.6			
				Slash targets only in <14 and <20 m areas					
2014							Cut and use herbicides in <11 m areas	2.5	2
							Slash targets only in <14 m areas (use selective herbicides)	9	7.5
							Slash targets only in <20 m areas	58	26.3
2016	Slash all vegetation that can grow into limits of approach	172	77.6						
2018				Slash all vegetation in <11 m areas	12	5.3	Control vegetation growth in <11 m areas	2.5	1.5
				Slash targets only in <14 m areas					
Total		688	310.4		278	125.1		158	85.6

workers to maneuver and created a potential fuel load threat. Coppices were so well established that they were growing at average rates of 1.5 ± 0.3 m relative to single stem seeded-in birch (1.1 ± 0.3 m). The faster growth rates of coppices necessitated more frequent clearing on a 2 to 3 year basis where there was low conductor to ground clearance. The combination of higher densities, growth rates and slash debris was making it increasingly difficult to maintain the right-of-way in a satisfactory condition. At the same time costs were escalating.

Clearly the status quo was not an option. In 1995, a thorough span by span inventory was developed for 60L210 with analysis of growth rates, stocking densities, terrain, accessibility, and line clearances. Based on the growth rates and line clearances it was determined that a majority of the circuit could be maintained on a six-year cycle. Areas of low clearance requiring more frequent treatment were identified and determined to be about 10% of the right-of-way. In the past, these low clearance sections were driving the entire treatment cycle. Public meetings were held in 1996 and options were discussed, including selective use of Garlon (triclopyr) basal, and Roundup (glyphosate) cut-stump treatments. The detailed data and prescriptive maintenance approach met with favorable public response. Approval was given to allow selective herbicide applications on Crown land portions of the right-of-way where the densities of birch were at their worst (60–100,000 stems ha^{-1}).

Contracts were developed for 1996–2000 to clear sections of the line using slashing and herbicide treatments to reduce target species densities. The results have been very promising. Stocking densities are falling and the corridor is now on a more manageable cycle of 6 years with spot clearing every 2–3 years in critical low clearance areas. Public response has been favorable and annual maintenance costs have been spread out. It is expected that over a 20-year period that costs for maintaining this line will be substantially reduced. Other benefits are becoming apparent as well. In areas where Garlon applications were made target vegetation densities have been dramatically reduced, opening up the right-of-way to establishment of low growing shrub cover. This is allowing old slash debris to rot down faster thereby reducing fuel loading, improving wildlife habitat and increasing accessibility to the line by workers.

2L123/128 Englishman River to Coombs

The Vancouver Island study site is located on a dual circuit 230 kV corridor between the Englishman River and Coombs, a relatively uniform and level area covering 42 ha. The corridor lies within the Eastern Very Dry Maritime Coastal Western Hemlock variant (CWHxm1) which occurs at lower elevations along the eastern side of Vancouver Island. This area is characterized by warm, dry summers and moist, mild winters with relatively little snowfall (Green and Klinka, 1994). Climax forests are dominated by Douglas-fir, Western hemlock, and Western red-cedar. Red alder, cottonwood, and bigleaf maple are common on seral sites.

In 1997, the corridor was thoroughly inventoried and short and long-term site objectives were developed. Past management of this area included mowing, hand slashing and girdling of the right-of-way every 4 years. Over time, this had resulted in high average densities of deciduous stems of 50,000 stems ha^{-1} with a range of 28,500 to 90,000 stems ha^{-1}. Over 85% of the targets were red alder that were growing at an average rate of 1.2 m yr^{-1} and were approaching 7 m in height (Fig. 2). Also present in smaller amounts were black cottonwood, arbutus, and willow. In contrast, conifer cover was typically low with densities of 5000 stems ha^{-1} or less. The majority of Douglas-fir and lodgepole pine individuals were 2.5 m tall with a few approaching 5 m tall. Minor amounts of Western red-cedar, and Western hemlock were also present. Ground cover was generally poorly developed (5–25% cover) over much of the treatment area with patches of bracken, grasses, salmonberry, thimbleberry, salal, and hairy manzanita present. The cost of $900 CDN per hectare to mow this right-of-way every four years was not sustainable. Therefore, this site was a good candidate for developing site specific treatments based on IVM principles.

Conductor to ground clearances dictated that tall growing target vegetation had to be removed in 1998 to maintain line security and public safety. An articulating excavator type mower was selected as the initial best management practice. This allowed for the selective removal of target vegetation while retaining any compatible ground cover present so that it could actively compete against target tree resprouts. The timing of this work was critical. The mowing was completed in late August when the target vegetation was under considerable stress and this resulted in a high level of natural mortality. In July 1999, the target vegetation that was mowed was followed up by a backpack foliar treatment using 2% Roundup (glyphosate) with the addition of Sylgard 309 (non-ionic silicone polyether surfactant). The results of the two step program were immediate. Selective mowing resulted in little disturbance to existing ground cover, the resprout of target vegetation was lessened because of the late summer mowing, and the spot herbicide treatment resulted in good mortality of surviving resprouts. The overall result was an excellent release of low-growing cover (Fig. 3).

This long-term, site specific management plan was instrumental in arguing for and getting sufficient project funds to do the work properly. Conducting a mandatory site preview of the work area resulted in contractor's expectations being clear which improved their bid prices and enhanced the quality of work performed. A more selective approach and use of best management practices has also improved relationships with regulatory agencies and with the public.

Fig. 2. Dense cover of mostly deciduous target species on 2L123/128 near the Englishman River prior to site treatments. Photo was taken in April 1998.

Fig. 3. 2L123/128 near the Englishman River after mowing in August 1998 with foliar application of glyphosate on target species resprouts in July 1999. A dense, compatible shrub layer has developed. Photo was taken in August 2000.

CONCLUSIONS

BC Hydro is beginning to accrue significant benefits from shifting to an Integrated Vegetation Management (IVM) approach. Using LapMap to create condition-based assessments of the right-of-way allows the development of site specific prescriptions with both short and long-term objectives to control problem vegetation. Different target species respond to manual, mechanical, and chemical treatments in different ways (BC Hydro, 1997). By assessing which species are causing problems, best practices solutions can be developed to reduce their densities. Having detailed information also allows for more accurate budget estimates and this helps to secure necessary funding to keep a smooth maintenance program running. It also allows for more meaningful consultation with the public and with regulatory agencies that gain confidence that rights-of-way are being properly managed. Integrated management also allows for the development of strategies to improve wildlife and recreational or even compatible business opportunities on rights-of-way.

The success of these trials has resulted in the approach being used more widely across the system on an operational basis. One benefit has been the standardization of work procedures (BC Hydro, 1997). The benefits have been so compelling that it has supported the development and implementation of a full scale Enterprise Geographic Information System at BC Hydro. This will eventually replace LapMap and allow for even more streamlined database, prescription and contracting functions.

The shift to IVM has also resulted in changes to contracting strategies. When contractors are given site-specific work, the initial reaction is to bid using the historical, non-selective cost of maintaining the right-of-way. But as contractors have become used to the selective approach, improvements in contractor prices have been seen. Contractors are now given more detailed work specifications that fully informs them of the amount of actual work, the target vegetation to be controlled, and clearer environmental guidelines to protect riparian and wildlife habitat. They are also able to benefit from the conductor to ground clearance models created for higher voltage circuits to identify potential low clearance hazards. Maintenance coordinators also use clearance isolines to ensure that tall growing vegetation in critical low clearance areas is not overlooked. This makes for a safer work environment.

Many contracts are now initiated with a mandatory on-site pre-tender meeting with contractors. This allows them to see exactly what they are bidding on which frequently results in better pricing. Contractors who do not attend are not allowed to tender blind and any such bids are rejected. Realistic pricing reduces the potential that a contractor who is awarded the work will walk away because they did not realize the full extent of the work required. Thus work is done in a more timely, organized manner.

The transition to full implementation of IVM takes some years to achieve. There is the need to obtain accurate mapping and inventories of the corridors upon which to base prescriptions and contracts. Follow up monitoring of work to determine whether site objectives are being met is also an ongoing endeavor. There are up front costs associated with these activities. But in the long run the benefits are worth it from an economic, environmental, and social point of view.

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Tree, Shrub, and Herb Succession and Five Years of Management Following the Establishment of a New Electric Transmission Right-of-Way through a Mixed Woodland

Richard A. Johnstone, Michael R. Haggie, and Hubert A. Allen, Jr.

A five-year study on vegetation succession was undertaken following the construction of a new electric transmission right-of-way (ROW) in Delaware, USA, that utilized both clear and selective cutting methods. Integrated vegetation management (IVM) methods were used as secondary interventions and compared against control sites. Restrictions have been imposed by regulatory agencies declaring that only selective clearing of targeted incompatible tall-growing trees and retention of existing compatible low-growing trees and shrubs is permitted for new ROW construction. Permanent upland quadrants were established for this study that compared tree, shrub, and herb populations following clear-cut and select-cut tree removal, and integrated vegetation management and no treatment interventions. Baseline data were gathered prior to construction and changes were documented for species numbers, diversity, stem count, and relative density. The management of desirable species and their relative value to wildlife are considered. Results show that IVM interventions triggered vegetation succession from mature woodland trees to low shrub/herbaceous communities as successfully in the clear-cut as in the select-cut quadrants. Total species numbers remained relatively stable but reflect a substitution of trees for herbaceous species while shrub species numbers remained relatively constant. The environmental effects of electric transmission ROW establishment and various vegetation management techniques upon plant species succession are discussed.

Keywords: Relative dominance index (RDI), wildlife use index (WUI), upland, Delaware, clear-cut (CC), select-cut (SC), integrated vegetation management (IVM), selective treatment

INTRODUCTION

Several studies have shown vegetation changes in existing electric transmission rights-of-way (ROW) following a variety of treatments and management practices (e.g., Draxler et al., 1997; Finch and Shupe, 1997; Garant et al., 1997; and Haggie et al., 1997). This study documents 5 years of vegetation succession following the establishment of a new electric transmission line through a mixed oak-holly-pine (*Quercus-Ilex-Pinus*) upland and contrasts the use of clear-cutting (CC) and select-cutting (SC) of trees for initial ROW clearing, with subsequent integrated vegetation management (IVM) or no treatment controls.

Since 1983 Delmarva Power, now Conectiv Power Delivery (CPD), has gradually implemented IVM in their transmission ROW vegetation management. CPD has evolved an IVM system which includes hand-cutting, mechanical control, herbicide treatment, and biological control (Hallmark, 1996). Herbicide use is coupled with a high degree of field crew education concerning the identification of desirable and undesirable tree and shrub species. These methods have not only produced a significant cost savings of $3 million to the company (Johnstone, 1997, pers. comm.), but have also created more than 3642 ha of wildlife habitat along 9171 km of ROW in Maryland, Delaware, and Virginia (Wildlife Habitat Enhancement Council,

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1992). Much of this habitat, ecologically termed old-field type, can have considerable value for certain wildlife species (Chasko and Gates, 1982 and Delorey, 1992). In this study undesirable species include all tall trees that are capable of growing to a sufficient height so as to interfere with overhead utility wires.

CPD, under whose auspices this research was initiated, has contracted with Chesapeake Wildlife Heritage to evaluate the effects of certain clearing methods, as well as herbicide and mechanical treatments, on plant succession in ROW sections on the Delmarva Peninsula.

GOALS AND OBJECTIVES

The research goal of this study was to document the vegetation changes that occurred following the establishment of a new ROW in a mid-Atlantic wooded upland area. The purpose was to address questions by federal and state regulatory agencies during the ROW construction permit process concerning the environmental effects of clear-cutting versus selective-cutting of trees. From an economic standpoint clear-cutting, the mechanical removal of all above ground vegetation, is preferred over selective cutting for ROW preparation and establishment. From an environmental standpoint selective-cutting has been suggested by the permitting agencies as the preferred method, since it retains the compatible low growing trees, shrubs, and herbaceous vegetation present at the time of initial ROW clearing.

Our research objective was to investigate whether a relatively stable shrub-herbaceous community could be established following a clear-cut, using judicious IVM interventions, that is as environmentally comparable as that perceptibly obtained with a selective-cut.

The utility company vegetation management objective is to cost-effectively foster relatively stable low-growing plant communities in order to minimize overhead transmission line interference and maintain access to facilities. This optimum situation can be most effectively achieved by using IVM with a gradual reduction of herbicides, ending with only periodic spot treatments (Bramble et al., 1987) and a reliance on natural allelopathy (Cain, 1997; Putnam, 1986; and Horsley, 1977).

This study explores the merits of clear-cutting versus selective-cutting in new ROW construction, accompanied by IVM interventions.

STUDY AREA AND SITE HISTORY

Located at Indian Mission off state Route 5 near Harbeson, Sussex County, DE, USA, the study area lies at coordinates 38°41′N and 75°14′W. New ROW construction commenced in the fall of 1992. This electric transmission line was initiated to facilitate power distribution from the generation point in Millsboro to Rehoboth Beach, Delaware (DP Circuit 13705 Indian River/Robinsonville). The 30 m wide construction line runs north to south through a 0.91 km tract of mixed timber, part of which was last logged in the 1950s. Age of the existing woodland was estimated based on tree size and ring count. Trees were of short to moderate size for the species norm due to the somewhat droughty underlying soil types, indicating an edatope. These were listed in the Soil Survey for Sussex County, Delaware as woodland classes 3o, 3s, and 2s (Ireland and Matthews, 1974). Trees consisted of primarily mixed oak-holly-pine woodland and the ROW is bisected west to east by Chapel Branch, a stream that drains into Rehoboth Bay via the Burton Prong of Herring Creek. The survey site was laid out along an upland ROW section to the south of the stream branch. The soils consist of loamy sand that is part of the Evesboro-Rumford association. These soils are moderately to excessively well drained having a highly permeable subsoil of sand to sandy loam. The upland study area lies on a 0–2% slope (Ireland and Matthews, 1974).

METHODS AND MATERIALS

A linear transect survey method suitable to following long-term vegetation succession was used (Smith, 1966). A 30 m wide by 100 m long centrally located section of ROW, with a 10 m central access route, was selected as representative of the upland woody vegetation. This block was subdivided into four 10 m × 50 m quadrants. The east side of the ROW was selectively treated (SS) in 1993 and 1997 with herbicide to control undesirable trees. The west side remained untreated (UT) as the control until 1997. ROW treatment history is summarized in Table 1.

Baseline data of tree, shrub, and herbaceous species were taken prior to new ROW construction in the fall (September to October) of 1992, and subsequently each fall from 1992 through 1997. Herbaceous data were also collected in the spring (May to June) from 1993 through 1997. A four letter code was assigned to each plant identified using the first two letters of the genus and species in the Latin name, e.g. *Vaccinium corymbosum* is VACO, or if only identified to genus, VASP.

Five 2 m × 10 m shrub plots, 10 m apart, were established north/south within each quadrant. Shrub survey lines were commenced 5 m from either end of each quadrant. One tree plot, 10 m × 50 m, was established within each quadrant. The end points of each transect line were marked with permanent stakes which allowed the same transect to be surveyed again in each subsequent year. See Fig. 1.

Table 1. Indian Mission Connective Power Delivery ROW construction and herbicide treatment history 1992–1997

Year/season	Treatment	Effected quads	Notes
1992 Fall	Clear-cut (CC) Select-cut (SC)	NW, SE NE, SW	CC = tree stumps & shrubs mown to ground level SC = undesirable trees and shrubs removed
1993 Fall	Initial herbicide Select-spray (SS)	NE, SE	Code 031[a], foliage/hydraulic broadcast NW, SW untreated (UT)
1994 Summer	Follow-up herbicide Select-spray	NE, SE	Same as 1993
1995	None	All	
1996	None	All	
1997 Summer	Follow-up herbicide Select-spray	All	Code 031G[b], foliage/hydraulic broadcast Code XG670[c]

Upland herbicide codes, mixtures, and rates

a-Code 031	1993	4.73L (1.25 US gal.) Accord* + 1.18dl (4 oz.) Arsenal + 1.89L (0.50 US gal.) Cleancut + 0.95L (0.25 US gal.) Weedar 64 + 1.18dl (4 oz.) 38F drift control in 378.5L (100 US gal.) water.
b-Code 031G	1997	4.73L (1.25 US gal.) Accord* + 0.95L (0.25 US gal.) Garlon 3A + 1.18dl (4 oz.) Arsenal + 1.89L (0.50 US gal.) Cleancut + 1.18dl (4 oz.) 38F drift controlin 378.5L (100 US gal.) water. *Glyphosate applied at a rate of 10.44 L/ha (4 qts/ac), 53.8% active ingredient (a.i.)
c-Code XG670	1997	4.73L (1.25 US gal.) Accord* + 4.14dl (14 oz.) Garlon 3A + 1.18dl (4 oz.) Arsenal + 56.78L (15 US gal.) Thinvert (total volume = 62.07L (16.4 US gal.)) in 378.5L (100 US gal.) water. Used in upland.

Trade names of herbicides used

Accord (common name: glyphosate isopropylamine), composition = 53% concentration of isopropylamine salt of N-[phosphono-methyl] glycine
Arsenal, (family name: imidazolinone), composition = isopropylamine salt of imazapyr (2-[4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1H-imidazol-2-yl]-3-pyridine carboxylic acid)
Garlon 3A, (common name: Triclopyr), composition = 3,5,6-trichloro-2-pyridinyloxyacetic acid
Weedar (common name: 2,4-D), composition = dodecylamine + tetradecylamine salts of 2,4-D
(Meister and Sine, 1996)
Surfactants used were Cleancut, Thinvert and 38F used for drift control

Abbreviations for Tables 1 and 2

Species code	Common name	Latin name
ACRU	Red Maple	*Acer rubrum*
CLAL	Sweet Pepperbush	*Clethra alnifolia*
ILGL	Inkberry	*Ilex glabra*
ILOP	American Holly	*Ilex opaca*
LEUS	Fetterbush	*Leucothoe sp*
LYLI	Male Berry	*Lyonia ligustrina*
NYSY	Sour Gum	*Nyssa sylvatica*
PITA	Loblolly Pine	*Pinus taeda*
PIVI	Virginia Pine	*Pinus virginiana*
QUSP	Oak	*Quercus sp*
RHOV	Azalea	*Rhododendron sp*
RUBS	Bramble	*Rubus sp*
SAAL	White Sassafras	*Sassafras albidum*
SMRO	Greenbriar	*Smilax rotundifolia*
SPSH	Sprayed Shrub	*Sprayed shrub*
VACO	High bush Blueberry	*Vaccinium corymbosum*
VAGA	Low bush Blueberry/ Huckleberry	*Vaccinium sp/ Gaylussacia sp*

+ — new species since 1992 baseline, ∗ — undesirable right-of-way species, CC — clear cut, SC — select cut, (X:X) = (U:D) ratio of undesirable to desirable ROW species. N.B. species are listed in order of dominance within each % group, % is rounded to the nearest whole number

Herbaceous plots 1 m square were laid out along the mid-line of the 2 m × 10 m shrub plots at 0, 5, and 10 m. These three points were permanently marked with wire flags. At either end of the transect a 5 m buffer was left to reduce the edge effect of shading from the adjacent woodland at the one end, and the wood debris effects within the access corridor at the other (Fig. 1). Herbaceous vegetation was stem counted by species and percent cover estimated following species identification. All specimens were identified to genus and, where practical, to species. A prefabricated meter square made from 12.5 mm PVC schedule 40 plastic water pipe was used along the survey line, within which the data were taken.

In the tree plots individuals were identified to species where possible, counted and measured at diameter breast height (DBH). Woody specimens ≥5 cm DBH were considered trees, and further subdivided into desirable and undesirable based on their potential to interfere with overhead wires. Woody specimens <5 cm DBH were considered shrubs and they were identified to genus or species and the number of stems counted. Only when these species reach a stage ≥5 cm DBHare they controlled by the utility company.

A relative dominance index (RDI) developed by Smith (1966) was applied in our studies (Haggie et al.,

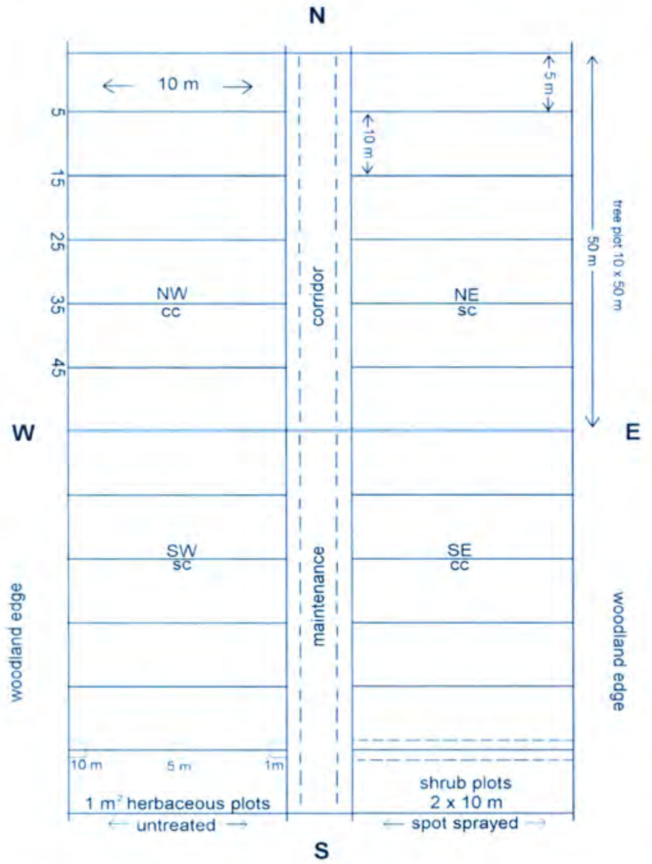

Fig. 1. Indian Mission Rights-of-Way Upland Research Plots. Quadrant NW is clear-cut (CC); removed trees and shrubs; left unsprayed for future maintenance. Quadrant NE is selective cut (SC); cleared trees and left shrubs; selective follow up. Quadrant SW is selective cut (SC); cleared trees and left shrubs; left unsprayed for future maintenance. Quadrant SE is clear-cut (CC); removed trees and shrubs; selective follow-up.

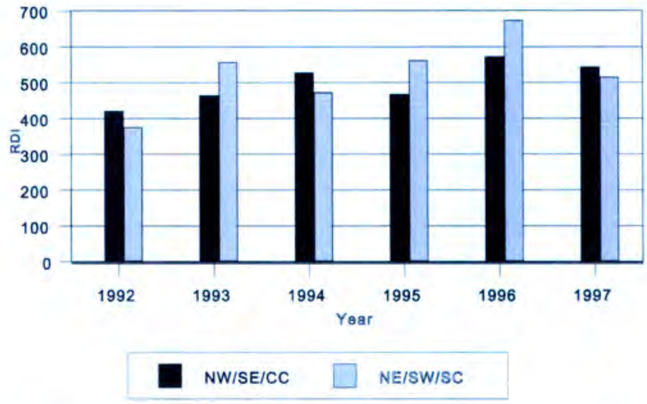

Fig. 2. Indian Mission Upland Shrub Relative Density Index (RDI) compares the close association of the desirable shrub densities in the CC and the SC. No significant difference was found between the plots (by ANOVA $p \leq 0.573128$).

1997) and used to compare the various species groups to each other, between seasons and years.

Nomenclature used for herbaceous and woody species was taken from Brown and Brown (1972 and 1984), and for bryophytes, Shuttleworth and Zim (1967).

RESULTS AND DISCUSSION

The ROW through the woodland was clear-cut of trees and shrubs in the fall of 1992, the standard establishment procedure, except where the specific quadrant treatments were installed as in Fig. 1. Only in the access lane were the tree stumps ground down and the wood chips deposited. The vegetation changes that followed can be broken down into 6 groups for analysis.

General overview

Tall growing undesirable tree species ≥5 cm DBH were eliminated from the study site at baseline due to the primary intervention of clear-cutting (preferred utility method) and selective-cutting (permitting agency method) in the fall of 1992. They did not start to reoccur in the select-cut until the fall of 1995 and in the clear-cut until 1996. The total number of shrub species remained relatively constant over the study period and even though their composition varied, their relative dominance as shown in Fig. 2 and total stem count increased over time. However herbaceous species increased dramatically after only 2 years from a baseline number of 5 to a maximum of 18 species in the fall of 1994. Thus from an aspect of plant diversity there was a shift from tree species to herbaceous species over the time of the survey once the tree competition that limited the herbaceous vegetation was removed.

Trees and shrubs (≥5 cm DBH)

The order of dominance in the baseline oak-holly-pine tree association consisted of three species of oak, (*Quercus alba* L., *Quercus rubra* L., *Quercus nigra* L.), American holly (*Ilex opaca* Ait.), loblolly pine (*Pinus taeda* L.) and red maple (*Acer rubrum* L.). This order was based on the total stem count of each species in all quadrants. Eleven total tree species were recorded in the 1992 baseline data.

In the select-cut quadrants the number of tree species dropped from a high of 10 [ratio 8 undesirable (U):2 desirable (D)] at baseline to 5 (4U:1D) at the end of the survey.

In the clear-cut quadrants species numbers were again 10 (8U:2D) at baseline to 3 (2U:1D) tree species at the end of the survey, two from sprouted stumps (red maple and American holly) and one from seed (loblolly pine).

In this type of woody association undesirable trees naturally dominate over the desirable species (ratio = 10U:2D at baseline). As the number of tree species reappeared in the SC following initial construction in 1992, there followed a significant annual increase in both the total stem count and RDI. These were composed of desirable species exclusively until 1995, since the undesirable species were either cut or selective

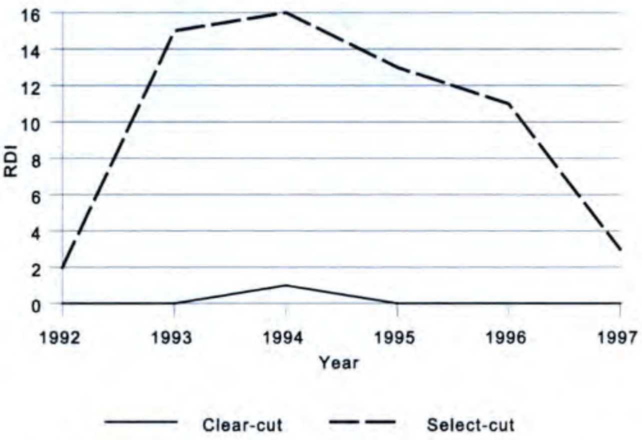

Fig. 3. Indian Mission Tree/Shrub for Flowering Dogwood compares the relative density (RDI) of Flowering Dogwood (*Cornus florida*) in the CC and the SC plots. The rapid increase in 1993 may be attributed to the release of the surrounding tree canopy. The drop in RDI after 1994 may be attributed to shrub competition and direct sunlight.

herbicide treated. The undesirable species started to attain tree dimension 3–5 years after construction but stem count remained low due to IVM interventions. No discernable difference was observed in numbers of desirable trees in the treated versus untreated plots, which indicated that the selective herbicide intervention in the year following construction was appropriately targeted by the field crews. (Field crew education is deemed an important aspect in achieving the stated goals.)

In the CC trees did not start to appear until 4–5 years after construction. The number of undesirable tree seedling species (<5 cm DBH) remained moderately constant each year (range 7–9) over the entire study period in both the CC and the SC, indicating that there was an ever-present natural cohort in this type of woodland ready for recruitment.

The desirable trees (<5 cm DBH) were differently affected, possibly due to their niche. These tended to be small, edge, or understory trees, such as hop-hornbeam (*Ostrya virginiana* (Mill.) K. Koch.) and flowering dogwood (*Cornus florida* L.) as shown in Fig. 3. The SC appeared to benefit these species after 2–3 years when their RDI peaked, but at the end of the five-year study their RDI was similar to the baseline. Competition from other plant species in the open ROW corridor diminished the initial benefit of their selective retention. The CC did not show an increase in RDI for these desirable species since they immediately had difficulty competing against other plant species after the initial clearing. The exception was American holly, the RDI of which peaked at the end of the study due to the sprouting of cut stems in the CC and possible allelopathic properties in the SC.

Shrubs, woody vines, and small trees (<5 cm DBH)

The total stem count of the shrub community remained quite constant over the five-year study. Range in total species numbers over time varied from 26 to 34 species with the peak occurring in 1995, 3 years post-treatment. At the commencement of the study 23 species of shrubs were identified in all quadrants and by the end there were 28 species. This represented a total gain of 5 species, with 3 (1U:2D) species being lost and 8 (1U:7D) gained. Twenty species persisted over the study period.

An analysis of the quadrants by CC and SC pairs evinces some useful comparisons in the similarities of shrub succession between the two construction methods as shown in Tables 2 and 3.

For taxonomic simplification, low-bush blueberry (*Vaccinium* (*vacillans*) Torr.) and huckleberry (*Gaylussacia sp.* H.B.K.) were combined into one botanical group (see VAGA, Tables 2 and 3). They were the dominant shrubs at baseline (CC = 68% and SC = 46%), but three years later demonstrated a reduction in stem count in both the CC (to 31%) and the SC (to 39%). The data in the two treatments following ROW construction correlate closely and eventually stabilize, despite there being an overall reduction of this species group by 46% in the CC (Table 3) and 10% in the SC (Table 2). This is partly explained by the higher baseline relative dominance in the CC and suggests that either this clearing method, type of competition and/or reduction in overstory does not benefit this species group. Statistically, however, no significant difference was found between the CC and SC quadrants (ANOVA $p \leq 0.573128$). Species that revealed an increase in the CC were sweet pepperbush (*Clethra alnifolia* L.), fetterbush (*Leucothoe racemosa* (L.) Gray), and blackberry (*Rubus sp.* L.), while fetterbush, blackberry, and inkberry (*Ilex glabra* (L.) Gray.) increased in the SC. Throughout the survey, irrespective of treatment, desirable shrub/trees, except for holly, appeared not to have good recuperative capabilities in this changed environment. Conversely undesirable species such as oaks, red maple, sour gum, and loblolly were found to persistently resprout and reseed.

Herbaceous vegetation, including succulent vines

From the baseline data herbaceous species increased from a total of 5 to 15 at the end of the study, with a peak of 18 species in the 3 middle seasons of 1994–1995. The drop in species numbers may be attributed to a maximum colonization at that time and subsequent interspecific competition from other herbs and shading from increased growth in the shrubs. This hypothesis is partly supported by the rapid increase in the herbaceous RDI over time (28.5–74.8) until the fourth year post-treatment (see Fig. 4).

Early dominant pioneering species of note were broom-sedge (*Andropogon virginicus* L.), panic grass (*Panicum* (*verrucosum*) Muhl. L.), sow-thistle (*Sonchus oleraceus* L.), greenbriar (*Smilax sp.*), sedges, (*Carex sp.* L.), and several mosses (bryophytes). After 2–3

Table 2. Indian mission upland shrub dominant species, selective cut

Year	1992	1993	1994	1995	1996	1997	%
							$\bar{x}$ # stems
							71–100
							61–70
	VAGA 46						51–60
		VAGA 42			VAGA 46	VAGA 43	41–50
			VAGA 36	VAGA 39			31–40
							21–30
	CLAL 16	CLAL 13 ACRU* 12	CLAL 14 LEUS 12	LEUS 16 CLAL 17	CLAL 12 LEUS 12	CLAL 15 (SPSH) 11	11–20
	RHOV 7 VACO 7 LYL 7	LEUS+ 8 QUSP* 6	VACO 9 ACRU* 8	VACO 6 ACRU* 5	ACRU* 5 VACO 5 RUBS 5	VACO 7 ACRU* 6	5–10
	QUSP* 4 ACRU* 3 ILOP 3 PIVI* 2	VACO 4 NYSY* 3 ILOP 2 ILGL+ 2	ILOP 4 QUSP* 3 ILGL 3 RHOV 3 SMRO 2	QUSP* 3 SMRO 2	VACO 3 RHOV 3 PITA* 3 QUSP* 2 SMRO 2	LEUS 4 SMRO 3 RUBS 2	>2–4
# sp < 2%	12 (6:6)	16 (5:11)	10 (5:5)	21 (7:14)	12 (5:7)	15 (7:8)	$\bar{x} = 14.3$
# sp ≥ 2%	9 (3:6)	9 (3:6)	11 (2:9)	7 (2:5)	11 (3:8)	8 (1:7)	$\bar{x} = 9.2$
# sp ≥ 5%	5 (0:5)	5 (1:4)	6 (1:5)	5 (1:4)	6 (0:6)	5 (1:4)	$\bar{x} = 5.3$
Total # sp	21 (9:12)	25 (8:17)	21 (7:14)	28 (9:19)	23 (8:15)	23 (8:15)	$\bar{x} = 23.5$
Total # stem	1882	2786	2364	2816	3368	2580	$\bar{x} = 2633$

Table 3. Indian mission upland shrub dominant species, clear cut

Year	1992	1993	1994	1995	1996	1997	%
							$\bar{x}$ # stems
							71–100
	VAGA 68						61–70
							51–60
		VAGA 42	VAGA 43				41–50
				VAGA 31	VAGA 36	VAGA 31	31–40
						(SPSH) 25	21–30
		CLAL 15	CLAL 13	LEUS 18 CLAL 14	CLAL 18 LEUS 13	CLAL 11	11–20
	VACO 7	ACRU* 8 LEUS+ 7 VACO 6	LEUS 8 VACO 7 ILOP 7	ILOP 7 VACO 6	VACO 6 RUBS 5	ILOP 7 VACO 5 RUBS 5	5–10
	ILOP 4 CLAL 4 QUSP* 4 LYLI 3	ILOP 4 QUSP* 3 NYSY* 3 SAAL* 2	QUSP* 4 ACRU* 3 LYLI+ 3	ACRU* 4 QUSP* 3 NYSY* 2 RUBS+ 2	ILOP 4 ACRU* 4 LYLI 3 ILGL 3 PITA* 3 QUSP* 2	ILGL 4 ACRU* 3 LEUS 2	>2–4
# sp < 2%	16 (8:8)	15 (4:11)	16 (6:10)	16 (4:12)	14 (7:7)	16 (8:8)	$\bar{x} = 15.5$
# sp ≥ 2%	6 (1:5)	9 (4:5)	9 (1:8)	10 (3:7)	12 (3:9)	9 (1:8)	$\bar{x} = 9.2$
# sp ≥ 5%	2 (0:5)	5 (1:4)	5 (0:5)	6 (0:6)	6 (0:6)	6 (0:6)	$\bar{x} = 5.0$
Total # sp	22 (9:13)	24 (8:16)	25 (8:17)	26 (7:19)	26 (10:16)	25 (9:16)	$\bar{x} = 24.7$
Total # stem	2105	2320	2637	2337	2861	2717	$\bar{x} = 2496.2$

years, several thoroughwort species, such as *Eupatorium sp.* L., started to appear in addition to deer-tongue grass (*Dichantelium clandestinum*) (L. Gould.) In the fourth year brambles (*Rubus sp.*) and lichens (*Lichenes sp.*) emerged. This living herbaceous group increased from 1% of the woodland floor at baseline to 48% at the end of the study, despite suppression from the 52% of non-living material (branches, logs, leaf litter) and associated shrub community. No differences were noticed between the CC and SC in the total living herbaceous RDI analysis, although there were species specific differences.

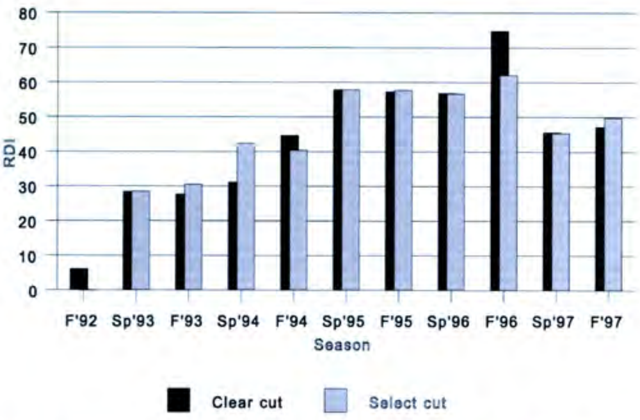

Fig. 4. Indian Mission Upland Herbaceous shows the very close comparison of herbaceous vegetation by relative density index (RDI) in the CC versus the SC plots. No significant difference was found between the plots in RDI but species variation was found.

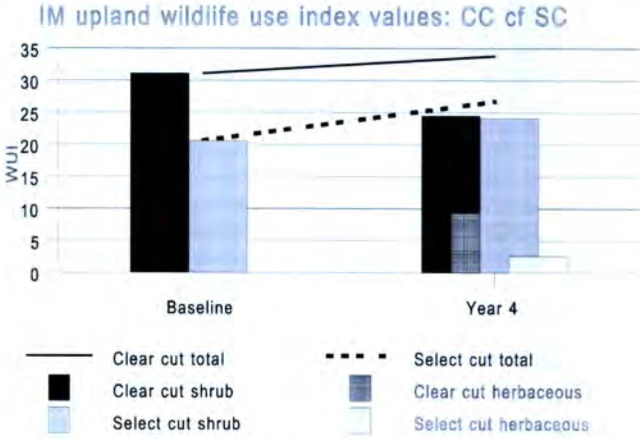

Fig. 5. Indian Mission Upland Wildlife Use Index Values: clear-cut compared with select-cut. An increase in total values in year 4 can be attributed to an increase in grasses with a high WUI, especially in the clear-cut.

Non-living material (NLM)

The herbaceous baseline data in the fall of 1992 consisted of a single dense layer of hardwood and softwood leaf litter that occupied the woodland floor (=99% NLM). In the fourth year following construction, prior to the final selective herbicide intervention, average NLM percent cover was 36.5% in the SC and 28.0% in the CC. This indicates a better rate of living plant colonization of ground cover in the CC, evidently due to shading by the remaining trees in the SC.

The RDI of the bare soil in the SC was 53.3 in the year after construction and 38.4 four years later while the CC was 47.6 after construction but 0 in the fourth year. The significantly greater SC bare soil RDI is only partly due to the shading and allelopathic effects of the remaining shrubs (Meilleur et al., 1994) and desirable trees (principally holly). This was unexpected and could have implications where clearing techniques are used in erosion-prone areas. This study suggests that long-term erosion control through increased plant cover of bare soil could possibly be better served with CC than SC. The authors however recommend further studies.

Wildlife implications

To determine a gauge of comparative wildlife use in the different ROW preparation methods, a Wildlife Use Index (WUI), adopted by the US Fish and Wildlife Service (USFWS), was adapted from Martin, Zim, and Nelson (1951). In order to make a valid comparison, trees (both desirable and undesirable) were excluded from the WUI evaluation. Trees such as oaks have a very high WUI, but only if allowed to grow to maturity, which is not possible within a ROW corridor. One limitation of the WUI is that not all species in the survey were evaluated by the USFWS. In such cases an assumed value of one was given.

A WUI was applied to the desirable dominant shrub and herbaceous species with an index ≥ 1 in order to assess comparative values for SC and CC. See Table 4. WUI values were also computed to compare baseline data with the final study year. At baseline, WUI of the CC quadrants was 31.1 (shrubs = 31.1, herbaceous = 0) and SC quadrants was 20.6 (shrubs = 20.6, herbaceous = 0). In the fourth year post-construction the CC was 33.8 (shrubs = 24.5, herb = 9.3) and the SC was 26.7 (shrubs = 24.1, herbs = 2.6) (see Fig. 5). The overall increase in the WUI can be attributed to an increase in shrubs and, particularly in the CC area, herbaceous species with a high wildlife value. These high WUI species include the panic grasses, *Panicum sps.*, deer-tongue grass, *Dichantelium sp.*, bramble, *Rubus sp.*, and sedges, *Carex sp.* (Table 4). The desirable trees do not have a high wildlife value, the exception being flowering dogwood. *Cornus florida* L., WUI = 58). Dogwood was retained in the SC area but its RDI declines over time in the open ROW corridor.

CONCLUSIONS AND RECOMMENDATIONS

The primary question of this investigation was whether adequate natural vegetation would colonize a clear-cut (CC) as opposed to a selectively cut (SC) newly constructed upland utility ROW. Data showed that early vegetation recovery (evaluated by % cover, total stem count, and RDI) in the CC quadrants was sufficient to reduce erosion as compared to the SC. In fact, shrub and herbaceous colonization of the CC areas was sufficient to achieve 100% living plant cover over the five-year study period, while the SC had more area of bare soil. This study suggests that the erosion control rationale for permitting agency restrictions on clear cutting and the preferences for selective cutting, may be misguided. This study showed that by solely evaluating the shrub and herbaceous colonization there can be equal or more potential cover and wildlife value after 5 years in a CC as opposed to a SC. Changes in

Table 4. Indian mission upland desirable vegetation wildlife use index values (WUI). From Martin, Zim, and Nelson, 1951*

Common name	Latin name	Species code	*WUI value
Bramble	*Rubus sp.*	RUBS	74
Deer-tongue grass	*Dichantelium sp.*	DISP	59
Panic grass	*Panicum sp.*	PASP	59
Flowering dogwood	*Cornus florida*	COFL	58
Sedge	*Carex sp.*	CASP	41
Low-bush blueberry	*Vaccinium sp.*	VASP	41
Greenbriar	*Smilax sp.*	SMIS	20
Azalea	*Rhododendron sp.*	RHOV	4
Huckleberry	*Gaylussacia sp.*	GAYS	2
Sweet pepperbush	*Clethra alnifolia*	CLAL	1
Fetterbush	*Leucothoe sp.*	LEUS	1

desirable shrub RDI and stem count all demonstrated comparable species occupation, species maintenance, species colonization, and extinction in both the CC and the SC. A general evaluation of the stem count and the RDI revealed that CC and SC do not significantly vary and colonized well two years after ROW construction and almost completely by the end of the study.

When select-cutting trees careful consideration should be given to the condition, growth stage and type of the tree selected. Tree density and tree height should be considered as well as the age of the woodland as a whole. Herbicide applicator education was found in this study to be of great importance in selecting the appropriate vegetation types to establish a viable desirable community. It is possible to make a general prediction of the eventual shrub/herbaceous composition following the clear-cutting of an eastern deciduous mixed upland forest with judicious follow-up selective application of herbicide to undesirable species. No replanting is needed to establish up to 100% ground cover. This can occur with either ROW method of establishment, clear-cut or select-cut, if a careful examination is made of the baseline shrub vegetation before ROW construction and knowledge has been acquired on the effects of cutting for different species. This study does not demonstrate that clear-cut is better than selective-cut. It simply shows that there are no major discernible differences between a clear-cut and a selective-cut ROW in their vegetational composition 5 years post ROW clearing and preparation.

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Gray Birch Ecology on an Electric Powerline Right-of-Way in Upstate New York

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Gray birch (*Betula populifolia* Marsh.) is an important tree species on powerline rights-of-way (ROWs) in the north temperate zone of North America. It is a pioneer species that can proliferate in the early plant succession environment of powerline ROWs. While a short tree at maturity (10–15 m), it is commonly a danger for the transmission of electricity. On a 17-yr-old 765 kV ROW in New York, stem densities of the gray birch population (trees greater than 1 cm diameter at breast height and approximately 3 m height) averaged 350 ha^{-1}. The ROW had been last managed with herbicides 11 years previous using an Integrated Vegetation Management approach. Treatments were basal and stem-foliar herbicides applied using non-selective or selective modes as part of a long-term study. Fifty-four gray birch trees from across a 25 km section of ROW were examined for height-age development patterns. Population density and age structure were measured on 11 treatment plots. Tree heights ranged to over 11 m and trees ages from 4 to 13 years. Most of the trees were established within 3 years after treatment. Young powerline corridors that have mesic to hydric moisture regimes are well-suited to birch invasion, particularly with management-related disturbance. Minimizing site disturbance and promoting the development of a tall-shrub community should reduce birch presence in older powerlines.

Keywords: Electric transmission lines, integrated vegetation management, right-of-way management, life history, autecology

INTRODUCTION

Gray birch (*Betula populifolia* Marsh.) is a common species of northeastern North America, with a range that extends from southern Quebec and eastern Ontario in Canada, to Delaware, Maryland, and eastern Ohio in the United States. It can also be found far south in the mountains of north Georgia and north Alabama. Range of this species is apparently extending west, north, and east (Lavoie and Saint-Louis, 1999).

Gray birch is plentiful throughout New York and New England, where, as a pioneer or early plant succession species, it covers large areas on abandoned farms and recently disturbed sites following fire and windstorms. It can be an important species following clearcutting and other regeneration cuts associated with forestry (Liptzin and Ashton, 1999).

Environmental Concerns in Rights-of-Way Management: Seventh International Symposium
J.W. Goodrich-Mahoney, D.F. Mutrie and C.A. Guild (editors)

Gray birch is an important species on powerline corridors in New York State (Environmental Consultants Inc., 1985; Nowak et al., 1995). It can grow tall enough to cause problems with the transmission of electricity. On some lines in upstate New York, gray birch is a recurrent problem, even with an integrated vegetation management approach aimed to control it (K. Finch, personal communication). One such problem line is the Volney–Marcy powerline in upstate New York. Birch has persisted for nearly two decades after initial clearing, surviving herbicide treatments in 1982, 1983, and 1988. Its persistence on this line seems inconsistent with life history characteristics and has befuddled both managers and scientists. In this paper, we investigate gray birch ecology on the Volney–Marcy line to: (1) determine how much gray birch is on the line and whether population densities and dynamics vary by mode and method of herbicide treatment, (2) determine why birch is on this right-of-way 17 years after initial clearing, and (3) predict the future presence of birch on this and like powerlines.

BACKGROUND: LIFE HISTORY CHARACTERISTICS OF GRAY BIRCH

Little has been written about the life history of gray birch, likely because it is not a commercially valuable species for most forestry objectives. The following literature, most of which pertains to other birch species, was used to extrapolate and compile information for gray birch: Marquis (1969), Brinkman (1974), Safford (1983), Perala and Alm (1990), and Hardin et al. (2000).

Reproduction of gray birch

Gray birch can regenerate both vegetatively and sexually. Vegative regrowth is by stump sprouting after the main stem has been severed. Birches are not prolific sprouters. In a study of 18 different powerline corridors in New York State, populations of gray birch stayed the same or were significantly decreased with handcutting or mowing treatments, indicating that many stems of birch can be killed with mechanical treatments (Environmental Consultants Inc., 1986). When birch does sprout, one to many stems are produced from each stump.

Birches, in general, are prolific seeders. They can produce large quantities of seed that may be dispersed long distances by the wind, particularly across crusts of snow. Birch seed is usually limited in dispersal to a distance of about two times the height of the producing tree. Bumper seed crops are infrequent, but moderate seed crops are common, with average annual production of up to 3–5 million seeds per hectare.

Sexual maturity and seed bearing seem to occur at an early age for gray birch. Gray birch generally begin producing seed at age 8, but has been observed producing seed as early as age 4 (Nowak and Ballard, personal observations). Seed matures in early fall and is dispersed from October to the early winter months.

As is common to most pioneer species, birch seed is small. Over 5,000,000 seeds are needed to total one kilogram. Small-seeded species are sensitive to environmental conditions at the time of germination. Condition of the seedbed and amount of exposure to direct sunlight affect germination and early survival. Best germination and early survival is where mineral soil has been exposed, and where there is shade. Moisture is critical. Soil organic horizons are often detrimental to germination of birch seeds because they have poor moisture holding capacity and regularly dry out in the summer. Scarification, the physical removal of the organic horizons or mixing with the mineral soil, is commonly used to promote birch regeneration, particularly on dry sites. On moist sites, it is not necessary to scarify the soil for seed germination. Good germination and survival occurs almost any place where soil moisture is high.

Growth of gray birch

Gray birch is shade intolerant and fast growing. Heights of 6–9 m are commonly attained by age 10 years, with a maximum height of 18 m.

Growth is affected by seedbed and light conditions. If the mineral soil is exposed, the loss of organic matter may create low nutrient levels or nutrient imbalances that lead to reduced growth. Birch requires highly illuminated environments to survive, but these environments can also reduce soil moisture. Best conditions for establishment and subsequent growth of birch is partially shaded conditions early, with full sunlight later. As young birch develop, increased light exposure leads directly to increased growth, particularly root growth. Root growth may be especially important where birch competes with other species.

Longevity of gray birch

Gray birch is recognized as being short-lived, but specifics on longevity are not published. Other short-lived birches such as paper birch (*Betula papyrifera* Marsh.) can live to 80 years. It is likely that gray birch may live to only half that age.

FIELD STUDY METHODS

Study site

The study took place on the 17-yr-old (1999 age) Volney-Marcy powerline corridor, a 765 kV transmission line ROW in the Towns of Lee, Western, and Floyd in Oneida County, New York (43°21′N, 75°32′W–43°15′N, 75°17′W) (described previously by Nowak et al., 1992; paraphrased as follows). The corridor passes through the Interlobal Highland Region, between the Tug Hill Plateau and the Mohawk Valley; it is covered by northern hardwood forest with a predominance of red maple (*Acer rubrum* L.) and eastern hemlock (*Tsuga canadensis* [L.] Carr.), although there was a mixture of both abandoned and active agricultural and forest land on and surrounding the study area, with sporadic inclusions of gray birch. The Volney–Marcy ROW is 68.6 m wide. The study area is approximately 25 km in length, generally running east–west in direction. On the south side of the Volney–Marcy powerline is the 28-yr-old (1999 age) New York Power Authority Fitzpatrick–Edic 345 kV transmission line; its ROW width is 45.7 m.

Soils of the study area are silt and sand loams, including a variety of Fragiaquepts, Eutrochrepts, and Haplaquepts of varied drainage; the dominant soil series encountered were Camroden, Pickney, Pyrities, Katurah, and Malone. Many of the soils have fragipans, which causes the sites to be wet with a perched water table. Most of the sites have mesic or hydric moisture regimes.

Experimental design

A completely randomized, unbalanced factorial design (two to three replications) was used to test second conversion cycle mode (nonselective and selective) and method (basal and stem-foliar) treatment effects on gray birch (see below). Treatment plots ranged in size from 0.23 to 0.75 ha, extending from edge to edge of the ROW. Treatment plots were systematically assigned within randomly chosen areas located across the study site and treated in mid-summer 1988. The original study had 19 treatment plots. Only 11 plots were used in this study.

Selective basal

Treatment of undesirable vegetation (trees that can grow more than 6 meters in height) during late July–August 1988 with a herbicide mixture consisting of 7.6 L of triclopyr at 0.480 kg ai ha^{-1} and 371 L of No. 2 fuel oil; it was targeted at the lower 0.3 to 0.6 m of individual stems, saturating the base of the stem and all exposed roots to the point of rundown and puddling around the root collar zone.

Nonselective basal

Treatment of all woody vegetation with a herbicide mixture and application method the same as that for the selective basal treatment. Herbaceous vegetation was not treated.

Selective stem-foliar

Treatment of undesirable vegetation with a herbicide consisting of a mixture of 1.4 L of triclopyr at 0.480 kg ai ha^{-1}, 1.9 L of a formulation of picloram at 0.060 kg ai ha^{-1} plus 2,4 D at 0.240 kg ai ha^{-1}, 0.95 L of adjuvant (crop oil concentrate) and 375 L of water, applied to leaves, branches and stems to a point of wetness.

Nonselective stem-foliar

Treatment of all woody vegetation with a herbicide mixture and application method the same as that for the selective stem-foliar treatment. Herbaceous vegetation was not treated.

Data collection

In summer of 1999, 11 years after treatment, gray birch population densities (only trees 2.5 cm diameter at breast height [1.37 m along stem above groundline] or greater) were measured using 1.8 m wide strip transects that covered 6 to 16 percent of the study plots. A 7.6 m wide buffer zone along the edge of a treatment plot was not sampled.

At the end of the 1999 growing season, five gray birch trees were felled from each study plot with a chainsaw. A large and a small tree were sampled at random, along with three moderate sized trees from along the edge of the study plot (away from permanent plant community measurement areas). Only four trees were used for stem analysis in one plot due to a sample transfer problem. One plot was not sampled due to an error in field work. A total of 54 trees were sampled. Diameter at breast height and total height of each tree was measured. Stem discs were cut at 1.2 m intervals, from the base of the tree to its tip. A total of 287 stem disc samples were collected.

Data analysis

Inspection of scatter plots of the data indicated that linear regressions would adequately describe height growth development patterns. Regressions equation slope coefficients were tested for homogeneity using analysis of variance. Regressions were fit to data from each treatment plot and the slope coefficients used as dependent variables. Regression intercept coefficients were held constant among treatments at a value of zero.

Analysis of variance was used to test treatment mode and method effects on gray birch population density. Age structure was determined by developing an age-dbh relationship: age $= 3.94x^{0.47351}$, $r^2 = 0.67$, $n = 54$; where x is dbh to the nearest centimeter). Age was predicted for all stems on the treatment plots using data from the strip transects. Age structure was used to determine the number of gray birch trees that were alive at time of treatment, but were not treated. Trees that were 12 years old or older were considered to be treatment misses.

An alpha-level of 0.10 was used as the critical value for significance testing, though p-values up to 0.20 were considered as indicative of potentially meaningful results.

HYPOTHESES, RESULTS, AND DISCUSSION

Height-age relationships

Hypothesis

Treatments with a high level of disturbance–the non-selective mode and stem-foliar method–would have larger slope coefficients in regressions of height vs. age. Greater disturbance would provide birch a less competitive environment, allowing it to grow faster.

Results and discussion

Height-age relations did not vary by treatment mode or method, hence, we reject the hypothesis. A single regression explained much of the variation in height growth as a function of age: height $= 0.70^*$ age, where height is expressed in meters and age in years; $r^2 = 0.91$; $n = 287$. Height growth rates of over 0.7 m per year were defined by the slope coefficient, a low value compared to the 1-m rate observed by Environmental Consultants Inc. (1984). Lower values on the Volney–Marcy site may be due to lower site quality or older tree populations. Young trees usually grow faster in height than older trees. Trees sampled on the Volney–Marcy ranged in age to 13 years, extraordinarily old for a powerline right-of-way. Usually, trees are removed before they reach 10 years age, else they grow into the conductors. Sample tree heights ranged from 2.4 to 11.6 m. The high clearance associated with a 765 kV line allowed for older, tall populations of trees to exist, yet still maintain a safe corridor.

Population densities

Hypothesis

Treatments with a high level of disturbance — the non-selective mode and the stem-foliar method — would have a larger number of birch trees and a greater proportion of gray birch trees than less disturbing treatments, such as the selective mode and basal treatment. Greater disturbance would provide birch more safe seedbeds, leading to greater number of trees established.

Results and discussion

No significant difference was observed among treatments in birch population density, which averaged 350 stems ha^{-1} (stems equal to or greater than 2.5 cm dbh) across all treatments. Total number of undesirable trees did differ among treatments, with the nonselective mode having less trees than the selective mode, 333–1255 stems ha^{-1}. Gray birch, as a percent of the total tree population, was marginally affected by treatment method ($p = 0.13$), with the basal treatments having relatively less birch than stem-foliar, 12–41%. It appears that stem-foliar treatments may have changed species composition by promoting the presence of birch, perhaps due to greater site disturbance. Hence, we tacitly accept the hypothesis that higher levels of disturbance increased the proportion of birch, but reject the hypothesis regarding total number.

Population age structure

Hypothesis

Age structure, i.e., the number of trees per age class, will show a progressive decrease with time. Most birch in forestry situations become established within the first 3 years after treatment (Safford, 1983). We hypothesized that most of the gray birch would be between 8 and 11 years old. Trees older than 11 years would be treatment misses.

Results and discussion

Sample tree ages ranged from 4 to 13 years. Sixty percent of the gray birch was established within the first 3 years after treatment, 34% between 4 and 8 years after treatment. Treatment misses accounted for 6% of the birch trees. This is consistent with our hypothesis. Most of the birch trees were established soon after treatment. However, a significant amount of birch continued to be established 4 years and more after treatment. We expected that the residual plant community would have fully reoccupied the site within a few years of treatment. Apparently, some areas must have remained relatively free of plants for the successful invasion of birch, or birch is more robust in its germination and establishment than described in the literature.

Percentage of trees that were missed from treatment was small and at a level consistent with other studies (Environmental Consultants Inc., 1984). We expect that the majority of missed trees were established just prior to treatment, and as such, were short and hidden by the herb and shrub community.

SUMMARY AND CONCLUSIONS

Young powerline corridors apparently can provide suitable environments for gray birch. Soils may be disturbed by heavy equipment during vegetation management treatments, particularly during initial clearing and early conversion treatments, providing adequate conditions for germination and early survival. Partial shade is provided by herbs and shrubs, but they do not effectively out-compete with birch for site resources because they themselves are also just becoming established. In the open environment of a young powerline corridor, birch can germinate in a cool, moist environment, develop for a few years, then have full sunlight after growing past the short desirable plant community.

Birch presence on the Volney–Marcy powerline corridor over the past decade can be attributed to the disturbance associated with the herbicide treatments, coupled with the generally wet soils across the study area.

Our expectation is that birch populations will be greatly curtailed with the next treatment, as long as site disturbance is minimized. This speculation is supported by Ballard et al. (this proceedings), as they observed that most of the advance regeneration of trees on the Volney–Marcy are maples and cherries. Birch will continue to be present on the Volney–Marcy into the future, primarily because of continued seed supply and moist seedbeds, but at much reduced amounts. Control of birch will be facilitated once a tall shrub community becomes established on the Volney–Marcy. But, as long as sites are disturbed and soil moisture is high, birch will be present.

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Evaluating Native Shrub Plantings as a Control for Tall-Growing Woody Tree Species in Powerline Rights-of-Way

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The effectiveness of planted native shrubs as a method for suppressing undesirable tall-growing trees is being evaluated at six recently constructed powerline right-of-way locations in northern Georgia. Three of the sites were formerly forested, and three were a herbaceous/grass/wooded mixture prior to line construction. At each site two shrub spacing treatments (1 × 1 and 2 × 2 m) and a control shrub spacing (1.5 × 1.5 m) of native shrub seedlings were established in a Randomized Complete Block design after an initial site vegetation survey. Shrub plantings were established without the use of herbicides or mechanical site preparation. Survivorship of planted shrubs across all sites declined from 72% in the first growing season to 38% at the end of the third growing season. Results show that in the first growing season after shrub planting the competition from tall-growing woody stems increased dramatically from 4 to 10 fold. In the second growing season, tall-growing woody stem densities on the formerly forested sites (high pre-planting tall-woody stems density) increased an additional 20–40%. On sites with high grass/herbaceous coverage, tall-growing woody stem densities decreased by an average of 20% in the second growing season. Planted shrub spacing treatments so far have not significantly affected the numbers of tall-growing tree seedlings/sprouts after three growing seasons. The effectiveness of shrub plantings may have been further limited by early growing season drought effects on the growth and survival of the planted shrubs.

Keywords: Shrubs, planting, ROW, survivorship, riparian, herbicides, competition, woody stems, forest wetlands

INTRODUCTION

Vegetation control in powerline rights-of-way is a continual and costly effort for utility companies. Rights-of-way (ROW) vegetation control under electric transmission lines typically relies on mowing and or herbicide application to control unwanted vegetation, particularly tree species capable of growing into the danger zone of transmission lines. Environmental concerns, vegetation control costs, and aesthetic considerations are a few of the issues that are stimulating interest in methods of controlling vegetation that can reduce mechanical or herbicide use and lengthen rotation cycles.

One potential method of natural control that has received much attention stems from the ability of communities of shrubs to resist invasion by, or to suppress, tall-growing tree species beneath their canopies (Niering and Egler, 1955). Niering et al. (1986) report that a shrub community of *Viburnam lentago* remained highly resistance to tree invasion for more than 50 years. In southern Quebec, studies of shrub communities in ROW by Meilleur et al. (1994) have shown that a number of species of shrubs have inhibitory effects on tree establishment beneath their canopies. Research efforts to encourage shrub community development in ROWs have for the most part focused on selective herbicide applications to control tall-growing tree species while allowing native shrub species to develop relatively stable communities (Bramble and Byrnes, 1976; Niering and Goodwin, 1974). Less research, however, has been done to examine the effectiveness of establishing na-

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tive shrub communities, a control for tall-growing tree species, particularly in riparian or wetland areas where herbicides use may be undesirable. Establishing and maintaining vegetation buffers in these areas using shrubs has the potential advantages of reducing maintenance activity to control tree species while providing cover to ameliorate water temperature effects and help maintain stable stream banks.

This study describes early results from direct plantings of native shrub species at three levels of spacing with respect to (1) the effectiveness of plantings to control re-sprout or seedling growth of tall-growing tree species, and (2) the survival rate of the planted shrub species. The plantings were made in forested riparian and forest wetland areas, transected by recently cleared powerline ROW. Study sites were mowed to facilitate planting but no further mechanical or herbicide control for competing vegetation was carried out during the three growing seasons of this study. A decision not to control existing vegetation was based on the objective to evaluate how effectively shrub plantings could be established in areas where the use of herbicides or extensive mechanical pre-planting preparation could be detrimental to the site environment or undesirable because of public concern.

METHODS

Study sites

Six sites were selected along powerline ROWs maintained by the Tennessee Valley Authority (TVA) in northwest Georgia (Fig. 1). The climate of the region is characterized by mild winters and warm humid summers with a mean annual precipitation of 136 cm evenly distributed through the year. The ROW at five of these sites were newly cleared within 1–2 years prior to initiation of the study in 1997, the Council Fire site had been cleared for 3 years. None of the six sites had experienced a vegetation maintenance cycle since line construction. The sites were selected based on the variety of soil conditions and vegetation type and abundance within and adjacent to the ROW. It was determined that this range of conditions would be representative of the conditions that could be encountered and would provide a realistic pilot test of the feasibility and effectiveness of shrub plantings within the ROW in this area.

Two of the sites, Calhoun and Swamp Creek, are classified as palustrian forested wetlands (PFO1A) by National Wetland Inventory (NWI) maps. The Bowater, Turner, Council Fire, and Peavine sites are forest riparian zone sites adjacent to second order streams in the study area. The Bowater, Calhoun, and Swamp Creek sites were 100% forested before ROW construction. The Council Fire, Turner, and Peavine sites had narrow (10–15 m) wooded zones along the stream bank sides of the plots with the remainder of the plots being covered by a mix of herbaceous and some tree species. The predominant forest type adjacent to all study sites is mixed-bottomland hardwoods with a component of upland species at the more well drained riparian sites. The forests adjacent to the Swamp Creek and Calhoun ROW sites are dominated by oaks (*Quercus sp.*), green ash (*Fraxinus pennsylvanica*), sweetgum (*Liquidambar styraciflua*), red maple (*Acer rubrum*), black willow (*Salix nigra*), and hickories (*Carya sp.*). The riparian sites were predominantly occupied by oaks (*Quercus sp.*), green ash (*Fraxinus pennsylvanica*), red maple (*Acer rubrum*), hickories (*Carya sp.*), elm (*Ulmus sp.*), and box-elder (*Acer negundo*).

Soils of each of the sites are formed in alluvial sediments and are acid to moderately acid with surface textures that range from silt loam to sandy loam. The riparian sites are well drained and do not exhibit redoximorphic features, however, the forested wetland sites at Calhoun and Swamp Creek are somewhat poorly drained and poorly drained, respectively. All sites are on nearly level ground with slopes of less than 3%.

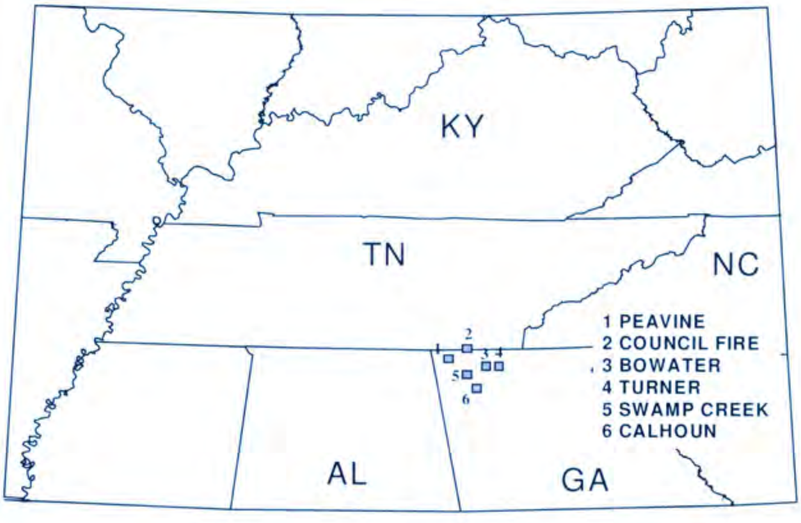

Fig. 1. Location of study sites in northwest Georgia.

Pre-planting vegetation measurements

Prior to the establishment of the plantings in the ROW existing herbaceous and non-shrub woody species within the 20 × 50 m plot areas were measured for stem density (stems/m^2) and species composition. Study plot boundaries were delineated and five randomly selected 5 × 10 m subplots within the plot area were used to visually estimate the percent cover of herbaceous species and to count and categorize woody stems by species and height classes of 0–0.5, 0.5–1.0, 1.0–1.5, 1.5–2.0, and >2.0 m. Herbaceous vegetation was identified to species when possible.

Experimental design

At each study site a single 20 × 50 m plot was established and oriented perpendicular to the ROW direction. At Swamp Creek and Peavine sites the ROW corridor was too narrow and plots were therefore oriented parallel to the ROW. The experimental design is a 3 × 4 randomized block with shrub seedling spacing of 2 × 2, 1.5 × 1.5, and 1 × 1 m, with each spacing randomly occurring once in each of the four blocks. This results in 12 treatment blocks, each with a dimension of 6.7 m × 12.5 m. A non-planted control was not used because under a mitigation or restoration scenario to maintain a buffer area, for riparian or wetland zones, some planting would likely be required. The 1.5 × 1.5 m spacing was thus considered a minimum planting density that would be used and thus served as the control for comparison with the 1 × 1 m and 2 × 2 m shrub spacing. Comparison of shrub spacing effects was within sites only. No statistical comparisons between sites were made.

Species selection

The species of native shrubs selected for planting by site are shown in Table 1. Shrub species chosen for use in this study were selected based on the following: commercial availability, native species, expected maximum height <15′, adaptability to soils and hydrology as indicated by published information, tolerant of moderate to full sun, moderate to fast rate of expected growth, and having potential as a food source and cover for wildlife. Planting of all study sites was carried out between late October 1997 and February 1998. Prior to planting each site, standing vegetation was mowed to facilitate plot layout and planting. No further chemical or mechanical vegetation controls were carried out through the three growing seasons of this study.

The number of shrub seedlings planted within each spacing x block combination at each plot was; 18, 32, and 72 for the 2 × 2, 1.5 × 1.5, and 1 × 1 m spacing, respectively. A total of 488 seedlings were planted at each site. Equal numbers of each of the four species selected for a site were planted in each of the spacing × block combinations. The bare-rooted 1–2 year shrub seedlings were planted using a 6″ power auger.

Vegetation and shrub survivorship measurements

During each growing season all study sites were remeasured for survivorship of planted shrub seedlings, herbaceous cover percent and the number and heights of tall-growing tree species (woody stem density). Shrub seedling survivorship was determined by counting each seedling in all treatment blocks and noting if seedlings were live or dead. Seedlings unaccounted for were added into the dead category. Survivorship of planted shrub seedlings was calculated as the percentage of the originally planted shrub species still alive. Herbaceous and woody stem density were measured in 3 replicate 1 m^2 quadrats randomly located in a 2 × 8 m area located in the center of each treatment block in order to avoid potential edge effects. All treatment blocks were measured at each study plot. Within each of the 1 m^2 quadrats a visual estimate of the percent cover of the five most abundant herbaceous

Table 1. Shrub species selected (•) for planting by site

Species	Site					
	Peavine	Calhoun	Turner	Bowater	Swamp Creek	Council Fire
Silky dogwood (*Cornus amomum*)			•	•		
American elderberry (*Sambucas canadensis*)	•	•	•	•	•	•
Winterberry holly (*Ilex verticillata*)			•	•		
Spicebush (*Lindera benzoin*)	•	•				•
Red chokeberry (*Aronia arbutifolia*)					•	
Gray dogwood (*Cornus racemosa*)	•	•			•	•
Nannyberry (*Viburnam lentago*)	•	•	•	•	•	•

species was made. Herbaceous plants were identified to the species level when possible but are reported here to family or genus level. Stems of all woody species within the 1 m^2 quadrats were counted by species and categorized into <0.5, 0.5–1, 1–1.5, 1.5–2, 2–2.5, 2.5–3, 3–5, and 5–7 m height classes. The mean woody stems density (stems/m^2) was calculated by summing the number of woody stems of all height classes within each of the three replicate 1 m^2 quadrats of a treatment block and dividing by the number of replicates. The overall treatment mean of woody stems density was calculated from the average of the treatment block mean woody stems densities.

Data analysis of the mean woody stems density within a spacing treatment was analyzed using analysis of variance procedure (SAS Institute, 1989) with Duncan's mean separation test. Dunnett's t-test was also used to compare the mean woody stems density in the 1 × 1 and 2 × 2 m to the 1.5 × 1.5 m control spacing.

RESULTS AND DISCUSSION

Herbaceous and woody stems density

The herbaceous composition at the family and genus level of all study sites has shown little change in three years. The five most abundant herbaceous species observed at each of the six location in this study are shown in Table 2. The herbaceous composition at these sites generally breaks down between grass and non-grass dominated communities. The most dominant families/genuses at the Calhoun, Bowater, and Swamp Creek sites are non-grass species whereas grasses dominate at the Peavine, Turner, and Council Fire locations.

Generally speaking most herbaceous species are not considered a problem from a ROW management point of view as long as they pose no threat to powerline operation or are not exotics. Planting of many herbaceous species, most notably grasses and other forage species, are sometimes done to enhance wildlife use within ROWs. Some grass dominated ROW herbaceous communities can also be resistant to tree invasion as shown by Hill et al. (1995). Planting shrubs in direct competition with herbaceous vegetation can have an inhibiting effect on the growth and survival of the plantings. In contrast, however herbaceous cover can also be beneficial to the establishment of woody plantings. Clewell and Lea (1989), for example, note that early successional herbaceous species can provide cover and shade for the trees planted for restoration of bottomland hardwoods. Shrub species not tolerant of light may therefore benefit from the presence of some herbaceous cover. The most serious competition to developing a shrub community is the pre-existing tall-growing tree species (as stems or seedbank), or those species which might be recruited into the ROW.

The average stem density of all species of woody stems from 1997–2000 at each site is shown in Fig. 2. The initial woody stems densities in 1997 prior to shrub planting ranged from 0.08 stems/m^2 (Peavine) to 1.63 stems/m^2 (Bowater). Woody stem densities at the Peavine, Turner, and Council Fire sites, which where occupied by narrow riparian forests adjacent to pasture or old field before line construction, were 0.08, 0.14, and 0.31 stems/m^2, respectively. The previously forested sites at Bowater, Calhoun, and Swamp Creek had stem densities of 1.63, 0.94, and 0.47 stems/m^2 respectively. The numbers of stems at all sites are reflective of coppice regeneration and root sprouting particularly at previously forested sites. These sites

Table 2. Five most abundant herbaceous families/genus by site. Abundance ranked by number (1 = most abundant, 5 = least abundant)

Family/genus	Site					
	Peavine	Calhoun	Turner	Bowater	Swamp Creek	Council Fire
Poaceae	1	3	1	3		1
Asteraceae/Vernonia			4			
Asteraceae/Aster	2		3			2
Asteraceae/Solidago		5		5		4
Asteraceae/Eupatorium					5	
Asteraceae/Ambrosia	4					
Bignoniaceae/Campsis	3					
Fabaceae/Trifolium	5					
Cyperaceae/Carex		1			2	
Caprifoliaceae/Lonicera		2		4	1	
Rosaceae/Rubus		4		2	4	
Juncaceae/Juncus					3	
Polygonaceae/Polygonum			2			
Violaceae/Viola			5			
Anacardiaceae/Toxicodendron				1		
Convolvulaceae/Ipomea						3
Passifloraceae/Passiflora						5

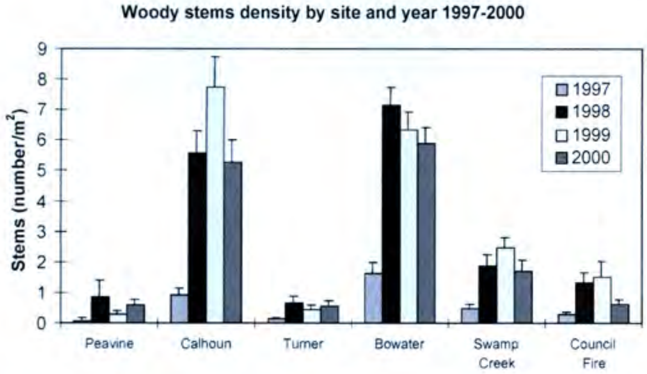

Fig. 2. Density of tall growing tree stems (number/m^2) for all study sites 1997–2000. Error bars represent standard error of the mean.

also face pressure from seedling recruitment from forests adjacent to the ROW.

Repeated cutting to control vegetation in these areas results in continual re-growth of woody species often in numbers greater than prior to cutting (Johnstone et al., 1984). This pattern can be seen at TVA sites in the large increases in the numbers of woody stems at all sites between 1997 and 1998 (Fig. 2). Woody stem densities in 1998 increased from 4 to 10 times the number in 1997. The greatest woody stem densities occur at Bowater and Calhoun sites with stem densities reaching 7.14 stem/m^2 in 1998 and 7.75 stems/m^2 in 1999, respectively. Overall stem densities from 1998 to 2000 remained high although a general trend of decreasing stem densities is occurring at each site (Fig. 2). A similar decline in overall stem density of woody species was observed by Brown, (1994) following clear-cutting for ROW near Toronto Ontario, Canada. Height growth of woody stems in this study has shifted from large numbers of small 0.5–1.0 m stems in 1998 to increasingly tall stems in 2000 (Fig. 3). Rapid height gain of competitive tall-growing tree seedlings can quickly and effectively shade out lower growing species.

Shrub survivorship

Survival rates of planted shrub species by site for 1998 and 2000 are shown in Table 3. Survivorship data for the Swamp Creek site in 2000 is not presented because initial 1998 planting at this site was accidentally mowed in the fall of 1998 and subsequently replanted in early 1999 so the current survival rate is not that of the original plantings. Not unexpectedly the survivorship of planted shrubs declined for all species across sites from the initial survivorship values in 1998. Large differences in survivorship are apparent between species across and within sites. The survival rate for silky and gray dogwood and nannyberry is greater than that of spicebush, winterberry holly and elderberry across almost every site. The somewhat lower survival rates of silky dogwood and nannyberry at the Turner site are largely due to herbivory by beaver and

Table 3. Shrub seedling survivorship (percent of initial number planted) by study site for 1998 and 2000

Site	Species	Year 1998	Year 2000
Peavine	Elderberry	96.7	42.7
	Gray dogwood	91.9	81.8
	Nannyberry	95.9	76.8
	Spicebush	45.1	5.0
Calhoun	Elderberry	55.7	24.4[a]
	Gray dogwood	84.3	67.0[a]
	Nannyberry	96.7	84.9[a]
	Spicebush	59.0	15.4[a]
Turner	Elderberry	69.1	61.8
	Silky dogwood	68.6	23.3
	Nannyberry	75.6	48.0
	Winterberry Holly	32.3	0
Bowater	Elderberry	78.5	11.7
	Silky dogwood	90.5	49.6
	Nannyberry	81.9	52.8
	Winterberry Holly	50.0	1.8
Swamp Creek	Elderberry	92.5	*
	Gray dogwood	76.2	*
	Nannyberry	96.7	*
	Spicebush	76.4	*
Council Fire	Elderberry	62.3	14.4[a]
	Gray dogwood	51.2	52.7[a]
	Nannyberry	63.6	43.3[a]
	Spicebush	56.2	4.4[a]

*Site damaged by mowing, re-planted early 1999.
[a]3 subplots damaged by mowing, data from 9 of 12 subplots.

from early spring flooding, which washed out a number of seedlings in early 1999. The very poor overall survival rate of spicebush and winterberry holly are strongly reflective of the small size and low root-shoot ratio of the seedlings as planted.

Drought occurring in May 1998 and in July–September of 1999, while affecting all plantings, exacerbated the insufficiency of the small roots systems of these species to take up moisture. Planted elderberry seedlings while large, had coarse root systems lacking in fine (<2 mm) roots necessary for water uptake, which likely compounded the effects of drought thus reducing seedling survival of. Seedling size and adequate root-shoot ratio of the two dogwood species and nannyberry were factors contributing to their better overall survival across soil edaphic conditions and the competition from existing vegetation that are present across study sites. The variation of species survival across sites indicate the need to conduct trials on growth performance of native shrub species across a range of soil conditions and seedling parameters (i.e., seedling size, root/shoot ratio) to develop general recommendations for matching species with sites.

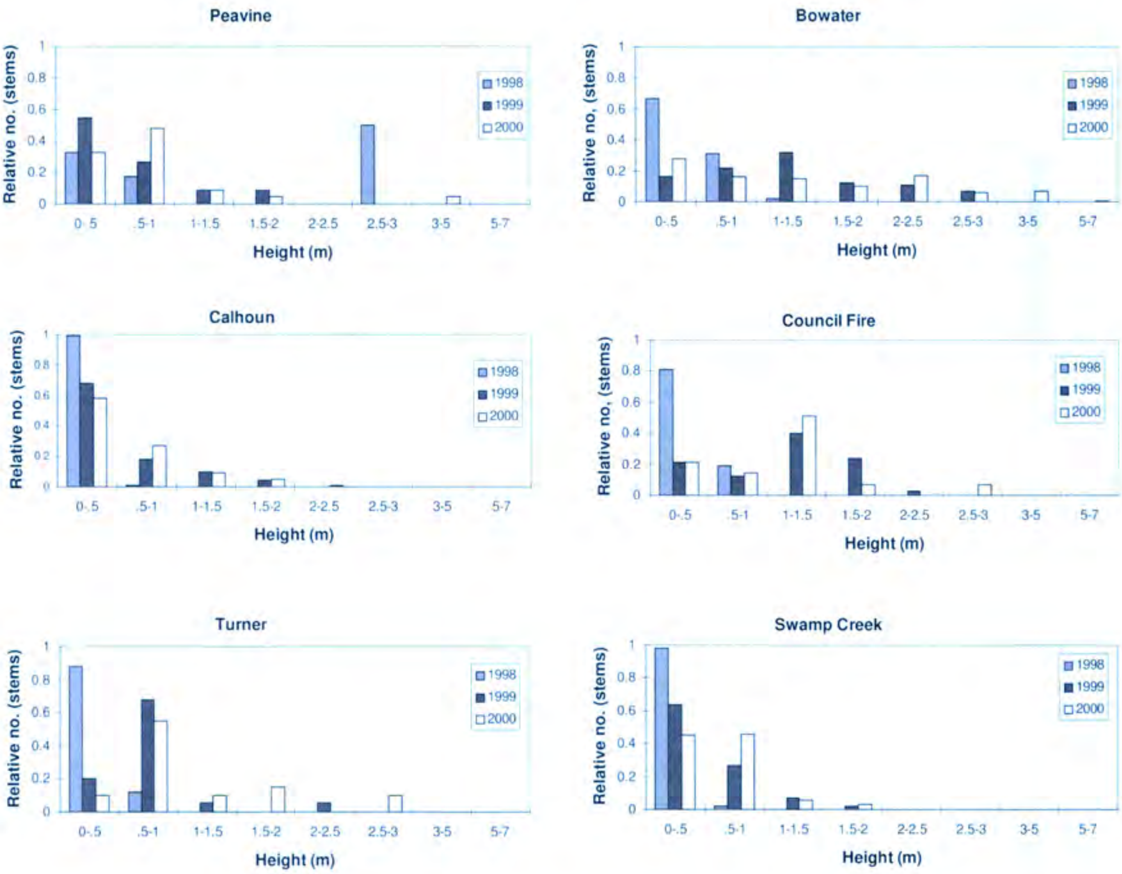

Fig. 3. Relative number of tree stems by site height category and year 1998–2000.

Shrub spacing effectiveness

Shrub spacing density had no effect on the numbers of tall-growing tree stems at any study site after three growing seasons (Table 4). Comparison of the 1 × 1 m and 2 × 2 m spacing to the control spacing 1.5 × 1.5 m using Dunnett's T test indicated no effect as well. The inability of planted shrubs in this study to control the seedling and re-sprout densities of tall-growing tree species after three growing seasons is not surprising considering the size of the seedlings when planted (0.5–1.5 m), low rate of planting survivorship and time necessary for establishment. Seedling survivorship and competition from herbaceous and other woody species are factors controlling the ability of any plantings to quickly develop into an effective control for tall-woody species. With the overall low level of shrub survival, the density of planted shrubs was not sufficient to be a controlling factor for tall-woody species in just three growing seasons. Additionally, the height of planted shrubs relative to competing vegetation particularly tree seedlings is another factor limiting the effectiveness of these plantings. Shrub seedlings planted in this study were 1–1.5 m tall with the exception of spicebush and winterberry holly (<0.5 m). Considering the time for plantings to become established, the seedlings could not develop enough height or spread to be competitive with existing vegetation particularly tall-growing woody species.

Table 4. Effect of shrub spacing on the density of tall growing tree stems by study site and year

Site	Shrub Spacing[1]	1998	1999	2000
Peavine	1 × 1	1.83a	0.42a	0.50a
	2 × 2	0.50a	0.33a	0.75a
	1.5 × 1.5	0.17a	0.25a	0.50a
Calhoun	1 × 1	4.58a	8.50a	4.67a
	2 × 2	7.17a	7.17a	5.00a
	1.5 × 1.5	5.00a	7.58a	6.17a
Turner	1 × 1	0.17a	0.33a	0.42a
	2 × 2	1.42a	0.87a	1.00a
	1.5 × 1.5	0.42a	0.08a	0.25a
Bowater	1 × 1	8.42a	5.41a	4.92a
	2 × 2	6.41a	6.67a	6.83a
	1.5 × 1.5	6.58a	7.00a	5.92a
Swamp Creek	1 × 1	1.17a	1.75a	1.42a
	2 × 2	2.60a	3.00a	1.79a
	1.5 × 1.5	1.92a	2.46a	1.92a
Council Fire	1 × 1	0.75a	1.38a	0.72a*
	2 × 2	2.50a	1.92a	1.00a*
	1.5 × 1.5	0.75a	1.50a	0.33a*

[1]Woody stems density values within year followed by the same letter are not significantly different (Duncans, $p = 0.05$).
*Only 3 of 4 treatment blocks measured.

Rapidly regenerating woody stems have the advantage in quick height growth over planted shrubs because of existing root structure and energy reserves. Some tall-growing woody species at Bowater for example, have increased in height from 0.5–1.0 m in 1998 to >3.0 m in 2000 (Fig. 3). This fact, coupled with the with low rates of survival and slow early growth of plantings, means that shrubs will not likely develop fast enough to compete with or control taller growing vegetation without measures to control competing vegetation and or increase the rate of spread and height growth of shrubs.

CONCLUSIONS

Spacing of planted shrubs showed no ability to control the numbers of tall-growing tree species after three growing seasons. The lack of effectiveness of plantings so far in this study are reflective of the short establishment time (three years), and the low overall rate of survival of the shrub species planted. The survivorship of the plantings was effected by both drought and competition from herbaceous and tall woody species within the ROW. Although gray dogwood and nannyberry had the highest survival rate across all sites, the need to better evaluate which species are suited for what conditions is indicated. While the principle of shrub community resistance to tree invasion is well established, the techniques for developing shrub communities where the shrub propagule pool may be sparse is not well established. For shrub plantings to develop into a control for trees species, methods which maximize the survival rate and competitiveness of shrub plantings must be developed. The survivorship and competitiveness of plantings for example, could be enhanced through planting of larger seedlings, periodic replanting to replace plants that die or planting very high densities of shrubs. Propagation methods like cutting back and layering could also be employed to increase growth and rate of spread of shrub species (Meilleur et. al., 1997). Controlling competing herbaceous and woody vegetation is likely the most important factor in how quickly shrub plantings become established and how effective they will become as a control for tall-growing tree species. Methods of controlling herbaceous and woody competition during the establishment phase of shrub plantings need to be developed. These methods, however, need to be compatible with the goals of the shrub plantings and any constraints which might limit how vegetation is controlled (i.e., herbicide use).

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Planting Shrubs for the Creation of Sustainable Power Line Rights-of-Way

Robert F. Young and Edward J. Glover

Nova Scotia Power Inc. (NSPI) develops sustainable rights of way (ROW) to ensure safe, reliable delivery of electricity. To achieve sustainable ROWs, NSPI implements an Integrated Vegetation Management program to develop plant communities that are compatible with power lines. These communities are established via *selective management* to control the growth of incompatible species, and some *active planting* of compatible species. In 1994 NSPI planted 2000 speckled alder (*Alnus rugosa*) seedlings using typical forest industry methods on ROWs to determine the viability of growing native alders in a controlled environment and to determine the viability of using alder as a form of vegetation control. In 1996, 14,000 alders were planted with the intent to study impacts on wildlife. In 1998, NSPI adopted a new vegetation management strategy wherein planting compatibles is recognized as an integral part of the company's program to manage ROWs. Currently, the company estimates that 38% of transmission lines are sustainable through the development of stable compatible vegetation. NSPI plans to increase the sustainable area on transmission and distribution systems by 10 and 15%, respectively, within 5 years. To meet these targets the company is planning to plant hundreds of thousands of compatible species annually on rights of way, commencing in 2000. NSPI is developing partnerships and strategies with others who will gain from planting initiatives. Pilot projects with two provincial Government departments have been started: (1) The Nova Scotia Department of Natural Resources (NSDNR) non-timber Integrated Resource Management (IRM) objectives are being supported by planting ROWs which cross provincial Crown Lands, and (2) Projects with the Nova Scotia Department of Transportation and Public Works (TPW) which involve management of roadsides through shrub planting to eliminate the need for frequent maintenance and to compliment the aesthetics of the roadside are underway.

Keywords: Compatible vegetation, speckled alder, stable community, Nova Scotia Power Inc.

INTRODUCTION

There have been many documented accounts on the possible use of stable compatible plant communities on power line rights-of-way (ROW) as a viable method for controlling the establishment and growth of trees (Welch, 1984; Berkowitz and Canham, 1993; Brown, 1993; Bramble et al., 1996). Through the selective application of a variety of vegetation control techniques naturally occurring shrubs eventually predominate on ROW thereby creating a relatively stable community of vegetation (Bramble et al., 1991). A stable community, or an ecosystem in a steady state, is a climax condition that is self perpetuating. The climax community results when no other combination of species is successful in out-competing or replacing the stable community (Kormondy, 1984). Many utilities focus on a strategy of promoting dense, low growing vegetation on rights of way (Welch, 1991). Compatible vegetation competes well for light and nutrients and therefore offers early successional biological control of ROWs by slowing the rate of tree invasion through site occupancy. This strategy also enhances the value of the ROW for wildlife and aesthetically.

NSPI implemented an Integrated Vegetation Management (IVM) program on the transmission system in 1988 to accomplish objectives for sustainable ROW

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through selective management of stable plant communities. Through IVM, several progressive methods of controlling the growth of incompatible vegetation, with the use of herbicides (Tordon 101, and Garlon 4), were selectively applied to promote the growth of naturally occurring shrubs and establishment of a herbaceous layer. As a result, compatible vegetation, comprised mostly of herbaceous vegetation, has resisted tree invasion on ROWs to a certain extent through site occupancy. In 1993 the company directed efforts in developing, to a greater extent, a taller shrub layer of 2–4 meters to create a stable community for effective control on the establishment and growth of trees for longer periods. Although herbaceous communities are most often diverse, they are not considered stable and are eventually replaced by taller vegetation or shrubs and trees (Bramble and Byrnes, 1982). Not all shrubs resist tree invasion, however on poor sites where the soil is acidic and poorly drained, which are typical to parts of Nova Scotia (Browne and Davis, 1996) species with nitrogen fixing capabilities can occupy a site as a homogeneous community for up to fifty years (Kimmins, 1996). Species such as lambkill (*Kalmia angustifolia*), bayberry (*Myrica pensylvanica*), and Canada holly (*Ilex verticulata*) have also been found homogeneously on ROWs classified as poor sites in Nova Scotia.

Even though shrub communities can be considered stable, and provide for sustainable ROWs, there is a limited amount of published evidence of any utility company actively establishing shrubs for this purpose. The majority of planting projects on the ROW are directed toward improving aesthetics and wildlife values.

This paper traces the chronological history of NSPI's efforts of developing and implementing a formal program of planting shrubs as a viable alternative for the long term management of incompatible vegetation on power line ROWs. The vegetation management team at NSPI leveraged this option for more than vegetation control in developing a new strategy for the utility in 1998. The qualitative benefits associated with planting have gained a high degree of public acceptance as programs which rely solely on herbicides remains to be controversial. Planting projects were easily aligned with several community environmental projects as well.

SETTING THE STAGE FOR CHANGE

In 1993 Nova Scotia Power Inc. started to actively investigate growing speckled alder (*Alnus rugosa*) in mass quantities in a controlled environment by pursuing the idea with a local nursery interested in growing native shrubs from seed. Speckled alder (Fig. 1), referred to as alder hereafter, was identified as the preferred compatible plant due to its ubiquitous nature in Nova Scotia and the already present dense thickets along ROWs.

Fig. 1. Speckled alder established on a power line ROW.

Alder also have the following additional benefits:

- A maximum height of 5 m at maturity;
- Ability to vegetatively reproduce;
- Beneficial to wildlife by providing food and cover;
- Survives in dense thickets;
- Regenerates quickly after disturbance;
- Demonstrated ability to be self perpetuating;
- Not susceptible to disease;
- Commonly invades open areas;
- Abundant seed crop.

In 1994 Nova Scotia Power undertook an experimental trial in collaboration with a Federal Agency (National Community Tree Foundation), to establish an alder plantation on a power line right of way with the objective of creating a stable plant community. Two thousand seedlings were planted at a spacing of 2.2 m × 2.2 m along the edge of a 30 m wide corridor in this first project of its kind in Atlantic Canada. Pertinent information was gained in understanding: (1) the success of growing alder seedlings in a controlled environment, (2) the effectiveness of transplanting using methods typical of the forest industry and planting without any site preparation, and primarily, (3) the viability of using alder as a cost efficient form of vegetation control.

Observations of the planted site after six growing seasons indicate that: (1) alder is capable of occupying a variety of sites, (2) alder has proven to be a hardy

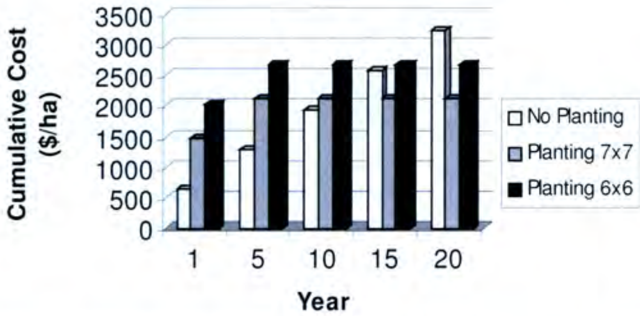

Fig. 2. Cumulative cost comparison of no planting versus a 6 ft. and 7 ft. plantation spacing.

species showing no signs of significant insect or disease damage, (3) alder has a high survivability rate as the percent mortality was recorded to be under 20%, and (4) alder exhibited a suitable growth rate. The 6-year-old plantation has achieved a height range of 1.4–2.5 m and an average crown width of 0.75 m.

Now that the planted stock are firmly established the company will determine if alder can sustain the site by restricting tree invasion in excess of ten years for the creation of a sustainable ROW. Key to the success of this project will be the ability of the plantation to provide crown closure before the next scheduled maintenance which is scheduled in 2004. The company expects that this will occur given the rate of crown expansion over the last two years which has averaged 20 cm/year. Annual monitoring of the plantation is very important in understanding the growth and development of this species as it has previously not been well documented.

If successful in establishing sustainable ROWs, Nova Scotia Power estimates that planting will provide cost savings when compared to the costs of traditional methods associated with IVM (Fig. 2).

IMPACT ON WILDLIFE

In 1997, 14,000 alder were used for another planting project implemented with funding from Habitat Canada, a national non-profit foundation, to gain insight on wildlife presence within ROWs characterized by predominantly alder cover versus existing vegetation conditions in relation to adjacent forest types. Ladino and Gates (1981) determined that certain small mammals crossed shrubby corridors 10 to 34 times as often as grassy corridors. Three study sites and three control sites were established adjacent to different forest types. Baseline tracking surveys were conducted in 1996. These surveys recorded red squirrel (*Tamiasciurus hudsonicus*), white tailed deer (*Odocoileus virginianus*), hare (*Lupes americanus*), and mice (*mice spp.*) as frequent users. There are no current results from this project as it is too early to report any change in wildlife use until the alder reach a significant size. NSPI intends to determine if there is a positive correlation between alder adjacent to specific forest stand types and the presence of wildlife on ROWs. These results will help direct future planting projects for habitat improvement.

Monitoring and the evaluation of this project is proposed to commence in 2002. It is expected that alder will have a significant impact on the use of ROWs by small mammals such as mice sp., and subsequently an increase in the number of red fox (*Vulpes vulpes*), bobcat (*Felis rufus*), and weasel (*Mustela erminea*) is expected. It is also hypothesized that a vegetation structure extending, both vertically and horizontally will increase the amount of wildlife movement across the right of way.

STRATEGIC APPROACH

In 1998, Nova Scotia Power Inc. undertook a review of its programs for vegetation management on transmission and distribution ROWs (Eddy and Young, 1998). As a result, the distribution system is now managed for the development of stable compatible plant communities by judicious use of herbicides and planting. Both systems are now managed under one strategy for creating sustainable ROWs. The company recognizes that the cost benefits of planting are long term and also that planting is a viable alternative to the use of herbicides.

Establishing compatible plant species is an integral part of the vegetation management program and, it is aligned with Nova Scotia Power's goal of continual improvement in environmental performance. Since 1995 the company has determined the percent of transmission line ROWs considered sustainable as a measure of environmental performance. Currently, the company estimates that 38% of transmission ROWs are sustainable (Fig. 3). Planting is now included in the management plans associated with all voltages of lines.

The strategic planting objectives are: (1) to actively establish compatible vegetation on 10% or 1650 ha of the transmission system, and (2) to actively establish compatible vegetation on 15% or 424 ha of the distribution system over the next 5 years. Since the adoption

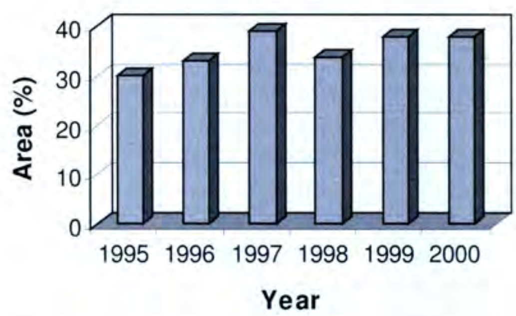

Fig. 3. Percent of transmission ROW not requiring vegetation control in a given year as a result of use of alternative vegetation management strategies.

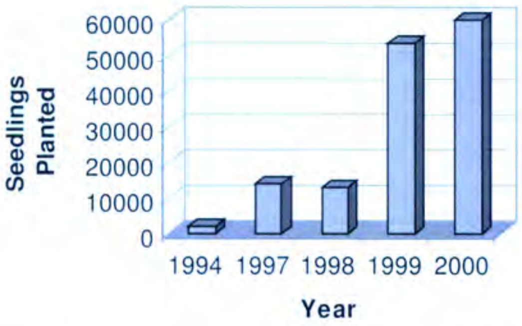

Fig. 4. Number of seedlings planted in Nova Scotia during the past 6 years.

of the new strategy, millions of shrubs will be planted as part of the regular maintenance program. Shrubs include: alder, red ozier dogwood, staghorn sumac, bayberry, and false mountain holly, high bush cranberry, etc. (Fig. 4).

To accommodate the effective implementation of a large planting initiative, three strategic changes were essential.

First, the distribution system was subdivided into four sub-programs which clearly defined the physical settings in which the system exists to more efficiently direct management: (1) rural wildland, (2) developing urban, (3) rural residential, and (4) mature urban. Rural wildland settings which comprise approximately 40% of the distribution system and the developing urban settings, are now managed under an IVM program of selective management which will promote the growth of naturally occurring compatible vegetation and include the active establishment of shrubs.

Second, the use of herbicides had to become an integral part of the selective management program on distribution, which prior to 1999 was not. The selective use of herbicides is required to control the growth of trees to promote the growth of naturally occurring compatible vegetation and protect the plantation from competing vegetation through site preparation and weeding applications. Nova Scotia Power recognizes that the use of herbicides may face some public controversy, however, the company is confident that the linkage with the goal of establishing compatible plant communities will effectively alleviate this concern and generate a greater public acceptance of this necessary component of an IVM approach.

Third, it was important that the costs associated with the establishment of compatible vegetation be viewed as capital expense intended to provide long term (15–20 yr.) advantages. The active establishment of compatible vegetation is now approached as an investment rather than a maintenance cost. In this context, the active establishment of compatible shrubs is viewed as a capital expense rather than an operating expense. Planting will result in an overall reduction in operating costs. Capitalizing this strategic initiative represents a significant contribution to the utility's funding efforts.

LEVERAGE TO CORPORATE COMMITMENTS

Within the Transmission and Distribution business unit, vegetation management on ROWs contributes significantly to the company's corporate commitments and strategies. Two general commitments being: "Safety as a First Priority" and "Continual Improvement in Environmental Performance;" Four corporate strategies being: Improvement in Customer Loyalty, Improvement in Employee Commitment, Managing Costs and Growing the Business.

Establishing compatible vegetation on ROWs contributes in some way to all of these areas of business focus.

- Increasing the amount of sustainable ROW will provide the public and the employees a much safer community in which to live and work.
- Planting creates environmental benefits through an eventual reduction in the use of herbicides and the creation of wildlife habitat.
- Planting is highly accepted by the public and is perceived as wise environmental stewardship.
- Planting contributes positively to "Customer Loyalty" by incorporating landowner's land use objectives and improving aesthetics.
- Increasing the amount of sustainable ROW will produce economic benefits — expected cost savings are $830.00/ha over a 20 year period.
- Employee Commitment is enhanced as employees may participate in the implementation of programs that contribute to the environmental and economic health of Nova Scotia communities.
- Planting projects provide opportunities for Nova Scotia Power to form positive partnerships with other stakeholders and government agencies.

SHARING STRATEGIES FOR SUCCESS

Two initiatives are currently underway to combine the expertise of external stakeholders and Nova Scotia Power for win-win outcomes. Nova Scotia Power, in developing new strategies is able to incorporate the objectives and strategies of others who use power line ROWs to conduct their business. The Nova Scotia Department of Natural Resources (DNR) and the Nova Scotia Department of Transportation and Public Works (TPW) are currently involved in projects that combine existing governmental expertise and planning resources for research with Nova Scotia Power's operational expertise and implementation budget.

Integrated Resource Management (IRM) Partnership

Nova Scotia Power Inc. strengthened working relations with the DNR in 1999. The company initiated a project to align its vegetation management program with a DNR objective of promoting areas of biodiversity, outdoor recreation, and wildlife habitat as part of a Provincial Integrated Resource Management (IRM) Strategy. The nature of this project provides many opportunities for publicising and promoting environmental stewardship.

A Memorandum of Understanding (MOU) was developed for the purpose of formalizing joint interests associated with the management of non-timber values on ROW. The specific objectives of the MOU are to facilitate both party's ability to:

1. Align NSPI's vegetation management on ROWs where they cross Crown lands, with the NSDNR's IRM objectives for areas of multiple land use, in particular the areas of wildlife habitat, outdoor recreation, and biodiversity;
2. Further develop and refine management planning and implementation techniques that will facilitate obtainment of IRM non-timber objectives within this context;
3. Develop a model that can be used to expand this form of management on powerline rights of way to private lands within Nova Scotia;
4. Further develop and refine a system of vegetation management on powerline ROWs that will reduce the long term requirement for repeated application of herbicides.

The first pilot project was established and designed early in 2000. As a first step, 2 hectares of ROW will be planted in August 2000 with a variety of compatible species, including; speckled alder (*Alnus rugosa*), wild raison (*Viburnum cassinoides*), and red ozier dogwood (*Cornus stolonifera*). In addition to habitat creation, the project is also designed to facilitate the evaluation of species selection, planting design and management. Comparisons will be made of species performance on a variety of sites and on sites that have and have not been treated with herbicides to remove competing vegetation before planting.

Roadside Partnership

Nova Scotia Power Inc. also outlined its new strategy and implementation plan to TPW personnel responsible for developing and implementing vegetation control programs on provincial roadways. The plan was well-aligned with the interests of the TPW for managing stable vegetative communities along roadsides. This presented the opportunity for a cost-sharing partnership between Nova Scotia Power Inc. and TPW on shared ROWs.

Nova Scotia Power made the necessary changes to it's implementation program to accommodate the needs of TPW and to establish a "roadside partnership." This common strategy for managing incompatible vegetation with an integrated vegetation management approach allows both parties to save on costs by sharing services that would otherwise be duplicated.

In addition, planting was completed as part of a pilot project with TPW in 1999. Through selective management, the entire right of way was managed for sustainability. The plants left to sustain the site differed across the ROW as only herbaceous growth was considered compatible at road side.

Roadside vegetation sustainability will reduce the frequency of regular vegetation control needed to provide appropriate sightlines and drainage. In addition, the aesthetics of the roadside are complimented through planting initiatives.

CONCLUSION

Creating sustainable power line ROWs using Integrated Vegetation Management is the essence of Nova Scotia Power's new vegetation management strategy for both the transmission and distribution systems. Actively establishing shrubs has been recognized as a viable long term method of controlling incompatible vegetation on ROWs through the creation of a stable compatible plant communities. Planting with compatible species will be implemented with target levels over the next five years.

Nova Scotia Power Inc. plans to carefully monitor the success of planting initiatives and discover ways of enhancing the effectiveness of planting compatible species.

Continual monitoring, tracking and studies are important for Nova Scotia Power Inc. to more fully understand and document how planting projects provide for economic, environmental and social benefits while maintaining ecological integrity.

Specifically, the possible use of alder as biomass needs to be investigated as alders can withstand repeated disturbance and continue to perpetuate as a dominant species. The possibility of planting alder as an option for the reduction of greenhouse gases through carbon sequestration is a possible area of evaluation.

Nova Scotia Power will continue to work with government conservation agencies and special interest groups with a mandate of environmental stewardship for implementing planting projects.

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Selecting Herbaceous Plant Covers to Control Tree Invasion in Rights-of-Way

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Following construction of a right-of-way, environmental regulation often requires the rapid restoration of a herbaceous plant cover to control erosion and/or attenuate visual impact. Herbaceous species can be selected with the added long-term goal of inhibiting tree invasion. We present a review of empirical evidence that can guide species selection. This review is based on an extensive survey and critical evaluation of relevant North American studies published in scientific papers, technical reports, and conference proceedings. Vegetation managers and scientists were also consulted for up-to-date information on on-going experiments. Observational and experimental evidence of inhibition in both natural and managed communities confirm that the biological control approach has significant potential. However, scientific evaluation of the long-term inhibition capacity of seeding mixtures is still rare. Ecological mechanisms favoring competitive ability are not always well understood but involve the sequestration of available resources and the modification of environmental conditions. Two approaches characterized experimental inhibition studies in rights-of-way. The first aims to test the interference potential of commercially available species commonly used in restoration, while the second favors the establishment of wild communities. Both approaches have their advantages and limitations, but several studies show that the establishment phase is crucial. Knowledge is lacking especially for the establishment of wild species. This review allowed us to identify 66 herbaceous species based on a critical assessment of the evidence provided. Besides inhibition potential, factors such as species availability and possible nuisance should also be considered.

Keywords: Biological control, cover crop, inhibition potential, restoration, seeding, vegetation management

INTRODUCTION

There has been a great deal of interest in reducing both the costs and the environmental impact of vegetation management practices in utility rights-of-way. As ecological studies have demonstrated the ability of some herbaceous and shrub communities to inhibit tree invasion (Pound and Egler, 1953; White, 1965), vegetation managers have been encouraged to use highly selective herbicide applications or cutting practices that minimize disturbance to competitive cover when present (Niering and Goodwin, 1974; Bramble and Byrnes, 1983). But such cover could also be introduced right after construction, when environmental regulation requires the restoration of the site to control erosion and/or attenuate visual impact (Brown, 1995). This approach implies that species should be selected not only to satisfy immediate restoration concerns, but also for their potential to form, in the long-term, low-maintenance communities capable of inhibiting tree invasion. However, information on the inhibition potential of herbaceous species or on selection criteria for improving seeding mixtures is not readily available and, despite the obvious need for such information, there have been very few attempts to summarize current evidence from the literature (but see Brown, 1989). Apart from introducing competitive cover in rights-of-way, knowing which species have the potential to form stable communities could also help managers target more efficiently practices that will help maintain

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or spread them. As well, summarizing the currently available information on species potential to inhibit tree invasion is essential to orient future research needs on the integration of ecological principles in vegetation management strategies.

This study was prompted by the need expressed by vegetation managers working with Gas Metropolitain in Quebec (Canada) to improve restoration practices of newly constructed pipelines with the added goal of long-term vegetation control. Our objective was to assess the available empirical evidence on the use of herbaceous cover to control tree invasion in order to identify species that could be of interest in future vegetation management program. Although some shrub species have demonstrated strong inhibition potential, our study focuses on herbaceous species compatible with pipeline utilities. We report here our findings on observational and experimental studies of inhibition in both natural and managed communities and submit a list of the species whose capacity to inhibit tree invasion has been observed or tested.

METHODS

This review is based on an extensive survey and critical evaluation of relevant North American studies published in scientific papers, technical reports, and conference proceedings. Several vegetation managers and scientists were also consulted for up-to-date information on on-going experiments. Relevant scientific papers have been mainly accessed through searching different databases including AGRICOLA (U.S.D.A.), BIOLOGICAL ABSTRACTS, ICIST, and CURRENT CONTENT. The NTIS (National Technical Information Service) database was used to obtain information from US and Canadian government agencies and other sources from the private sectors in order to locate research reports often not available in other databases. All previous issues of the proceedings of the International Symposium on Environmental Concerns in Rights-of-Way Management were also searched for relevant information. Internet sites reporting information on research activities in universities, research institutes, federal or provincial agencies and ministries, and utility companies (e.g., Canadian Gas Association, Empire State Electric Energy Research Corporation, Gas Research Institute, Hydro-Québec, Ontario-Hydro, etc.) were consulted. Several of these sites identified people responsible for research activities, some of whom were contacted.

RESULTS

From more than 700 references uncovered in the literature search, 214 were found relevant and were retained for final analysis. Our review included a critical summary of ecological principles involved in inhibition studies that will be published separately. In order to identify species that presented a potential for the establishment of a stable cover in our area, we focused especially on information relevant to a north-eastern American context.

Evidence of inhibition comes from various sources including experimental evaluations in field or in greenhouse conditions of the inhibition potential of selected species, or field observation, in natural or managed environment, of relatively stable herbaceous communities. Ecological mechanisms favoring competitive ability are not always well understood but involve the sequestration of available resources and the modification of environmental conditions. Allelopathic effects, the emission by some species of substances capable of inhibiting germination or growth of neighboring species, are often cited as a possible competition mechanism (Horsley, 1977a,b; Tillman, 1982). Such processes remain controversial however (Byrnes et al., 1993), but the fact that complex competition mechanisms are not always well understood does not prevent using competitive effect to our advantage.

Summary of the available evidence allowed us to identify 66 herbaceous species whose potential to form stable populations or communities resistant to tree invasion has been observed or tested (Table 1). They include 25 grasses or sedges, 11 legumes, 25 herbaceous dicots, and 5 pteridophytes.

For each species, we provide a list of the scientific studies consulted (Table 1). Evidence comes from various sources. Because objectives and methodology widely differ from study to study, reliable comparisons and a definite assessment or ranking of the inhibition potential of a particular species are difficult to achieve. For example, a naturally occurring population of a species may have been investigated in the field for its capacity to form a stable cover, but such capacity may not have been demonstrated in experimental seeding. On the other hand, experimental seeding may have been conducted, but if the population failed to establish an efficient cover for different reasons (inadequate site preparation, unreliable seed sources, constraining environmental conditions, etc.), then it does not necessarily mean that the species has no potential for future use. Consequently, instead of trying to establish a definite ranking of the species that were uncovered in our literature search, we chose to report, for each species, the type of scientific evidence used to compile our list. Evidence was classified according to the following categories.

Experimental seeding in right-of-way

The 46 species in this category have all been planted in experimental plots in electrical, pipeline, or highway rights-of-way using a replicated design or, for two studies, as regular cover crop for restoration purposes that were later evaluated through observational design (Suffling, 1979; Sharp et al., 1980). A total of

Table 1. Herbaceous species whose capacity to inhibit tree invasion has been observed or tested

Species	Experimental seeding in rights-of-way	Field evaluation of inhibition potential	Greenhouse evaluation of inhibition potential	Observation of stable communities	Origin, uses or possible nuisance
	Reference number				
Grasses and sedges					
Agropyron repens[1]	21	32	20	4	Int-Inv
Agrostis alba	24-35-44-47-48-49		8-10	4	Ero-For-Int-Inv-Res
Agrostis canina			10		Int-Inv-Orn
Agrostis stolonifera		42			Int-Inv
Andropogon gerardii	35-43-48-49			37	Ero-For-Inv-Res
Bromus inermis[2]		31-42	2-10		Ero-For-Int-Inv
Carex sp.				51	
Carex crinita	47				
Dactylis glomerata[1]	11	18-39	8-9-10-40		For-Int-Inv-Orn
Danthonia spicata		5-14			
Elymus canadensis	43				For-Inv
Festuca arundinacea[1,2]	35-48-49	5-39-46	8-10		Ero-For-Int-Inv-Orn
Festuca ovina			10		Ero-Inv-Orn-Res
Festuca rubra[1]	11-21-24-30-35-44-48-49	12-19	8-9-10-20	33-37-41	Ero-Inv-Orn
Lolium perenne	21-35-48-49	12	20		Ero-For-Int-Inv-Orn
Panicum virgatum	35-48-49			37	Ero-For-Inv-Res
Phalaris arundinacae[2]	21-24-30-44-47	42	10		Ero-For-Inv-Orn
Phleum pratense	21-24-30-44-47	13-42	8-10	4-41	For-Int-Inv
Poa annua	44				Int-Inv
Poa compressa		42		4	Ero-Int-Inv-Orn
Poa pratensis	21-44-47	13-19	8-10-40	4	Ero-For-Inv Orn
Schizachyrium scoparium[1]	35-43-48-49	16-25		17	For-Inv
Scirpus pedicellatus	47				
Scirpus rubrotinctus	47				
Sorghastrum nutans	43				For-Res
Legumes					
Coronilla varia[1]	11-35-48-49	38-42	8-9-10		Ero-For-Int-Inv-Orn
Lathyrus sylvestris[1]	35-48-49			37	Int-Res
Lotus corniculatus	11-35-48-49	32-42	8-9-10		For-Int
Medicago sativa		1	9-10		Int
Melilotus alba		18-42	8-10		For-Int-Inv
Melilotus officinalis			8-10		For-Int-Inv
Trifolium hybridum	21				Ero-For-Int
Trifolium pratense	21				For-Int
Trifolium repens	24-30	12-42	8-10		For-Int-Inv
Vicia cracca	21		20		Int-Inv
Vicia sativa	44				Int-Inv
Dicots					
Achillea millefolium				4	Ero-Inv-Orn
Anaphalis margaritacea				4	Orn
Aster ericoides	15			3	Orn
Aster nova-angliae	15				Orn
Aster ontorianis	47				
Aster pilosus	15				
Aster ptarmicoides	15				
Aster puniceus	15				
Aster simplex	15				
Aster umbellatus	15				
Aster sp.	21-47			4-51	
Centaurea nigra[1]	21		20		Int-Inv
Desmodium canadense	43				
Epilobium angustifolium			9		Inv-Orn
Eupatorium maculatum	47				
Hypericum perforatum	21		20	4-41	Int-Inv
Hypericum repens			9		
Monarda fistulosa	43				Orn
Rudbeckia hirta	43				Orn
Solidago canadensis	15-47				Inv
Solidago gigantea	47				

Table 1. (continued)

Species	Experimental seeding in rights-of-way	Field evaluation of inhibition potential	Greenhouse evaluation of inhibition potential	Observation of stable communities	Origin, uses or possible nuisance
	Reference number				
Solidago graminifolia	15	5-14			
Solidago nemoralis	15				
Solidago rugosa		5-14			
Solidago sp	21-47			33-51	
Ferns					
Athyrium filix-femina			9		Orn
Dennstaedtia punctilobula[1]		5-14-25-29		36	Orn
Onoclea sensibilis			9	37	Orn
Pteridium aquilinum	47		9		Inv
Thelypteris noveboracensis		29		36	Orn

Numbers in the table refer to documents from the reference section.
Origin, uses or possible nuisance, according to USDA–NRCS (1999): Ero = erosion control; For = forage; Int = introduced; Inv = invasive; Orn = ornamental (lawn, etc.); Res = restoration.
[1] Best inhibition potential in field conditions.
[2] Best inhibition potential in lab conditions.

eleven studies, conducted in eastern United States and Canada, were included in this category. Their objective was generally to assess inhibition potential of one or several herbaceous covers seeded in the right-of-way or, at the very least, to determine the seeding conditions necessary for the establishment of a presumably low-maintenance herbaceous cover (U.D.A. Inc., 1996; Cain, 1997; Suffling, 1998). Monitoring of species establishment and competitive effect had been conducted for 1 year after seeding at the time of publication (Suffling, 1979; U.D.A. Inc., 1996) up to 10 or more years (U.S.D.A., 1981, 1983; Oyler and van der Grinten, 1984). Preselection of species to conduct experiments was based mostly on observed evidence of inhibition in natural or managed communities and/or, in a few cases, on greenhouse screening tests of inhibition potential (Brown, 1995; FRDF, 1993). Species traits such as rapid growth, vigorous vegetative reproduction, abundant seed production, dense underground, and/or aerial structures that are thought to correlate with competitive ability were often favored. Estimation of inhibition potential was done mostly through a statistical evaluation of the relationship between herbaceous cover and tree density in seeded and control plots. Failure of establishment of a cover dense enough to control tree invasion was occasionally invoked to explain a species relatively low performance in the field. There were, however, usually no thorough investigation of the factors that may have led to poor establishment. Inadequate site preparation and/or environmental constraints were generally suggested as possible causes.

Field evaluation of inhibition potential

This category comprises 16 studies that had as a main objective to provide a quantitative or semi-quantitative evaluation of inhibition of establishment or growth of tree species by a competitive herbaceous cover in field condition for forestry or horticultural purposes, or in natural environment. Inhibition, in these cases, is mostly seen as a non-beneficial effect. We have also included in this category studies that aimed to identify naturally occurring low-growing communities in rights-of-way and that provided a statistical evaluation of the potential of such communities to limit tree establishment under different abiotic conditions (Bramble and Byrnes, 1976; Byrnes et al., 1993; Canham et al., 1993; Hill et al., 1995). A total of 22 species were evaluated in these conditions, 13 of which were also included in the previous category (Table 1). Parameters used to evaluate inhibition potential in experimental plots compared to controls included survival, density, height, diameter, and biomass of tree species seeded, transplanted or naturally occurring in the parcels.

Greenhouse evaluation of inhibition potential

Six studies tested inhibition of establishment or growth of tree species by a total of 26 herbaceous species in greenhouse assays. Parameters used to evaluate inhibition potential included survival, density, height, and biomass of tree species grown in containers with herbaceous competitors. Experiments in controlled environment have generally been useful to rapidly screen species for inhibition potential for further field experiments (Brown, 1990, 1992, 1993; FRDF, 1993), but results in such conditions do not necessarily guarantee that the species will express the same potential in nature (FRDF, 1994).

Observation of stable low-growing communities

Included here are 8 studies reporting the observation of naturally established herbaceous communities that appeared to have been stable for several years in sites that were presumably capable of supporting trees, although there were no experimental evaluation or comparison of inhibition potential of the species involved. Twenty species were identified in this category. Several ecological studies on successional dynamics in old-fields or rights-of-way that greatly contributed to current interest in biological control approaches in vegetation management are included here (Bard, 1952; Pound and Egler, 1953; Beckwith, 1954; White, 1965; Stalter, 1978; Niering, 1987). Resistance to invasion by woody species was generally assumed to be the result of the highly competitive ability of the herbaceous cover, although other factors such as constraining abiotic conditions or low invasion pressure have not necessarily been ruled out.

Finally, the analysis of the evidence provided allowed us to identify a subset of 11 species for which experimental results demonstrated best potential in field and/or in lab conditions (Table 1). For example, *Dactylis glomerata* was tested in lab (Shribbs et al., 1986; Brown, 1990, 1992, 1993) and in right-of-way conditions for 5 years (Brown, 1995) where it was found to affect tree survival. As well, *Coronilla varia* and *Lathyrus sylvestris* have been the object of long-term monitoring that demonstrated their strong capacity to inhibit tree invasion (U.S.D.A., 1981, 1983; Oyler and van der Grinten, 1984). Information on best potential is given as an indication and readers are encouraged to consult available published data for detailed evaluation of a particular species.

DISCUSSION

In spite of the strong interest in enhancing ecological practices in right-of-way vegetation management, there are surprisingly few long-term experimental evaluations of inhibition potential of herbaceous cover in rights-of-way, or results of such evaluations are not readily available. Information from rigorous experimental settings in right-of-way conditions is extremely valuable and should be used whenever possible to determine species potential. Nevertheless, the majority of studies presented here suggest that low-growing species can be used to delay invasion of trees, and that some covers are better than others in doing so. However, information on a particular species inhibition potential is often hard to obtain. Because methodologies vary widely from study to study, it is not obvious, from a management point of view, how to select appropriate species. This, combined with a lack of critical synthesis of the available evidence, likely contributes to delay applications.

Apart from the evidence mentioned, other factors must be carefully considered especially when it comes to the introduction of species in rights-of-way. Among those, origin (indigenous, naturalized or exotic), ecology, use (erosion control, forage crop, ornamental, restoration), possible nuisance (e.g., invasive species, potential host to crop pests, toxicity to livestock), and availability of seeding mixtures are especially important. These factors must be carefully weighed against other possible benefits in terms of vegetation control before implanting a species. We are including, as an indication, information on origin and some potential uses and nuisance (Table 1). The latter point is especially important since species are selected for traits that can potentially make them aggressive in new habitats. Indeed, 31 of the species in our list have been reported as showing invasive behavior in some conditions or others (U.S.D.A.–N.R.C.S., 1999). It remains to be assessed locally how such behavior would limit applicability. A light-requiring species that has the potential to invade agricultural fields, for instance, may cause little problem in a forested context. It is therefore essential, if introduced in a new environment, that a species propensity to invade or modify adjacent habitats be closely monitored.

Two approaches broadly characterized inhibition studies in rights-of-way. The first aims to test the inhibition potential of regular cover crops generally widely used for erosion control and restoration purposes (e.g., Suffling, 1979; U.S.D.A., 1981, 1983; Brown, 1995), while the second favors the establishment of wild communities that have been shown to be relatively stable (e.g., U.D.A. Inc., 1996; Cain, 1997). Both approaches have advantages and limitations, and managers are faced with choices on the basis of available evidence. Indeed, some commercially available cover crops (e.g., *Dactylis glomerata*, *Coronilla varia*) have demonstrated their inhibition potential and such species could easily be integrated into a restoration program or could be used to fine-tune mixtures currently used. However, species in this category are usually of introduced origin, although most have long been naturalized in North America. As said before, the introduction of non-native organisms in a new environment should always be considered with extreme care. More data are needed, however, to determine inhibition potential of currently available cover crops, as relatively few studies have compared several crops for their long-term performance.

On the other hand, several vegetation management projects have promoted the use of wild species (e.g., Gouveia, 1987; Harper-Lore, 1996; Honig and Wieland, 1997; Suffling et al., 1998). This is especially true in the Prairies, where exotic species are seen as a threat to local diversity, or in highway rights-of-way, where local display of wild flowers often receive driver's as well as conservationist's approbation, while reducing maintenance cost. The establishment of communities of wild species known to form relatively stable communities in natural settings (e.g., *Solidago*, *Aster*) offers an interesting alternative for vegetation control in rights-of-way.

Such species are assumed to require little maintenance and contribute to enhance local biodiversity. Local species can be found for a wide range of environmental conditions. Moreover, the introduction of attractive communities of wildflowers, especially in areas where public acceptance and aesthetic appreciation is important, can facilitate right-of-way integration in the landscape. Often, commercially available non-native species are seeded with wild species to facilitate the establishment of the latter or to provide a ground cover prior to wild species establishment. Nevertheless the studies reviewed here show that several constraints still limit their use. There is still much to learn on how to establish wild communities and how to formulate seeding mixtures best adapted to local environmental conditions in rights-of-way. When experimental seeding fails, there is often no follow-up that would help correct problems and improve conditions for subsequent introductions. Getting a reliable local source of quality seeds may still be a problem in some areas, and quantities are often limited.

CONCLUSION

Ever since the studies of Pound and Egler (1953) and Niering and Goodwin (1974) on stable communities, there has been an interest in using low-growing species to interfere with tree establishment and/or growth for management purposes. The evidence presented in this paper is in support of this approach, but there are still several constraints that limit broad range applicability in rights-of-way, especially when it comes to species introduction. In particular, thorough investigation of the potential of species widely used in restoration programs to form relatively stable communities in the long-term is lacking, whereas the conditions of establishment of wild communities are often poorly known, at least in northeast Canada. Information from the studies that have been conducted is often not readily available, especially to the manager that has to make an efficient decision on which strategy and species to use to satisfy both immediate concerns with site restoration and long-term vegetation management objectives. Regarding the latter point, there is most certainly an advantage in coupling information on species ability to stabilize sites after construction with data on their long-term capacity to form stable communities that inhibit tree invasion, and this right form the early stages of restoration planning. By providing a synthesis on available evidence of inhibition for herbaceous species, we hope this review will facilitate further applications.

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Systematic Method for Forest Vegetation Management in the Rights-of-Way (ROW)

Javier Arévalo-Camacho, Jorge Roig-Solés, Leticia González Cantalapiedra, Carlos Morla Juaristi, Fernando Gómez Manzaneque, Elena Bermejo Bermejo, David Galicia Herbada, and Felipe Martínez García

The problems met in Spain when herbicides are used for management of the rights-of-way (ROW) for power transmission lines and the extensive current legislation that protects both vegetation and habitats, have made it necessary to search for and develop environmental-friendly methods to carry out the systematic removal of vegetation incompatible with the power line operation. To that end RED ELÉCTRICA has engaged a research project to draw up a manual that specifies the type of management applicable in each situation based on the existing type of vegetation. Due to the phytoclimatic variety in Spain it is impossible to define a sole procedure applicable to all the lines of the transmission grid. A systematic research plan has been carried out in ten stretches of different power transmission lines located throughout the country, requiring surveys of some 140 km of rights-of-way to identify the best-suited species for each type of forest or formation and find a customized method based on selective removal of species and proliferation of most suitable ones in order to preserve vegetation cover, to lower impacts, to increase time intervals between maintenance operations and to reduce costs of long-term management while keeping the existing safety ratios.

Keywords: Vegetation, forest management, rights-of-way (ROW), power lines

INTRODUCTION

This work describes the project RED ELÉCTRICA DE ESPAÑA has under way, in cooperation with the Botanics Unit of the Forest Engineering School of the Madrid Polytechnic University, to improve management of forest vegetation while maintenance work is carried out along the power transmission lines rights-of-way. The reliability of REE's environmental management policy, ISO 14001 certified, is fully matched by this work.

A research project has been carried out based on a systematic survey of the 18,000 km of 400 and 220 kV transmission lines that make up the Spanish Grid, in order to draw up a ROW management manual describing the applicable procedures and vegetation maintenance criteria. The manual will be helpful for maintenance personnel as a methodological guide that sets clear management criteria, identifies the existing "types" of vegetation and simplifies decision-making.

The target of this project is to supply scientific information about the existing vegetation in ROWs to transmission lines managers, and rationalize or improve their medium-long term maintenance operations spacing and even theoretically dispensing them, by changing the current vegetation cover to better suited one to the presence of the transmission line. In this way, a dual target can be met, besides the technical-financial issue through lowering maintenance costs and increasing safe periods for the transmission line also that of a rights-of-way best matched to the surrounding area.

The project was structured in three phases. During 1995–1996, the 445 forest species, trees, and shrubs, found in Spain were first studied to identify their "compatibility" with power lines based on an index or rating (ICL) according to their anatomical characteristics (Arévalo, Roig et al., 1997B).

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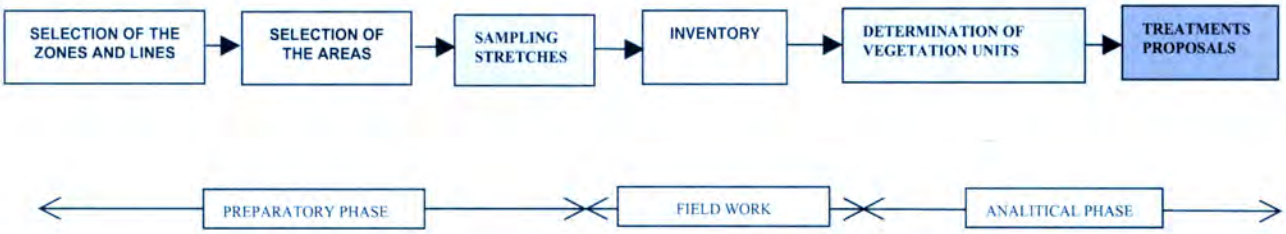


Fig. 1. Methodology.

During the second phase, carried out between 1996–1998, in three campaigns going from spring to fall, fieldwork was systematically performed to identify a number of forest type associations found in the ROWs. Management actions adequate to the current conditions were proposed for each of them to establish stable trees and shrub cover compatible with power lines and achieve long-term coexistence, removing or keeping from developing those species that might provoke problems to the lines while promoting the favorable ones.

At the present third phase we are drafting the respective manual and, in order to adjust further, we are carrying out surveys to determine the outcome of the proposed measures applied to predetermined plots and stretches.

Management actions have been proposed for each one of the identified vegetation types and defined in such a way that they can be applied to other stretches and power lines. Consequently from this project will issue a number of proposals or actions criteria that will allow managers to handle each identified vegetation formation in a similar way and help them to find solutions to problems that may arise when new ROWs management criteria are applied.

The effort is intended to develop a methodology that can rationalize the vegetation cover management along the high-voltage transmission lines. This management pretends, while meeting the required safety, to minimize negative impacts on vegetation and landscape, consequence of the erection and operation of such infrastructures.

Initially, time and money investment for implementing the proposed actions will be superior to that required by currently applied maintenance methods. In a large number of cases, their implementation can lead to results that show a clear improvement when compared to those achieved by the current management and, in general, lead to clear savings at a medium-long term. It has to be pointed out that these proposals have to be implemented in consensus with the owners of the affected areas or with those responsible for forestry management.

METHODOLOGY

First of all and considering the problems inherent to the development of the project we had to define a methodology in order to achieve the goals. The methodology that had to be designed meets the scheme shown in Fig. 1.

The works developed in each of the tasks that make up this methodology are described below.

SELECTION OF THE ZONES TO BE STUDIED

The selection of the zones to be studied was extremely relevant since the study was intended to determine a number of management proposals for the different vegetation communities in the power lines ROWs, susceptible to be applied along the power line or any other alignment where similar formations are found.

In order to study the most representative zones considering the vegetation formations crossed over by the lines, we first evaluated the existing Transmission Lines Grid throughout the country and its relation with the forest stands. We came to the conclusion that the territorial distribution is heterogeneous and power lines run through different phytoclimatic regions.

Other interesting features to make field work more cost effective, were: the concentration or proximity of several power lines, the protection status of natural areas crossed by the ROWs, the high diversity of forest stand and finally the need to have clear corridors in which maintenance work had not recently been performed so vegetation associations were most natural.

Accordingly ten zones crossed over by power lines were selected based on a geographic distribution whereby their biogeographic characteristics would be as different as possible. Four of them were located in the Atlantic zone; four in the Mediterranean zone, and two were intermediate zones where the botanical features of each zone and their transition could be observed.

The first four zones are located in the northwest of the peninsular, where and due to the abundant rainfall, Euro Siberian deciduous forests are found.

Typical Mediterranean brushwood and forests are located in the second four zones where holly oak and cork oak predominate as can be observed in the regions of Castile, Estremadura, and Andalusia.

Finally, the two intermediate zones are transition areas from the Euro Siberian to the Mediterranean

Table 1. List of the covered power lines

Surveyed areas	Power lines	Stretches	Length (km)	Sampling area
Lugo-Orense (96)	Belesar–Puebla de Trives	0–15		4
Barcelona (96)	Sentmenat–Begues	45–63		5
Cáceres (96)	Gillona–Almaraz	504–514		3
Cádiz (97)	D. Rodrigo–Pinar del Rey	220–254	15	
Cuenca (97)	Trillo–Olmedilla	154–185	14	
Toledo (97)	Aceca–Puertollano	119–145	13	
Orense-León (98)	Trives–La Lomba	85–110	12	
Barcelona (98)	Ascó–Sentmenat	322–337	9	
Asturias (98)	Lada–Velilla	54–88	15	
Guipuzkoa (98)	Arkale–Moguerre	32–47	7	

biogeographic regions. This is evidenced by the existing sclerophyllous formations that may reach a maximum in certain zones while an ocean deciduous forest would cover the balance. The Mediterranean element is predominant in the Catalonian area, mainly holly oak stands, although some sub Mediterranean species are also common. In addition and in this case, a significant stretch of the selected power line runs through an area protected by Law, the San Llorenç del Munt i Serra de l'Obac Natural Park.

Inside these overall surveyed areas, specific power lines, and spans between towers where the fieldwork would be carried out had to be selected.

This selection was carried out in a drafting room based on the study of the existing vegetation and power lines alignments maps and the careful viewing of available videos filmed from a helicopter. In this way, existing forest formations were identified beforehand to set them apart from crop and pasturelands, which were not worth surveying, and the stretches where the fieldwork had to be performed were determined.

Based on this selection, the fieldwork was targeted on some 120 km of power lines representing ten different line stretches. It should be kept in mind that the fieldwork has covered, approximately twenty-one kilometers, 8 stretches and 40 sampling areas, which were part of the above-mentioned lines and others located nearby. The covered ROWs are listed in Table 1.

Spain's bioclimatic zones and the selected areas for the study are shown in Fig. 2, location of the selected areas is shown in Fig. 3.

SAMPLING AREAS SELECTION

A sampling process including all the different vegetation formations was required due to the problems inherent to an exhaustive sampling of the selected stretches. In this way, only specific sampling locations would be surveyed based on the knowledge collected beforehand in the different zones of the stretch. Once the power lines and the respective stretches had been set aside, specific fieldwork zones or sampling areas were selected inside each stretch. An exhaustive inventory of the species had to be made that could be applied to the complete formation.

The selection was based on films of the power lines made by RED ELÉCTRICA. The films allowed identifying the sampling areas taking into account mainly the physiognomic or habit features of the vegetation representative of the diversified vegetation cover of the complete stretch. The size of the sampled areas was most often matched with the rights-of-way surface bounded by two successive pylons, a span. At times, the sampling area was larger, two spans or, in few occasions and due to variations in size of the existing vegetation units, smaller.

An inventory of the existing vegetation taxon was made for each sampled zone. A number of standard plots, about 20 × 20 m, were through the usual statistical methods identified to carry out an exhaustive field sampling of the existing woody vegetation and of the different ecological characteristics of the sampled plot, such as height, substrate, slope, in addition to a listing of the observed species and the relative quantity.

Although grasses were left out, all the brushwood, shrub, and trees were identified in the Mediterranean area, since these are the basic biological types most applicable in the rights-of-way management proposals.

FIELDWORK

The fieldwork was partly based on the information supplied by the power line design, specifically, the alignment, plan view, and profile elevation as well as the access sketches.

A card that shows all the information about the different items deemed relevant was drafted during the field data gathering process. In the species inventory, not only those identified in the ROW, including cover extent and average height of each specie, but also the ones found in the surrounding areas were noted. At the same time, a simple sketch or draft showing both a longitudinal section and a plan view was provided to see the vegetation structure and composition in these zones.

Fig. 2. Spain's bioclimatic zones (ALLUE).

1. Steppe zones and continental depressions (kermes oak, buckthorns, dogwood, Aleppo pine and juniper stands).
2. Typical Mediterranean zone. Sclerophylous formations (holly oaks and cork oaks stands, and Mediterranean pine forests).
3. Sub-humid Mediterranean zone. Wilting plants formations (mossy oaks, *quercus lusitánica* and pine forests).
4. Mountain Atlantic zone. Mountain deciduous trees formations (beech, oak, and birch stands).
5. Hilly Atlantic territory. Deciduous trees formations (oak stands) as well as holly oaks and laurel (bay) stands.
6. High mountains zone. Sub-alpine dwarf mountain pine stands, brushwood, scrub, alpine pasturelands.

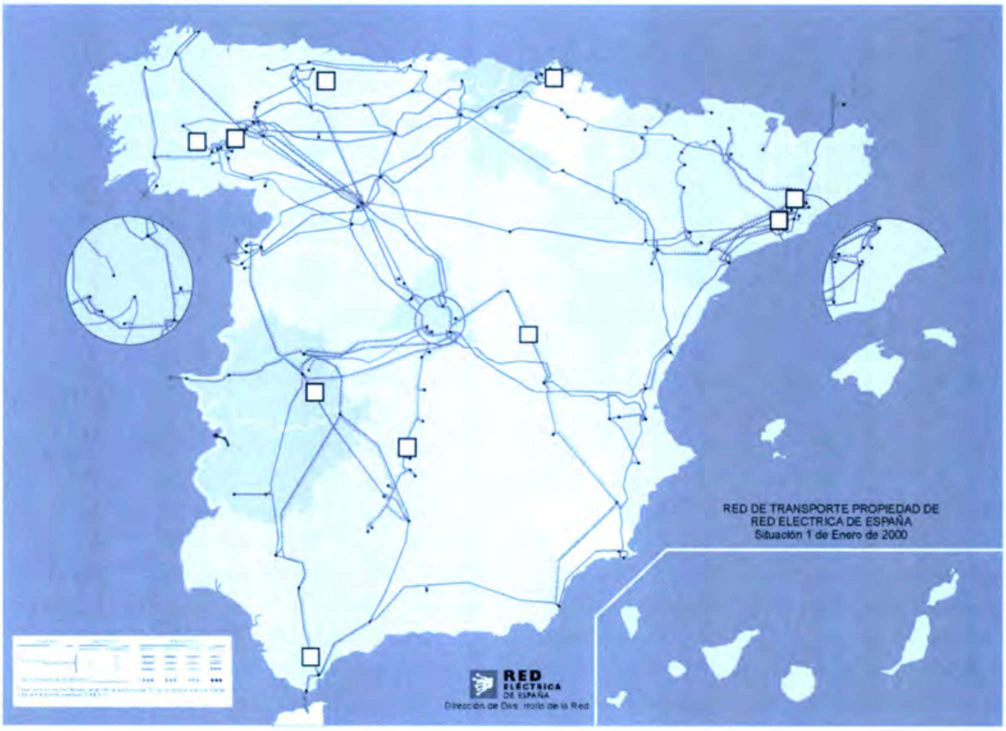


Fig. 3. The selected areas used.

BREAK DOWN LISTING OF THE VEGETATION COMMUNITIES

From the compiled data and the experience built up during the fieldwork and review of the videos, the different vegetation communities of each of the studied sections were broken down.

The term, *vegetation community*, has to be understood as that part of the ROW alignment that can be represented and holds a more or less, from a physiognomic and floristic point of view, homogeneous vegetation formation, showing boundaries that can clearly be distinguished from the adjacent areas inside the ROW itself.

Priority has been granted to the formal or physiognomical features to define the vegetation communities' typology and attention has been focused on the vegetation elements that can easily be seen due to their frequency and size, i.e., *Quercus robur, Quercus ilex, Quercus suber, Fagus sylvatica, Pinus spp.* On the other hand and due to the fact that it was going to be used by maintenance staff, the typology was planned to be synthetic, not broken down in excess, showing however the main characteristics or parameters, easy to understand, free of both, a too technical or specialized language and a highly complex nomenclature.

According to the mentioned principles, the following criteria was applied to define the identified units in the section under study:

1. *Heterogeneous composition*. It is mentioned only when a "mosaic" was found, i.e., unit consisting of a number of different intermingled formations of similar surface and, due to the small size, it was not possible to define them individually. Generally speaking, these units have been disturbed by human actions.
2. *Predominant structural type*. Five main types were found: forest; brushwood; grass, crop, and man-made pastureland.

   Due to its larger complexity and presence in all units, brushwood was divided into five subtypes based upon the RUIZ DE LA TORRE (1981) classification: shrub (3–7 m); high (1.5–3 m); medium (0.5–1.5 m); low (0.05–0.5 m), and creeping (0.05–0.5 m). The difference versus the preceding subgroup was only due to the habit or height.
3. *Vegetation Density*. The density of the vegetation formation was broken down in three classes: open, when trees were sufficiently spaced, over 2 or 3 meters between tops; thin when trees were close or adjacent, and; dense when trees structures were intertwined leaving no empty spaces between them.
4. *Floristic Composition: Predominant taxon (s)*. If one or two taxa were predominant, it has been stated as follows: "... are predominant."
5. *Modifiers*. If relevant taxa or formations were dispersed in stands or border strips of local significance only and, due to their size, could not be represented, they have to be shown preceded by the + sign.

It is deemed that, when combined, the mentioned different criteria can generate multiple types of vegetation communities, which are sufficient to clearly show the existing variability in the surveyed power lines.

The communities' characteristics were completed with two additional parameters, which are highly significant to recommend any possible action that would modify both their composition and structure: the traffic ability and the visual integration with the environment.

The traffic ability shows the level of difficulty to walk through the existing formation in the ROW. This characteristic has to be evaluated since a more or less thin vegetation cover in the rights-of-way is required to provide to individuals access to the facility, for technical inspection and maintenance operations. On the other hand, visual integration shows up to what point the rights-of-way vegetation blends in the natural environment under study.

PROPOSALS

The proposals for action were planned taking into account the following criteria:

1. The first and foremost requirement to be met by the proposals is the constitution of a vegetation cover in the ROW compatible with the power line management. The planned vegetation cover has to meet the established requirements for minimum vertical clearance from the vegetation cover to the power transmission cables; the current legal requirement is of 4.20 m for 400 kV, with an assured margin of a five years minimum. This is why the growth data and maximum height of all the plants in the intended vegetation cover are so significant.
2. The defined characteristics of the cover to be established have to meet the overall criterion of achieving the best and largest possible homogeneity with the environment, but always subject to line safety limits. This implies that just after safety comes the need to keep or restore ecological values by matching the territorial vegetation with the environmental conditions.
3. Generally, traffic ability under the power line will be negatively affected if a compatible vegetation cover is established. For this reason during the selection of the species and as far as possible, efforts have to be devoted by avoiding the selection of thorny vegetation and trying to achieve adequate densities to minimize that loss of traffic ability.
4. While designing the cover to be established we have to grant careful attention to the characteristics of the vegetation natural dynamics that arise from the territory where the power line is located. As far as the floristic structure and composition of the planned cover is more closely matched with the mentioned dynamics both implementation and

maintenance costs will be smaller. However seeding and planting operations will usually be required during initial stages of the project implementation, after which natural reproduction will do the work.

5. The new cover to be established shall also be designed to meet a criterion for optimal stability, taking into account the already mentioned characteristics of the regional vegetation dynamics. The review periods shown in a monitoring plan to be established for each stretch of the planned power line, have to be most expanded possible to reduce control works: pruning, propping, thinning, etc., that eventually might be performed. The ecological and biological characteristics of the species in question, as well as peculiar features of the regional climate will always determine those periods.
6. The starting conditions to plan the best possible alternative can obviously be rather different. The main one arises from whether it is a new or an existing power line where virtually and due to repeated cleaning and site clearing operations the soil is initially bare. To the contrary in the first case, that is to say that of a new line, the previously existing forest or shrub exception making of croplands, peripheral areas of a city and industrial zones, will usually be available, what implies a much better starting point. The initial conditions could also imply a type of vegetation, natural or man-made, not compatible with power line management. In this case, the initial tasks for implementing the vegetation cover will be more complex and costly.

Generally speaking, the proposals are intended to achieve either one or both of the following actions:

- *To remove some species*. The removal will be selective and manual, depending mainly on the compatibility and level of traffic ability in the unit. Therefore we will focus the tasks on removing or curbing those species that reach excessive heights and impair thus the compatibility, as well as thorny or intricately branched plants that generate more or less closed vegetation groups. These species are generally heliophilous and related to the pioneer stages of succession, having then a higher invasive capacity. The fastest growing species will also be candidates for removal.
- *To favor some species*. All species compatible with the power line in each unit have to be included. Both the species, which have to be left in the rights-of-way due to their good qualities as well as those to be promoted or restocked, are included in this chapter. The actions to keep and introduce other species will be intended to maximize the visual integration effect, taking into account the already mentioned considerations.

However, we have paid attention to traffic ability when drawing up a proposal. Consequently, in many instances, the role of those species considered to be adequate has to be to provide ecological conditions that discourage re-colonizing by the already mentioned invading species besides their contribution to increase environmental integration. The weight given to each criterion depends on the initial situation of the vegetation community, upon which we decide its priority.

Finally it has to be highlighted that the ecological integration criterion has been strictly met during the species selection. Native species found to be best suited to the edaphic and climatic conditions of the territory, have always been used to restock.

The intended integration with the environment will be even furthered, if these actions are implemented in a way that minimizes the negative impact that may arise if a too clear borderline is established at the boundary between the right-of-way and the surrounding area. Therefore, these actions have to be implemented making the difference from the center to the edges of the ROW and taking into account the composition and structure of the vegetation at surrounding area. It means that unless for maintenance reasons it is inconvenient, the removal of species has to be greater in the middle of the right-of-way than at the edges, while, for the retained or replanted species, this action will be more intensive at the edges than at the center.

The works to restore and establish the proposed vegetation cover have to promote natural regeneration as well as seeding and planting. It is necessary for such reestablishment that previous actions are properly performed to avoid increasing soil erosion.

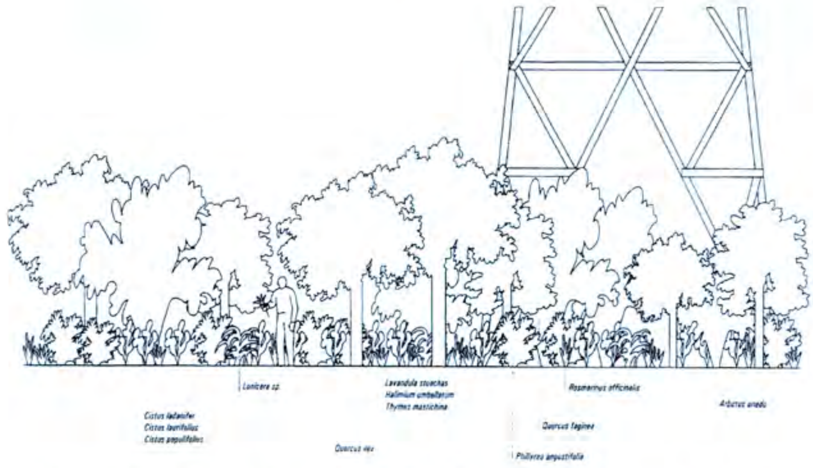
Following the description of each proposed vegetation community; a table has been drafted with the most relevant species, in a positive or negative sense, for the development and maintenance of the proposed vegetation cover. In that table are mentioned besides the theoretical ICL (Compatibility Index of Lines, Arévalo et al., 1995), height, regeneration, and recommended rating found during the fieldwork.

RESULTS

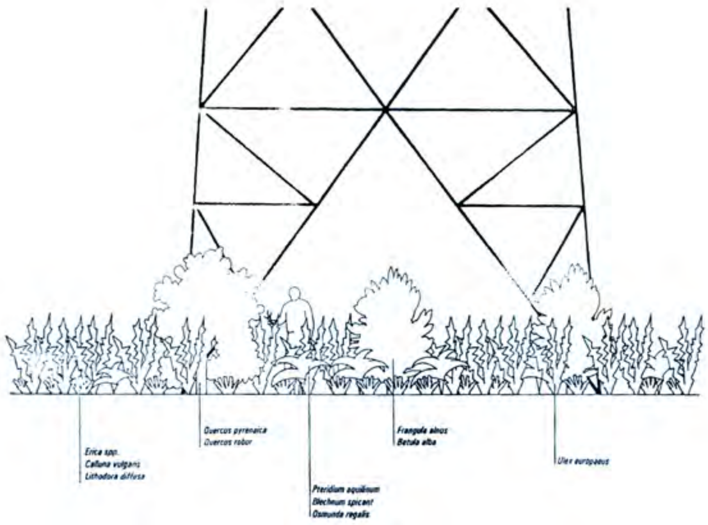
Up to seventy different vegetation communities were identified during the project and proposals meeting the already mentioned criteria were submitted to define steps intended to lower the number of such units. Finally we got a total of nine different communities, this made possible a simplified, easier, and less costly long-term management.

The following units were defined:

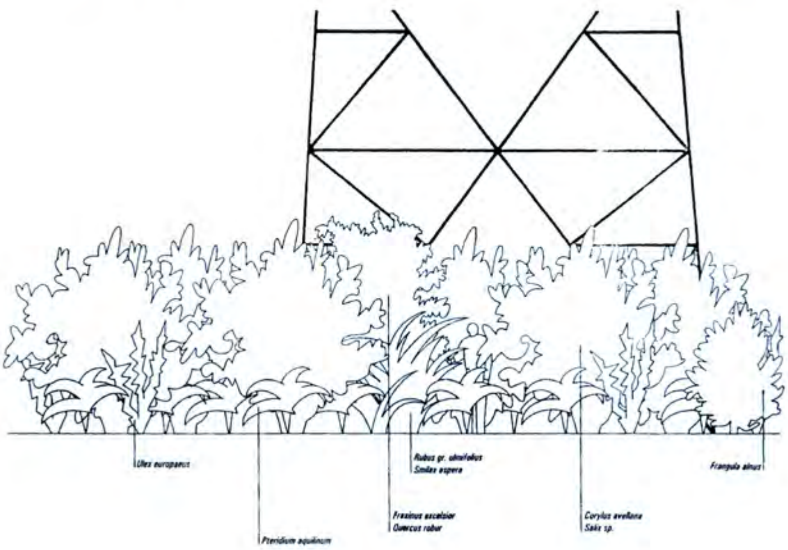
1. Thin forest where oaks predominate
2. Thin forest where holly oaks predominate
3. Thin forest where cork oaks or *Quercus lusitanica* predominate
4. Thin forest where chestnuts predominate
5. Thin forest where beech trees predominate
6. Thin forest on riversides
7. Shrub-forest where trees species predominate (same as those found in the already mentioned forests)



Dense shrub where *Quercus ilex* and *Arbutus unedo* predominate

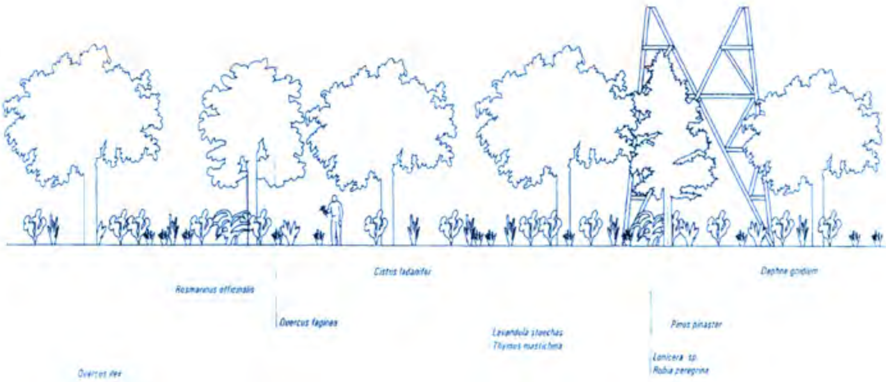


Dense shrub where *Erica spp* and *Ulex eropaeus* predominate

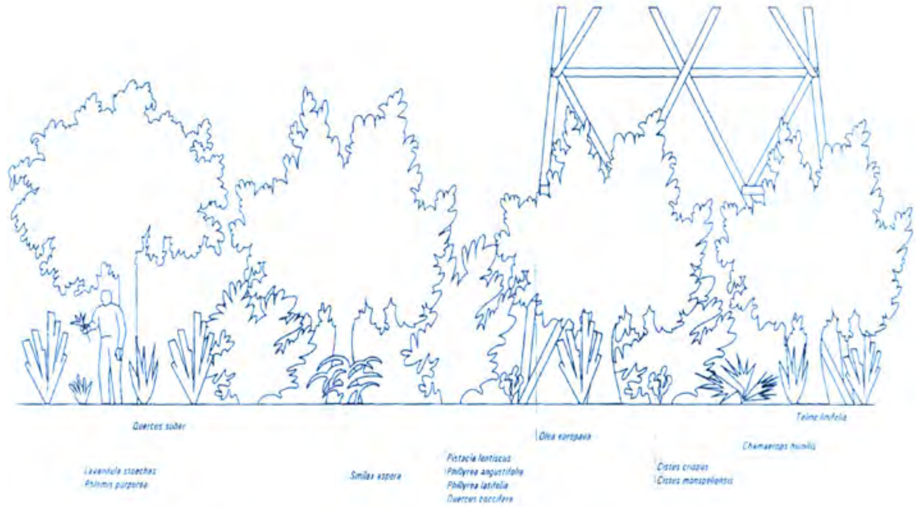


Dense shrub where *Corylus avellana* and *Pteridium aquilinum* predominate

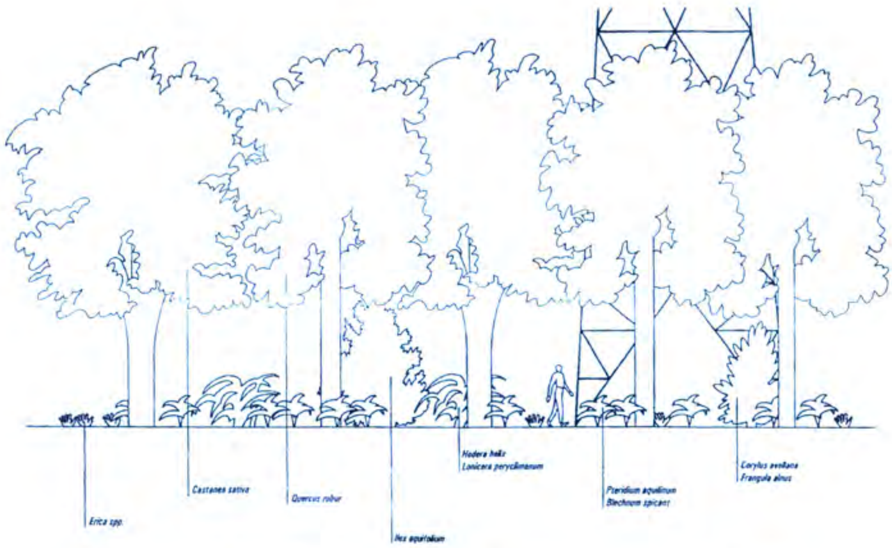
Fig. 4. Examples of before treatment and after.



Thin forest where *Quercus ilex* predominate

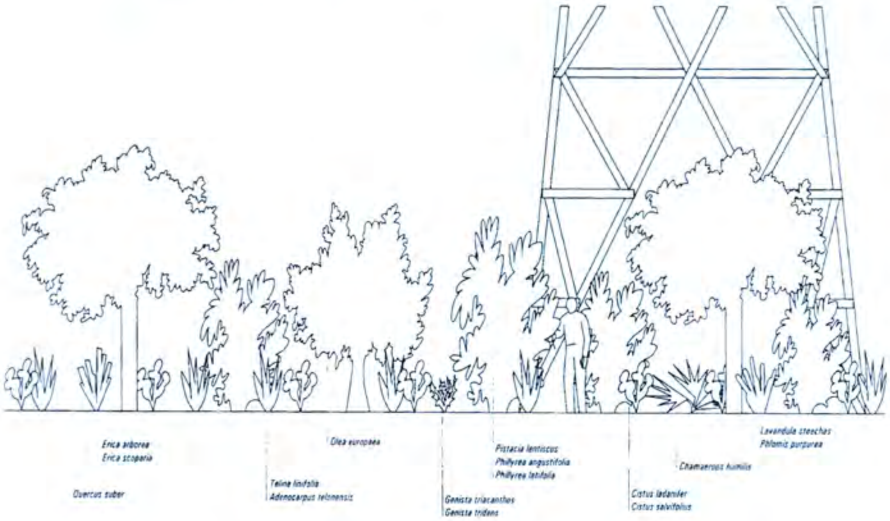


Thin forest where *Quercus suber* predominate

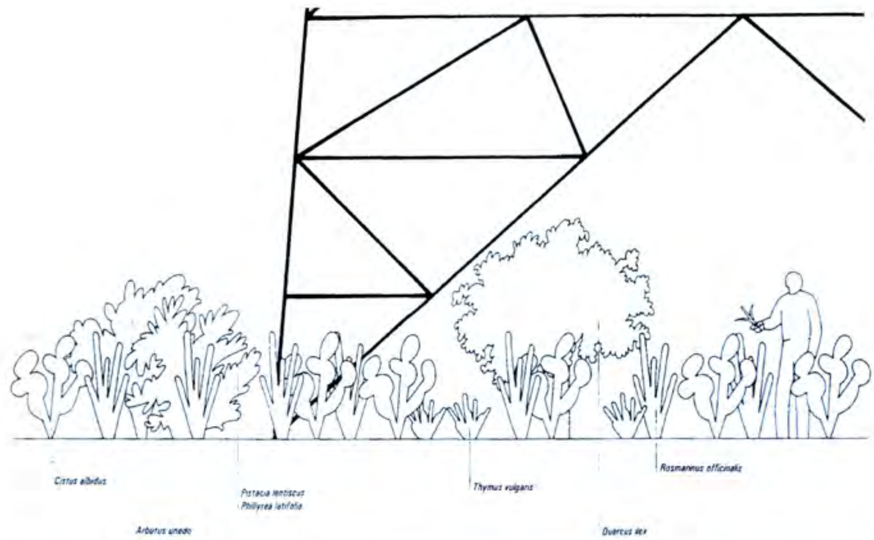


Thin forest where *Quercus robur* and *Castanea sativa* predominate

Fig. 4. (continued).



High thin shrub



Medium thin shrub where *Rosmarinus officinalis* and *Cistus albidus* predominate

Fig. 4. (continued).

8. Medium thin shrub where soft stem species predominate
9. Medium thin shrub on degraded zones (broom and rock roses)

Management, always aiming at promoting a controlled speedup of natural evolution of the existing vegetation, has to be achieved in several steps.

- Removing selectively the thorny heliophylous shrub.
- Thinning out shrub vegetation to promote the natural regeneration of species with the best characteristics.
- Increasing the area covered by the higher vegetation, big and small trees, to control germination of the unwanted species.
- Establishing a high coverage and low-density stable trees stand with thinned undergrowth where one or several trees species of growth that can be easily controlled in height by pruning and/or topping are predominant.

In highly degraded zones, far from the most developed formations and where management will not improve the conditions, actions will be limited to some selective thinning, avoiding any increase of erosion processes, to improve traffic ability and boost the most favorable species. An example of before and after treatment is shown in Fig. 4.

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Long-Term Vegetation Development on Bioengineered Rights-of-Way Sites

David F. Polster

Soil bioengineering has been used for the treatment of steep and/or unstable rights-of-way sites for many years (Schiechtl, 1980). Although these techniques can provide initial stability, the question of long term stability of soil bioengineered sites has not been addressed. Pioneering plants such as willows are used for soil bioengineering. These provide an environment in which later successional species can invade. As this transition takes place the later successional species must take over the stabilizing function from the pioneering plants. Slope buttressing, soil arching and root reinforcement are the three principle means of slope support provided by these later successional species (Gray and Leiser, 1982). These must replace the structural support provided by the soil bioengineering structures to avoid collapse of the slope. This paper explores the transition from the initial support provided by soil bioengineering treatments to the long-term slope support provided by the later successional species. Right-of-way sites such as along a new railroad corridor, pipeline corridor and highway right-of-way where soil bioengineering was used to provide initial stability have been investigated to determine the nature of the transition from this initial stability to long term stability. Examples are drawn from British Columbian sites.

Keywords: Soil bioengineering, steep slopes, unstable slopes, plant succession, soil erosion

INTRODUCTION

Soil bioengineering is an effective tool for the revegetation of steep or otherwise unstable sites. Soil bioengineering uses living plant materials to construct structures that perform some "engineering" function. Steep slopes can be treated with wattle fences or modified brush layers to provide a stable surface on which vegetation can establish and grow. Seepage areas can be stabilized using live pole drains while riparian vegetation can be restored using various forms of live staking. Pioneering plant species, primarily willow, are used for soil bioengineering (Schiechtl and Stern, 1992). These short-lived initial species must give way to longer-lived later successional species in order for vegetation to be maintained on the treated site. This change in species must be accompanied by an equivalent change in roles performed by the species. For instance, where wattle fences are used to provide living retaining walls, the supporting function provided by the wattle fences must be retained by any subsequent vegetation or the vegetation cover will be lost. Similarly, where live pole drains have been used to provide drainage, the subsequent vegetation must also provide drainage. The function provided by the vegetation must be continuously provided even though both the species and the structure of the vegetation changes.

The study of the development of vegetation on reclaimed sites provides important information for the formulation of future reclamation programmes. Where soil bioengineering has been used to provide the initial stability needed to get vegetation started on a site, evaluation of the changes in both the species and the function performed by those species provides clues for solving future problem sites. Plant responses to external stresses (unstable slopes, seepage, etc.) are well known. The "harp" shaped trunks of trees develops in response to an unstable surface while "knees" and other structures develop in plants grown in anoxic seepage environments (Easu, 1960). Understanding the role played by the different species at each successional

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stage can allow effective selection of species for subsequent reclamation projects. Successional reclamation (Polster, 1989) provides a model to emulate in the development of effective restoration programmes.

Successional reclamation has been used as a model for the treatment of a number of sites throughout western Canada. Although the early results of these reclamation programmes are promising, little attention has been directed at the long-term development of vegetation on sites where successional reclamation has been used. Initially, successional reclamation seeks to establish an erosion controlling cover of successionally appropriate vegetation on the disturbed sites. Typically agronomic grasses and legumes are used. This plant cover is supplemented with the establishment of pioneering woody vegetation, either directly through planting or by allowing native pioneering species to establish naturally. This vegetation cover provides conditions that assist in the establishment and growth of later successional species until eventually a cover of climax species is established on the disturbed site. The time required for this process to unfold on reclaimed sites dictates that the successional processes themselves be used as a surrogate for these later successional stages. Successional processes, primarily species replacement, provide an excellent tool for evaluating the potential long-term development of vegetation on disturbed sites.

This paper reviews those features of a successional reclamation programme that encourage the further development of vegetation on a site. Features of soil bioengineering that encourage natural successional processes are discussed. Key features of the early soil bioengineering work can have a profound influence on subsequent plant establishment and in turn on the establishment of later successional species. Successional stagnation (Kimmins, 1987) can develop on sites where inappropriate seed mixes have been used to establish the initial cover on a site. This can make it very difficult to establish later successional species and may prevent the establishment of woody species entirely. Keystone species (Mills et al., 1993) can play a critical role in the establishment of later successional species. The pioneering species used in soil bioengineering provide a key role in the development of plants on difficult sites. Conclusions regarding the development of effective reclamation programmes are presented.

SUCCESSIONAL RECLAMATION

Successional reclamation is the term applied to a reclamation model that seeks to enhance natural successional processes for the rehabilitation of drastically disturbed sites. The major aim of successional reclamation programmes is the re-integration of the disturbed sites with the natural successional processes. These processes operate in the local area to revegetate natural disturbances. The study of natural successional process on natural disturbances (Straker, 1996) can provide clues of the factors that can assist in the establishment of natural successional processes on sites disturbed by human activities. Polster (1991) lists five factors that limit natural vegetation growth on drastically disturbed sites. These are steep slopes; adverse texture; poor nutrient status; adverse chemical properties and soil temperature extremes. Amelioration of these adverse conditions is the first prerequisite in the development of a successional reclamation programme.

Steep slopes and unstable sites prevent vegetation establishment by having a continually moving surface. Soil bioengineering (Schiechtl, 1980) can be used to provide initial stability to sites where the surface movement is preventing natural plant growth. The use of soil bioengineering for treatment of unstable sites in British Columbia is becoming common (Polster, 1997 and 1999). By providing the initial stability, soil bioengineering allows other plants to establish and eventually provide the stability needed to maintain vegetation on the site. Soil bioengineering uses pioneering plants that quickly give way to later successional species. Once the later successional species are well established they can take over the support of the slope through buttressing as well as the root network that is formed (Gray and Leiser, 1982). The initial stability provided by the soil bioengineering thus solves the problem of unstable sites and initiates the successional processes that lead to stable ecosystems.

Adverse soil textures can prevent vegetation growth. The coarse rock that accumulates at the toe of free dumped waste rock dumps is very difficult to revegetate. Resloping waste rock dumps to cover this coarse material with fine textured materials that accumulate near the top of the dump slope is the major means of addressing this problem (Popowich, 1978). Natural talus slopes provide a similar condition and allow the study of natural means of overcoming the problems associated with coarse textured materials (Polster and Bell, 1980). Natural accumulations of organic matter in the crevices between the boulders at the base of talus slopes provide a substrate in which vegetation can become established. Pocket planting, where soil is placed in the interstitial spaces between the rocks mimics this natural process and can be used to establish pioneering vegetation in coarse rock areas. Modified brush layers are used to treat sliver fills composed of side cast blasted rock. Fine textured soils can also be problematic for plant establishment, although generally fine textured soil problems are associated with the stability of the soil. Soil bioengineering techniques such as live smiles and live staking can be used to treat fine textured soils.

Poor nutrient status can limit natural vegetation establishment on drastically disturbed sites. Typically drastically disturbed sites have very limited nutrient levels (SEAM, 1979). Fertilizer can be used to overcome this initial problem, however, in the long term, nutrients must be supplied by local nutrient cycling and the fixation of atmospheric nitrogen by legumes and other nitrogen fixing species. Use of a balanced seed mix that contains 30–40% legumes will assist in establishment of vegetation on low nutrient sites. The pioneering species used in soil bioengineering can survive on sites where nutrients are limited.

Adverse chemical properties such as acid rock drainage (ARD) or sodic spoils can present significant challenges for the establishment of vegetation (Morin and Hutt, 1997). Although there are some plants that can grow under extremes of pH, metals and other adverse chemical components, most plants are stressed under these conditions (Farmer et al., 1976). Treatment of these conditions is often very difficult and specific methods of treatment are used for specific sites.

Soil temperature extremes, either hot or cold, can slow or even prevent natural vegetation establishment and growth. Dark coloured substrates on south facing (Northern Hemisphere) slopes can become very hot under the summer sun. These hot temperatures can kill young plants by denaturing the proteins that make up the various constituents of the plants. Similarly, cold temperature such as occurs in arctic regions can severely limit or even preclude vegetation growth (Bliss and Wein, 1972). Modifications to the surface of the soil can be used to ameliorate adverse temperature conditions. Disking in an east-west direction will create small soil windrows with northern and southern exposures. With dark substrates that are prone to being too warm vegetation can be established on the northern exposures while in cold climates the southern exposures will provide slightly warmer micro-sites that will allow vegetation to establish. Dark substrates can be treated with heavy mulch applications that reduce the albedo of the surface and thus prevent overheating.

Other site features such as exposure to various environmental influences including prevailing winds, sunlight, salt spray and ice scouring can influence the patterns of vegetation establishment. Successional change in these communities may be primarily influenced by the site factors and therefore difficult to manage from a restoration perspective.

Once the vegetation limiting features of the site are addressed, pioneering vegetation can be established. The pioneering vegetation must provide a stable environment, space for invading native species and enhancement of the site relative to the species that will follow. One of the primary aims of the initial vegetation cover is to protect the site from excessive erosion. Invading vegetation can not become established on an actively eroding site. A cover of seeded grasses and legumes is typically used to control erosion, however, too dense a cover of seeded species will prevent invasion of later successional species by closing the space needed by the invading plants. Therefore an open cover of seeded species is needed. This cover should include a good balance of grasses and legumes to provide site improvements that enhance the ability of later successional species to establish and grow.

Establishment of the pioneering cover leads the way towards establishment of later successional species. Whereas the pioneering vegetation is typically herbaceous in nature in most parts of British Columbia woody species dominate the next phase of vegetation that establishes. The various alder species that occur in British Columbia act as pioneering woody species in many ecosystems. Other deciduous species such as cottonwood and aspen may act in this capacity in some ecosystems. These plants play a pivotal role as a bridge between the short-lived herbaceous cover and the longer lived conifers that dominate most forest ecosystems in the province. It is in this pioneering woody species cover that allows later successional conifers can establish. The role of these seral species is essential to the long-term health of forest ecosystems.

Replicating the essential features of natural successional patterns on drastically disturbed sites provides productive ecosystems. Each stage in the process is important, from the initial erosion controlling cover of grasses and legumes through the later successional woody species. Successional reclamation duplicates the vegetation patterns found in natural successional sequences.

MEASURES OF SUCCESS

The success of a soil bioengineering project can be measured by determining the stability of the treated site and by investigating the invasion of the reclaimed site by native species. Site manipulations that encourage establishment and growth of native species contribute to the long-term success of the reclamation efforts. The following case studies present examples of where soil bioengineering and successional reclamation have been used to reclaim drastically disturbed right-of-way and other sites.

Reclamation of landslides that arise from poorly constructed resource roads is undertaken to reduce erosion and lessen the impacts of the landslides on aquatic habitats. Reclamation treatments on two adjacent watersheds in Clayoquot Sound on the west coast of Vancouver Island were carried out in the mid 1990's. In one watershed, a successional approach, including soil bioengineering, was used and a balanced seed mix was applied resulting in the establishment of an open stand of vegetation. In the other watershed, the seed mix was not balanced and resulted in the establishment of a dense stand of seeded species. Assessments conducted in 1999 (Warttig and Wise, 1999) found that there were four times as many native pioneering species (primarily red alder) on the disturbed

Table 1. Plant[1] establishment on UBC slopes

Initially (1989/90) planted species	1999 established species	2001 established species
Agrostis gigantea	Agrostis gigantea	Agrostis gigantea
Dactylis glomerata	Alnus rubra	Alnus rubra
Festuca rubra	Cytisis scoparius	Cytisis scoparius
Medicago sativa	Dactylis glomerata	Dactylis glomerata
Phleum pratense	Festuca rubra	Festuca rubra
Poa compressa	Medicago sativa	Medicago sativa
Salix scouleriana	Phleum pratense	Phleum pratense
Salix lucida	Poa compressa	Poa compressa
Trifolium hybridum	Polystichum munitum	Polystichum munitum
	Pseudotsuga menziesii	Pseudotsuga menziesii
	Rubus spectabilis	Rubus spectabilis
	Salix scouleriana	Salix scouleriana
	Salix lucida	Salix lucida
	Trifolium hybridum	Sambucus racemosa
		Tolmiea menziesii
		Trifolium hybridum
		Tsuga heterophylla

[1] Nomenclature follows that given in Douglas et al., 1989–1994.

sites in the watershed where successional reclamation was used.

The CP Rail Roger's Pass Project was the first use of successional reclamation for a major project. Many soil bioengineering treatments were undertaken on difficult sites on the Roger's Pass Project. Reclamation work on this project was conducted from 1983 to 1989. The reclamation work conduced on this project was the subject of an intensive study that culminated in the production of a thesis in 1998 (Lamb, 1998). Conclusions from this study indicated that the agronomic species were persistent and native invasion was most rapid along the edges of the disturbed areas. Native species invasion on the reclaimed sites may be limited due to the planting of native pioneers on most sites. Later successional conifers such as spruce, hemlock and cedar have been found on the treated sites (Lamb, 1998). Soil bioengineering sites have performed well and have effectively stabilized the treated sites.

Soil bioengineering was used to treat actively eroding water control structures on the Vancouver Island Gas Pipeline adjacent to the Big Qualicum River near Qualicum Beach north of Nanaimo on Vancouver Island, BC, Live silt fences as well as live bank protection was used to control erosion on a constructed drainage ditch. Initially, the soil bioengineering provided immediate relief from the active erosion while over the long term the willows used in the bioengineering provided a pioneering cover that encouraged invasion of skunk cabbage, horsetail and other wetland species.

Although not on a right-of-way, reclamation of the sand cliffs surrounding the University of British Columbia in Vancouver, BC, undertaken from 1988 to 1990, provides an excellent example of how natural successional processes can be harnessed to lead to a stable long-term vegetation cover. Soil bioengineering and successional reclamation were used. This reclamation work resulted in the establishment and dominance of willow and agronomic grasses and legumes on the slopes during the early 1990s. An assessment of the species composition of the stand on the slope revealed that initial rapid invasion of the site by red alder lead to a dominance by alder by the late 1990s. In addition, Douglas fir, sword fern and salmonberry were found on the slopes in 1999. Table 1 presents a synopsis of the floristic changes that have occurred on this site since treatment.

CONCLUSIONS

The use of soil bioengineering and successional reclamation methods in the establishment of vegetation on drastically disturbed right-of-way sites can enhance the speed at which natural processes and native species establish on a site. Providing space for invasion by natives is essential. Space can be provided by avoiding the use of a sod forming seed mix for the initial cover. In addition, fertilizer should be applied carefully to avoid the establishment of a dense thatch that will restrict native species invasion and growth. Stability of the site is essential for the establishment of native species. Soil bioengineering can be an effective means of providing site stability. Additional study of the long-term development of vegetation on reclaimed sites is warranted. However, an initial evaluation of the progress of sites where soil bioengineering has been used indicates that the initial objectives of reclamation programmes, that of stability and revegetation, are being met.

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Summary of the Mitigation Program for Rare Plant Populations along the Portland Natural Gas Transmission System (PNGTS) and PNGTS/Maritimes & Northeast Joint Facilities Projects

J. Roger Trettel, Sandra J. Lare, and Brett M. Battaglia

During 1998 and 1999, Portland Natural Gas Transmission System ("PNGTS") and Maritimes & Northeast Pipeline, L.L.C. ("Maritimes") (collectively the "Owners") constructed approximately 292-miles of 12-, 24-, and 30-inch outside diameter pipeline (the Projects) through portions of Massachusetts, New Hampshire, Maine, and Vermont. Prior to construction, background research and field surveys were performed identifying the rare, threatened, and endangered ("RTE") plant and animal species located along the project route. Field surveys identified a total of 25 different RTE plant species located in 57 discrete populations; no animal species were identified. All plant species identified were state-designated, and no Federally-designated Threatened or Endangered species were identified. Avoidance of RTE plant populations was the preferred form of mitigation considered, however avoidance was not always feasible. Where avoidance was not possible, alternative mitigation measures were developed in conjunction with the appropriate regulatory agencies. A key component of the mitigation program involved removal and temporary nursery storage of rare plants during construction, and subsequent replanting in their approximate original locations following the completion of construction. Other mitigation measures included topsoil segregation/replacement and use of timber mats to cover and protect the populations from heavy equipment traffic. Post construction monitoring after the first growing season revealed that all but one of the rare plant populations is viable and vigorous following the first growing season. Based on initial results, we conclude that the techniques implemented were successful. Proper transplanting during the appropriate season, special care and over-winter handling by a qualified nursery, and replanting in suitable habitat and during the appropriate time window, are critical factors in determining program success. Such techniques may be applicable to other pipeline projects.

Keywords: Rare plant populations, suitable habitat, mitigation, replanting, monitoring plan

INTRODUCTION

During 1998 and 1999, Portland Natural Gas Transmission System ("PNGTS") and PNGTS/Maritimes and Northeast Pipeline constructed approximately 292 miles of 12-, 24-, and 30-inch outside diameter pipeline through the states of Vermont, New Hampshire, Maine, and Massachusetts. As part of the environmental review and permitting process for the project, background research and field surveys were performed to identify the presence of state and/or Federal plant and animal rare, threatened, and endangered (RTE) species of concern. Results from this background research and field surveys identified a number of state-designated populations of various rare species of concern throughout the project area (see Table 1).

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Table 1. State designated species of concern-Portland Natural Gas Transmission System (PNGTS) and PNGTS/Maritimes and Northeast Joint Facilities projects

Common name	Scientific name	Town	Approximate MP	State status
		New Hampshire		
Great Bur-reed	*Sparganium eurycarpum*	Newton	20.00–20.10	T/S2
		Greenland	39.13–39.15	
Atlantic White Cedar	*Chamaecyparis thyoides*	Newton	22.26–22.43	S1/S3
			24.04–24.34	
Swamp Azalea	*Rhododendron viscosum*	Newton	24.04–24.34	T/S3
Featherfoil	*Hottonia inflata*	E. Kingston	25.19–25.41	State Record
Small Whorled Pogonia	*Isotria medioloides*	E. Kingston	25.93–26.05	E/S2
Robust Knotweed	*Polygonum robustis*	Exeter	29.60–29.62	T/S2
Thin-leafed Alpine Pondweed	*Potamogeton alpinus*	Exeter	29.75–29.79	T/S2
Lined Bulrush	*Scirpus pendulus*	Stratham	37.08–37.09	T/S2
Bush's Sedge	*Carex bushii*	Greenland	39.15–39.18	E/S1
Hairy Hudsonia	*Hudsonia tomentosa*	Newington	45.11–45.30	T/S1
Northern Blazing Star	*Liatris scariosa*	Newington	45.11–45.30	?
Hidden Sedge	*Carex umbellata*	Shelburne	91.55–91.58	E
			91.58–91.63	
			92.90–93.10	
			93.45–93.49	
			93.73–93.84	
			94.12–94.28	
		Maine		
Annual Salt Marsh Aster	*Aster sublatus*	Eliot	52.50–52.53	E/S1
Muhlenberg's Sedge	*Carex muhlenbergii*	Eliot	53.72–53.73	E/SH
Smooth Winterberry	*Ilex laevigata*	Eliot	53.98–54.14	SC/S2-S3
Small Reedgrass	*Calamagrostis cinnoides*	Eliot	54.00–54.05	E/S1
		S. Berwick	62.70–62.74	
		Wells	68.54–68.60	
			69.35–69.36	
			69.74–69.81	
			70.21–70.25	
			70.30–70.36	
		Kennebunk	77.76–77.93	
			78.03–78.11	
			78.16–78.24	
		Arundel	78.39–78.42	
			78.46–78.60	
White Wood Aster	*Aster divaricatus*	S. Berwick	55.88–55.91	T/S1
			56.03–56.06	
			56.39–56.51	
			56.54–56.58	
Pale Green Orchis	*Platanthera flava*	S. Berwick (Nowell Farm)	60.48–60.63	SC/S2
		N. Berwick		
		Kennebunk	64.72–64.77	
			74.13–74.15	
Lined Bulrush	*Scirpus pendulus*	S. Berwick (Nowell Farm)	60.48–60.63	?
Swamp Saxifrage	*Saxifraga pensylvanica*	S. Berwick	60.48–60.63	T/S2
		S. Berwick (Nowell Farm)	60.63–60.67	
		N. Berwick	64.48–64.63	
			65.08–65.10	
			65.14–65.15	
Wiegand's Sedge	*Carex wiegandii*	Saco	85.53–85.61	S2
American Chestnut	*Castanea dentata*	Kennebunk	75.15–75.40	S2-S3
Northern Blazing Star	*Liatris scariosa*	Kennebunk	73.32–73.35	T/S1
White Topped Aster	*Aster paternus*	Kennebunk	73.32–73.35	T/S1
			73.55–73.66	
Water Starwort	*Callitriche heterophylla*	Gilead	98.69–98.79	E
Scarlet Oak	*Quercus coccinea*	S. Berwick	62.70–62.74	E/S1

E = State endangered species. S1 = State identified as critically imperiled because of extreme rarity (5 or fewer known occurrences). T = State threatened species. S2 = State identified as imperiled because of rarity (6–20 known occurrences). SH = State identified as historically known in one area. S3 = State identified as very rare or only found locally in a restricted range (21–100 known occurrences). SC = Specibel Concern.

Avoidance of RTE plant populations that were found along the project route was the first mitigation measure considered by the Owners. Avoidance measures included implementation of route changes and/or reduction of construction workspace in areas of rare plant occurrence. To further ensure that rare plant populations located adjacent to the work area would be protected during the construction phase, orange exclusion fencing was to be erected as a physical and visual barrier to equipment, and "Exclusion Zone" signs would be placed where they were visible to workers.

In approximately 57 cases, completely avoiding the species of concern locations was not feasible. This was due to constraints posed by existing land uses, other environmental resources, the large size of the populations, and engineering constraints. Where avoidance was not possible, the Owners developed alternative mitigation measures in conjunction with the appropriate species of concern agencies in each state. This report provides a summary of the mitigation program that the Owners implemented to minimize impacts to plant species of concern that were unable to be avoided.

STANDARD MITIGATION MODEL

As stated above, avoidance of species of concern population was the priority of both the Owners and the regulatory agencies in the development of the mitigation program. Where avoidance was not feasible, the initial mitigation model put forth by regulatory agency personnel was the concept of full right-of-way (ROW) sod salvage and storage of the segregated material adjacent to the workspace. Based on previous experience, this standard model seemed to present complications that would make the program difficult to implement and hamper its overall success. Such complications include the following:

- Full ROW sod salvage would require substantial extra workspace in the vicinity of the plant population, thus potentially impacting additional area of the population off-ROW and requiring acquisition of additional temporary workspace. Most often, the goal is to minimize workspace requirements, i.e., the project footprint, and consequent ground disturbance in such areas.
- In populated areas, this additional required workspace could be difficult to acquire and may adversely affect landowner relations.
- Segregated plant material stored on site is subject to accidental damage caused by construction equipment, as well as desiccation and risk of burial.
- Segregated plant material stored on site requires monitoring and maintenance throughout the construction period, including routine watering and exclusion fencing repair. Storage of material on site creates additional logistical issues to track.

ALTERNATIVE TO STANDARD MODEL

Based on the constraints identified above, the Owners coordinated with the regulatory agencies to develop an alternative set of procedures for implementing mitigation. The program that was developed, as presented below, consisted of a more tailored, less intensive set of techniques. The basic components of this program included:

1. Limited transplanting to adjacent sites of certain site sensitive species. In such cases, species with highly specific site requirements would likely only survive if moved to an adjacent site with very similar conditions (e.g., aquatic species such as featherfoil and water starwort).
2. For less sensitive species, transplanting of a significant percentage of the population and storage of plant material in a nursery. The percentage of the population transplanted would be based on the overall size and density of the original population. Following construction, the plants would be re-installed in their approximate original location on the ROW.
3. In a limited number of areas, the mitigation strategy would involve a combination of transplanting and nursery storage, combined with timber matting to protect the residual population.

SPECIFIC METHODS

Based on the basic model presented above, the following presents the specific procedures that were implemented relating to plant removal, handling, nursery storage, and replanting on the restored ROW.

Population exclusion and plant removal

Beginning in late May 1998, a qualified botanical field team initiated the mitigation program. The field team consisted of botanists from Northern Ecological Associates, Inc. (NEA), and representatives of a local qualified plant nursery.

In areas where the approved mitigation called for exclusion fencing to be erected, the field team installed orange flagging to indicate the locations for fence installation. Contractor environmental crews then installed orange exclusion fencing, and Environmental Inspectors posted "Exclusion Zone" signs to ensure these areas were avoided during construction.

The botanical team identified populations of individual species of concern and conveyed this information to the nursery staff. Nursery personnel used small hand spades and shovels to manually remove the plants. Care was taken to excavate the maximum amount of the root systems and to minimize damage to the plants. The size of the soil plugs removed was based on the root structure, density of the species, and size of the plants. For example, small reedgrass (*Calamagrostis cinnoides*) individuals were removed with large soil plugs due to the high density of the populations and braided root systems; whereas swamp saxifrage (*Saxifraga pensylvanica*) specimens were removed in individual plugs due to the low density of individuals and simple root systems. In areas where sod salvage was the approved mitigation/plant removal technique, large sections of the sod (approximately 50 × 50 cm) approximately 10–15 cm deep were removed in association with the individual identified plants.

The herbaceous portion of the plants were then "trimmed back" by clipping off the top of the plant at a height of 10–15 cm from the top of the soil. By reducing the aboveground portion of the plant, the root system can better endure the stress of removal, transport, and processing. The plants and sod sections were wrapped in moistened burlap, allowing the plants to receive oxygen and maintain moisture during transport to the nursery.

Nursery storage procedures

After delivery to the nursery, the plants were kept in a cool, dark, and damp holding area until they were processed. Processing generally was performed within a few hours of arrival at the nursery. Processing consisted of the division of plant material (except for woody RTE species) into manageable clumps to be potted into 1-gallon pots. Woody RTE species (e.g., American chestnut) were stored in a balled and burlaped condition and supported by a wire frame. Sod salvage sections were contained in the larger 50 × 50 cm portions. Once potted, the plants were lightly fertilized with *Osmocote Plus* (a widely used slow release nursery fertilizer) to help overcome the stress associated with transplanting and encourage regrowth. The plants were then inventoried and labeled for location in the nursery storage area for the remainder of the growing season.

Plants were stored in various outdoor locations at the nursery, based on the species' hydrologic requirements. For example, emergent herbaceous species were moved to a wetland/drainage swale area where natural moisture conditions would be available to the plants. Upland species were located in well drained, dry sites.

The plants received a second light application of fertilizer two to three months after processing, in preparation for the winter season. It is important to note that minimal fertilizer is used only to combat the stress of relocation to the nursery. The nursery attempted to best simulate normal habitat conditions by preventing the plants from becoming dependant on artificial fertilizers. Natural precipitation was the primary means of watering while the plants were stored in their outdoor locations. However, during dry periods and when the plants appeared stressed, the nursery provided supplemental watering to maintain the vigor of the plants.

During the winter dormancy season, the plants were moved to a common outdoor area near a large structure to minimize wind exposure. Three different layers of cover were used to protect the plants during the winter. First, a dark felt material was laid on top of the plants. Next, a foam pad ("microfoam") approximately 1 cm thick covered the felt. Finally, a special heavy-duty plastic material covered the foam. The purpose of the three layers was to minimize extreme temperature fluctuations during the cold season and to assist with maintaining a higher overall temperature, especially in the event of a severe cold spell or extended freeze period. When the winter dormancy storage season ended, the plants were returned to their respective areas at the nursery to simulate their hydrologic requirements until the time of replanting on the ROW.

Replanting procedures

The majority of sapling tree species were replanted in their approximate original location on the restored ROW during late autumn 1998, following leaf fall and establishment of winter dormancy. The timing of this planting served to minimize stress to the saplings, improving their chance for survival.

Based on weather conditions and consultation with the botanists and nursery representatives, all remaining RTE species were systematically replanted in their original locations in the spring of 1999. A light application of *Osmocote* fertilizer was used to minimize the stress of relocation and encourage regrowth. Watering occurred naturally, however during periods of low precipitation, the nursery compensated with supplemental watering until the plants were successfully re-established. Exclusion fencing and/or flagging surrounded the replanted sites in order to discourage disturbance until the populations reestablished themselves in their environment. Although it was acknowledged that this exclusion fencing/flagging could potentially draw attention to the species, the necessary protection from all terrain vehicle traffic offset this risk.

MONITORING

Permit conditions issued by the various regulatory agencies required that long-term monitoring be a component of the overall mitigation program. As required, the Owners sponsored post-construction monitoring of all rare plant sites affected by construction to assess the condition of the population and the success of mitigation efforts. Monitoring was performed by a qualified botanical team and was scheduled to maximize positive identification and accurate assessment of plant condition.

For RTE populations involving plug removal and replanting, the botanical team surveyed the sites once within the first 60 days of the first growing season (i.e., June–July, 1999). This first survey provided initial verification of the condition and survival of the transplants, and identified whether immediate remediation, such as watering, may be required.

Following this initial survival survey, the Owners initiated a systematic monitoring program required by permit condition for at least the first two growing seasons. The first growing season survey was to be performed at two different times during the first year: mid-season (July) and late-season (August–September), when plants are still vigorous and readily identifiable. The second year surveys will be conducted two separate times at similar intervals.

All locations were systematically surveyed to monitor the individual population. Randomly spaced 1-square meter quadrats were sampled as appropriate to provide a quantitative assessment of percent cover (portion of an area covered by the vertical projection of the plant to the ground surface) and density (number of individuals per unit area, e.g., # of stems/m^2). The number of quadrats sampled is dependent upon the relative size of the population within the area of suitable habitat (i.e., a wetland system), such that the area sampled will be approximately 10% of the total population area. Quadrats were sampled within the disturbed area and in adjacent undisturbed areas (where applicable) for comparison. Monitoring results were documented on data forms for each site. In addition, the results of this sampling were compared with records of preconstruction conditions to determine relative success.

During the first growing season surveys, detailed documentation concerning survival and relative vigor of the population was produced. This data indicated that the majority of the populations were viable and robust after the first growing season; therefore no consultation with appropriate state and federal agencies was necessary to consider the need to develop any necessary ameliorative actions.

REPORTING

Following completion of each year's monitoring program, permit conditions require the Owners to prepare a detailed report documenting the results of the surveys and the overall condition of the plant populations. Mitigation will be considered successful if the population has achieved 80% of its original cover or density within the disturbance area. If the 80% threshold has not been achieved after the second growing season, an assessment will be made in consultation with the New Hampshire Natural Heritage Inventory, Maine Natural Areas Program, or the Massachusetts Natural Heritage and Endangered Species Program regarding the need for continued monitoring and/or additional mitigation measures.

An additional component of the post construction monitoring report will be assessments of the relative success of different mitigation measures. The Owners will identify specific measures that have proven to be successful, as well as items that are ineffectual. Recommendations for improvement of the program will be presented as appropriate. This information will be useful in the development of future RTE plant mitigation programs for pipeline projects in the region.

OVERALL FIRST YEAR RESULTS

The objective of the RTE Mitigation Program was to ensure that the Project was in compliance with state and Federal permit conditions requiring the identification of RTE species prior to construction, that unavoidable impacts were effectively mitigated, and that post-construction monitoring of the mitigated species of concern was properly performed.

RTE species that had been removed from sites along the construction right-of-way prior to construction in 1998 were replanted between June and July of 1999 following construction, with the exception of sapling species, which were replanted on October 30, 1998. The status of these replanted populations was later monitored within a 60-day time period with one visit to each site. The monitoring occurred in late July and early August of 1999.

In general, the first year of monitoring indicated that the majority of the sites appeared to be in satisfactory condition. Many of the populations appeared vigorous and several plant populations had expanded in size, despite a growing season marked by unusually hot and dry conditions. Much of the initial success can be attributed to proper replanting and periodic watering/maintenance performed by the contracted nursery.

Marginal plant vigor was observed at five populations located in certain wetland emergent habitats. This appears to be due in most part to the quality of the topsoil segregation conducted at these wetland sites. In particular, topsoil and subsoil appear to have been mixed, thus leaving exposed and hardened clay at the surface. This clay layer appeared to reduce the amount of vertical water flow and penetration from rainfall. Surface and subsurface soil conditions were dry, although moisture was available in adjacent off right-of-way wetlands.

As would be expected, replanted RTE populations relocated at sites, which closely match original conditions of soil type, moisture content, and exposure appear to be most successful. Furthermore, grass and sedge species (particularly small reedgrass and hidden sedge) appear most likely to become thoroughly re-established. Continued monitoring in the year 2000 growing season will provide more conclusive data on these RTE mitigation efforts, especially on the response of these plants to the drought conditions of 1999 and to competitive exclusion by other species.

CONCLUSIONS

Implementation of the RTE monitoring program for this project has been shown to be initially successful in mitigating adverse impacts to plant species of concern. The concept of maximum avoidance coupled with transplantation and off-site storage is a workable methodology based on early monitoring results. Key to the success of this technique is working with an experienced and qualified plant nursery in the vicinity of the project area, that will ensure plant materials are properly monitored and cared for in appropriate soil and moisture conditions. Follow-up monitoring, maintenance, and watering during the first critical growing season also appears to be important.

Preliminary results appear promising, but are based on only one year of data. General survey results from this season's monitoring effort have identified some mortality due to competitive exclusion by aggressive pioneers on the newly revegetating right-of-way. Long-term monitoring will be required to assess the overall efficacy of the technique.

In economic terms, the overall cost of the Program was relatively low in comparison with the cost of rerouting of the pipeline and the potential added environmental impact of clearing new corridor. Because none of the species mitigated with this program had Federal legal protection under the Endangered Species Act, it was not necessary to employ particularly extreme measures or entertain the possibility of stopping the project. The Program that was implemented took into consideration the state-level status of each of the species, the relative abundance of the particular species, and the potential for success, and has been shown to be an effective means of mitigating impacts to rare plant populations under these circumstances.

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Right-of-Way Disturbances and Revegetation in Alpine Tundra: An Evaluation of Natural Revegetation on Plateau Mountain, Alberta

Laura A. Van Ham and Richard D. Revel

Reclamation of abandoned rights-of-way at alpine and subalpine elevations as well as in arctic locations has long been a formidable task for industry. As a means to further explore reclamation options for high elevation and northern locations, the authors undertook an alpine revegetation research project on the summit of the Plateau Mountain Ecological Reserve (elevation 2348–2500 m asl), located near the south end of Kananaskis Country, Alberta, Canada (50°13′N, 114°31′W). Plateau Mountain is one of a limited number of southern Rocky Mountain permafrost sites, and as such, exhibits characteristics of alpine and arctic tundra soil, vegetation and climate. Plateau Mountain was developed for sour gas production in the early 1950s and several rights-of-way and well sites have since been abandoned but not formally reclaimed. This site provided an excellent opportunity to study natural revegetation processes operating in an alpine/arctic tundra environment. Two linear right-of-way (road, pipeline) and one point (well site/surface clearing) disturbance types were studied and four levels of disturbance recognized: *undisturbed*, *near disturbance*, *severe*, and *less severe*. Natural revegetation of disturbed sites was analyzed via an adapted transect and point frame sample plot vegetation inventory that included both disturbed and adjacent undisturbed terrain. Measured reclamation parameters (e.g., species presence, frequency of occurrence, species richness, and similarity to undisturbed vegetation (Is_S) are indicative of successful natural revegetation of disturbed sites. Portions of the field results are presented, including the species list and species presence in the four distinguishable terrain types (*undisturbed*, *near disturbance*, *severe disturbance*, *less severe disturbance*). Based on these and an extensive literature review of alpine and arctic tundra disturbances, considerations for reclamation of high elevation and arctic disturbances focussing on enhancement of natural revegetation processes are discussed.

Keywords: Natural revegetation, disturbance, reclamation, petroleum industry, right-of-way, alpine

INTRODUCTION

Alpine and arctic environments have long been subject to natural disturbance (e.g., landslide, frost heave) with differing levels of intensity and frequency depending on the site. Generally, these sites are left to recover naturally and in a relatively intact environment they will progress through patterns of vegetative succession from bare ground to vegetated alpine communities. Over the past century, and in some parts of the world even longer, incidences of human caused disturbance in alpine and arctic environments are increasing. Recovery of these disturbances varies in terms of success and timeframe depending largely on nature of the disturbance (i.e., size, intensity and frequency of the disturbance activity), site characteristics as well as the intentions of, and actions taken by, the disturber.

Plateau Mountain, the study site for this research project, is located near the south end of Kananaskis Country in the front ranges of the Rocky Mountains, Alberta, Canada (50°13′N, 114°31′W) (Fig. 1). Some-

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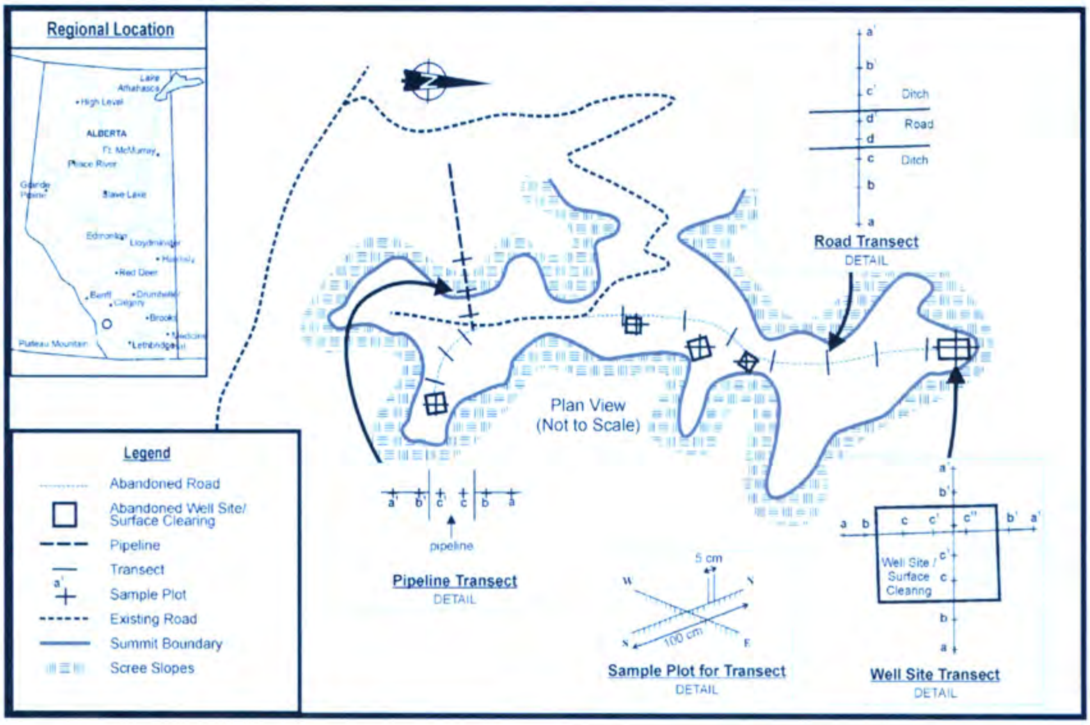

Fig. 1. Regional location of Plateau Mountain study area and vegetation inventory sampling design on disturbed sites.

Fig. 2. Looking west, area of micro-relief features and distinct patterned ground on the summit of Plateau Mountain. July, 1999.

what unique to the peaks in the vicinity, the summit of Plateau Mountain is an approximately 15 km^2 flat top. Elevations across the summit range from 2348 m above sea level (asl) near its northern extent to 2500 m asl near the south end. Treeline in the vicinity of Plateau Mountain is at approximately 2290 m (Woods, 1977), well below the summit's lowest elevations. The topography is generally flat with areas of very gently sloping terrain and micro-relief features (e.g., micro-hummocks) associated with patterned ground processes (Fig. 2). Plateau Mountain is located within the Savanna Creek gas field, where oil and gas exploration and production activity has been occurring since 1956.

Plateau Mountain is a relatively unique site in the southern Rocky Mountains in that large portions of the surface are covered by patterned ground features (Fig. 2) and it has a permafrost core. The summit of Plateau Mountain is believed to have been a

Fig. 3. Typical alpine tundra vegetation on the summit of Plateau Mountain. Note the well-camouflaged ptarmigan in the center of the photo. July, 1997.

"nunatak," meaning its surface was completely above the upper elevation limits of the late Pleistocene glaciation (Woods, 1977; Bird, 1990; Gadd, 1995). During this time, the glacier-free summit was exposed to a colder periglacial environment than surrounding glaciated areas, and experienced greater intensities of freeze-thaw activity (Woods, 1977). This periglacial environment has been documented as responsible for the mountain's relict permafrost core (Harris and Brown, 1982) as well as for initiation of many of the summit's patterned ground features (Woods, 1977).

Alpine areas in the front ranges of the Rocky Mountains are characterized by short, cool growing seasons, long, cold winters, high winds, effectively low precipitation, and intense radiation (Baig, 1972; Macyk, 1989; Walker, 1995; Millar, 1993). Soils on the summit of Plateau Mountain are classified as undeveloped or as orthic or cumulic regosols or turbic cryosols, indicating very poor profile development caused by unstable or perennially frozen conditions that inhibit horizon formation (Alberta Energy and Natural Resources, 1984). Vegetation on the summit is well adapted to the harsh growing conditions, with most plants being perennial and exhibiting short, clumped, or cushioned growth forms and both sexual and asexual reproductive capabilities. Large areas of the summit are described as fellfield tundra, with the stony, cryoturbated portions of the patterned ground features dominated by epipetric and terricolous lichens and the stable central portions by turf forming vegetation (Bryant, 1968; Bryant and Schienberg, 1970; Griffiths, 1982). Wildlife inhabiting summit areas (e.g., marmot, pika, ptarmigan) are also well adapted to the alpine environment (Fig. 3).

The summit of Plateau Mountain and portions of its outlying areas were designated as an Ecological Reserve on December 12, 1991. Ecological Reserves are defined as "areas selected as representative or special natural landscapes and features of the province, which are protected as examples of functioning ecosystems, as gene pools for research, and for education and heritage appreciation purposes" (Alberta Environmental Protection, 1990). This designation limits the types of industrial activities and guides the types of research activities that are allowed within the ecological reserve boundaries.

Disturbance history

Mechanized access to the summit of Plateau Mountain was reached by 1956 with the construction of an oil and gas field road up the west slope and south across the middle portion of the summit to reach a sour gas well site (5-32-14-4 W5M). Further development activity occurred between 1956 and 1958 with the north-south extension of the summit road to access proposed drill sites near the north (3-17 and 7-5-15-4 W5M) and southeast (15-29-14-4 W5M) extents and in 1978 to reach a sour gas well site at the far southern extent (6-29-14-4 W5M). The Savanna Creek gathering system, constructed in about 1961, is located at the south end of Plateau Mountain. Construction activities for all phases of exploration and development have utilized native materials only (i.e., roads and well sites were prepared with materials present onsite).

The 5-32 and 6-29 well sites are currently in production and their access road is utilized daily by the Savanna Creek Gas Field operations staff. The 3-17 site was drilled in 1956 and abandoned in 1957. The 7-5 and 15-29 proposed drill sites were abandoned prior to drilling. In addition, between 1956 and 1958 a number of sites were prepared by surface clearing for an undocumented purpose and were likely abandoned immediately following preparation. The abandoned access roads, particularly to the 3-17 well site, were subject to regular vehicle traffic until a locked access gate was installed near treeline along the summit access road in 1980. From 1980 to 1989, vehicle travel on the abandoned summit roads was prohibited except with special permission from Alberta Environment. Since 1989, no vehicle traffic has been permitted on abandoned roads. Generally, sites were abandoned and no reclamation undertaken. At the time that the field work for this research project was conducted, most sites had been left to revegetate naturally for 37–40 years with one site for only 8 years.

Objectives

The objectives of this research project were as follows:
1. document the temporal and spatial characteristics of gas field related disturbances on Plateau Mountain;
2. document the natural revegetation of disturbed sites relative to disturbance severity in terms of species presence, frequency, frequency class, richness, and similarity to adjacent, undisturbed terrain;
3. evaluate the relative success of natural recovery of disturbed sites; and
4. develop recommendations for revegetation of disturbed sites within the Plateau Mountain Ecological Reserve and other similar alpine and arctic tundra sites.

METHODS

Two types of abandoned gas field surface disturbances were selected as sample sites for field investigation, linear right-of-way disturbance (road top, road ditch, pipeline) and point disturbance (well site/surface clearing).

Disturbed sites were classified at two levels according to Chambers (1995) and Chambers et al. (1990):
1. *severe* — which refers to disturbances that remove surface soil horizons and their seedbank and propagule pool (e.g., road ditch and well site/surface clearing); and,
2. *less severe* — which refers to disturbances that retain surface soil horizons and their seedbank and propagule pool in place (e.g., road top, and pipeline).

Adjacent, undisturbed terrain was also analyzed for comparison with disturbed terrain, and undisturbed sites were classified at two levels:
1. *undisturbed* — vegetation plots located 15 m from the disturbances and considered unaffected by the adjacent disturbed terrain; and,
2. *near disturbance* — vegetation plots located 5 m from disturbance and considered to be subject to influences from the adjacent disturbed terrain.

A transect based inventory system was established to cover vegetation sampling across the disturbed sites and in the adjacent undisturbed vegetation (Fig. 1). Transects were oriented perpendicular to the axis of linear disturbances (road top, road ditch, and pipeline) and marked at their approximate midpoint with a metal spike driven flush with the ground. Two transects were utilized to bisect point disturbances (well site/surface clearing). Transects started in undisturbed terrain 15 m from one side of the disturbance, extended across the disturbed areas and ended in undisturbed terrain 15 m from the opposite edge of the disturbance. Replicate (i.e., one on each side of the disturbance) sample plots were set-up along the transects in *undisturbed* (a, a′) and *near disturbance* terrain (b, b′) (Fig. 1). Along road right-of-way, disturbed terrain was sampled in replicate in the *severe* (road ditch, c and c′) and *less severe* (road top, d and d′) locations. *Less severe* disturbed terrain was also sampled along the pipeline right-of-way in replicate on either side of the right-of-way (c and c′). *Severe* disturbed terrain on well site/surface clearings was sampled in triplicate along each of the two bisecting transects (c, c′, and c″).

A point frame sample plot was used to document vegetation along the transects (Fig. 1). Modeled after the standard 1 m^2 quadrat to sample herb cover (Krebs, 1989), the point frame is a 1 m by 1 m bisect with nails driven through the frame to mark sample points. Forty points in total were sampled, 20 along each axis spaced 5 cm apart. Terrain features were recorded where the forty sample points contacted the terrain surface. For the purpose of this study, a terrain feature refers to the following: (1) vascular plant genus and species, (2) moss, (3) terricolous lichen, (4) epipetric lichen, (5) unknown vegetation, (6) litter, (7) bare ground, (8) gravel/cobble/boulder, and (9) cryptogamic soil. In total, 168 sample plots were recorded including 43 in *undisturbed*, 45 in *near disturbance*, 52 in *severe disturbance*, and 28 in *less severe disturbance* terrain. Within each plot, terrain features were recorded at the 40 sample points for a total of 6720 sample points, including 1720 in *undisturbed*, 1800 in *near disturbance*, 2080 in *severe disturbance* and 1120 in *less severe disturbance*.

Data analyses for this research paper included: species presence, frequency (Krebs, 1989; Zar, 1984) and frequency class (Randall, 1978). Raw data from the 6720 sample points were recorded in a frequency table organized by sample plot. Frequencies were grouped by averaging the frequency values of similar sample plot locations (Krebs, 1989; Hurlbert, 1984). Frequency is the number of sample points terrain feature *x* is recorded out of a total of 1720 sample points for *undisturbed*, 1800 for *near disturbance*, 2080 for *severe disturbance*, and 1120 for *less severe disturbance*. Frequency classes (I to V) were also determined for similar sample plot locations (Raunkiaer, 1934 in Randall, 1978). Frequency class is obtained from the number of times terrain feature *x* appears in a sample plot location out of a total of 43 plots for *undisturbed*, 45 for *near disturbance*, 52 for *severe disturbance*, and 28 for *less severe disturbance*. This value is converted to a percent, and the frequency class obtained as follow: 0–20% = frequency class I, 21–40% = frequency class II, 41–60% = frequency class III, 61–80% = frequency class IV, and > 81% = frequency class V. Frequency class values were used in conjunction with the frequency data to evaluate the distribution and abundance of species and other terrain features on disturbed and adjacent undisturbed sites. A more detailed data analysis of the inventory results can be obtained from Van Ham (1998).

RESULTS

The results of the study are shown in Table 1. On the basis of the data gathered, the list of 79 species and other terrain features identified during the study is divisible into six general groups with subgroups. Group One includes nine species recorded only on undisturbed terrain (i.e., *undisturbed; near disturbance*). Group Two includes nine species recorded only on disturbed terrain (i.e., *severe; less severe; severe and less severe*). Groups Three and Four include 26 species recorded on both undisturbed (*undisturbed* and *near disturbance*) and disturbed (*severe, less severe*) terrain. Twelve species found on *near disturbance* and disturbed terrain (i.e., *near disturbance, severe; near disturbance, less severe; near disturbance, severe, less severe*) were separated from the other species into Group Three, as these species may reflect an influence of disturbed terrain colonizers on adjacent, *near disturbance* vegetation communities. Group Four includes 14 species recorded on *undisturbed, near disturbance* and disturbed terrain (i.e., *undisturbed, severe; undisturbed, near disturbance, severe; undisturbed, near disturbance, less severe; undisturbed, severe, less severe*). There were no species found in the *undisturbed, near disturbance, less severe* terrain combination. Group Five includes 30 species found on all terrain types (i.e., *undisturbed, near disturbance, severe*, and *less severe*). Group Six includes five nonvegetative/unknown vegetation terrain features that were recorded; each of these features was found in each of the terrain types (i.e., *undisturbed, near disturbance, severe, less severe*).

The total number of species recorded by terrain type was highest for *severe disturbance* terrain (57), followed by *near disturbance* terrain (56), *less severe disturbance* terrain (48) and *undisturbed* terrain (44). *Severe disturbance* terrain exhibited the highest number of unique colonizing species as well as the highest total number of colonizing species. A total of 56 plants were found in at least one undisturbed (*undisturbed, near disturbance*) and one disturbed (*severe, less severe*) terrain type. Thirty species were found in all four nondisturbance/disturbance types, nine species were found in undisturbed only and nine species in disturbed only.

The frequency and frequency class attributes for the vegetation and other terrain features are also included in Table 1. The top five frequency terrain features with a minimum frequency class of III (i.e., present in at least 41% of the plots sampled) for the four disturbance types are listed in Table 2.

DISCUSSION

Species abundance, distribution, and colonization patterns

In general, the vascular plants and other terrain features recorded during this inventory are typical of the study site's alpine location and environment. Where classification to species level was possible, plants recorded are all native, perennial species and most are described as alpine, subalpine, or mountain woodland species. Plant forms were invariably low growing, and many are characterized as cushion or sprawling plants. Shrubs and trees exhibited characteristic krummholz forms found in windy, alpine environments and were limited in distribution to wind protected slopes and depressions. Only nine species were limited to disturbed sites and nine species to undisturbed sites. Thirty species were found in all disturbance types and an additional 26 species were found in at least one undisturbed and one disturbed site. These findings reflect what Chambers (1993 and 1995) referred to as a limited number of viable life histories found in alpine/arctic tundra environments. Contrary to lower elevation and latitude areas, early seral plant species often persist into late seral communities in alpine and arctic areas. This reflects, in part, the low numbers of species with life-history traits adapted for survival and persistence in the extreme tundra environment.

All species found in either undisturbed (Group One) or disturbed (Group Two) terrain were found at relatively low frequency and frequency class indicating they are not abundant, nor are they widely distributed across the study area. Species found in Group One are not favorable for alpine revegetation efforts as they are naturally low in abundance and have not colonized the disturbed sites. However, while Group One species appear to be unfavorable for disturbance colonization from seed, they are potential

Table 1. Species presence, frequency and frequency class by disturbance type[1,2,3]

Species	UD		ND		S		LS	
	%F	FC	%F	FC	%F	FC	%F	FC
1. Species found on undisturbed sites only								
Agoseris glauca var. *dasycephala*	0.09	I						
Aster alpinus ssp. *vierhapperi*	0.25	I						
Carex maritime var. *incurviformi*	0.20	I						
Potentilla hyparctica	0.29	I						
Saxifraga oppositifolia	0.03	I						
Anemone lithophila			0.04	I				
Astragalus alpinus			0.50	I				
Phyllodoce glanduliflora			0.50	I				
Saxifraga lyallii			0.03	I				
2. Species found on disturbed sites only								
Pedicularis bracteosa					0.22	I		
Phacelia sericea					0.03	I		
Picea engelmanni					0.16	I		
Salix commutata					0.70	I		
Salix vestita					0.04	I		
Sibbaldia procumbens					0.39	I		
Campanula uniflora							0.05	I
Epilobium angustifolium					0.31	I	0.57	I
Saxifraga caespitosa ssp. caespitosa					0.21	I	0.38	I
3. Species found on disturbed and near disturbance sites only								
Achillea millefolium			0.50	I	0.20	I	0.14	I
Cassiope tetragona			0.25	I	0.04	I	0.05	I
Salix glauca L.			0.32	I	0.10	I	0.68	I
Stellaria longpipes var. *altocaulis*			0.06	I	0.05	I	0.26	I
Taraxacum ceratophorum			0.04	I	0.03	I	0.57	I
Trisetum spicatum			0.03	I	0.47	I	0.97	I
Oxytropis splendens			0.17	I	0.08	I		
Polygonum bistortoides			0.03	I	0.04	I		
Salix barrattiana			0.31	I	1.41	I		
Draba sp.			0.17	I			0.10	I
Poa sandbergii			0.25	I			0.33	I
Saxifraga cernua			0.33	I			0.14	I
4. Species found on disturbed and undisturbed sites, but not on all levels								
Oxytropis podocarpa	0.37	I			1.75	I		
Potentilla fruiticosa	1.33	I			0.08	I		
Arnica angustifolia ssp. *tomentosa*	1.07	I	0.08	I	0.03	I		
Carex obtusata	4.23	II	3.17	I	0.16	I		
Hedysarum sulphurescens	0.16	I	0.33	I	0.16	I		
Salix arctica	1.69	II	2.57	II	0.12	I		
Senecio Lugens	0.06	I	0.16	I	0.21	I		
Solidago multiradiata	0.25	I	0.96	I	0.12	I		
Cerastium beeringianum	0.04	I	0.17	I			1.17	I
Dodecatheon sp.	0.08	I	0.08	I			0.42	I
Haplopappus lyallii	0.58	I	0.24	I			0.42	I
Kobresia myosuroides	5.35	I	5.19	I			1.39	I
Erigeron compositus	0.08	I			1.24	I	1.75	I
Poa alpina	0.03	I			0.60	I	0.05	I
5. Species found on all levels of disturbed and undisturbed sites								
Agropyron violaceum	0.01	I	0.14	I	0.18	I	0.69	I
Androsace chamaejasme	1.33	II	0.32	I	0.31	I	0.24	I
Antennaria alpina	0.87	II	1.30	II	0.59	I	1.27	II
Carex albo-nigra	3.48	II	4.32	II	1.08	I	2.19	II
Carex phaeocephala	0.18	I	0.77	I	0.37	I	0.42	I
Deschampsia caespitosa ssp. *caespitosa*	0.67	I	0.87	I	0.08	I	1.44	I
Dryas octopetala ssp. *hookeriana*	13.02	III	14.23	III	1.44	II	2.57	I
Erigeron aureus	0.26	I	1.58	I	0.37	I	0.42	I
Festuca brachyphylla	0.23	I	0.63	I	2.32	II	2.34	II
lichen, epipetric	15.56	II	8.89	II	1.04	I	4.44	I
lichen, terricolous	6.72	IV	4.22	IV	0.52	I	2.27	II

Table 1. (continued)

Species	UD		ND		S		LS	
	%F	FC	%F	FC	%F	FC	%F	FC
Luzula spicata	0.17	I	1.27	I	1.41	II	0.42	I
Minuartia sp.	2.12	III	2.38	II	1.71	II	1.67	II
moss	4.65	IV	7.63	IV	10.73	IV	8.99	III
Myostis alpestris	0.03	I	0.33	I	0.03	I	0.33	I
Oxytropis sericea	0.66	I	0.17	I	0.86	I	0.28	I
Poa arctica	0.09	I	0.42	I	0.24	I	1.17	I
Poa pratensis	0.87	I	0.47	I	0.93	II	4.44	III
Poa sp.	0.03	I	0.28	I	0.03	I	4.67	I
Polygonum viviparum	0.79	II	1.63	II	0.71	I	0.28	I
Potentilla diversifolia	5.19	III	8.18	III	3.13	III	10.54	IV
Potentilla nivea	0.56	I	0.16	I	0.29	I	2.81	I
Rumex sp.	0.03	I	0.17	I	0.03	I	0.05	I
Saxifraga bronchialis	0.76	I	10.17	I	0.20	I	0.16	I
Saxifraga nivalis	0.12	I	0.35	I	0.11	I	0.28	I
Sedum lanceolatum	0.18	I	0.16	I	0.07	I	0.14	I
Silene acaulis	1.05	II	0.56	I	0.57	I	0.38	I
Smelowskia calycina	0.28	I	0.5	I	0.65	II	0.42	I
Stellaria monatha	0.45	I	0.76	II	0.34	I	1.39	II
Tolmachevia integrifolia	0.22	I	0.83	I	0.30	I	0.05	I
Total	**44**		**56**		**57**		**48**	
6. Non-vegetative and unknown vegetation								
unknown vegetation	0.18	I	0.08	I	0.44	I	0.42	I
litter	4.86	IV	7.42	IV	2.16	III	4.77	IV
bare ground	1.8	II	1.7	II	6.14	III	1.75	II
gravel/cobble/boulder	14.49	III	8.77	III	51.03	V	26.44	V
cryptogamic soil	1.72	II	0.85	I	0.72	I	0.42	I

[1]Disturbed and undisturbed sites were classified according to levels as follows: UD = undisturbed (15 m from edge of disturbation), ND = near disturbance (5 m from edge of disturbation), S = severe disturbance (removed surface soil/seed bank), LS = less severe disturbance (retained surface soil/seed bank).

[2]%F = frequency in percent, FC = frequency class. See methods section for explanation of frequency and frequency class.

[3]Species authorities sourced from Moss (1994), Hitchcock and Cronquist (1973), MacKinnon et al. (1992), Scotter and Flygare (1993), Gadd (1995) and Vitt et al. (1988).

Table 2. Top five frequency terrain features for disturbance types examined

Undisturbed	Near disturbance	Severe disturbance	Less severe disturbance
gravel/cobble/boulder (14.49%, III)	*Dryas octopetala* (14.23%, III)	gravel/cobble/boulder (51.03%, V)	gravel/cobble/boulder (26.44%, V)
Dryas octopetala (13.02%, III)	gravel/cobble/boulder (8.77%, III)	moss (10.73%, IV)	*Potentilla diversifolia* (10.54%, V)
terricolous lichen (6.72%, IV)	*Potentilla diversifolia* (8.18%, III)	bare ground (6.14%, III)	moss (8.99%, III)
Potentilla diversifolia (5.19%, III)	moss (7.63%, IV)	*Potentilla diversifolia* (3.13, III)	litter (4.77%, IV)
litter (4.86%, IV)	litter (7.42%, IV)	litter (2.16, III)	*Poa pratensis* (4.44%, III)

candidates for reclamation by transplanting if there is interest in increasing species richness and including later seral stage species in primary or secondary successional stage reclamation efforts. Species found in Group Two are also unfavorable for alpine revegetation efforts as they were not recorded in undisturbed (*undisturbed* and *near disturbance*) terrain (i.e., not typical to Plateau Mountain) and are also not abundant or widely dispersed in the disturbed terrain indicating only marginal colonization success.

Species recorded in disturbed terrain (*severe* and *less severe*) only (Group Two), likely colonized by one of several ways: seed rain from non-summit areas; seed rain from rare summit species; or, in *less severe disturbance* areas where the seed bank was retained, germination and propagation from the soil seedbank and propagule pool. Species dispersal from non-summit species is possible due to the extreme winds as well as transport by animals and vehicle traffic. Species dispersal to disturbed areas by rare summit species is also possible as early seral species in alpine environments are often present at lower abundance in later seral stages.

Species found only in the *less severe disturbance* areas are potentially recruited from their relatively intact seedbank and propagule pool that lie dormant until a disturbance instigates germination or propagation. Seedbank and propagule recruitment is quite likely happening in conjunction with seed rain colonization in *less severe disturbance* types on the summit of Plateau Mountain, however it does not dominate colonization. Only one species was found in *less severe disturbance* only (i.e., likely recruited from seed bank). From Group Five, it appears that colonization potential of several species is enhanced by seed bank recruitment. Twenty of the thirty species in Group Five have higher frequency in *less severe* than *severe disturbance* type. However, this difference may also be attributable to the more favorable site conditions found in *less severe disturbances*. The predominance of shrub species in the Group Two *severe disturbance* terrain reflects the nature of the disturbance. The majority of these shrubs were recorded in road ditch disturbance where the extra shelter has allowed shrubs to colonize more readily than in the other, more exposed undisturbed and disturbed terrain locations.

Species included in Groups Three and Four were also found at relatively low frequency and frequency class indicating they are not abundant, nor are they widely distributed across study area. Group Three represents species that were found in disturbed (*severe* and *less severe*) and only *near disturbance* terrain. This group was separated from those found in *undisturbed*, *near disturbance* and disturbed terrain as some of the species likely reflect invasion from disturbed to adjacent, *near disturbance* sites. Several of these species, 7 of 12, have higher frequencies in *disturbed* than *near disturbance* terrain. Species that are likely invading *near disturbance* areas include *Achillea millefolium*, *Taraxacum ceratophorum*, *Oxytropis splendens*, *Draba* sp., *Saxifraga cernua*, *Stellaria longpipes* var. *altocaulis*, and *Trisetum spicatum* which are typically found in disturbed sites, naturally disturbed sites (e.g., river banks, scree, rocky slopes) or dry, gravelly soils. Chambers (1993) has reported that despite lower vegetation cover and species numbers, severely disturbed borrow pits exhibit higher seed rain densities than undisturbed turf vegetation at the same site. Seed production and dispersal from disturbed sites to small-scale disturbances (e.g., cryoturbated soils, small mammal digging) in *near disturbance* areas may in part explain the inventory results.

Contrary to Group Three, Group Four species generally exhibit higher frequency and frequency class in undisturbed (*undisturbed*, *near disturbance*) than disturbed (*severe*, *less severe*) terrain. These data reflect movement of species from undisturbed to disturbed ground.

Group Five, representing species found across all disturbance types (*undisturbed*, *near disturbance*, *severe*, *less severe*) includes the greatest number of species and generally the highest frequency and frequency class values compared to all other groups. Species particularly worth noting include *Potentilla diversifolia* and moss in *severe* and *less severe* disturbances and epipetric lichen, terricolous lichen, *Poa pratensis* and *Poa* sp. in *less severe disturbance*. This pattern of most species occurring in all four disturbance types is to be expected as species found in high abundance (frequency) and widely distributed (frequency class) also appear to be the best natural colonizers of disturbed ground. This again reflects Chambers (1993) findings that early seral plant species often persist into late seral communities in alpine and arctic areas.

Also in Group Five, species frequency was higher in *less severe* than *severe disturbances* for 20 of the 30 species and higher in *less severe* than all other disturbances (*less severe*, *undisturbed* and *near disturbance*) in 11 of the 30 species. This is indicative of more favorable site conditions in *less severe* vs. *severe disturbances* (see next section for discussion) propagation from the seedbank as well as species that are more prominent in early vs. later successional stages. A number of grass and sedge species reflect this early successional stage prominence. Similar tendencies have been previously noted by Rikhari et al. (1993) for alpine areas in other parts of the world where he found that grasses predominate early in secondary succession (*less severe disturbances*) of alpine Himalayan meadows, with sedges increasing thereafter.

Group Six highlights non-vegetative (and unknown vegetation) terrain features recorded during the inventory. As expected, bare ground and gravel/cobble/boulder dominate disturbed sites. However they are notably more predominant in *severe* over *less severe disturbance*, a difference that will be discussed in the following section. Bare ground and gravel/cobble/boulder are also quite prominent on undisturbed (*undisturbed* and *near disturbance*) terrain, a fact that must be considered in conjunction with the disturbed group results as alpine areas are typically rocky and small-scale disturbances are common. The gravel/cobble/boulder component of the *severe disturbances* was generally small gravel and indicative of a poorly vegetated site, while this component of the *less severe disturbances* was generally not indicative of poor vegetative cover or extensive gravel. Litter, most common in undisturbed areas (*undisturbed* and *near disturbance*), is also fairly common in disturbed areas particularly *less severe* disturbed areas. Litter is an important component of vegetation communities as its decomposition provides nutrients to existing and colonizing plants and its abundance increases as part of the natural revegetation process.

Severe vs. less severe disturbance

It is obvious from the results of this study, as well as literature reports, that reclamation success in alpine and arctic areas is greatly enhanced by sites that have retained their surface soil horizons (i.e., *less severe disturbances*). Vegetative ground cover, based on species frequency and observations of the researcher, is considerably higher in *less severe* than *severe disturbances*. This is expected as *less severe disturbances* retain soil nutrient content that is characteristically sparse in alpine environments and beneficial to species colonization as well as the seedbank and propagule pool. This allows for secondary successional processes.

However, the results of this study also indicate that in *severe disturbance* sites, a deficiency of available soil nutrients often favors colonization of nitrogen fixing species which in turn will ameliorate harsh disturbed site characteristics (Bishop and Chapin, 1989; Baig, 1992; Chambers, 1995; Smyth, 1997). Two of the three nitrogen fixing *Oxytropis* sp. (*O. podocarpa* and *O. splendens*) are found in *severe disturbances* only and *Oxytropis sericea* is found in both *severe* and *less severe*, but at a higher frequency in *severe*. This is characteristic of primary successional processes that necessitate a period of site amelioration to more favorable conditions for advanced stages of species colonization and maintenance.

Considerations for exploration, development, production, and interim reclamation

Developed in the 1950s, it is unlikely that gas field exploration, development, production and reclamation on Plateau Mountain underwent the level of environmental assessment that would be undertaken today. While certain measures were consciously taken to limit disturbance to the summit area, it is likely that more could have been incorporated into the planning stages of exploration and development. In addition, interim reclamation measures could have been taken prior to full gas field abandonment to enhance the success and shorten the timeframe of site recovery following abandonment. Several of the measures discussed below apply equally to arctic disturbances as conditions at high elevations, particularly areas of permafrost, tend to be similar to those experienced at high latitudes.

Measures for consideration during the exploration, development, and production and interim reclamation phases of alpine and arctic development include:

1. Limit areas of clearing and grading — Plateau Mountain is a flat, treeless summit that likely did not require the amount of grading that was conducted to construct rights-of-way and facilities. Well site, road, pipeline, and facility design should attempt to incorporate less traditional shapes and sizes to conform more readily with biophysical characteristics of the site while maintaining other technical and safety requirements. Initiate reclamation measures on unused portions of exploration and development disturbances by either allowing for/encouraging natural revegetation or undertaking formal reclamation.
2. Avoid removal of the vegetative and organic mat in areas of permafrost — Disturbance to vegetative and organic layers in areas of permafrost, particularly in arctic areas, has been shown to initiate permafrost degradation and terrain changes in both alpine and arctic areas (Hayhoe and Tarnocai, 1993; Nicholas and Hinkel, 1996; Swanson, 1996). Vegetation in alpine and arctic areas is generally limited to low-growing shrubs and herbs that generally will not interfere with standard construction activities. Where possible, the vegetation mat should be left in place, particularly for temporary disturbances (e.g., pipeline construction). For permanent or long-term disturbances, the vegetative and organic layers could be covered (e.g., geotextile mat, gravel or log cap) for removal post-abandonment.
3. Avoid permanent removal of soil — in areas of temporary disturbance, the soil horizons should be stockpiled and protected from erosion for replacement immediately following disturbance. Weed (i.e., non-native) species invasion on stockpiled soils is generally not an issue in alpine and arctic environments as weeds do not survive more than a few growing seasons. In areas of permanent or long-term disturbance the soil horizons could be left in place and rights-of-way and facilities constructed over top.
4. Avoid or limit disturbance to sensitive features — where possible, exploration and development activities should be planned to avoid sensitive features (e.g., patterned ground, rare plants, and plant communities). Loss of sensitive features may be impossible to mitigate, and as such, are permanent project losses. Under certain circumstances these losses may be considered as significant effects of the project on the environment.
5. Limit the introduction of non-native materials during facility construction — where possible, introduction of non-native materials for right-of-way and facility construction should be limited to minimize the cost of removal during final reclamation.
6. Modify our expectations for site reclamation to correspond with natural processes — natural revegetation in alpine and arctic environments is a slow process (Houle and Babeux, 1994) and the potential for full recovery of these landscapes following human disturbance is questioned by some researchers (Curtin, 1995). Climatic patterns (e.g., global warming) and other environmental conditions are continuously shifting and may no longer be commensurate with pre-disturbance characteristics of the site and existing alpine and arctic tundra vegetation may be in equilibrium with past not present climate (Curtin, 1995; Harper and Kershaw, 1996). Mimicking the natural revegetation processes on

disturbed sites will maximize the potential for site recovery to pre-disturbance or the "new equilibrium" of predisturbance condition. However, the timeframe for achieving pre-disturbance condition may not be synonymous with the time frame for reclamation approval from regulatory agencies.

CONCLUSION

The results from this research project indicate that natural revegetation of abandoned gas field disturbances on the summit of Plateau Mountain has been quite successful in terms of the sites following rather favorable natural successional process (i.e., species presence, expected patterns of primary and secondary succession on *severe* and *less severe disturbances*, overall frequency of vegetative ground cover). Where erosion is not an issue, which includes the majority of the abandoned disturbances, these processes should be allowed to continue without further disturbance. However, the following final reclamation measures could be incorporated into the abandonment plans for existing, used, or eroding abandoned disturbances on the summit of Plateau Mountain, as well as for other alpine and arctic areas:

1. Reclamation Goal — Prior to site reclamation, establish goals that reflect the nature of the disturbance, the needs of the surrounding area and the plans for post-disturbance land use. This should include consideration of erosion control and slope stability, aesthetics, wildlife habitat, recreation, and restoration to the sites original condition.
2. Site Preparation — Re-contour right-of-way and facility disturbances to predisturbance condition. On Plateau Mountain, this would include primarily the existing roadbeds where redistribution of the surface soil horizon across the disturbance (i.e., across ditches and roadbed) would facilitate site recovery. Re-contouring should be conducted to minimize disturbance to natural revegetation processes that are occurring on unused portions of existing right-of-way and facility disturbances (e.g., unused portions of well sites). Consider use of erosion control devices in areas where water erosion may be an issue. Wind erosion, particularly in alpine locations, is a very natural and common process and may be unmitigateable short of establishing a vegetative cover.
3. Surface Preparation — Utilize surface preparation techniques that will alleviate soil compaction, allow for moisture infiltration, reduce near surface wind speeds and provide sheltered micro-sites for seed and propagule entrapment (e.g., rough rip and harrow). However, attempt to find a balance that achieves surface preparation objectives while limiting the potential for wind erosion of the resulting soil texture. Additional measures could be taken to create small-scale surface manipulations that mimic natural conditions (e.g., create small depressions and elevations, use on-site boulder and rock material to provide micro-sites of wind protection, shade, and moisture collection). Addition of soil nutrients (e.g., fertilizer) is generally not recommended during surface preparation as this introduces an unnatural boost of nutrients into characteristically nutrient-starved alpine and arctic environments, potentially enhancing the establishment of non-native (i.e., weed) or invasive native species. However, in areas where topographical features increase the likelihood of water erosion, nutrient addition may be desirable to assist with quick (i.e., one season) establishment of a ground cover crop.
4. Revegetation — Select revegetation techniques carefully to coincide with desired results. As evidenced from this study, and several others in literature, harsh environmental characteristics of alpine and arctic areas limit the number of species that will survive and reproduce over the long-term. For long-term survival of vegetation and recovery to pre-disturbance condition, it is necessary to consider species adapted to alpine and arctic environments. For Plateau Mountain, where introduction of non-native material is prohibited from the Ecological Reserve, this may require onsite collection of seed for distribution to disturbed sites or allowing natural revegetation to take its course. For other alpine and arctic locations native seed, plugs, and seedlings are available from several distributors. In areas where wind and water erosion are an issue and the genetic source of the vegetation is not, revegetation using an aggressive cover crop to minimize erosion may be desirable. This technique limits erosion, adds organic content to the soil and allows for native seed entrapment during the first few seasons following reclamation. As previously discussed, weed species invasion on disturbed sites is generally not an issue in alpine and arctic environments, as weeds are unlikely to survive more than a few growing seasons.
5. Maintenance — Monitor the progression of revegetation, either assisted or natural, following site abandonment and reclamation. Monitoring should continue until goals specified in the reclamation plan are met. In alpine and arctic sites where environmental conditions are characteristically severe, the goal should be to achieve a desired combination of species presence (i.e., native species), progressive ground cover (i.e., increasing ground cover season to season) and levels of erosion comparable to adjacent, undisturbed sites (i.e., wind and water erosion is not counteracting revegetation success). More traditional goals such as soil structure and chemistry and vegetation density will likely not apply. Consultation with regulatory agencies should focus on establishing clear and agreed upon reclamation goals that are appropriate for the conditions of the site and the nature of the disturbance.

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Managing the Green Heritage of Highways Rights-of-Way in Southern Quebec: A New Ecological Landscape Approach

Yves Bédard, Daniel Trottier, Luc Bélanger, Jean-Pierre Bourassa, Nancy Champagne, José Gérin-Lajoie, Gaston Lacroix, and Esther Lévesque

The Ministère des Transports du Québec maintains 2000 km of highway corridors scattered throughout southern Québec (Canada). Traditional methods of controlling vegetation along these highways result in a boring landscape, deteriorate the various wildlife habitats and impoverish wild plant life while generating high maintenance costs. Recently, it has been preferred to develop new maintenance methods that improve the safety of the highway system's users, satisfy neighboring residents, beautify the landscape and consider the plant life and wildlife present along the highways. The new approach eliminates systematic multiple annual mowing, except on the first two meters from the pavement, where maintenance will even be accentuated (four or five mowings per year) to ensure highway safety (visibility) and better control of ragweed (*Ambrosia artémisiifolia*), a noxious allergenic plant. Since 1998, three different highway sections have served as experimental sites for a three-year period to assess biodiversity benefits as well as road user's perceptions. These sites are located in three fragmented landscapes, one partially forested, another agricultural and the other suburban. The objective is to compare the experimental sites where the new approach is used with sections where the traditional way of management is maintained. The benefit on the plant and animal diversity, on the quality of the habitats of the new approach is evaluated herein after one year (1999). Preliminary results indicate that the plant diversity is minimal in the agriculturally intensive zone compared to the partially forested zone and the suburban zone. The roadside habitat near forests appears with the highest animal diversity (insects, small mammals, and birds) followed by suburban and agricultural sites. After this first year of monitoring, the results suggest, however, no differences have yet to appear in both animal and plant abundance and diversity between the new approach and the traditional way of managing roadside vegetation along highways in southern Québec.

Keywords: Vegetation, management, rights-of-way, landscape

INTRODUCTION

The Ministère des Transports du Québec (MTQ thereafter) maintains 2000 km of highway corridors scattered throughout southern Québec. Traditional methods of controlling vegetation along highways result in a less-than-exciting landscape, deteriorate the various wildlife habitats and impoverish wild plant life while generating high maintenance costs. The MTQ has thus preferred to develop according to information provided in recent literature related to landscape and road ecology (Drake and Kirchner, 1987; Noss, 1991; Bennet, 1991, 1992; Jaarsa and Langevelde, 1997; Farmar-Bowers, 1997), new maintenance methods that improve the safety of the highway system, satisfy neighbouring residents, beautify the landscape and enhance the plant life and wildlife present along the highways. Until now, the traditional method for the ecological management of highways has been multiple annual mowing, from the edge of the asphalt-covered pavement to the property line. In rural areas, two or three mowings per year were required, while in urban areas, three or four mowings were necessary each year, sometimes more.

Environmental Concerns in Rights-of-Way Management: Seventh International Symposium
J.W. Goodrich-Mahoney, D.F. Mutrie and C.A. Guild (editors)

The new approach eliminates systematic multi-annual mowing, except on the first two metres from the pavement, where the frequency will even be increased (four or five mowings per year) to ensure highway safety (visibility) and better control of ragweed, a noxious, allergenic plant. The new approach will consist of allowing the local plant life to flourish, thereby providing motorists with a more beautiful and diversified landscape. Only periodic cutting (in late autumn of each year or every two to three years, depending on the results of experimentation in progress; see below) will be used to control the growth of certain woody plants that can endanger the safety of highway users. Details regarding this method of management are presented in Table 1 and in Fig. 1.

This approach is based on experiences elsewhere, particularly in Ontario (Canada), in some US states, Netherlands, England, and in France (Way, 1977; Laursen, 1981; Warner, 1992; Camp and Best 1993a, 1993b; Bekker, 1995; Meunier et al., 1999a, 1999b, 2000). It also originated at the 5th *International Symposium on Environmental Concerns in Right-of-Way Management* held in Montréal in 1993, where the outcome of studies carried out in Southern France on the extensive management of roadside vegetation were presented. Some time later, some reference documents were drafted (Anonyme, 1994; Coumol and Chavaren, 1995). This information served as the foundation for developing the MTQ's project. A mission to France was then organized to find out how these new practices were implemented in this country and to learn about the major constraints encountered (Y. Bédard, MTQ, personal comm.).

The most important lesson drawn from this mission is that, even though ecologically and scientifically speaking, the benefits of this new management method appear obvious, its social approval is far from being won, and ignoring this aspect could be detrimental to the project. It is important, then, to understand from the outset that highway corridors benefit from a high degree of visibility and that they are part of many people's everyday reality. In addition, such people have their own viewpoint on plant maintenance that is not necessarily in keeping with that being proposed. Based on this observation, the MTQ has directed its approach as follows: (1) conduct public awareness campaigns, targeting the various sectors of the population, on the objectives and advantages of such new management methods, (2) conduct an experimental pilot project in different regions aiming to respond to public awareness, and (3) provide scientific documentation on the results of experimental sections of the highways. When these three stages have been accomplished, the MTQ should be able to develop the standards for maintaining vegetation, taking into account the following concerns: the surrounding landscape, wildlife habitats, biodiversity, wildlife hazards (Oxley et al., 1979) or other associated impacts (Reijnen and Foppen, 1994a, 1994b), highway safety (Bellis and Grave, 1971; Ferris, 1979), and economical factors.

The management standards shall be adaptable to the specific conditions of each region or landscape crossed in order to optimize the positive impacts. Savings generated by fewer mowings will be reinvested in part for new landscapings and their maintenance, as well as the planting of shrubs and trees along highway rights-of-way. In addition to having a positive impact on the landscape, tree planting will play a positive role in carbon dioxide fixation in order to reduce harmful effects of climate change. Objectives of this paper are to present the results of the first year of monitoring that aims at evaluating the overall biodiversity values of rights-of-way in southern Québec and comparing over the three-year period, the experimental sites where the new approach is being used with other sites still managed with the traditional method. The benefits of the new approach on plant and animal diversity and on the quality of the habitats will then be evaluated.

METHODS (EXPERIMENTAL DESIGN)

In 1998, three experimental stretches of roads varying in length from 3 to 7 km were established in different landscape settings, as follows: Partially forested (along highway A-40, Donnacona), Agricultural (along highway A-20, St-Hyacinthe), and Suburban (along highway A-573, Québec City). These stretches of roads were clearly identified by signs announcing the experimental project. Started in 1998 and originally slated for three years, the project was extended to five years, considering that the scientific monitoring was begun only in 1999 regarding the biological aspects and in 2000 for the visual impact (see Discussion).

Plant and animal communities are currently being monitored by specialists from the Université du Québec à Trois-Rivières and the Canadian Wildlife Service (Environment Canada). For flora, special attention will be given to the specific composition, the height and the proliferation of harmful species. For fauna, the specialists will be monitoring the bird population, small mammals, amphibians, reptiles and insects. Just like the plant species, special attention will be paid to any species that could be harmful to human and particularly to farmlands according to information provided by the existing literature (Bellis and Grave, 1971; Perris, 1979; Oxley et al., 1974). A follow-up on road kills will be carried out to assess the impact of the new method of managing roadside vegetation on the number of animal deaths.

RESULTS AND DISCUSSION

After the first summer (1999) of intensive plant and animal sampling, some interesting facts came to light.

Table 1. Summary of the new approach for using and managing roadside vegetation

Vegetation management	1 Middle ditch	2 Inner slope	3, 4 Green shoulder	5 Outer slope	6 Side ditch	7 Embankment
Existing situation	• Generally wet environment • High vegetation • Periodic mowing • Occasional digging	• Moderately drained environment • Low herbaceous vegetation • Periodic mowing	• Meadows • Annuals adapted to a dry, impoverished environment (e.g. ragweed) • Periodic mowing	• Moderately drained • Low herbaceous vegetation • Periodic mowing	• Wet environment • High vegetation (sometimes shrubby) • Cutting (variable) • Occasional digging	• Natural environment • Highly variable vegetation and maintenance
Proposals for managing green sections	• No maintenance (ditch shaded by shrubs) except for selective cutting every 10 years • Ditch cleaning using "lower third" method**	• Control of woody plants to maintain a high grassland (every 2 or 3 years) • Planting of shrubs to form hedges	• Mowing 4 times/yr (closer to soil)	• Control of woody plants to maintain high grassland (every 2 or 3 years)	• No cutting • Development of shrubby ground cover • Ditch cleaning using "lower third" method	• No maintenance • Development of fallow land • Planting • A certain control of vegetation to maintain visual openings
			Impact of ecological management			
Ecological	• Creation of habitats for microfauna • Diversification of vegetation • Ecological filter	• Diversification of plant and animal species • Diversification of habitats	• Better control of ragweed	• Diversification of plant and animal species • Diversification of habitats • More valued fauna compared to zone 2	• Diversification of plant and animal species • Diversification of habitats • Protection of aquatic milieus • Ecological filter	• Defragmentation of riparian habitats • Development of an ecotone • Diversification of plant and animal species • Diversification of habitats
Landscape	• Integration in landscape	• Makes for a more interesting landscape according to different flowering times • Diversifies the landscape with local variation in plant species	• Transitional zone between road and zones 2 and 5 • Visual showcasing of meadow	• Ensures a visual continuity between zone 7 and the road • Makes for a more interesting landscape according to different flowering times • Diversifies the landscape with local variation in plant species	• Integration with the landscape	• Visual harmonization of the road with surrounding landscape • Structuring of the landscape as perceived by motorists
Economic	• Lower cleaning costs due to decrease in peat formation • Decrease in extent of excavation due to use of "lower third" method	• Lower cutting costs • Investment necessary for planting	• Higher costs compared to current frequency of mowing	• Lower cutting costs	• Lower cleaning costs due to decrease in peat formation • Decrease in extent of excavation due to use of "lower third" method	• Lower cutting costs • Decreased cost of maintaining fences when shaded by forest cover • Investment necessary for planting

Table 1. (continued)

Vegetation management	1 Middle ditch	2 Inner slope	3, 4 Green shoulder	5 Outer slope	6 Side ditch	7 Embankment
Safety	• Partial reduction in night glare for motorists	• Partial reduction in night glare for motorists • Snowtrap effect • Slowing of vehicles that lose control (skidding) • Increase motorists' attention	• Plainer view of guideposts and road signs	• Snowtrap effect • Slows skidding vehicles • Increase motorists' attention	• Snowtrap effect	• Snowtrap effect

*These sections are referred to in Fig. 1.
**Maintenance method not affecting vegetation alongside ditches.

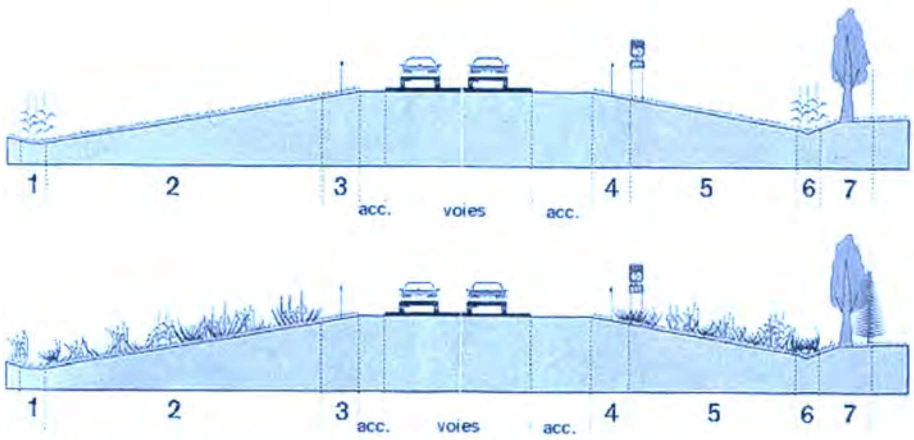


Fig. 1. Different highway areas regarding vegetation management, southern Québec.

Preliminary results of vegetation studies suggest that plant diversity is lower in the agriculturally intensive zone (187 species) compared to the partially forested zone (225 species) and the suburban zone (193 species) (Table 2). Such differences may reflect the influence of adjacent vegetation and the past mowing history of the site. For each zone, the sites with the highest frequency of mowing had the lowest plant diversity (Table 2). To evaluate the distribution and abundance of an aggressive species of reed-grass (*Phragmites communis*) a parallel study is being conducted. Water availability seems to play an important role on the height of these plants whereas adjacent habitats and the frequency of mowing seem to influence its distribution. The species is widespread in agricultural habitats and only scattered in the two other regions (Table 3). These patches will be monitored throughout the study to evaluate colonization rate.

The faunal composition of the three study sites has been evaluated. The results after the first year reveal a moderate diversity of insect groups, although a greater abundance within some of these groups such as Coleoptera, Collembola, and Hymenoptera (Fig. 2). The roadside habitats near forests appear to have the best insect diversity, followed by suburban and farming sites. Higher densities of insects were observed in late summer and that, for each study site (Fig. 3). Small mammals were also studied and findings show the highest diversity near forested habitats. Amphibians and reptiles seem to be rare in the agricultural landscape. The program of preservation of fragmented habitats will probably help creating corridor effects sustaining an animal life that is more diversified and less exposed to road influences.

Finally, observations of the bird community indicate that rights-of-way on farming sites were used by less species but by a greater number of individuals compared to other sites (Table 4). In the forested landscape, 51 different species were monitored compared to 25 species in the agricultural sites and 33 in the suburban one. In addition, there were fewer individuals and species observed in the highway corridor (all sites combined) than in the adjacent zone (51 species and 4271 individuals compared to 40 species

Table 2. General site characteristics and overall plant diversity based on 1999 vegetation sampling. Species were identified in permanent 1 m^2 quadrants ($n = 120$–150 per site) as well as in large scale surveys along 250 m stretch of the highway right-of-way located in southern Québec and totaling more than 2 km per site

	Agricultural	Partially forested	Suburban
Species richness	187	225	193
Number of plant families	47	52	41
Most frequent species			
	Festuca rubra	*Vicia cracca*	*Agropyron repens*
	Phragmites communis	*Poa pratensis*	*Agrostis alba*
	Poa pratensis	*Taraxacum officinale*	*Taraxacum officinale*
	Vicia cracca	*Agropyron repens*	*Vicia cracca*
	Taraxacum officinale	*Agrostis alba*	*Poa pratensis*

Table 3. Abundance, density and size of Phragmites communities in 1999 within the three experimental sites of the pilot project along highway rights-of-way in southern Québec

	Agricultural	Partially forested	Suburban
Number of colonies	Continuous	3	10
Size of colonies (m^2), $x \pm$ SE	n/a	94 ± 33	32 ± 19
Linear proportion of right-of-way occupied by phragmites	66.7%	0.8%	1.3%
Density (shoot/m^2), $x \pm$ SE	118 ± 8	94 ± 24	78 ± 19
Maximum height (m), $x \pm$ SE	0.88 ± 0.08	1.98 ± 0.41	1.78 ± 0.18

and 1497 individuals, respectively). After the first year of monitoring, the results suggest no differences in the abundance and diversity of the bird community between the new approach and the traditional management method; the number of species varied from 34 to 49 whereas the total of number of individuals recorded ranged from 1160 to 1578 with no apparent relationship to mowing frequencies. Over the next two years, the quality of the habitats will probably increase in the three sites leading, in particular, to a greater diversity of plants and animals. In case of road-killed animals, sample size was too small to allow any statistical comparison.

The Chair of Landscaping and Environment at Université de Montréal received in 1999 the mandate to monitor the evolution and transformation of the landscape along the three experimental sections over the next three years. The follow-up will be performed using photographic surveys taken from different viewpoints and at different times of the year. The photographs will be used as a basis for the visual analysis. Interviews will also be carried out to find out how road users view the approach. The data from the flora monitoring and its changing situation will be used to predict the future changes in the landscape. No result are available on this aspect of the project.

CONCLUSION

Preliminary results of this study have shown that the value of rights-of-way along southern Québec's highways varied depending on the landscape type where they were located as observed by Meunier et al. (1999a,b, 2000). However, after one year of monitoring, there was no evidence yet of differences in plant and animal abundance or diversity between newly managed and traditionnaly managed studied rights-of-way. We believe, however, that over the next two years, the quality of the habitats will probably increase in the three sites leading, in particular, to a greater diversity of plants and animals as it has been noticed elsewhere in similar experiments (Oetting and Cassel, 1971; Page and Cassel, 1971; Way, 1977; Voorhees and Cassel, 1980; Laursen, 1981; Warner, 1992; Camp and Best, 1993a,b; Bekker, 1995). New way of ecologically managing roadside vegetation along southern Québec's highways should therefore help foster a greater biodiversity of wildlife habitats along roadsides and reduce their defragmentation, enhance the landscape, generate savings, boost highway safety, and in so doing contribute in a certain way to sustainable development. Influence on animal road-kills frequencies still have to be assessed to determine if newly managed areas could act as an ecological trap.

The final data from this monitoring study will be made available in 2002 as regards the biological aspects, and in 2003 for the visual landscaping aspects. We will then be in a position to illustrate the many advantages of this new approach to maintaining highway rights-of-way. Presently, preliminary results at least do not point out any particular drawbacks, only potential benefits. Regarding the landscape, the effect was remarkable right from the first year of implementation, when the wildflowers were left to bloom freely.

As to the communications aspect, much effort has been spent to reach the various groups of the population, mainly those affected by the pilot projects.

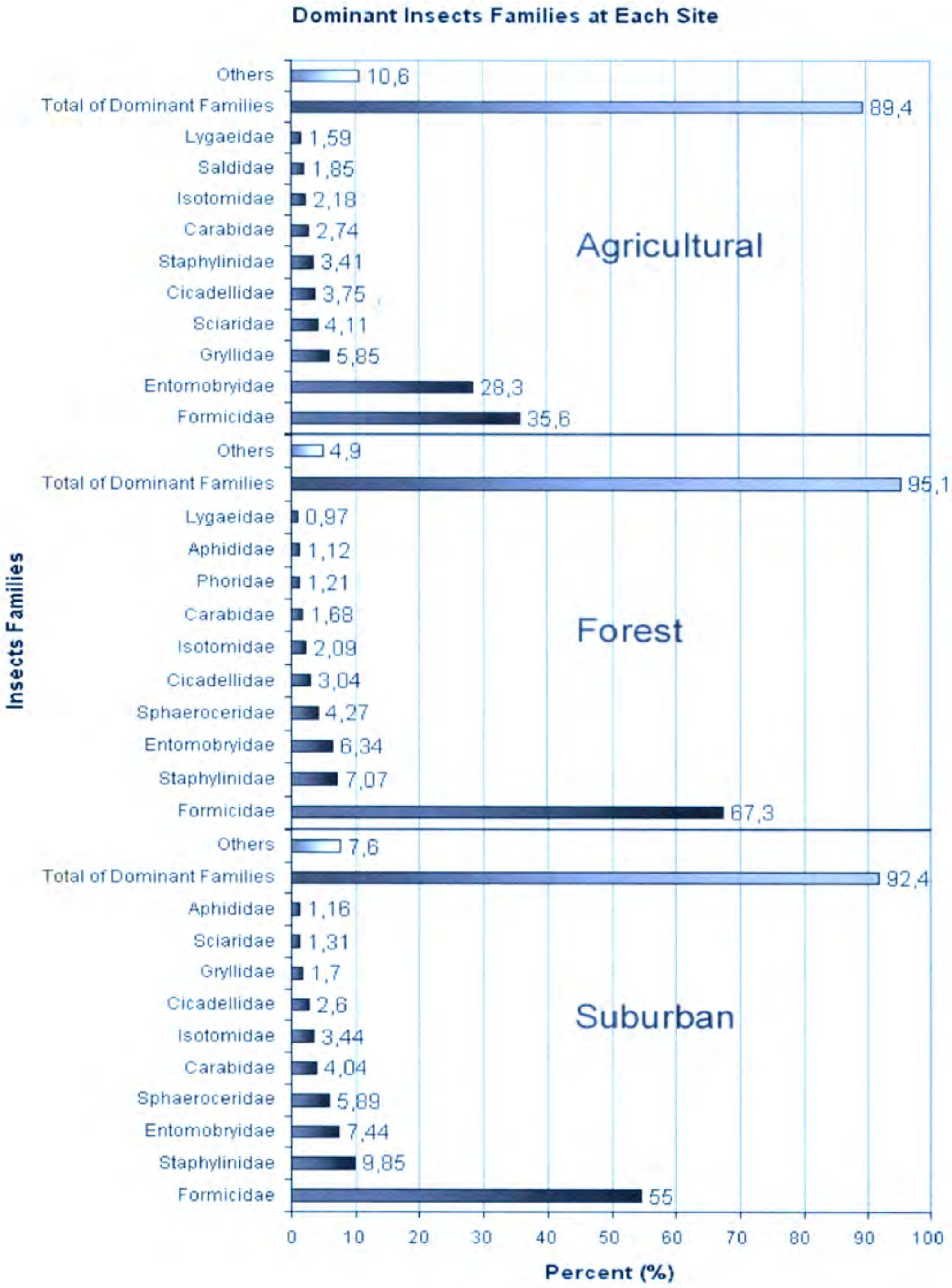
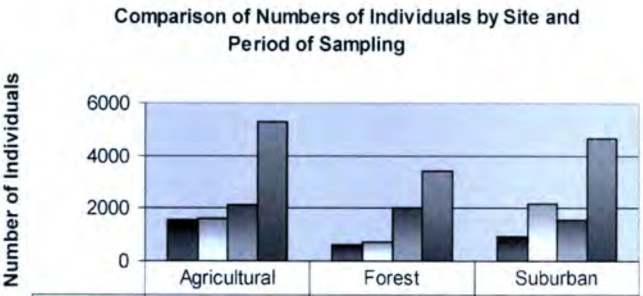


Fig. 2. Dominant insect families at each study site along highway rights-of-way, southern Québec.

Table 4. Overall bird abundance and diversity based on 1999 transect surveys along experimental stretches of highway rights-of-way, southern Québec

	Agricultural	Partially forested	Suburban
Species richness (total no. of species recorded)	25	51	33
Bird abundance (total no. of individuals recorded)	2828	1513	1473
Survey effort (total no. of bird surveys per study site)	9	9	9



	Agricultural	Forest	Suburban
May-June	1549	625	924
June-July	1602	726	2154
August	2133	2042	1572
Total	5284	3393	4650

Fig. 3. Comparison of numbers of insects by study site and period of sampling, along highway rights-of-way, southern Québec.

People from the MTQ met with groups representing farmers, municipalities and various interest groups to inform them of the objectives sought by the pilot project. The employee groups of the MTQ were also informed, both as regards senior management and the maintenance teams in the various regions. Although overall the methods were met with approval, this new method has generated much apprehension; however, the pilot project should dispel these concerns. As regards the general public, several television and radio shows were produced, and a folder and many articles appeared in newspapers and magazines. A second wave of public awareness campaigns is expected to take place when the new method will be applied on a larger scale. To date, the bulk of public opinion has been very positive and often quite enthusiastic, to such an extent that many regions have been prompted by public pressure to manage certain stretches of highway in accordance with the new methods proposed.

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Roadside Vegetation Management on Québec's Highways: A Visual Landscape Monitoring Research Project

Philippe Poullaouec-Gonidec, Gérald Domon, Sylvain Paquette, and Christiane Montpetit

Inspired by ecological, economical, landscape, and security concerns, the ministère des Transports du Québec recently initiated an alternative method to manage highway roadside vegetation. This method uses differential mowing to allow natural regeneration along three experimental corridors. As a part of an overall monitoring program, this landscape monitoring research attempts: (1) to characterize the landscapes generated by this new management in order to assess the changing visual experience and the users' perceptions; (2) to evaluate the achievement of the project's objectives (visual diversity, integration, etc.), and, finally, (3) to provide recommendations for improvement. This paper presents the original methodology developed to attain these goals. First, key viewpoints are selected using a two-step visual inventory. Using GIS, potential observation areas are identified based on typical situations derived from the highway layout, slope, viewshed and land use characteristics. These key viewpoints are then precisely located from a systematic visual analysis. Second, diverse mediums (panoramic photographs, videotapes) monitor the roadside vegetation changes (2000–2002) affecting visual experience. In addition to expert analysis, open-ended questions and *in visu* semantic scale tests produce a qualitative evaluation of highway users' attitudes. This evaluation explores overall landscape experiences, how roadside vegetation characteristics improve driving enjoyment and affect users' preferences.

Keywords: Aesthetic, landscape monitoring, Québec, roadside vegetation, user's perception

INTRODUCTION

This landscape monitoring research project is situated at the junction of two processes. On the one hand, the ministère des Transports du Québec (MTQ) recently initiated an alternative method to manage highway roadside vegetation reflecting ecological, economical, landscape, and security concerns. On three experimental highway corridors (Fig. 1), each representative of distinct highway contexts (forest, agriculture, and peri-urban areas), this method uses differential mowing to allow the natural regeneration of vegetation. From this perspective, the MTQ pursues landscape objectives (e.g., harmony, integration with surrounding context, etc.) for which landscape monitoring is necessary to characterize and assess vegetation changes that affect visual, aesthetic and sensory qualities. On the other hand, the Chaire en paysage et environnement de l'Université de Montréal (CPEUM) has already developed a general landscape monitoring framework in order to facilitate decision-making processes (Poullaouec-Gonidec and Domon, 1999). Within this context, the integrated roadside vegetation management project constitutes a unique opportunity to improve this framework and develop new tools for landscape management.

This visual landscape monitoring research pursues a three-fold objective. It attempts: (1) to characterize the landscape experience generated by the new vegetation management in order to assess the changes

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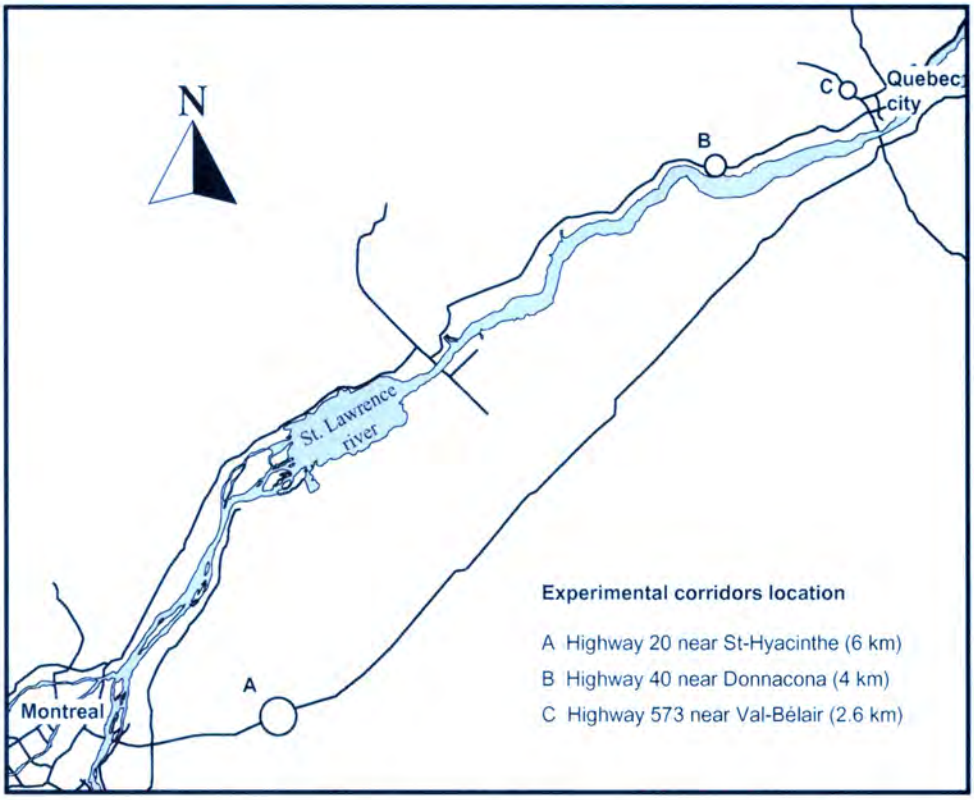

Fig. 1. Location of the three experimental highway roadside vegetation management projects in Québec (Canada).

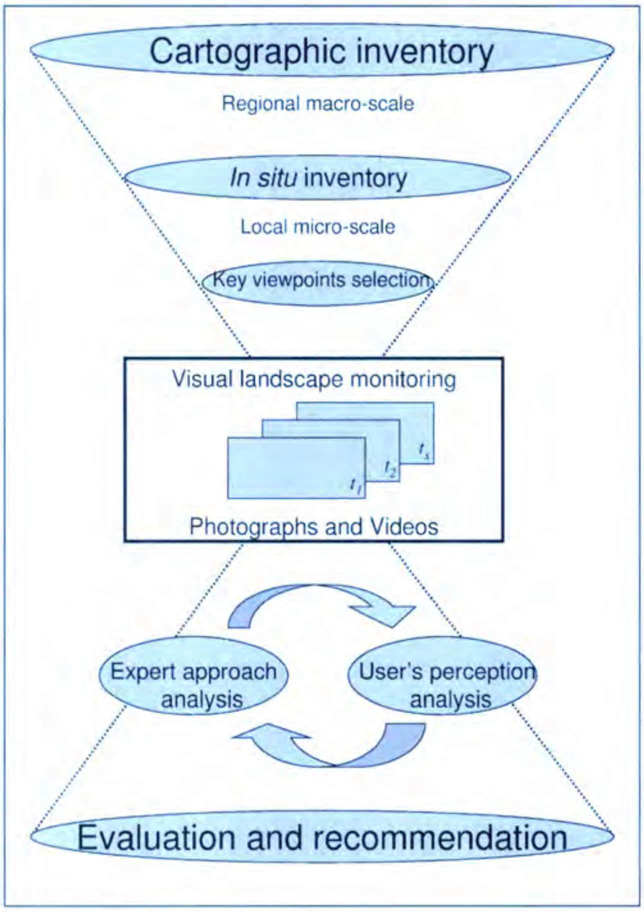

Fig. 2. Visual landscape monitoring research design.

in visual experience (expert approach) and the users' perceptions; (2) to evaluate the achievement of the experimental project's objectives (visual diversity, integration, etc.). Finally, this research endeavors to (3) develop a visual landscape monitoring system which includes the methodological strategy retained, recommendations for improvement and a didactic multimedia tool for results divulging and heightening public awareness. To successfully fulfil these objectives, it is imperative to develop innovative monitoring strategies adapted to the characteristics of the new vegetation management program.

In this way, the current paper gives particular attention to the original methodology developed that integrates the expert as well as the user's perception approaches (Fig. 2). Thus, it successively presents the key viewpoint selection strategy put forward and the landscape monitoring program conditions. It then gives an overview of the way visible landscape changes generated by the new roadside vegetation management are analyzed as well as the methodological design used to assess perceived landscape transformations from the highway users' perspectives.

METHODOLOGICAL FRAMEWORK

Landscape characterization and evaluation methodological approaches are numerous and diverse (Zube et al., 1982; Domon et al., 1997). Even if four groups of conceptual positions or paradigms can be distinguished (expert, cognitive, psychophysic, and experiential), the respective contribution of each of them is recognized and the combination of different approaches necessary (Smardon et al., 1986). However valuable, this combination of approaches is, in fact, rarely put into practice. By revealing and characterizing highway landscape on the basis of the visual landscape transformation (expert approach) and the user's perception, this research specifically aims to adopt such an integrated approach. In this manner, it constitutes a new and original methodological contribution.

Key viewpoints selection

Visual inventory methods generally help to provide a relatively exhaustive portrait of the visible landscape features. In the specific context of highway rights-of-way, landscapes scenes that could be monitored are nearly unlimited given that highway user are continuously in motion. Under such conditions, it is necessary to develop strategies capable of identifying and pointing out landscape situations that constitute a significant visual experience for the highway users. The cartographic inventory and the *in situ* visual inventory presented in the next sections attempts to precisely identify such significant key viewpoints.

Cartographic inventory

The contribution of cartographic and geographical information systems (GIS) for visual and landscape characterization studies is well recognized (Bishop and Hulse, 1994; Pâquet et al., 1994). Used at a preliminary stage of the visual inventory in this project, GIS tools provided a cartographic synthesis of the potential observation areas. Given this context, the cartographic inventory represents a determining methodological step considering that the MTQ intends to generalize the new roadside vegetation management to the whole of Québec's highway network.

Based on the highway visual experience described by many authors (Tunnard and Pushkarev, 1963; Appleyard et al., 1964), some visual effects appear to act more strongly on the driver's visual attention. Among these, horizontal curves, upgrade or downgrade slopes, lateral enclosures or visual openings are of special interest. Some of them appear to modify the driver's visual experience by bringing more roadside into view (e.g., horizontal curve, upgrade slope, etc.) while others seem to contribute to focus the highway user's visual attention on the surrounding landscape (downgrade slope, lateral openings, etc.).

In order to bring out these visual effects, the cartographic inventory attempts to institute a preliminary characterization of the experimental highway corridors on the basis of the highway layout, slope, land use, and viewshed (Fig. 3). Elevation, hydrographic, and highway network information provided from the

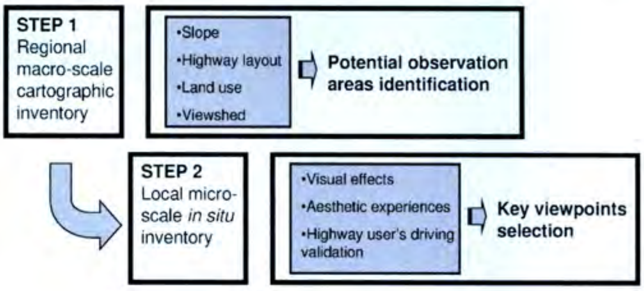

Fig. 3. Two step visual inventory.

1:20,000 scale cartographic database of the ministère des Ressources Naturelles du Québec is processed with Map Info (Version 4.1) and Vertical Mapper (Version 2.5) software. Land use is interpreted using 1:40,000 scale black and white aerial photographs (1994). The land use classification includes five categories: forest, open land, abandoned land, urban land, and hydrographic network. Based on the elevation data, potential views are spatially delimited for each experimental site using the Vertical Mapper (V.2.5) viewshed analysis tool. To do this, a multiple viewshed analysis is performed at an observation height of 1.2 m (corresponding to the car driver's vision) at points scattered along the highway corridor. As suggested by Pâquet et al. (1994), 500 m separates each point, a distance corresponding approximately to the foreground length. The resulting visibility frequency derives from a multiple viewshed area overlay. Thus, a cartographic synthesis resulting from topographic (Fig. 4), viewshed (Fig. 5), highway layout, and land use characteristics (Fig. 6) helps to identify potential observation areas. Ultimately, this cartographic inventory attempts to single out typical situations which appear to direct visual attention on the roadside vegetation or on the surrounding landscape. The following *in situ* visual inventory provides a more detailed examination of these situations.

In situ visual inventory

Before the selection of definitive key viewpoints, an *in situ* visual analysis is completed for each experimental highway corridor. While it contributes to the validation of visual effects identified at the cartographic inventory stage, this two-way inventory allows the identification of visually significant scenes (Fig. 3). A five step *en route* methodological strategy composes this analysis, with a multidisciplinary team of four experts participating in each of the stages. An overview of the visual experience perceived when driving through the highway experimental corridor is first obtained in order to formulate general impressions of the roadside as well as the surrounding area. Second, a low speed (10 km/h) tour allows to exhaustively describe all visual sequences (curves, visual corridors, lateral openings, etc.) and roadside elements (roadsigns, pylons, vegetation, buildings, etc.) which

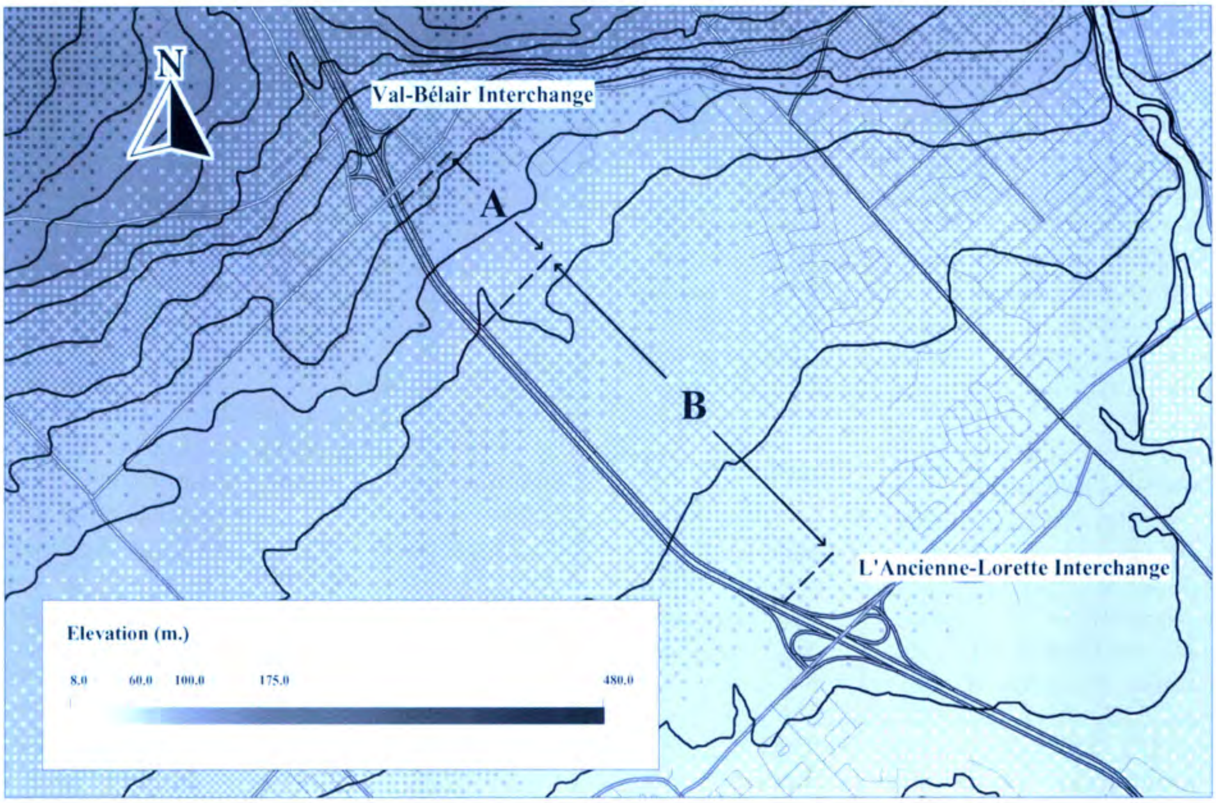

Fig. 4. Topographical situations along the Highway 573 experimental site (1:20,000). Highway section A corresponds to steeper slope (85–100 m) than section B (65–80 m).

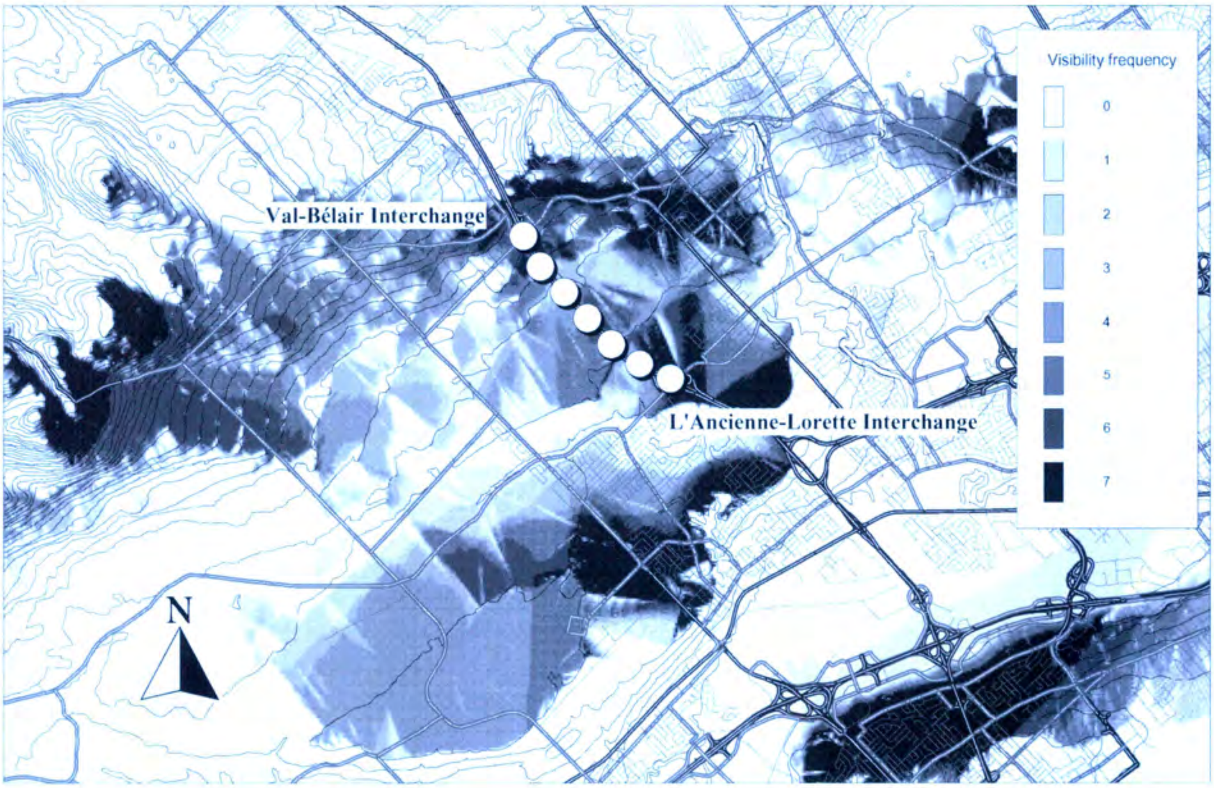

Fig. 5. Viewshed delimitation calculated from seven points scattered along the Highway 573 experimental corridor (1:20,000).

Fig. 6. Land use and highway layout of the Highway 573 experimental corridor (1:20,000). A and B sectors indicate anticipated curve effects.

capture the user's visual attention. At this stage, potential viewpoints are selected. A detailed visual analysis grid (characterization of the foreground, the middle ground and the background, landmark identification, rupture element, etc.) is completed to describe each viewpoint. A 100 km/h tour in the right lane of the experimental corridor that corresponds to a highway driving situation is then done to validate and, if necessary correct the key viewpoints selected. At this stage, a set of key viewpoints situated 60 cm into the highway's right shoulder as well as a set of complementary observation points (lateral angle views and contextual observation points) is identified (Fig. 7). For the purpose of this monitoring program, a total of 28 key viewpoints were selected. Finally, panoramic frontal view photographs and right lane frontal videos tracking (at 100 km/h) are used to document these key viewpoints and the highway experimental corridors in driving situations.

Landscape monitoring

Following examples of visual monitoring initiated particularly in France ("Observatoire photographique du paysage," ministère de l'Environnement, 1996), this visual landscape monitoring survey is based on a set of precise technical conditions which are strictly observed. The observation mediums and the technical monitoring conditions within these specifications are briefly described hereafter.

Documenting landscape changes over time

Color panoramic photographs (120–180°) obtained through QuickTime Software (Apple Computer Inc., 1997) constitutes the main observation medium upon which the monitoring project is founded. When integrated with QuickTime technology, the options given by these multiple shot panoramic photographs provide a visual field that is close to the *in situ* visual experience of the highway user. Moreover, considering the new possibilities resulting from multimedia systems, panoramic photographs provide more flexibility for analyses related either to the expert approach (visual monitoring) or to the user's perception data (e.g., preference tests).

For all monitoring projects, the initial conditions are of particular importance. These conditions must be strictly observed during the entire monitoring period in order to evaluate and analyze the observed phenomenon changes with the same accuracy. Thus, the photographic shot series (180°-view angle) for each of the key viewpoints selected and precisely identified on the shoulder's highway is taken with consistent optical height, lens format and orientation angle (Fig. 8). Particular photographic shooting conditions (weather, traffic conditions, etc) are also noted. As previously mentioned, scanned images are added using the QuickTime system. Panoramas created for each key viewpoint are used for further analysis (expert and user's perception approach). During the first monitoring year, photographic shots are taken every two

Fig. 7. Key viewpoint illustration of (a) a curve situation; (b) a lateral wooded screen situation; (c) a background predominance view, and (d) a wide-open view (Highway 20 near St-Hyacinthe).

weeks from May to October 2000 and once a month during the winter. If necessary, the photographic shot frequency for the second and the third monitoring years will be adjusted on the basis of the first year's (2000) roadside vegetation changes examination.

Unlike the panoramic photographs that capture fixed images, the frontal oriented video allows for movement, a condition that remains specific to the highway driving visual experience. Although video technology scans a relatively narrow visual field compared to standard driving conditions, it nevertheless provides more flexible manipulation possibilities in the context of recreating similar highway driving situation under laboratory conditions (Mertes et al., 1991). Moreover, many studies take advantage of the video technology at the user's perception level of evaluation (Craik, 1975; Evans and Woods, 1980; Feimer, 1984). From this perspective, video sequences are recognized for soliciting a wide range of individual interpretations (Bishop and Hulse, 1994) when compared to standard photographs. Thus, in addition to the photographic monitoring, frontal oriented video trackings

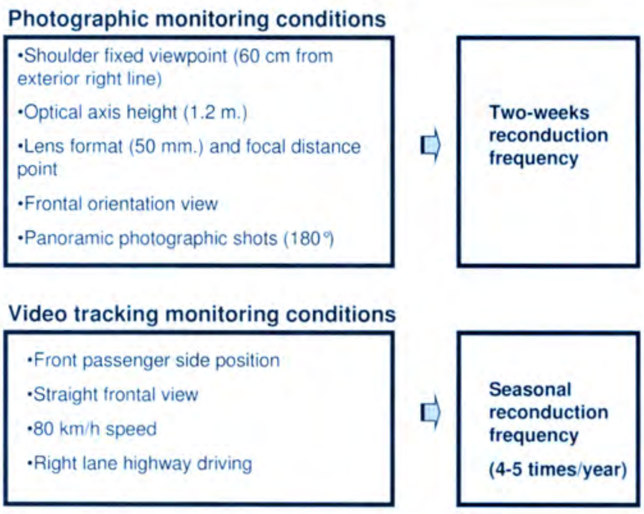

Fig. 8. Visual landscape monitoring conditions.

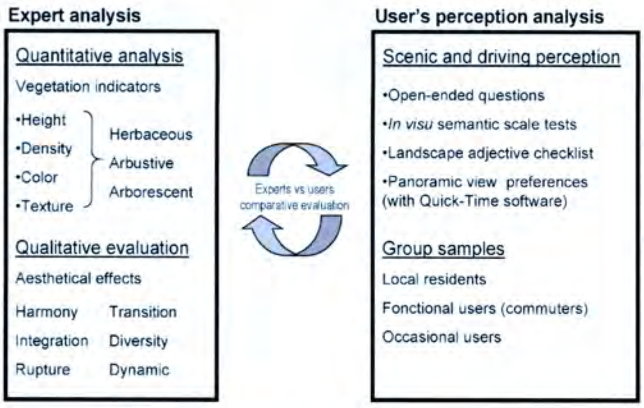

Fig. 9. Expert and user's perception analysis frameworks.

taken from the highway's right lane are seasonally documented in order to monitor the visual experience in movement (Fig. 8).

Analyzing landscape changes

As previously mentioned, landscape transformation analysis performed on the monitoring visual documentation collected is based on a combination of two distinct but complementary conceptual strategies: namely, the expert approach and the users' perceptions analysis.

Expert approach

From the expert perspective, three distinct image analyses are proposed (Fig. 9). A preliminary quantitative characterization of the roadside vegetation which affects the visual experience (height, density, color, texture related to each vegetation stage) is accomplished. Then, a qualitative reading of the visual changes bring out the aesthetic quality and the sensory nature of the changing landscapes. This qualitative evaluation is particularly useful to compare the expert approach evaluation with the aesthetic preferences observed from the user's perception analysis (see next section). On the basis of these complementary analyses, the achievement of the MTQ's landscape related objectives (visual diversity, integration, harmony, etc.) is assessed. The originally proposed landscape objective criteria are subjected to modifications or additions as the monitoring project advances and the user's perception results follow.

Furthermore, given the large amount of photographs resulting from the current monitoring project (more than 500 panoramic photographs per year), a semi-automatic image analysis system will be explored on an experimental basis. Such a system, derived from the development of content-based image retrieval systems (Nastar et al., 1998), would allow to classify and index, as well as perform multiple queries on the iconographic database (photographs and videos). This system would allow comparisons and contrasts based on quantitative as well as qualitative visual characteristics that contributed to the highway landscape's evolution.

Highway user's perception approach

The originality of this visual landscape monitoring research lies in its intent to integrate the expert approach as well as the user's landscape perception analysis. In this context, the landscape perception evaluation aims specifically: (1) to reveal dimensions (ecological, aesthetic, or functional) which appear to mark the users' overall experiences of the highway corridors under the new roadside vegetation management; (2) to show how roadside vegetation attributes improve driving enjoyment; and (3) how these attributes distinctly affect the highway user groups' preferences.

The proposed combination of qualitative analyses attempts more to acquire a comprehension of the predominant factors susceptible to influence user's aesthetic satisfaction and highway driving enjoyability than to validate or statistically generalized hypothesis. User group perception surveys are scheduled every year of the landscape monitoring project for a total of three survey sets. A brief description of the survey design including the population groups studied and the documentary sources used is presented in the following paragraphs.

User perception survey design

Three distinct highway user groups constitute the experimental sample population: (i) functional or commuting users (individuals using highway for work or business purposes); (ii) local residents familiar with the surrounding area; and (iii) occasional users taking the highway to touristic and recreational destinations, who would be more likely to focus their attention on landscapes attributes. Like the work of Brush et al. (2000), population subsamples are selected from a wide variety of local and regional associations: business, tourist, farmer, roadside resident, car driver, and regional planning professional. All subsamples are composed of ten individuals. A total of 30 subjects are then expected to participate during every year of the monitoring project (2000, 2001, and 2002). The size of these samples is sufficiently important to achieve objectives of the proposed qualitative survey.

The survey design is devised to assess perception in a progressive manner, starting with general impressions with regard to the highway landscape experience to specific aesthetic preferences. Each subject has to complete a questionnaire, which includes five distinct parts:

1. During video sequence viewing, subjects are first invited to express spontaneous impressions as well as to respond to open-ended questions. Answers and commentaries are recorded and transcribed. Then, a transcription content analysis helps to generate categories of discussion with regard to the overall representation of the experimental vegetation management project.

2. Second, from a selected set of panoramic photographs showing diverse roadside vegetation situations and successions, participants are asked to identify their preferred views. Full panoramas created with QuickTime technology allows each participant unrestricted horizontal movement. An open-ended questionnaire aims to identify elements which attract the participant's attention and whether they correspond to a pleasant or unpleasant aesthetical experience. The subjects are invited to justify their answers.
3. Third, attitude scale tests are completed by subjects from a set of selected views. Scales are constructed from a selection of binomial adjectives (e.g., diversified–monotonous; ordered–disordered) commonly used to describe landscape scenes (Craik, 1975; Evans and Wood, 1980; Feimer, 1984) as well as from preferences scales (e.g., favorable–unfavorable). Criteria underlying view selection are based on variables identified at the expert analysis stage which appear to influence visual experience (e.g., standard roadside vegetation management vs. experimental situations; year *a* vs. year *b*; spring vs. summer vegetation; flowers vs. scrubs).
4. In order to bring out factors which appear to act on expressed perceptions, information related to participants' sociodemographic status (age, occupation, sex, etc.) as well as to use and site familiarity (leisure activities, highway use frequency and motives; rural, suburban or urban place of birth, actual place of residence, etc.) are collected. A multivariate analysis will help to discern dominant tendencies with regard to the individual variability observed.
5. Finally, a set of questions focusing on the overall appreciation of the MTQ's roadside vegetation management experimental project and its further development is presented to every subject.

As mentioned above, in order to compare expert and non-expert points of view (Fig. 9), relationships existing between the user's perceptions and qualitative expert evaluations are systematically examined through multivariate analysis.

INTERESTS AND GOALS OF THE HIGHWAY ROADSIDE VEGETATION MONITORING

The interest in this monitoring project initiated by the MTQ and CPEUM is threefold. First, on landscape research level, this project allows the development of an original methodological strategy that combines expert and users' perception approaches as well as both quantitative analysis and qualitative aesthetic evaluation. Second, the highway landscape dynamics revealed during the three years monitoring project will enable to provide documented and informative recommendations for the improvement of the roadside vegetation management program. Third, the creation of a multimedia tool (available on CD-ROM or Internet) integrating multiple observation mediums (photographs, QuickTime panoramas, video sequences) will help to divulge monitoring results as well as to serve didactic and public awareness purposes from a user-friendly interface.

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Natural Regeneration on a Pipeline Right-of-Way in the Boreal Forest of West-Central Saskatchewan

M. Ealey and J. Virgl

Following pipeline construction activities, rights-of-way (ROW) that traverse previously undisturbed landscape units are typically seeded as part of the final reclamation program. Agronomic species are often used in these seed mixtures but there is growing awareness that these species may alter or influence the ecological integrity of the landscape unit disturbed by pipeline construction. We conducted a study on a pipeline ROW to assess the influence agronomic species have on natural secondary succession. The study was also completed to evaluate if there are any ecological impacts or benefits derived from not seeding the disturbance corridor at the end of a reclamation program and if there is significant differences in plant recovery among the three primary work lanes within a pipeline construction ROW. Results from the study indicated there was a significant variation in species richness between seeded and non-seeded areas, indicating that agronomic species pre-empt the reestablishment of a desired endemic community. However, there was not a significant variation between work lanes within the ROW, indicating that typical construction associated with each lane did not influence plant establishment and regeneration.

Keywords: Agronomic species, revegetation, species richness, succession, ecological integrity, vegetation management, species diversity

INTRODUCTION

Following pipeline construction activities, ROW that traverse landscapes units that were previously undisturbed (i.e., retain a native or endemic flora cover) are typically artificially seeded as part of the final reclamation program. The primary objective of this common revegetation practice is to accelerate the establishment of plant cover that in turn will mitigate soil erosion, promote terrain stability, and enhance aesthetics. Secondary goals include the reestablishment of forage cover, provide or assist in the regeneration of wildlife habitat, and, through resource competition, suppress plants that are deemed to be an invasive nuisance and noxious species or otherwise classified as undesirable on pipeline ROW (i.e., tall or large diameter woody species).

Historically in Saskatchewan and else where, seed mixtures used for revegetation programs on reclaimed pipeline ROW were largely comprised of agronomic or exotic/alien species with little regard to the ecological setting to which they were introduced. Usually, agronomic forage species were used due to their availability in commercial quantities, predictability in regards to viability and stand establishment, ease of handling (i.e., specialized equipment is not required for seeding), and most are relatively cheap to purchase. Furthermore, agronomic species have a good ability to withstand grazing, mowing, burning, mechanical, and chemical treatments (Romo and Lawrence, 1990), and there was more knowledge available on how to prepare seed beds, apply the seed, and manage stands of agronomic species in comparison to endemic species (Sims et al., 1984).

Though varieties of agronomic species were, and continue to be, widely used for revegetation programs, there is a growing volume of literature indicating that the introduction of these species to previously undisturbed landscapes can alter the function, structure, and ecological integrity of the natural biota (Simberloff, 1981; Vitousek et al., 1981; D'Antonio and Vitousek, 1992; McCanny et al., 1996). With this awareness, there

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is an increased desire to investigate and employ alternate ways of reclaiming natural habitats disturbed by pipeline construction and other developments. One growing and popular approach to minimize the use of agronomic mixtures is to utilize seed mixtures that are comprised of plant species that are endemic to the area that has being reclaimed. In addition to minimizing the introduction of exotic species to a natural landscape unit, it is anticipated that the use of native species in seed mixtures will circumvent or manipulate the temporal element associated with ecosystem succession. However, the wide scale use of native species has been compounded by inherent limitations that include: restricted availability in commercial quantities; high seed costs; erratic production of desired seeds; limited information on endemic species ecology and ecosystem processes; difficulties associated with storing and applying the seed; and, seeds are often unpredictable in regards to seed germination, viability, emergence, and survivability (Romo and Lawrence, 1990; Gerling et al. 1996; Pyke and Archer, 1991).

The objectives of this study were to: (1) evaluate natural regeneration or secondary succession of a plant community on a disturbed pipeline ROW, (2) assess if the use of an agronomic seed mixture used to revegetate segments of the ROW pre-empted native species succession, and (3) determine if plant recovery/growth varied among construction lanes (work side, trench area and storage/spoil side) within the ROW. The results of this study should contribute to the information necessary for making recommendations in regards to when it may or may not be necessary to use agronomic or native seed mixtures if the maintenance of ecological integrity is the prime objective of the revegetation program in similar areas. Furthermore, it will help determine if specific revegetation measures may be required for specific activity lanes within a typical pipeline construction ROW.

STUDY AREA AND METHODOLOGY

Study area

The study was conducted on a segment of the TransGas Ltd. (TGL) 20-m wide construction ROW used for the installation of a 500-mm O.D., high-pressure gas pipeline during the summer and autumn of 1995. During construction, all standing vegetation was cleared from the entire ROW, and topsoil/organic material was lifted and salvaged in storage windrows. During the reclamation stage, the ROW was re-contoured, salvaged topsoil/organic material was replaced, and residual slash was spread over the surface to mitigate erosion, provide a source of future organic material, and to create micro-sites (safesites) for germinating or recovering plants. Following completion of clean-up operations, ROW segments extending through natural habitats was aerial seeded with a seed mixture comprised of agronomic species (Table 1). However, a 350-m section of the pipeline ROW within this area was intentionally not seeded. The rational behind this was to establish a plot that could later be used to assess the process of natural secondary succession on pipeline ROW through forested habitats and allow for a comparison analysis between artificially seeded and non-seeded portions of the disturbance corridor.

Table 1. Seed mixture goodsoil to rosetown pipeline — North Spread TransGas

Species (scientific name)[1]	Variety	Percentage of seed mixture	Seeding rate (kg/ha)
Creeping Red Fescue (*Festuca rubra*)	Boreal	41.7	12.72
Timothy (*Phleum pratense*)	Climax	20.8	6.34
Slender Wheatgrass (*Agropyron trachycaulum*)	Revenue	9.2	2.80
Northern Wheatgrass (*Agropyron dasystachyum*)	Elbee	7.5	2.29
White Clover (*Trifolium repens*)	Common	20.8	6.34
Total		**100**	**30.5**

[1] Scientific names taken from Budd's Flora of the Canadian Prairie Provinces (Looman and Best, 1987).

The ROW is located in the Bronson Upland landscape area of the Mid-boreal Upland Ecoregion of Saskatchewan (Acton et al., 1998). The area experiences a dry sub-humid continental climate characterized by warm summers and cold winters (Hart and Hunt, 1981) with mean daily temperatures ranging from a low of −18.1°C in January to a high of +16.5°C in July (Environment Canada, 1993). Average annual precipitation is approximately 424.2 mm, of which 74% falls as rain and 26% as snow (op.cit.). The terrain is generally characterized by a moderately sloping, hummocky glacial till plain with pockets of glaciofluvial deposits. The dominant soils are gray luvisolic soils that have formed in weakly to moderately calcareous, loamy glacial till (Saskatchewan Soil Survey, 1995). These soils are highly leached, resulting in low organic matter levels and have sandy loam to loam surface textures. The predominate vegetation community is a continuous canopy of trembling aspen (*Populus tremuloides*); however, mixedwood stands and small patches of white spruce (*Picea glauca*) and jack pine (*Pinus banksiana*) occur intermittently within the immediate study area.

METHODOLOGY

In 1997, five permanent transects were randomly placed perpendicular to the ROW alignment within a 300-m (length) non-seeded plot and repeated in an adjacent 300-m plot that was sown with the agronomic seed mixture. Within each plot, to compare plant establishment on each activity area or lane within the ROW, the disturbed corridor was divided into three strata; work side, trench area, and storage (spoil) side. In addition, a reference or control strata was located 10-m off ROW (undisturbed) on the west end of each transect.

At each strata location along the transect, a quadrat (1.0 × 1.0 m) was placed on the surface to delimit a data collection area. Data collected from each quadrate included species composition (type/diversity/richness), frequency (density) and percent cover. Data was collected in August 1997 and again in August 1999.

Though beyond the scope of this paper, common concerns associated with pipeline construction are the disturbance or modification of the soil profile (i.e., admixing, pulverization, displacement of organic material, compaction, etc.) which in turn can significantly influence reclamation and associated revegetation success. Nonetheless, during the field study, topsoil depths were measured along each transect and soil samples were collected and analyzed for macronutrients, pH, SAR, and organic content, as well, soil bulk density was measured at random locations within strata.

STATISTICAL METHODS

Statistical analysis

A three-way analysis of variance (ANOVA) was used to test the effect of location (seeded vs. non-seeded), site (control, spoil side, trench, work side), and year on species richness or species diversity. If a significant interaction was generated, the model was reduced to examine the effect of explanatory variables on species richness, independently. Subsequent to detecting a significant site or year effect, species richness between sites or years was deemed to differ significantly if 95% confidence intervals did not overlap. A $P > 0.05$ was judged to be not significant. Statistical analysis was performed using the SAS statistical package (Windows version) for microcomputers.

RESULTS

Analysis of variance generated a significant 3-way interaction between location, strata sites, and year ($F_{3,64} = 2.79, P = 0.05$). Although the number of species was lower on seeded transects than non-seeded transects, the effect was not similar across strata sites or between years (Fig. 1). Partitioning the analysis by location indicated that species richness was marginally different among strata sites on non-seeded transects ($F_{3,32} = 2.98, P = 0.05$), but varied strongly among sites on seeded transects ($F_{3,32} = 192.47$, $P < 0.01$). Most of

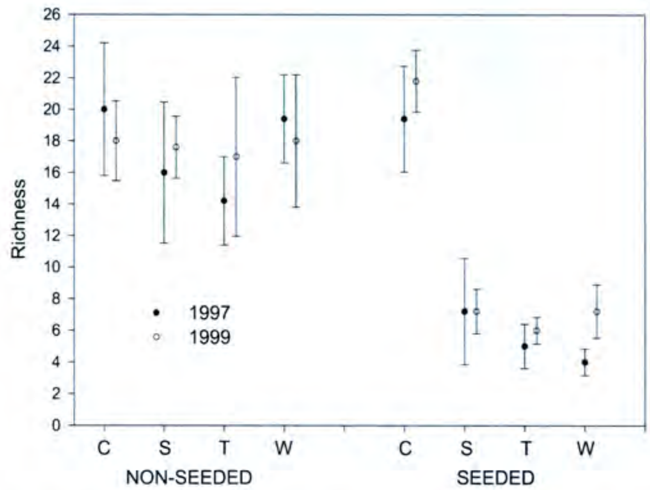

Fig. 1. Variation (mean ± 95% CI) in species richness among sites and between years on non-seeded and seeded areas (C, control; S, spoil; T, trench; W, work).

the variation on seeded transects was due to the difference between control and exposed sites. For seeded transects, species richness was 3–4 times greater on the control site than on exposed strata sites (Fig. 1). Examination of species richness by strata site indicated that control sites on seeded and non-seeded transects were not different. However, for the remaining sites, non-seeded transects contained significantly more species than seeded transects (Fig. 1, Tables 2 and 3). Finally, with the exception of the seeded work side, mean species richness was generally not different between years ($F_{1,64} = 3.14, P = 0.08$; Fig. 1).

CONCLUSION

In this case study, the results indicate through the variation in species richness that the practice of applying an agronomic seed mixture does hamper or pre-empt natural secondary succession processes on a reclaimed pipeline ROW. Romo and Krueger (1986), Wilson (1989), and D'Antonio and Vitousek (1992) and others also report a similar trend.

Considering that there was no significant variation between disturbance strata within the ROW, it appears that typical construction activities associated with each strata within the ROW did not hamper plant regeneration even though richness was marginally lower on the trench area. However, this also could be a function of employing construction techniques (i.e., removing and salvaging propagule laden topsoil and then replacing it during the reclamation stage) to ensure there is minimal soil loss and admixing, excessive compaction to the topsoil horizons, and minimal dilution of the seedbank.

If the goal of a revegetation or vegetation management program is to reestablish a native plant community in forest covered areas disturbed by linear

Table 2. Species richness — non-seeded vs. seeded goodsoil to rosetown pipeline – North Spread TransGas

Non-seeded plot				Seeded plot			
Transect[1]	Strata[2]	Species richness		Transect[1]	Strata[2]	Species richness	
		1997	1999			1997	1999
NS1	A	22	15	S1	A	22	23
NS2	A	14	18	S2	A	19	20
NS3	A	22	20	S3	A	18	21
NS4	A	22	17	S4	A	16	24
NS5	A	20	20	S5	A	22	21
NS1	B	19	18	S1	B	11	8
NS2	B	18	18	S2	B	9	8
NS3	B	18	16	S3	B	5	6
NS4	B	15	16	S4	B	5	8
NS5	B	10	20	S5	B	6	6
NS1	C	17	19	S1	C	5	7
NS2	C	16	20	S2	C	4	5
NS3	C	16	11	S3	C	4	6
NS4	C	12	15	S4	C	5	6
NS5	C	13	20	S5	C	7	6
NS1	D	20	17	S1	D	3	8
NS2	D	19	20	S2	D	4	9
NS3	D	19	15	S3	D	5	7
NS4	D	20	23	S4	D	4	6
NS5	D	16	15	S5	D	4	6

[1] Five permanent transects were placed across the right-of-way on the non-seeded and seeded plots (i.e., first transect on the non-seeded plot is NS1).

[2] On each transect, the right-of-way was divided into four strata; A = control (undisturbed), B = spoil side, C = trenchline, and D = workside.

Table 3. Species occurrence on the non-seeded (NS) and needed (S) plots goodsoil to rosetown pipeline — North Spread TransGas

Species[1]	Occurrence (1997 and 1999)[2]									
	NS		S		NS only		S only		NS and S	
	97	99	97	99	97	99	97	99	97	99
Achillea millefolium	x	x		x	x					x
Agrostis scabra	x	x			x	x				x
Agropyron trachycaulum	x	x	x						x	
Anemone canadensis		x				x				
Anemone cylindrica		x								
Antennaria spp.		x								
Aster ciliolatus	x	x	x			x			x	
Calamagrostis canadensis	x	x			x	x				
Campanula rotundifolia		x				x				
Carex sp.	x	x	x	x					x	x
Cirsium arvense	x	x			x	x				
Crepis tectorum	x				x					
Deschampsia caespitosa		x				x				
Eleocharis palustris	x				x					
Epilobium palustre	x	x			x	x				
Equisetum arvense	x	x			x	x				
Equisetum scirpoides	x	x								
Festuca rubra				x	x		x	x		
Fragaria virginiana	x	x	x	x					x	x
Galium boreale	x	x			x	x				
Galium triflorum	x	x							x	x
Gentiana amarella	x	x							x	x
Geranium bicknellii	x				x					
Geum aleppicum	x				x					
Geum macrophyllum		x		x						x
Hordeum jubatum		x				x				
Juncus bufonius	x				x					

Table 3. (continued)

Species[1]	Occurrence (1997 and 1999)[2]									
	NS		S		NS only		S only		NS and S	
	97	99	97	99	97	99	97	99	97	99
Juncus dudleyi	x				x					
Juncus spp.	x	x	x						x	
Lathyrus ochroleucus	x	x			x	x				
Lathyrus venosus		x				x				
Luzula spp.		x				x				
Maianthemum canadense	x	x	x			x			x	
Matricaria matricarioides	x				x					
Mentha arvensis		x				x				
Mertensia paniculata	x	x			x	x				
Mitella nuda	x	x			x	x				
Moehringia lateriflora	x				x					
Moss spp.	x	x	x	x					x	x
Oryzopsis asperifolia	x				x					
Petasites palmatus	x	x			x	x				
Phleum pratensis	x	x	x	x				x	x	
Picea mariana		x				x				
Plantago major	x	x	x	x					x	x
Poa palustris		x				x				
Poa pratensis	x	x	x			x			x	
Polygonum arenastrum	x				x					
Potentilla norvegica	x				x					
Ranunculus abortivus	x		x						x	
Ranunculus cymbalaria		x				x				
Ranunculus sp.		x				x				
Ribes lacustre	x				x					
Ribes oxyacanthoides	x	x			x	x				
Rosa acicularis	x	x	x			x			x	
Rubus idaeus	x	x	x			x			x	
Rubus pubescens	x	x			x	x				
Salix spp.	x	x			x	x				
Scirpus spp.	x				x					
Solidago canadensis		x				x				
Sonchus arvensis	x	x			x	x				
Stellaria longifolia	x	x			x	x				
Symphoricarpos albus	x	x			x	x				
Taraxacum officinale	x	x	x	x					x	x
Thalictrum venulosum	x				x					
Trifolium repens	x	x		x						
Urtica dioica	x		x						x	
Vicia americana	x	x	x			x			x	
Viola adunca	x	x			x	x				
Viola canadensis	x				x					
Viola renifolia	x				x					
Total	54	51	16	10	35	35	1	2	18	10

[1]Scientific names taken from Budd's Flora of the Canadian Prairie Provinces (Looman and Best, 1987).
[2]Excludes undisturbed control plot in adjacent forest.

developments, it appears that in some cases that it may be more beneficial to allow secondary succession to proceed in the absence of an artificial seeding program. This would be particularly applicable if soil erosion is not a concern and the revegetation program was considering the use agronomic or exotic species. Furthermore, in addition to cost saving associated with seed purchase and application, permitting secondary succession to proceed unimpeded will help maintain ecological integrity and promote biodiversity.

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Rare Plant Impact Mitigation for the Alliance Pipeline Project

Gina Fryer, Gordon Dunn, and Paul Anderson

Alliance Pipeline Limited Partnership (Alliance) has constructed approximately 2330 km of natural gas pipeline from northeast British Columbia, through Alberta to the Saskatchewan-North Dakota border. Vegetation assessment is a requirement of National Energy Board regulated pipeline projects. Rare plant surveys and vegetation community typing through nine distinct ecological regions were undertaken in the summers of 1996 through 1999, along the mainline and laterals in segments of native vegetation. Forty-seven species of rare plants, as well as a number of significant plant communities, were identified along the Alliance right-of-way. Mitigation to avoid or minimize impacts was developed for each rare plant site or significant community identified. Mitigation measures implemented during construction included re-routing or re-aligning the pipeline within the right-of-way, narrowing down the right-of-way, transplanting of individual plants, and seed collection for re-establishment after construction. Rare plant survey work is normally required for National Energy Board regulated pipeline projects that traverse native vegetation. Information regarding the effectiveness of the mitigation implemented for conservation of rare plants and sensitive plant communities would be of benefit for the planning of future projects. As part of Alliance's post-construction reclamation monitoring program, an assessment will be conducted to document the survival of rare plant populations disturbed during construction. Vegetation survey methodology, impact mitigation planning, and a preliminary assessment of the successes and difficulties of the mitigative measures implemented are discussed.

Keywords: Vegetation assessment, significant plant communities, rare plants, mitigation, survey methodology

INTRODUCTION

The Canadian portion of the Alliance pipeline includes the construction of approximately 2330 km of natural gas pipeline from northeast British Columbia, through Alberta to the Saskatchewan–North Dakota border. Clearing of the pipeline right-of-way began in February 1999. Mainline construction began in June 1999, and is now mechanically complete.

Rare vascular plant survey work is normally required along the segments of National Energy Board regulated pipeline projects that traverse native vegetation. Part VII of the Guidelines for Filing Requirements states (National Energy Board 1995):

"9 (2) *The assessment conducted pursuant to subsection (1) shall consider, but not be limited to, the following:*

(e) *with respect to the biotic environment (all organic matter and living organisms and their interacting natural systems)*

(iii) *for plant and forest communities of ecological, economic or human importance*

(C) *rare or unique species or species assemblages, including plant species with federal, provincial, regional or local designated status (vulnerable, threatened, endangered or extirpated).*"

Since a large portion of the Alliance pipeline traverses native vegetation in forested areas, it was not feasible to conduct field surveys for rare plants along the entire route. Therefore, a vegetation assessment methodology had to be developed to prioritize areas along the route and identify vegetation community

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types with higher potential for the occurrence of rare plant species.

The objectives of the vegetation assessment undertaken by Alliance were:

1. to develop an effective method for identifying areas with high potential for rare plant occurrences;
2. to implement field surveys of the high potential areas for rare plant occurrences; and
3. to develop effective and feasible mitigative measures for the conservation of rare plant species found on the right-of-way.

Information regarding the effectiveness of the survey methods and of the mitigation implemented for conservation of rare plants and significant plant communities would be of benefit for the planning of future pipeline projects.

METHODS

Survey methodology

A literature review was conducted to obtain the most current information on known and potential rare plant species and significant plant communities occurring within the general project region. Primary sources included provincial Conservation Data Centres (CDC) and government agencies, plus various reports on rare plants (e.g. Argus and Pryer, 1990; Wallis, 1987; Wallis et al., 1987) and environmentally significant areas (e.g. Wallis and Knapik, 1990; Geowest Environmental Consultants Ltd., 1994, 1995).

The Alberta Natural Heritage Information Centre (ANHIC), British Columbia CDC and Saskatchewan CDC provided updated tracking lists of rare plant species known or expected to occur within the project region, plus element occurrence records of known rare plant locations in the vicinity of the proposed route (Alberta Natural Heritage Information Centre, 1996; British Columbia Conservation Data Centre, 1996; Committee on the Status of Endangered Wildlife in Canada, 1996; Saskatchewan Conservation Data Centre, 1996). Based on this information plus other relevant sources (e.g. Wallis et al., 1987; Argus and Pryer, 1990; Harms et al., 1992; Fernald, 1993; Saskatchewan Environment and Resource Management, 1996), a checklist of vascular plant species of concern in the vicinity of the proposed Alliance project by province was developed, to be used for field surveys.

Preliminary identification of native vegetation portions of the mainline route was undertaken during an aerial reconnaissance of the proposed route. Based on this assessment and on interpretation of aerial photographs, a selection process for the determination of priority sampling sites along the mainline was initiated.

In parkland and prairie areas, sampling segments were identified to include all large tracts of noncultivated land, river valleys, grazing reserves and other sites with expected high potential for the occurrence of rare plants (e.g. Environmentally Significant Areas). An attempt was made to sample all major vegetation community types in these areas subject to limitations imposed by accessibility, time constraints and weather conditions.

In the forest regions, areas of high potential, as determined from air photo interpretation of vegetation community types, were sampled. Sampling was conducted by teams of two botanists walking the proposed route. Rare plant surveys and vegetation community typing through nine distinct ecological regions were undertaken in the summers of 1996 through 1999, along the mainline and laterals in segments of native vegetation

Where rare plants were encountered, documentation using data sheets, airphoto mosaics, NTS maps and photographs was completed. An area up to a distance of 500 m away from the right-of-way in either direction was examined to determine if the species was distributed beyond the expected zone of disturbance. Rare plant sites were marked in the field with numbered stakes and GPS locations were recorded for each individual stake by the survey company responsible for right-of-way survey and staking. The GPS data of rare plant locations was then entered into the main survey data bank and survey sketches were produced showing the locations of rare plants in relation to the actual right-of-way boundaries.

Mitigation planning methodology

The survey sketches were used, along with other NTS topographic maps and aerial photography, to determine the most appropriate mitigative actions to be implemented. Factors commonly considered in selecting mitigation included but were not limited to: number of rare plant individuals at the site; rarity ranking of the species (i.e. S1, S2, SU); location of the individuals in relation to the right-of-way boundaries; and anticipated construction necessities (i.e. extra workspace requirements for grading hills or crossing watercourses, etc.).

Once a site was assessed in this way and the preferred mitigative measure selected, data sheets including the original survey notes from the field botanists, the survey sketches showing right-of-way boundaries and plant locations, and instructions for mitigation to protect the rare plant or community were provided to Alliance's Environmental Inspectors. The Environmental Inspectors were then responsible for supervising the implementation of mitigative measures during construction. Where unforeseen difficulties arose during construction, such as extra grading width requirements, the Environmental Inspectors were able to consult with a Vegetation Resource Specialist to adjust or change the pre-planned mitigation in order to best protect the plant species of concern.

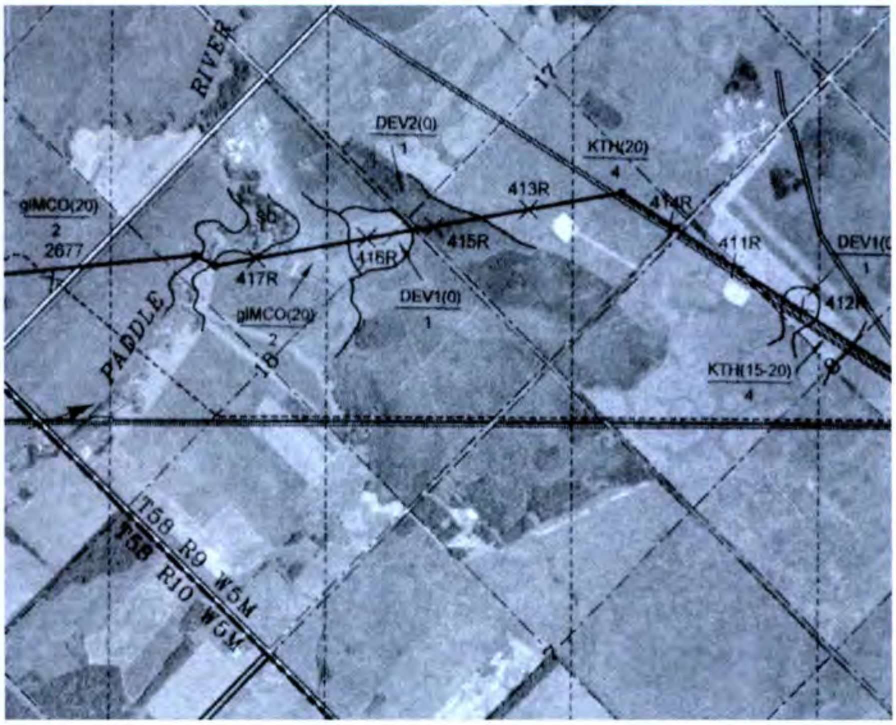

Fig. 1. Aerial photograph showing the re-route around the bog at KP 507 to avoid the *Malaxis paludosa*.

RESULTS AND DISCUSSION

Survey results

Forty-seven species of rare plants, as well as a number of significant plant communities, were identified along the Alliance construction right-of-way in Canada. Some of the rare plant species were downlisted, partially as a result of the number of areas these rare plant species were found in Alberta during the Alliance surveys (e.g. *Angelica genuflexa*, originally an S2 species at the start of the surveys was downlisted off the ANHIC watch list, in 1998 (Gould, 2000)).

Mitigation measure implementation

Mitigative measures implemented during construction for rare plants included re-routing or re-aligning the pipeline, narrowing down the right-of-way, transplanting of individual plants, topsoil seed bank salvage, and seed collection for re-establishment after construction. Mitigation measures utilized for rare plants are outlined below with brief descriptions and examples. Post-construction monitoring has been undertaken along segments of the pipeline constructed in 1999, and the success of some of the mitigative measures identified.

Re-routing

Re-routing the pipeline to avoid rare plants usually provides the most complete protection but is not always feasible or practical. Other considerations such as safety concerns, geotechnical constraints, engineering difficulties, or landowner routing preferences must also be considered before a re-route can be implemented. However, the Alliance pipeline was re-routed, when feasible, at a number of locations for the purpose of avoiding rare plant communities.

For example, the pipeline was re-routed around a bog where the bog adder's-mouth, *Malaxis paludosa* (S1) was found on the Alliance right-of way at KP 507 (Fig. 1).

Narrowing of right-of-way disturbance

Narrowing of the area of ground surface disturbance on the right-of-way as much as feasible within the constraints of safety and construction logistics will avoid the rare plant species and at least a portion of its habitat.

The right-of-way was narrowed down by 8 m on the workside to avoid the lance-leaved loosestrife, *Lysimachia lanceolata* (S1S2 in 1996, but no longer on the Tracking or Watch list for Alberta (Gould, 2000)) during construction over the summer of 1999 (Fig. 2). During post-construction monitoring in summer 2000, the plant was located (Fig. 2). This is in a low wet area surrounded by willow and aspen, within a cultivated field (KP 769.9–770.0). The landowner is planning to use the disturbed portion of the right-of-way for crop now, but the portion that was saved from disturbance remains native (Fig. 3).

Douglas hawthorn, *Crataegus douglasii* (S3W), was fenced and avoided during construction (KP 639.9). During post-construction monitoring in summer 2000, the Douglas hawthorn was thriving (Fig. 4).

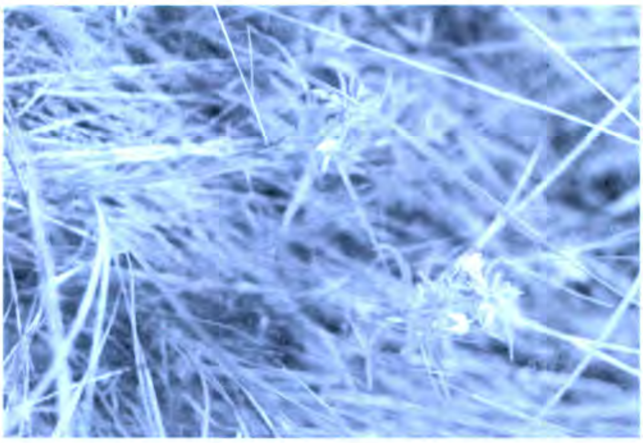

Fig. 2. *Lysimachia lanceolata* at KP 769.9.

Fig. 3. Photo showing the narrowing down of the right-of-way by 8 m at KP 769.9 (full right-of-way width shown in foreground).

Avoiding or minimizing extra workspace and grading requirements

Where extra workspace was necessary in areas of significant plant communities, a site-specific layout was developed and the area to be disturbed was minimized. Extra workspace and grading was minimized or avoided and the width of topsoil stripping restricted to reduce the extent of disturbance to native vegetation.

Salvage of plant species of concern

Species of concern that would have been affected by surface disturbance, were transplanted, using plugs, cutting collection or seed collection. Specific procedures for rare plant salvage were determined by the Resource Specialist based on factors such as species characteristics, location and timing of salvage, and construction operations. Salvaged plants or propagation materials were reestablished on the right-of-way or in nearby areas with appropriate habitat as directed by the Environmental Inspector or Resource Specialist.

Two clumps of long-leaved bluets, *Hedyotis longifolia* (S2), were transplanted to the immediate north of the right-of-way just prior to construction by hand (KP 876.4). The two clumps of long-leaved bluets were located again during post-construction monitoring in

Fig. 4. *Crataegus douglasii* was fenced and avoided during construction.

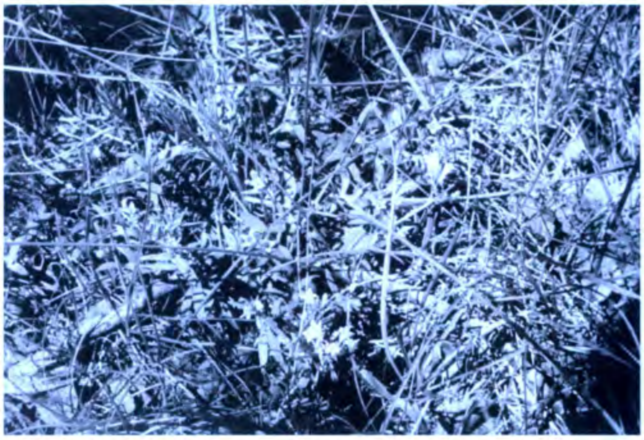

Fig. 5. *Hedyotis longifolia* one year after the transplant, at KP 876.4.

summer 2000 (Fig. 5). Goldthread, *Coptis trifolia* (S2 in 1996, S3W in 2000) was transplanted off the Windfall Compressor Station at KP 421 using a backhoe, in the spring of 1999, just prior to construction. It was transplanted to a similar habitat adjacent to the Compressor Station (Figs. 6–8). The goldthread survived the transplant and was located during post-construction monitoring in summer 2000 (Fig. 9).

In several instances involving rare annuals, seed was collected and stored for dispersal onto the right-of-way following construction. In these cases the plant species were also found in disturbed areas and therefore capable of surviving on the disturbed right-of-way.

In addition, for annual plants where transplanting was not practical and the seeds had already dispersed, the seeds in the topsoil or strippings were salvaged separately and re-distributed during clean-up. For example, topsoil at the linear-leaved plantain, *Plantago elongata* (S2S3) site were saved separately and replaced during clean-up (KP 943.3–943.4). The narrow-leaved plantain was noted during post-construction monitoring in summer 2000 (Figs. 10 and 11). Similarly, topsoil at the awned or mountain mousetail, *Myosurus aristatus* (S2) site was stored separately during construc-

Fig. 6. Vegetation left in an island surrounding the *Coptis trifolia*, on the Windfall Compressor station site, KP 421.

Fig. 7. Removal of *Coptis trifolia* and surrounding sod with a backhoe.

Fig. 8. Salvaged *Coptis trifolia* and sod being replaced in the cleared transplant site.

tion (KP 1236.60–1236.64). Following construction, the slight depression in the right-of-way was recontoured and the strippings re-spread (Figs. 12 and 13). Although the awned or mountain mousetail was not seen during post-construction monitoring in the summer 2000, it may be found growing next year, once the vegetation has had a chance to fill in.

Fig. 9. *Coptis trifolia* one year after transplanting.

Fig. 10. *Plantago elongata* one year following construction.

Fig. 11. *Plantago elongata* habitat regenerating at KP 943.3.

The awned umbrella sedge, *Cyperus aristatus* (S1) was located during a preconstruction vegetation survey (KP 1466.25). It was located on the Alliance right-of-way and an adjacent right-of-way. The Alliance right-of-way was narrowed down and 5 m of the adjacent right-of-way was used. Transplanting by hand with sod plugs was also conducted (Figs. 14 and 15). Monitoring will be conducted in 2001 to determine whether the transplanting was successful.

Fig. 12. Site where *Myosurus aristatus* was found. Strippings were removed separately and replaced following construction (KP 1236.60).

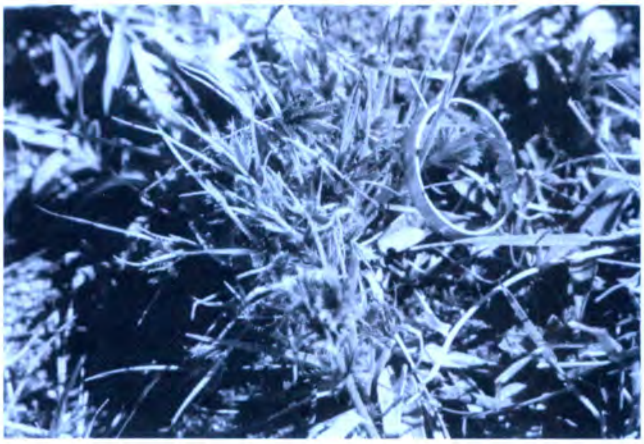

Fig. 14. *Cyperus aristatus* (wedding band on right for scale).

Fig. 13. Slight depression recontoured on the right-of-way following construction.

Fig. 15. Sod plugs of *Cyperus aristatus* prior to re-planting (KP 1466.25).

DISCUSSION

Alliance's vegetation survey methodology was highly successful in identifying and locating rare plant species that would be impacted during construction. As mentioned above, some species previously thought to be in peril were found in such abundance and widespread distribution that they were downgraded in rarity ranking on provincial species of concern lists. It is likely that some rare plants were overlooked in areas classified as low in priority and not field surveyed by Alliance. However, by concentrating on high priority areas, the limited resource of qualified botanists experienced in rare plant identification was best utilized.

Protection of rare plant communities that were located was most effective where pipeline re-routes were possible since both the rare species and the associated habitat were left undisturbed. Narrowing the right-of-way to avoid all or part of a rare plant community appears to be a good conservation method and was most often the method implemented because it presents fewer problems in coordinating with other considerations such as safety and engineering concerns.

Construction right-of-way avoidances may not be possible in areas that require extensive grading. Many of the areas of remnant native vegetation in Saskatchewan and eastern Alberta remain uncultivated due to adverse grade or drainage problems. As a result, these areas often require extensive right-of-way preparation making narrow downs difficult or impractical.

Disturbance of the rare plant and surrounding habitat was done when re-routing and narrowing down were not feasible. Salvaging rare plants, either by transplant, seed collection or topsoil seed bank salvage, appears to be initially successful in some of the locations where these methods were implemented by Alliance. However, Fahselt (1988) cautions that transplants of rare species often are initially successful but frequently die out or fail to reproduce a viable community in the longer term. Future monitoring of the sites along the Alliance right-of-way where rare plant salvage methods were implemented will hopefully provide some insight into the effectiveness of this as a conservation measure.

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Automating Monitoring and Management of Roadside Vegetation

Nancy P. Cain, Kevin McKague, Laura A. Kingston, and Steven Struger

An integrated system was evaluated for monitoring of desirable roadside vegetation, weed locations and related features. The system incorporated a global positioning system (GPS) for locating the sites in the field and a geographic information system (GIS) for storing, managing, manipulating and displaying the data. Weed areas, desirable vegetation, water features, culverts and sensitive adjacent land use were recorded. Methods of recording each feature type, using polygon, linear or point data were explored using field collection tests. Two systems of collecting the information were compared — a polygon, field-based collection system and a linear, vehicle-based collection system. In a replicated field trial, the linear system provided an estimated one-third cost saving in field data collection, but only resulted in a 10% total time savings compared to the polygon system, due to the additional data post-processing required with the linear collection system. The data collected with these automated systems can be used for planning of operations, contract management, automating herbicide application, quality control and communication of vegetation features for planning, design and construction.

Keywords: Rights-of-way, integrated vegetation management, maintenance, GPS, GIS, weed control, brush control, selective maintenance

INTRODUCTION

One of the objectives of selective vegetation control, as part of integrated vegetation management (IVM) programs, is to leave desirable vegetation intact when applying chemical or mechanical brush and weed control. This desirable vegetation includes competitive vegetation that is resistant to invasion by weeds and brush, such as planted areas of crown vetch and bird's-foot trefoil, and naturally-occurring areas of raspberry, asters, goldenrods, dogbane, Canada blue-joint and other competitive species. Areas of competitive vegetation will expand if not stressed by herbicide applications or other maintenance activities. Over time, these areas can significantly reduce the amount of weed or brush control required on a ROW.

It is a time consuming task to identify areas of competitive vegetation on an extensive right-of-way (ROW) system, requiring specially-trained personnel. It is equally challenging to keep track of the locations of this vegetation and to communicate this information to in-house and contract staff.

Monitoring for IVM programs

A key component of IVM programs is to monitor for weed and brush species, as well as naturally occurring, competitive vegetation. Comprehensive monitoring can be done on a regular basis to evaluate where control is required and where natural vegetation is developing. The use of global positioning systems (GPS) and geographic information systems (GIS) provides a method of recording locational information in the field and storing it in a digital form on base maps. This information can then be updated on a regular basis or following ROW activities to evaluate the effectiveness of maintenance operations.

Integrating IVM with contract weed and brush control programs

The simplest approach for chemical weed and brush control programs is to apply one herbicide to all ROW areas in the target zone, in a continuous operation. A challenge of using selective weed control, as part of

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an IVM program, is to apply herbicides in a manner that will not damage stands of competitive vegetation. This involves using selective herbicides or physically selective applications. Since most of the herbicides used for weed and brush control on ROW will damage broad-leaved, competitive species, it necessary to use physically selective applications. Examples are spot applications such as basal-bark, cut-surface or targeted foliar applications; or turning broadcast sprayers off when an area of desirable vegetation is reached.

In order to accomplish this manually, applicators that are knowledgeable in identification of competitive species are required. Alternatively, maps or ROW markings identifying these sensitive areas are required to effectively guide the operations.

A second challenge is that contract operations are usually paid on the basis of area treated or amount of herbicide used. This is in direct conflict with the goal of not treating areas with competitive vegetation. A method is required to incorporate into tender documents the location of desirable, competitive vegetation, the location of target weed and brush vegetation, and to indicate exactly how much area requires herbicide application. Identification and recording of these areas can be done in–house or by a separate contractor. This information would allow preparation of more accurate tender information by property owners, submission of more realistic bids by contractors, and a method of monitoring the results of the weed and brush control operations.

If information on the location of desirable vegetation is available, then not disturbing desirable vegetation can be made a condition of a work contract. This would create a strong economic incentive for the contractor to not treat desirable vegetation, especially if there is a penalty.

Automated Vegetation Recording System

A system was evaluated using commercially available technology to monitor the location of desirable vegetation, weed locations and related features on highway ROW. The system evaluated incorporated a GPS for locating the sites in the field and a GIS for storing, managing, manipulating and displaying the data. An operational system was tested on two-lane and four-lane controlled access highways in southern Ontario. Different systems of collecting and organizing the data were compared for ease of operation and the time involved working in the field and on the computer.

METHODS

Software and hardware

For the field collection of vegetation and feature data for this project, a Trimble AgGPS model 132 Receiver was used, with an L-band satellite differential correction of the signal (provided by OmniSTAR Inc.). The GPS unit was used in a backpack frame or mounted on a vehicle, which required unscrewing the antenna from the backpack frame and placing it on the vehicle roof with a magnetic mount.

The GPS unit was connected to an Apple Newton Message Pad 130 computer used as either a hand-held unit in combination with the backpack or as a part of a truck-mounted system. The software used for the field data collection was Fieldworker Pro, Version 1.2.5. For GIS data processing and map production, ArcView GIS 3.0a software was used, on an Intel Pentium computer. ArcView was used for this project, since this software was being used for other GIS operations at the Ontario Ministry of Transportation (MTO). Fieldworker Connect was used to facilitate transfer of the data from the Newton Message Pad to the desktop computer.

Background mapping data

Ontario Base Map (OBM) digital data were used for the background map data. The OBM data was imported for the highway test areas in North American Datum 1927 (NAD 27). The OBM data was transformed from NAD 27 to NAD 83 using Geographic Translator software (Blue Marble Geographics). Only relevant data layers that provided useful background information for the mapping of vegetation data were used:

- transportation network,
- vegetation,
- fencelines,
- drainage network,
- water bodies,
- culverts,
- lot & concessions,
- gravel pits & piles,
- buildings not to scale,
- buildings to scale.

Field data collection

Two systems for field data collection were tested. In the first system, called the Polygon System, the locational data for each vegetation area of interest (for example, desirable or weed area) were collected by walking the boundaries of the polygon in the field and recording the location of these boundaries, resulting in polygon data. The limits of adjacent properties were recorded by walking along the fence line, resulting in linear data. Water courses such as rivers, drainage ditches and culverts were collected as lines or point features, whichever was most suitable. For this system, the GPS unit was mounted on the backpack and carried by one person; a second individual drove the vehicle along the road as required.

In the second system, called the Linear System, data was collected from the vehicle, driving on the shoulder of the road. This second system was developed, as a means of reducing the time in the field, with an eye to using only one person if possible. For this system, all features were recorded as point or line data, whichever was most suitable. For areas of vegetation and the limits of adjacent properties, the start and finish of each area was recorded, resulting in a line feature. Whether vegetation or weed areas were directly adjacent to the road or further back from the shoulder was recorded as attribute data.

For all data, appropriate attributes were recorded. Examples included weed identification and density, desirable vegetation identity, type of adjacent land use and type of water body.

For quality control of the GPS and mapping process, the locations of road intersection control points and structures, collected by GPS, were compared with the known locations of these points on the OBM base maps after conversion to NAD83.

Data management

The data were downloaded to a desktop computer in a comma-delimited format, and translated into an ArcView compatible format. The point, line and polygon data were imported as themes into ArcView, and saved and manipulated as shape files for mapping. The field data were manipulated to provide suitable visual representations on maps; for use in geoprocessing to determine the area of different operations; and for prescription map preparation for automated herbicide applications. These operations required that the weed areas to be treated and the sensitive areas to be avoided be represented by polygons in the GIS.

Linear data was offset (moved in one direction) a set distance and then buffered to create a polygon within the GIS. In this way, adjacent property qualities would be represented by polygons outside of the ROW. Likewise, point culverts would be represented by a 20 m diameter circle (10 m buffer), to indicate the desired spray buffer. With the linear data collection method, weed areas or desirable vegetation areas within the ROW would be represented by polygons, created by offsetting and buffering the original linear data. The polygons representing the weed areas were manually edited to reduce the length of the polygons to the original length of the collected line, so zones of herbicide application would not extend into sensitive zones.

Paper maps were prepared on 28 by 43 cm (11 by 17 in) sheets at 1:10,000 scale. For the map presentation, features from the OBM data were represented with colours and patterns that were consistent with the OBM source data. Colours and patterns were chosen for the collected features; sensitive vegetation, weeds, environmentally sensitive areas and sensitive adjacent land use; that were easy to distinguish and conveyed an appropriate message. The weed areas were portrayed in green, while the remaining areas were portrayed in patterns of red and yellow. Contour and spot height layers were not plotted on the maps, to reduce the amount of visual information, however these layers were processed since they could have potential application in the planning and design uses of the data.

Time trials to assess data acquisition costs

To help quantify operational costs of these data collection methods, time trials were completed for both data acquisition; and the data storage, management and mapping stage of the work. The time trial experiment undertaken compared the time required to use the Polygon Method of data collection versus the time required for the Linear Method. As indicated, the Linear Method was developed to reduce the field time needed to collect the necessary data. The trade-off with applying the Linear Method is the additional computer data post processing time required to offset and buffer zones of weeds, sensitive features or adjacent land uses and, in turn, produce polygons required for the identification of areas to spray. The objective of the time trials was to see if the extra computer time required for the Linear Method exceeded any savings in the time realized in the field data collection step.

The experiment compared field time (data collection and data preparation for input to a GIS) and computer data post processing time for vegetation mapping on two Ontario provincial highways, Highway 19 between Ingersoll and Tillsonburg and Highway 24 between Brantford and Cambridge. Both sites were located in rural agricultural areas and had weed infestations of thistle species, wild carrot and milkweed (noxious weeds in Ontario). Sensitive vegetation areas included prairie vegetation, sumac, crown vetch and other desirable species that would be sensitive to herbicides targeting broad-leafed weeds. The experiment was a randomized complete block design with 4 replicates. Each experimental unit was 4.2–4.9 km long and included both sides of the highway.

The unit costs used in the calculations were \$58.10/hr plus \$0.36/km for field data collection and \$45.27/hr for computer data processing plus \$1.12/km for paper costs. These cost estimates did not include overhead.

The data were analyzed for treatment main effects using SAS (SAS Institute Inc., 1992) GLM procedure for analysis of variance. The data were checked to ensure that they met normality and other ANOVA assumptions using the Shapiro–Wilk test statistic for normality and tests for homogeneity of variance (SAS, Univariate procedure).

RESULTS AND DISCUSSION

Results of time trial

The unit time, including field data collection and computer data post processing time per kilometer was significantly more for the Polygon Method of field data collection, 50 min/km, compared to 44 min/km for the Linear Method (treatment effect $P = 0.0077$, Table 1). This translated to about a 10% savings in time using the Linear Method. When converted to costs per hour,

Table 1. Comparison of time involved in field data collection and data post processing for the linear and polygon methods

Method of data collection	Time per length of highway (min/km)[1]		
	Field data collection	Data post processing	Total
Linear method	28.4	15.9	44.3
Polygon method	41.5	8.2	49.7

[1] Each mean represents 4 blocks.

Table 2. Estimated cost involved in field data collection and data post processing for the linear and polygon methods

Method of data collection	Estimated cost per length of highway ($/km)[1]		
	Field data collection	Data post processing	Total
Linear method	$27.51	$12.02	$39.53
Polygon method	$40.20	$6.21	$46.41

[1] Unit cost of $58.10/hr plus $0.36/km for field data collection and $45.27/hr for computer data processing plus $1.12/km for paper costs. Cost estimates do not include overhead.

using estimates of time and equipment (Table 2), there was a 15% cost saving with the Linear Method.

It took roughly 1.5 times as long to collect the field data using the Polygon Method (i.e., 42 min/km compared to 28 min/km). However, it only took one-half as long for the GIS operator to process the data following field data collection with the Polygon Method compared to the Linear Method (i.e., 8 min/km compared to 16 min/km).

The calculations above were based on using a two-person field crew. In an additional time trial, time measurements made on two blocks from the initial experiment indicated that one person could collect field data using the Linear Method in 29 min/km, compared to 28 min/km with two people. This one-person test can only give an indication of the actual time, since the operator had participated in the earlier field data collection. Since this would reduce the cost per hour to $37.45, the projected cost for a one-person linear data collection method would be $18.23 for field data collection and yield a total cost of $30.25. This translated into a one-third saving compared to the Polygon Method.

Factors such as the end purpose for the data being collected, staff availability, and roadside work safety issues would be significant in deciding which method might ultimately be used for a specific application. For example, in situations with a wide right-of-way, such as along a restricted access four-lane expressway, the more precise information possible with the Polygon Method could easily justify the extra cost associated with its use. Here, herbicide application could involve off-road equipment, compared to primarily truck-mounted application equipment on two lane highways with narrow ROW.

Use of GIS ROW vegetation data

Data on the location and attributes of desirable, competitive vegetation, weed or brush, sensitive zones such as water and sensitive adjacent land use, presented on a suitable background map, can be used for numerous applications relating to IVM and other operations that impact ROW vegetation. Examples of uses of this data relating to road ROW management are listed below.

Location and extent of weed or brush infestations

This information can be used to plan maintenance operations and to monitor the results of weed and brush control operations.

Area of herbicide application

With the data on weeds and brush, and sensitive zones such as desirable vegetation, water courses, and sensitive adjacent land use, GIS data processing can be used to determine the actual area or linear length of weeds or brush to be treated. This information can be used for planning of in-house operations or for preparation of tender and contract documents. Maps of the areas to be treated can be provided to staff or contractors to guide weed and brush control operations.

Automated herbicide application

The digital information indicating where herbicide applications are required can also be used to prepare a prescription map necessary to operate an automated herbicide sprayer. This herbicide application system uses the prescription map, a computer operated spray controller, and a GPS unit to apply the herbicide in the appropriate locations (Domingue and Turbide 1996).

Location of competitive vegetation

This information can be used to monitor the effects of maintenance on the development of desirable, competitive vegetation and to limit the effects of other maintenance that would have a negative impact on this vegetation, such as mowing.

Direction of vegetation maintenance activities
This type of system could be used to produce maps to guide other maintenance activities such as mowing for in-house staff or contractors. For example, maps could indicate where safety mowing is required, or where mowing is desired around landscape features and specialty plantings.

Planning, design, and construction
The location and identification of desirable vegetation and environmentally sensitive areas can be provided to staff or consultants involved in planning and design and contractors involved in construction. The retention of established, competitive vegetation wherever possible, will reduce revegetation costs and long term maintenance.

Use of GPS and GIS in an integrated system for selective vegetation management facilitates directed application of herbicides to target weeds and brush, while leaving desirable competitive vegetation intact. The data on vegetation and sensitive areas allows more effective preparation of vegetation management contracts and communication with both in-house and contract staff. Having an up-to-date record of the location and identity of desirable, competitive vegetation as well as weeds and brush, provides the tools to effectively monitor selective brush and weed control as part of IVM programs.

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Highway Rights-of-Way as Rare Plant Restoration Habitat in Coastal Virginia

Philip M. Sheridan and Nancy Penick

Significant loss of rare plants and their habitats have occurred on the coastal plain of Virginia through urbanization, drainage of wetlands, fire suppression, and land use changes. Existing conservation practices such as easements and preserves have been somewhat successful in preserving biodiversity but have neglected the role that highway rights-of-way could serve as restoration areas for rare plants and their ecosystems. We propagated a number of rare plant species, many only still surviving on powerline rights-of-way, and reintroduced them in appropriate habitat on mitigation projects and cloverleafs along Virginia Department of Transportation highway rights-of-way. Key elements of our program include: utilization of indigenous plant stocks from the local area, registry of reintroductions with state authorities, management of sites through mechanical or chemical means, and monitoring of the population biology of introduced plants. Highway rights-of-way represent a potentially underutilized area for rare plant conservation and could augment species preservation and recovery efforts.

Keywords: Biodiversity, bogs, pitcher plants, VDOT

INTRODUCTION

Rights-of-way have been studied and surveyed for their potential for harboring rare plant populations (Sheridan et al., 1997). Throughout the southeastern United States a unique assemblage of plants occurs in wetlands called pitcher plant bogs (Folkerts, 1982). These wetlands contain interesting species such as pitcher plants, sundews, bladderworts, and orchids. Pitcher plant bogs typically associate with xeric uplands dominated by longleaf pine, *Pinus palustris* Miller, to form an ecosystem, which is maintained in an early successional phase by natural, lightning-caused fires. After four centuries of European settlement in coastal Virginia, however, much of this original habitat has been destroyed or significantly altered through either urbanization, fire suppression, and agricultural and silvicultural practices (Frost, 1993; Sheridan, 1986).

Conventional approaches to conservation of pitcher plant bogs and longleaf pine habitats in Virginia have consisted of acquiring extant fragments of these rare habitats. However, this approach to biological conservation fails to mitigate for past losses in habitat and populations of rare species. In addition, conservation biologists in Virginia have typically tended to attempt to acquire large parcels of land and failed to acquire or protect smaller parcels, which although potentially threatened by future development trends, contain high biological diversity. As a result, a net loss of rare plant diversity occurs through extirpation of local populations.

What we have attempted to do over the past several years in Virginia is to demonstrate that highway rights-of-way, consisting of compensation, mitigation, and cloverleaf sites can serve as habitat and backup sites for potentially threatened indigenous rare plant populations. We use elements of the pitcher plant/longleaf pine ecosystem as models for rare plant conservation on highway rights-of-way and think that our methods may be successfully applied in other regions by conservation biologists and right-of-way managers. The use of highway rights-of-way as rare plant restoration habitat may prevent loss of rare plant biodiversity while at the same time providing an aesthetically pleasing alternative to the conventional suite of plants used in highway rights-of-way.

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MATERIALS AND METHODS

Our study was confined to highway rights-of-way and mitigation sites on the coastal plain of Virginia. We developed a five-step process for rare plant conservation consisting of discovery, research, propagation, reintroduction, and education. Components of these methods follow.

Discovery

Rare bog plant propagules (seed or rhizome divisions) of *Drosera capillaris* Poiret, *Eriocaulon decangulare* L., *Helenium brevifolium* (Nutt.) Wood, *Platanthera blephariglottis* (Willd.) Lindl., *Sarracenia flava* L., and *S. purpurea* L., were located on power line rights-of-way as previously described (Sheridan et al., 1997) or were harvested from failing, fire suppressed sites. Plant rarity was determined by consulting Killeffer (1999). Longleaf pine seed was collected from one of the few natural stands left in Virginia on International Paper property (Sheridan et al., 1999a).

Propagation

Plants were raised (seed or rhizome divisions) in either above ground beds or pots at the Meadowview Biological Research Station in Woodford, Virginia following the methods of Sheridan (1997) and Sheridan and Karowe (2000).

Reintroduction

Field evaluations were performed to find appropriate sites for rare bog plant reintroduction. Since pitcher plant bogs are considered nutrient deficient, early successional communities (Juniper et al., 1989; Plummer, 1963) with a diagnostic suite of plant species (Folkerts, 1982) we selected sites for reintroduction based on presence of associate species. Typical associate species that we used to indicate appropriate hydrology, soils, and light availability were *Lycopodium appressum* (Chapman) Lloyd & Underwood, *Osmunda cinnamomea* L, *Magnolia virginiana* L, *Smilax laurifolia* L, and *Sphagnum* sp. Selection of sites for longleaf pine planting were based on site availability more than soils or hydrology since this species has a wider ecological tolerance than the bog species. Reintroduction procedures followed established protocols (Maryland Natural Heritage Program, 1999).

Four sites were located for rare plant reintroduction, three in Prince George and one in Greensville County, Virginia. An alphanumeric site code was assigned to each site as previously described (Sheridan et al., 1997) while specific site names utilized by the Virginia Department of Transportation (VDOT) were retained for ease of discussion and communication. Sites are as follows: Greensville County, Otterdam Swamp, VAGREE020; Prince George County, 35/95, VAPRIN004; Prince George County, 295/460, VAPRIN005; Prince George County, Fort Lee, VAPRIN006. Generally sites were not disturbed prior to planting with the following exception. VAPRIN004 had a canopy of red maple (*Acer rubrum* L.) which was mechanically removed in March 1998. Garlon herbicide was applied directly to cut stump bases as recommended by label directions for such treatment and woody debris removed from the site. Soil pH was measured for selected VDOT sites utilizing EM Science color pHast indicator strips in a 1 soil:1 distilled water solution or sent to the Virginia Cooperative Extension Service for analysis (natural sites). Soil pH was then compared to natural pitcher plant habitats in Georgia and Virginia.

Pitcher plant and associate wetland plant species reintroductions were done from April to September during 1998–2000 to assess the relative success rate of time of planting. Plantings consisted of either bare root or container stock and involved inserting plants in freshly opened holes in the ground followed by gentle soil closure around the crown of the plant. In previous pilot projects (Sheridan, 1996) we have found that hummocks, seepy (but not ponded or flooded) mineral soil, and toe slope seepage seem to be preferred habitats for pitcher plants and associate flora. Therefore we made an effort to select this habitat in our planting scheme for maximum success. Plants were then flagged and labeled. Longleaf pine seedlings were planted following the methods of Sheridan (2000) at the 295/460 site or were planted using a dibble bar at the Otterdam Swamp wetland mitigation site. We collected survival data for both longleaf pine and pitcher plants on an annual basis. Survival data was not collected on other bog plant introductions (e.g., *Drosera*, *Helenium*, etc.) due to logistic and time constraints. However, we think that longleaf pine and yellow pitcher plant survival data may provide a relative measure of the success of associate bog plant introductions.

A rare plant reintroduction form was then prepared listing the name of the site, map location, plants introduced, their quantity, and origin within the state. The rare plant reintroduction form was then provided to state regulatory authorities for tracking purposes.

Research

We utilized mitigation sites as virtual laboratories to perform large-scale experiments in plant ecology. Specifically, Otterdam Swamp is now being used to test *in situ* the long term fitness of progeny from our inbreeding/outbreeding experiments with *S. flava* (Sheridan and Karowe, 2000), to investigate the effects of nutrient inputs on pitcher plant seedlings, and to track local migration of rare plant species.

Education

We involved Potomac Elementary School (King George County, Virginia) in propagating, experimenting with, and introducing rare plants on the Otterdam Swamp wetland mitigation site (Sheridan et al., 2000a) via the

Toyota Tapestry Grant as a funding source. We wanted to determine whether young students could successfully complete a rare plant conservation program with a highway department while at the same time increase their awareness of environmental issues.

RESULTS

A total of 1126 yellow pitcher plant have been introduced on VDOT rights-of-way with survival averaging 66% (Fig. 1, Table 1). Somewhat surprisingly, the July pitcher plant introduction at Fort Lee had the highest survival rate. However, this must be tempered by our observation that clump size was greatly reduced by drought stress in comparison to plantings at other times of year. In addition, the lower success of the fall plantings at Fort Lee is largely due to a hurricane which dislodged and buried a number of pitcher plants. Soil pH at the introduced pitchers plant sites was 4.5 and fell within the expected pH 4–5 for natural pitcher plant bogs both in Virginia (Table 2) and Georgia (Plummer, 1963). Longleaf pine survival at the 295/460 site is 76% after two growing seasons (Sheridan, 2000) (Fig. 2).

The involvement of Potomac Elementary School in all phases of the rare plant reintroduction at Otterdam Swamp was successful (Fig. 3). Project objectives were met within the one year time frame of the Toyota Tapestry Grant. Students determined that pitcher plant seedlings benefit from a variety of fertilizers (Sheridan et al., 2000a). Students also gained new understanding of what rare plants occur in Virginia, where they are found, why they have become rare, and how they can prevent extinction of rare species through cooperative ventures with state agencies such as the Virginia Department of Transportation (Armstrong, 2000; Harris, 1999; Tennant, 2000).

Fig. 1. Yellow pitcher plant, *Sarracenia flava* L., in bloom during their third successful year at Fort Lee wetland mitigation site.

DISCUSSION

To our knowledge, this is the first restoration effort to take indigenous rare plants and relocate them within their historic range on appropriate habitat on highway rights-of-way. Although rare plants are known to naturally occur on highway rights-of-way (Martz, 1987) their deliberate introduction into synthetic habitats on highway rights-of-way is new. Furthermore, the concept of using these habitats to maintain biodiversity in the face of continued urbanization and fragmentation of habitat expands the potential range of environments available to conservation biologists.

Highway rights-of-way are presently underutilized for rare plant conservation and have great potential for recovering losses in rare plant populations. As an example, there are now less than 100 clumps of native yellow pitcher plant (*Sarracenia flava*) left in the wild in Virginia. Our work with the Virginia Department of Transportation has increased the native population by seven times. Hence a significant increase in population

Table 1. Month, year, quantity, and survival of *Sarracenia flava* planted at VDOT wetland mitigation sites

Site code	Site name	Mo./Yr.	Quantity	No. surviving	Surviving (%)
VAGREE020	Otterdam	4/2000	361	295	80
VAGREE020	Otterdam	5/2000	365	161	44
VAPRIN004	35/95	4/1998	36	28	78
VAPRIN006	Fort Lee	7/1998	45	45	100
VAPRIN006	Fort Lee	9/1999	319	215	67
Total			1126	744	66

Fig. 2. Longleaf pine, *Pinus palustris* Miller, grass stage seedling after two growing seasons at the 295/460 cloverleaf.

Table 2. Soil pH of native and introduced pitcher plant wetlands in Virginia

Site code	Site name	pH
Native		
VADINW001	Shands	4.0
VASUFF001	Kilby	4.4
VASUSS001	Sappony	4.8
Introduced		
VAGREE020	Otterdam	4.5
VAPRIN006	Fort Lee	4.5

Fig. 3. Jerry Pruyne, of Virginia Department of Transportation, helps Potomac Elementary School students plant yellow pitcher plant seedlings at Otterdam Swamp wetland mitigation site. Photo by Victor J. Griffin, Virginia Dept. of Transportation.

size of this rare species will have occurred due to use of appropriate habitat on highway rights-of-way for restoration purposes. In the case of longleaf pine (*Pinus palustris*), a keystone species in southeastern pineland ecosystems, highway right-of-way habitat is allowing a 11% increase in population size since only 4432 longleaf pine remain in Virginia (Sheridan, 1999b). Clearly these are significant contributions to rare plant species recovery.

Are there any regulatory consequences to planting rare plant species on highway rights-of-way? We designed our program to minimize or eliminate any potential conflicts. One of the more important components is providing state natural heritage personnel with a rare plant registry form with relevant data for tracking purposes. We were under no obligation to provide such information in Virginia, since we were not working with Federal or State endangered species, but felt that a cooperative effort with state authorities could only be beneficial. We also only used indigenous plant stocks from the local area to prevent any concerns about "genetic pollution" or importation of pests. We also selected species for reintroduction that were historically much more common but had been locally extirpated due to land use changes. Our choice of planting sites (wetland mitigation sites) also ensured that rare species plantings would not present a future problem since wetland mitigation sites are already tightly regulated and future road designs avoid impacting these habitats. In the case of our cloverleaf plantings, the choice of longleaf pine avoids potential conflict since this tree is a commercially utilized tree by the Virginia Department of Forestry and highly unlikely to be regulated by the Division of Natural

Fig. 4. Mark Mikolajczyk kneeling to the right of ten year old bald cypress, *Taxodium distichum* (L.) Richard, which has been stunted due to unusual soil chemistry at Otterdam Swamp wetland mitigation site.

Heritage. We think that innovative programs to maintain rare species, such as the safe harbor program with the red-cockaded woodpecker (Costa, 1999), will be one of the ways to minimize conflicts between regulators, private landowners, and other agencies while at the same time providing effective, cordial, conservation programs.

Highway rights-of-way are particularly good sites for rare plant refuges because they are monitored and maintained by local departments of transportation. Survival potential is high because the sites may be managed with either mechanical or chemical means. Given that many plant species have suffered significant habitat loss in coastal Virginia, and that appropriate habitat may be found on highway rights-of-way, a logical decision would be to use these areas as rare plant conservation habitat. Why insist that rare plants should only be allowed to persist in the few refugia that have escaped destruction or degradation? This extremely conservative approach needlessly handicaps rare plant conservation when alternative approaches to restoration are now available. Furthermore, state rare plant reintroduction guidelines now allow rare plants to be planted in areas where they may not have naturally occurred (Maryland Natural Heritage Program, 1999).

How do we evaluate the long-term success of our rare species plantings and what is the likelihood of their persistence? A key element to answering this question is the need to understand the ecology of the species that is being restored. In our case we have been working with pitcher plants and their wetland plant associates for over twenty years. Although we continually obtain new insights on the ecology of these species we are able to recognize habitat that offers the greatest likelihood of success and persistence.

Pitcher plants and associate species in the southeastern US are adapted to ecosystems that are considered nutrient deficient, early successional communities. Generally this early successional state, and suppression of woody competition, is naturally accomplished by frequent, lightning caused fires (Folkerts, 1982; Frost, 1993). However, in rare cases, persistent natural gaps can be found that apparently prohibit woody invasion by chemical means (Sheridan et al., 2000b). Two of the wetland mitigation sites we selected for our rare plant reintroduction (Fort Lee and Otterdam) contain pyritic soils which produce excessive acidity to the point that woody growth is either stunted or killed (Figs. 4 and 5). Prior to our restoration work these were considered problem sites because of failed plantings (Whittecar and Daniels, 1999). However, based on the presence of associate plant species suggesting appropriate pH, we were able to exploit this niche for the planting of rare species adapted to these conditions. Furthermore, the chemical inhibition of woody growth may ensure long-term persistence of our selected, herbaceous species. Monitoring of reproduction and spread of offspring will quantify this success.

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Fig. 5. Natural stunting of baid cypress has been recorded in western Florida peatlands where Keith Underwood and Guy Englin stand next to 300 year old cypress trees which only reach 2 m. Inhibition of woody growth provides refugia for rare wetland plant species such as pitcher plants.

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Part III
Corridors

Co-Location of Linear Facilities: Realistic Opportunity or Unrealistic Expectation

David F. Jenkins

Since the early 1970s, co-location of linear facilities (which includes the concepts of joint use of existing rights-of-way, paralleling of existing rights-of-way, multiple use [by various facilities] of existing rights-of-way, etc.) has been advocated as a means of reducing overall impacts associated with the construction of new linear facilities. Overall impacts may be reduced if a new linear facility is co-located with a well-sited existing linear facility. However, several factors affect the degree to which co-location offers benefits when siting linear facilities. Factors that affect the success of co-location include inconsistent siting criteria for different types of facilities (e.g., overhead facilities, such as electric transmission lines, versus underground facilities, such as pipelines) and reliability and safety issues for the co-located facilities. Additional effects of co-location on the landowners currently affected by an existing right-of-way must be considered in determining the advantages and viability of co-locating new facilities. Both utilities and regulatory agencies should consider not only the broad advantages of co-location, but also site-specific and landowner-related issues if co-location is to be used in the most advantageous manner.

Keywords: Co-location, joint use

INTRODUCTION

In 1970, the Federal Power Commission published guidelines for the siting of rights-of-way for electric transmission lines (Federal Power Commission, 1970). The first of 23 guidelines for the selection of routes for rights-of-way stated that "existing rights-of-way should be given priority as the locations for additions to existing transmission facilities, and the joint use of existing rights-of-way by different kinds of utility services should be considered." Since that time, the concept of co-location of linear facilities (including joint use of existing rights-of-way) has become doctrine for the siting and permitting of new linear facilities and co-location has become a standard part of permitting new facilities. Utilities planning new facilities propose co-location as a means of facilitating regulatory approval of their proposed facilities, and regulatory agencies advocate and require co-location as a well-intentioned effort to minimize overall impacts of new linear facilities. Thousands of miles of linear facilities have been co-located in rural and urban environments, wooded and agricultural areas, and on private and public lands. Experience over the last 30 years has shown that co-location can, in fact, minimize some impacts associated with new linear facilities. However, co-location of new linear facilities with existing linear facilities is not always the best approach to minimizing the overall impact of two (or more) linear facilities.

The concept and benefits of co-location have been discussed for years in professional publications and conferences, such as the Symposia on Environmental Concerns in Rights-of-Way Management. These discussions have ranged from the advantages of co-location with respect to regional planning goals, to the design, and construction factors that affect co-located facilities, and the compatibility of construction and operations parameters of co-located facilities (Howlett, 1976; Steinmaus, 1982; Jenkins, 1987). However, co-location of a new linear facility adjacent to an existing linear facility is not a universal means of mitigating the

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impacts of construction and operation of linear facilities and can exacerbate problems associated with the existing right-of-way.

This paper reviews factors that affect the benefit that can be realized by co-locating new linear facilities with existing linear facilities. The changing physical, regulatory, and social environments affect the applicability of co-location. Potentially conflicting criteria for the siting of different types of linear facilities (i.e., unlike linear facilities) may affect the viability and benefit of co-locating unlike linear facilities. Reliability and safety issues associated with co-located facilities and the effects of co-located facilities on landowners also influence the overall benefit of co-location in the "big picture" of linear facility siting. The discussion is directed to rights-of-way for electric transmission lines, pipelines, fiber optic facilities, and other facilities that typically allow secondary land uses.

THE CHANGING ENVIRONMENT

The physical, regulatory, social, and technological environments within which linear projects are being developed continue to change, affecting strategies in siting, permitting, and constructing new facilities on or adjacent to existing rights-of-way. The number of new rights-of-way continues to increase to meet the demands of growing population and the shifting of population centers. Simply put, more people need more of the services provided by linear projects.

However, development has affected the siting of linear facilities in different ways. Continued residential, commercial, and industrial development logically encourages co-location of utilities to minimize the construction of new rights-of-way and the associated impacts on existing land use patterns and new development. But, development can also reduce opportunities for co-location of new facilities. In many areas, development has occurred up to the existing rights-of-way, with not only developed properties abutting the right-of-way, but, in many cases, with the foundations of residential, commercial, and industrial structures adjacent to the edge of the right-of-way. This abutting development can eliminate or severely restrict the degree to which new linear facilities can be located on or adjacent to the existing right-of-way and also results in an increased number of potentially concerned landowners to participate in the permitting process.

Changing construction technologies have helped to eliminate the need for cleared rights-of-way in sensitive areas, thus eliminating the "existing right-of-way" and a primary advantage when applying the co-location concept. Notably, the horizontally controlled direction drill technology, so successfully used for pipeline and fiber optic construction, can allow (where appropriate subsurface conditions exist) these underground facilities to be installed under areas or features that should or must be avoided (e.g., waterbodies, wetlands, cultural resource sites, and other sensitive areas) without creating a cleared surface right-of-way. Horizontally controlled direction drill technology has been successfully employed to install segments of large-diameter pipeline of over a mile in length. As a result, the advantage of co-locating a new linear facility adjacent to an "existing" cleared right-of-way no longer exists along those route segments.

Advances in information technology have affected the social environment and the process for permitting new facilities, in general, including new linear facilities, whether co-located or not. Landowners, citizens, and special interest groups who take an active interest in the permitting of new facilities are using new communication technology to aggressively advance their particular objectives relative to new linear projects. In meeting their particular objectives (not infrequently, to oppose a proposed linear project), these groups are aggressively using the Internet to distribute information, organize support functions, etc. Few utilities have been able to use the Internet as effectively to meet their needs in developing new projects. Increased public scrutiny may, in fact, encourage the jurisdictional regulatory agencies and the utilities themselves to adopt co-location for certain segments of projects in the belief that the application of the co-location principle with the general benefits may reduce public opposition and delays in the regulatory process.

FACTORS INFLUENCING THE EFFECTIVENESS OF CO-LOCATION

Siting principles and co-location

Conceptually, co-location of a new linear facility with an existing linear facility can offer benefits by: (1) reducing the total width of required right-of-way and the associated clearing and construction impacts; (2) consolidating similar land uses; and (3) reducing fragmentation of wildlife habitat and other land use areas. However, a well-sited right-of-way for an electric transmission line or other aboveground linear facility is not necessarily a right-of-way also well suited for a pipeline or other underground facility.

When new linear facilities were sited in the past (those that now constitute the "existing rights-of-way"), little if any consideration was given to the shared or adjacent use of the right-of-way by new, subsequently constructed facilities. Occasionally, a company would purchase more right-of-way than needed at the time, construct the required facility on the needed right-of-way, and reserve the remaining (vacant) right-of-way for future expansion. However, planning was almost universally in terms of constructing a "like" facility on the additional right-of-way in the future. That is, an electric transmission company would purchase right-of-way not only to construct a new transmission line at that time, but also to ensure that (the additional) right-of-way would be available to upgrade the voltage of the existing electric transmission line or to construct an additional electric transmission line. Extra right-of-way was not typically purchased with the thought of that right-of-way being used for a different type of facility — not for the future construction of a pipeline.

The right-of-way requirements for unlike linear facilities are not necessarily consistent. Existing rights-of-way designed for one type of facility do not always present a logical location for a second, unlike facility. The construction and operations requirements of overhead versus underground facilities differ sufficiently that co-location of these unlike facilities may not only be unrealistic, but may actually result in more long-term impact than if the two facilities were sited on independent rights-of-way.

For example, the right-of-way for an electric transmission line could cross numerous non-forested wetlands. However, if the wetlands can be spanned, there may be little or no impact to the wetland resource. If the same right-of-way were used for co-location of a pipeline or other underground facility, the requirement for a continuous trench across the wetlands could result in significantly more impacts. Fewer overall impacts could result if the two different facilities were constructed on independent rights-of-way. Likewise, an underground facility, such as a pipeline or fiber optic facility, could be sited through or near a residential area with little or no visual impact. Co-location of an electric transmission line adjacent to that existing right-of-way could result in increased visual impacts. Clearly, the co-location of unlike linear facilities can result in additional site-specific impacts relative to independent sitings of the two facilities.

However, the conceptual benefits of co-location have lead several federal, state, and local land management agencies to apply the concept of co-location in the most generic of manners. Several agencies have established "utility corridors" across publicly owned or publicly managed lands in which all utilities (e.g., roadways, overhead electric transmission lines, pipelines, etc.) must be located if they are to cross that land. In many cases, these corridors have been sited only to avoid "sensitive areas." Even if appropriate siting criteria had been considered during the siting of the original corridor, differing construction and operations requirements for the unlike facilities (and associated impacts) that could potentially occupy the utility corridor could limit the effectiveness of the corridor. Consequently, the impacts from the construction of utilities in that single corridor without considering facility-specific characteristics may actually result in increased impacts within that corridor area.

In the zeal to co-locate a new linear facility on or adjacent to an existing right-of-way and to realize the conceptual benefits of co-location, the construction- and operations-related impacts of the new facility may not be adequately considered in the decision to co-locate the new facility. The site-specific, as well as the broad scale, impacts and benefits must be weighed in such a decision.

Facility reliability and safety

The affects of construction and operation of a new co-located linear facility on the existing facility, and vice versa, may also determine the feasibility of co-location and the benefits that may or may not be realized.

The reduction in right-of-way width requirements will be determined by how close the new facility can be located to the existing facility. Centerline separation between electric transmission lines, pipelines, and fiber optic facilities can be calculated on strict operational characteristics of each facility, based on such factors as electrical clearance between transmission line conductors, induced currents in pipelines located adjacent to electrical transmission lines and the need for cathodic protection for the pipeline, etc. However, other less technical factors may require increased centerline separation and affect whether co-location is acceptable.

The possible damage to the existing linear facility during the construction of the new co-located facility is a real concern, with numerous examples to justify that concern. In one case, the jurisdictional regulatory agency required co-location of a new natural gas pipeline adjacent to an existing electric transmission line right-of-way in a relatively undeveloped area in the northern United States. Damage to the transmission line from blast rock and other construction activities resulted in several outages on the transmission line during construction.

In another case, a pipeline company proposed the co-location of a proposed new natural gas pipeline with an existing high-voltage electric transmission line, with the right-of-way for the pipeline almost completely within the existing electric transmission right-of-way. However, the electric transmission line served a major metropolitan area and was considered by the state public utility commission to be a key link in the regional electric transmission grid. The state public utility commission opposed the co-location because of the possible damage to the electric transmission line during construction of the pipeline and the catastrophic results if the pipeline were to explode. An alternate route, suggested to avoid co-location with the electric transmission line, would have been co-located with existing roadways, but would have affected orders of magnitude more landowners.

Accidents involving conductor-to-equipment flashover and conductor-equipment contact during the construction of adjacent, co-located facilities have resulted in the death and injury of several construction workers. Damage to pipelines, fiber optic lines, and other underground facilities also occurs all too frequently during the construction of adjacent facilities. The resulting loss of service and damage (e.g., resulting from explosions of damaged natural gas pipelines) can be significant.

Although application of the co-location concept may be applied by the jurisdictional regulatory agency for valid reasons, the unanticipated secondary consequences of co-location can be negative. In cases such as these, increased centerline separation between the co-located facilities to reduce the possible risk of physical impact on the original facility during construction could have been a realistic consideration. More prescriptive conditions on permits and certificates to avoid the dangerous aspects of co-location should also be a consideration during permitting.

EFFECTS OF CO-LOCATION ON LANDOWNERS

The benefits of co-location are typically associated with broad land use planning principles or goals (e.g., consolidating land use types, reduced total clearing and land disturbance, reduced fragmentation of land use areas, etc.) and ecological benefits (e.g., reduced clearing, use of common access roads, reduced fragmentation of habitat, etc.). Although impacts may be consolidated and the number of new rights-of-way may be reduced, co-location of rights-of-way also consolidates, increases, and exacerbates the impacts on the underlying landowners.

Two types of "owners" can be affected by the co-location of new linear facilities on or adjacent to existing rights-of-way. The first is the underlying landowner of the right-of-way. This may be the utility company owning the linear facility (the facility landowner) if the right-of-way is owned in fee. Or, the underlying landowner may be a private party, in which case the utility company would own some form of easement on the property for the right-of-way. If the utility company owns an easement, it owns rights (through the easement) and the easement may also be affected by the co-location of a new facility.

The new co-located facility may also require additional new right-of-way adjacent the existing right-of-way, which could also involve additional owners.

Effects on the facility landowner

Utilities constructing a new linear facility adjacent to their own existing, like facility realize the greatest benefit of co-location. This is especially true if the utility company owns adjacent, vacant right-of-way. If the utility company had the foresight to purchase additional right-of-way or easement at the time the original facility was constructed, the loss of that right-of-way for the construction of unlike or unrelated facilities can have potentially significant affects. First, the utility company would lose the ability to develop a new facility if a second utility company used that vacant right-of-way for the development of a co-located facility. Vacant right-of-way for future development can be of enormous value which protects against encroachment by future residential and commercial development that could make right-of-way acquisition and permitting much more difficult at a future time. However, under the co-location concept, this vacant right-of-way represents an ideal opportunity for siting a new linear facility. Even though the owning utility company may be compensated for the fair market value of the property by the second utility company, the value of having vacant right-of-way available for future development of a new facility will be lost.

If the facility landowner must, in fact, develop the new facility that was originally envisioned for the vacant right-of-way and the vacant right-of-way is no longer available, the owning utility company will now have to site the new facility on a new right-of-way with the attendant impacts. The additional costs to the facility landowner for permitting a new facility on a new right-of-way could be significant relative to the cost of using the previously available vacant right-of-way.

The requirement for co-location can necessitate special design, construction, and maintenance procedures for both the existing facility and the new, co-located facility. Insulating segments of conductors on electric transmission lines may be required to allow the safe operation of construction equipment next to the line for the installation of the co-located facility. Special blasting or horizontally controlled directional drill procedures may be required to avoid actual or potential damage to existing facilities adjacent to the new co-located facilities. Cathodic protection requirements may increase for a new pipeline if the centerline separation between the pipeline and the adjacent electric transmission line is decreased through the permitting process. Although the additional costs associated with these special design and construction considerations may be more than offset by the reduced impacts resulting from co-located facilities, they are still real costs associated with co-location that must be borne by the utilities.

Effects on the private landowner

Regardless of the circumstances under which a private landowner became an owner of a linear facility right-of-way, he/she is a prime candidate for the co-location of a second linear facility (or more) on his/her property. In many cases, the landowner does not realize that, regardless of the wording of the easement held by the utility company for the right-of-way across the property and regardless of commitments made by the utility company that only one facility would be constructed on the right-of-way, a second facility could, in fact, be constructed. Because of the simple fact that the landowner has an existing right-of-way on his/her property, they may be required to "sponsor" a second, co-located facility, and likely an expanded right-of-way, even if the original right-of-way was poorly sited and did not adhere to otherwise accepted siting principles.

Not only will the wider right-of-way result in restrictions on a much larger portion of the landowner's property, but the restrictions may also be multiple and different depending on the types of facilities. Co-located facilities (even of the same type) may have different inspection and maintenance schedules and requirements. Instead of having a single set of equipment and workers on the right-of-way over a given time interval, the different utilities may each be on their own inspection and maintenance schedule, resulting in more frequent activities on the rights-of-way.

Co-location of a new facility on or adjacent to an existing right-of-way can also limit a landowner's options with respect to negotiating payment for the new right-of-way or easement. If a new, non-co-located right-of-way or facility were to be negotiated with a landowner, some flexibility typically exists with respect to the exact location of the right-of-way on the property and (if the new right-of-way is not taken by eminent domain) in negotiating the price of the right-of-way or easement. If the jurisdictional regulatory agency dictates the co-location of a new facility, little if any flexibility remains for the landowner to negotiate since the location of the new co-located facility is dictated by the location of the existing facility. In addition, if the right of eminent domain is granted as part of the permit to allow the utility company to acquire additional right-of-way for a new co-located facility, the leverage that the landowner has available to negotiate price of the land or easement is typically defined by the state or local courts. As such, the application of co-location on a private property further limits a landowner's options.

Legitimate questions raised by various technical disciplines relative to Although the potential impact to each individual property will vary based on the configuration of the existing and co-located rights-of-way and based on restrictions on the secondary land uses on that existing right-of-way, the additional restrictions may be significant to the landowner.

CONSIDERATIONS AND RESPONSIBILITIES OF THE REGULATORY PROCESS

Regulatory agencies in general have come to embrace and adopt the concepts of co-location of linear facilities. The political and public scrutiny in the permitting of linear facilities has resulted in some land management agencies unrealistically embracing the co-location concept and in some jurisdictional regulatory agencies incorporating the requirement for joint use into permits, licenses, co-location of linear facilities and rights-of-way, but especially applicable to private landowners, are "How many adjacent co-located rights-of-way are too many? How wide is 'too wide' for adjacent co-located rights-of-way?" These questions have been raised relative to visual impact regarding the concept of "visual saturation" and the number of aboveground (electric transmission) facilities that can be co-located before "too many" have been located together. Ecologists and wildlife biologists, while embracing the use of co-location to minimize habitat fragmentation and right-of-way clearing, have also questioned the value of increasing widths of co-located rights-of-way when species of animals will no longer cross the open space of multiple cleared rights-of-way. The landowner can legitimately ask the same question regarding "How much is too much?" when the issue of new, additional rights-of-way on his/her property is again and again proposed in the name of "co-location." and certificates. The application of the joint use concept is becoming part of the rationale for the expedient justification for some regulatory agencies to approve needed utility projects. The burden of actually applying the concept is then left to the owners of the existing and proposed linear facilities.

The propensity for regulatory agencies to advocate and/or dictate co-location of new facilities is well understood by the utilities industry. In fact, some utilities will propose co-location of their proposed new facilities simply as a means to facilitate, and hopefully accelerate, the permitting process for the new facility. The utility company may not necessarily see the need for co-location of their proposed facility. However, even though co-location may not provide for the least impacting route or provide opportunities for the most economical or efficient design for the new facility, the additional cost associated with co-location is viewed by many utilities as the cost of getting the new facility permitted in the shortest amount of time.

It is the responsibility of the regulatory agencies to realistically evaluate proposals for new linear facilities and evaluate the overall impacts associated with co-located facilities versus independent facilities with new rights-of-way taking into account some of the factors discussed above.

CONCLUSION

Co-location of linear facilities and rights-of-way can reduce the overall impacts of construction and operation of new linear facilities. However, the benefits of co-location can be offset by negative aspects.

Co-location is not a panacea for the siting of new linear facilities. Both utilities and regulatory agencies should consider co-location as only one of many criteria in the planning and siting of new facilities and must weigh the broader advantages of co-location against site-specific and landowner-related issues and impacts. Co-location can compound and exacerbate impacts to the private landowner with the existing right-of-way on his/her property and to the utility with the existing facility on the right-of-way. While the siting, permitting, and construction processes for a new co-located linear facility are relatively short term, multiple linear facilities and the associated impacts on a private landowner will last for the operational lives of the co-located facilities. Co-location does represent an opportunity to reduce overall impacts from the construction and operation of linear facilities; however, the overall benefits of co-location may not live up to expectations.

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Saturation Threshold in a Multi-Pipeline Corridor Expansion Project

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TransCanada PipeLine Ventures Ltd. Partnership, on behalf of NOVA Chemicals Corporation, constructed a 273.1-mm (10-inch) ethylene pipeline within an existing multi-pipeline corridor between two petrochemical plants in the Joffre area, east of Red Deer, Alberta. The ethylene pipeline was constructed within a 10-m (33-foot) wide area between two existing operating pipelines. The pipeline crossed in and out of the corridor seven (7) times between the two petrochemical plants. The objective of this paper will be to discuss thresholds and related saturation indicators arising from construction in a multi-pipeline corridor. The paper will evaluate the project-related communication with the regulatory agency, owner and contractor, the atypical planning required, and the specific use of certain construction equipment, such as Low Ground Pressure (LGP) dozers and backhoes to conserve topsoil, for safe construction of this pipeline within this multi-pipeline corridor. Environmental and safety concerns were met during construction by maintaining equivalent land capability and preserving the integrity of the operating pipelines within the corridor. The saturation point for the multi-pipeline corridor was based on stakeholder, environmental, and constructability thresholds. These thresholds may be useful in the assessment and planning of pipelines within other multi-pipeline corridors.

Keywords: Threshold, constructability, environmental assessment, management system, soils handling, stakeholder

INTRODUCTION

TransCanada PipeLines Limited ("TransCanada") operates approximately 38,000 km of natural gas pipelines across Canada. TransCanada has over 19,000 km of right-of-way in Canada, traversing many different environments ranging from Taiga Plains through to the Boreal Shield and Mixedwood Plains, and crossing some 21,150 properties. In managing this extensive linear system, TransCanada faces the challenges of corridor issues on an ongoing basis. One of the corridor issues to be addressed is the concept of the saturation level of a corridor based on the evaluation of thresholds.

TransCanada has developed working definitions for both threshold and saturation level which will be applied to the following discussion. A "threshold" is "the point at which an identified negative effect begins to be realized." An analogy would be a glass of water. At some point the glass becomes full (the threshold) and one more drop of water results in an overflowing cup (negative effect).

TransCanada sees three primary categories of thresholds in all its rights-of-way, each of which may consist of various other thresholds. Firstly, TransCanada has identified the need to manage the stakeholder thresholds. There can be numerous stakeholders interested in some or all of TransCanada's rights-of-way, and each brings to the table a unique view of the acceptable tolerance for development. Secondly, TransCanada recognizes the need for environmental thresholds to be addressed in its environmental assessment activities. The analysis of thresholds also forms an important component of a cumulative effects assessment. Thirdly, as a pipeline company, TransCanada must incorporate the concept of constructability thresholds into its planning activities. TransCanada must be able to construct and operate

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its pipelines in a safe manner and must therefore understand what construction and operation limitations exist. Each of these thresholds varies from location to location.

TransCanada submits that all thresholds must be taken into account when determining the saturation level for a particular corridor. The working definition of "saturation level" of the corridor is "the point at which mitigation of the effects of the proposed development on a given threshold is not attainable." For example, the space available for an additional pipeline in a corridor with four operating pipelines may exceed the threshold for constructability. That is, there may be too many pipelines within the corridor to safely construct another pipeline.

TransCanada manages its rights-of-way by seeking a balance of the multiple thresholds to be considered in all its work. By managing and working within the limits of each of these thresholds, the company is working towards the sustainable development of Canada's resources.

The focus of the following discussion is the management of multiple thresholds within a right-of-way, from a pipeline perspective. The 1999 Prentiss Ethylene Pipeline Project will be used in this paper to demonstrate how TransCanada applies its Health, Safety and Environment (HSE) Management system to address the challenges of working within an existing corridor that has multiple pipelines and thresholds.

Health, Safety, and Environment Management system

The primary tool that TransCanada uses to ensure consideration of the multiple thresholds is the Health, Safety, and Environment (HSE) Management system and its associated tools and processes. The basis of TransCanada's HSE Management system is to ensure: effective planning; implementation of the plan; monitoring of the plan implementation; and continuous improvement of the plans and processes. TransCanada has developed a set of environmental standards which outlines the company's policy approach to protection of natural resource integrity as well as the commitment to implementation of those protection measures (TransCanada PipeLines Limited, 1999). The standards are supported by "how to" procedures which align to meet or exceed all relevant legislative requirements. Through the management system, processes have been established to ensure communication of these standards and procedures to stakeholders for their comment and support.

Within the management system framework, TransCanada has developed an approach for managing thresholds that is applied consistently during the planning, implementation, and monitoring phases of a project. The steps of this approach include: identifying issues; understanding the thresholds; considering mitigation; and, developing a plan. Each of these steps is discussed below within the context of the Prentiss Ethylene Pipeline Project and the stakeholder, environmental, and constructability thresholds.

With the construction and installation of additional pipeline(s) within a multi-pipeline corridor, the need to manage activities within the limits of stakeholder, environmental, and constructability thresholds is critical. The limits of the various thresholds can be identified using the following measures:

- Stakeholder thresholds — stakeholder concerns are elevated into the political and socio-economic arena to the extent that communication, arbitration, or negotiation methods have not succeeded in modifying or changing attitudes and ideals to allow for additional development;
- Environmental thresholds — the environmental impacts associated with the development cannot be mitigated (e.g., where construction mitigation could only occur within a critical time of a species' life cycle, such as calving); and
- Constructability thresholds — construction of the pipeline would cause significant safety risks to individuals and adjacent pipelines.

Project

In 1999, TransCanada PipeLine Ventures Ltd. Partnership ("TransCanada Ventures") designed and constructed the Prentiss Ethylene Pipeline Project ("Prentiss Project") near Joffre, Alberta. TransCanada Ventures led the project on behalf of NOVA Chemicals Corporation ("NOVA Chemicals"). The Prentiss Ethylene Pipeline is NPS (Nominal Pipe Size) 10 and is 9.7 km in length. The pipeline is located northeast of Red Deer between the NOVA Chemicals' Joffre Petrochemical Plant and the Union Carbide Canada Ltd. Plant site.

The pipeline route was located in the Central Parkland natural subregion of Alberta. The pipeline route was dominated by clay loam till deposits that were the result of a compacted mixture of sand and clay transported by glaciers. Fluvial deposits occurred along existing and abandoned stream channels. Glacial till, and fluvial and glaciolacustrine veneers over glacial till made up 86, 9, and 3% of the route, respectively. Topsoil depths along the route ranged from 15 to 100 cm, with an average depth of 35 cm.

The area of the pipeline route is one of the most productive agricultural zones in Alberta with most native vegetation being replaced by barley, wheat, canola, and oat crops. The route also encountered pasture and hayland consisting of legume and grass species. The land use composition in the area was approximately: 7.3 km/66% cultivated; 1.9 km/17% hayland; 0.5 km/4% pasture; 0.4 km/3% native range; 0.05 km/0.5% wooded; 0.4 km/4.0% wetland; 0.5 km/4% industrial; and 0.3 km/2.4 stream/slough.

The project planning, construction, and operation had to consider that there were only 10 m of right-of-way available for pipeline installation within the

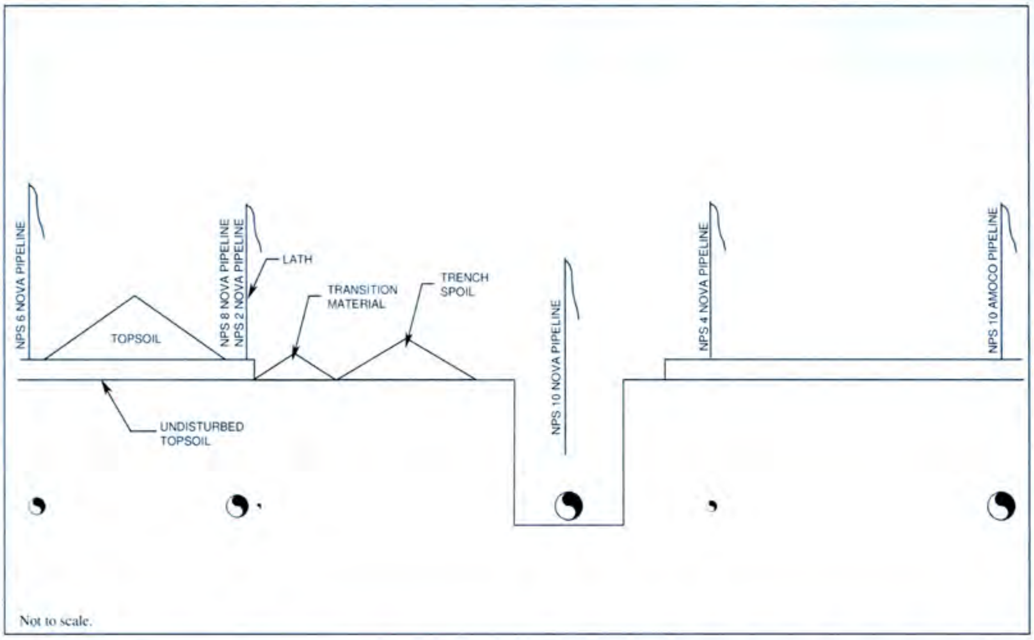

Fig. 1. Typical right-of-way configuration for the Prentiss Ethylene Pipeline Project.

existing multi-pipeline corridor. This 10-m space was bounded by an abandoned (nitrogen filled) NPS 4 pipeline and a dual pipe trench containing an NPS 8 and an NPS 2 pipeline. In addition, the corridor also contained two more pipelines, totalling five pipelines in a 48.3 m wide corridor (BOSS Environmental Consulting Ltd., 1999; TransCanada PipeLine Ventures Ltd. Partnership, 1999). The configuration of the corridor is shown in Figure 1.

The Prentiss Project was not only unusual by how it was constructed but also by how the various project activities were shared between NOVA Chemicals and TransCanada Ventures. For example, the landowner and public consultation process normally would have been undertaken by the main project team which, in this case, consisted mainly of TransCanada Ventures representatives. However on this project, NOVA Chemicals was the primary contact in discussing the pipeline expansion plans with landowners along the proposed right-of-way due to their long-term relationships to the Joffre and Red Deer communities. TransCanada Ventures supported the project by providing pipeline construction and operation expertise and by ensuring that the management framework integrated all issues that were identified during the public consultation process.

DISCUSSION

Although, each threshold had a different measure, the underlying issue on the Prentiss Project was the same for each threshold — soils handling. Soils handling became a concern due to past construction activities in the corridor that resulted in topsoil–subsoil mixing. Previous pipelines had been constructed under less rigorous regulatory requirements and construction techniques. As such, in many locations, the topsoil and subsoil were mixed to varying degrees.

The issue of soils handling manifested itself in a different way for each threshold category. The stakeholder threshold was identified as the existing width of a corridor (i.e., no more land could be taken for development). The environmental threshold was identified as soil quality, a surrogate in this case for equivalent land capability. The constructability threshold was the effective (i.e., safe) implementation of the construction plan, which included special requirements for soils handling in a narrowed right-of-way.

The resolution of the soils handling concern and the management of each of the thresholds was undertaken by working with the key stakeholders and "experts" for each of the thresholds when developing plans and monitoring implementation.

Stakeholder threshold

Identifying issues

Through stakeholder consultation, it was identified that soils handling was a key issue for landowners and regulatory personnel. As mentioned earlier, this area is one of the most productive agricultural areas in the province and it had already been affected by past construction activities (e.g., soil mixing). As a result of the soils handling practices undertaken in the past, many stakeholders did not want to see the corridor expanded any further.

Understanding thresholds

Many regulators receive numerous submissions from landowners identifying their concern that multiple pipeline rights-of-way can be a serious impediment to use of their land. Landowners have questioned the need for each company to acquire a new right-of-way, thereby expanding the overall width of the corridor, when an existing right-of-way may contain only one pipeline.

For the Prentiss Project, the stakeholders (landowners) had reached their threshold limit and therefore, there was opposition to expanding the corridor. The stakeholders believed that further expansion of the corridor would result in decreased land capability resulting from soil mixing.

Considering mitigation

Once the thresholds are understood, the proponent can begin considering mitigation measures. Working with the concerned stakeholders, TransCanada Ventures and NOVA Chemicals agreed to mitigate the stakeholder threshold by working within the confines of the existing corridor. Further, a detailed soils handling plan outlining protection measures for the current construction, including how to address existing areas of soil admixing, was also developed. In many areas the right-of-way was actually returned to an improved condition following construction. For example, buried topsoil was recovered.

Developing plans

To address the stakeholder threshold, a plan was developed to include mitigation measures, ensure ongoing stakeholder communication, and to monitor the effectiveness of the implementation of the plan, including soils handling. The stakeholder threshold provided the boundaries for the design of the construction plan. To stay within the limits of the stakeholder threshold, the right-of-way had to be maintained within the existing corridor. This threshold strongly influenced the constructability of the pipeline.

Environmental threshold

Identifying issues

The evaluation and identification of environmental issues related to using the existing corridor was undertaken during the environmental assessment (EA) process. The EA evaluates the potential effects of the proposed project on natural resources such as: soils; vegetation; water; wildlife and fisheries, including the associated habitat; air; and historical and paleontological resources. TransCanada Ventures conducted the EA using standard guidelines and assessment procedures through which all projects are evaluated.

Although there were many issues along the right-of-way, the key environmental issue identified through the EA process was soils. In this case, the concern was related to soil quality, which can be used as a surrogate for land capability.

Understanding thresholds

The soil quality issue posed a concern for this project, as topsoil-subsoil mixing had occurred during past construction in the corridor, which potentially could not be mitigated using standard construction and mitigation practices. It is very difficult to separate soils that have been mixed and farmed for many years.

The collection of soil profiles along the proposed pipeline right-of-way was used to identify the soil quality. This information allowed for the planning of specific mitigation practices that addressed and alleviated concerns associated with previous construction practices that may have affected the equivalent capability of the soils. Within the context of the Prentiss Project this information ensured that the project team could address specific construction practices within the time frame of the project schedule and could incorporate innovative and practical approaches.

Considering mitigation

In the planning of appropriate mitigative measures, undertaking appropriate soils handling within the confines of the existing corridor was the key consideration. Technical constructability considerations to address soils handling included: space requirements for topsoil and spoil storage; extra temporary work space requirements for areas where congestion of existing oil and gas facilities would be encountered; and, constraints associated with watercourse, road, railway, and foreign pipeline crossings. These technical constraints were then evaluated in the context of potential mitigative measures that would assist in the alleviation of topsoil-subsoil mixing concerns.

Developing plans

The project team worked with regulatory personnel and affected landowners to address the soil mixing concern by implementing a stripping procedure for previously disturbed soil profiles. The objective of the procedure was to improve the soil condition by reducing and undoing some of the mixing that had occurred in the past.

To further address the environmental threshold of soil quality, TransCanada Ventures designed its reclamation plans and techniques to prevent topsoil loss from wind and water erosion in the short-term and establish compatible vegetation cover as soon as possible following construction. Seed mixes were developed with stakeholders to meet their needs and concerns while at the same time maintaining compatibility with the surrounding resources and land uses.

Also as part of the plan, TransCanada Ventures undertook environmental monitoring during construction to ensure the plan was implemented properly and that soil quality was protected, and improved where possible. TransCanada Ventures also undertook post-construction monitoring to assess the success of the mitigation measures and determine any outstanding issues.

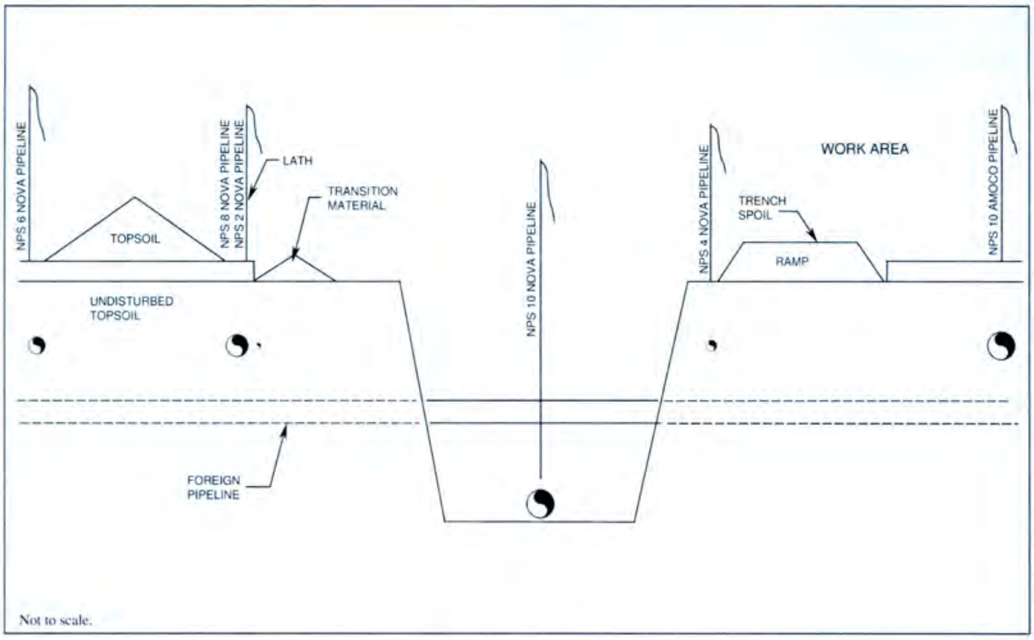

Fig. 2. Typical right-of-way configuration for a foreign line crossing for the Prentiss Ethylene Pipeline Project.

Constructability threshold

Identifying issues

During the planning phase of the project, the project team identified the need to address constructability concerns. One area of concern was a congested area located just north of the Joffre Plant site. Although there were many congested areas along the route, this one kilometre section was an area where the alignment:

- consecutively crossed two railway beds and a road crossing;
- was partially being used as a parking lot;
- crossed a major highway; and
- intersected four pipelines at the approach to the tie-in at the Joffre plant site (where there was a significant rise in elevation).

Understanding thresholds

As a result of managing the other thresholds through working within a confined right-of-way, the constructability threshold, measured by the level of safety, was close to its acceptable limit. The corridor contained multiple operating pipelines where standard construction techniques would need to be modified to address safety considerations of equipment and personnel to enable the effective implementation of the plan, including soils handling. Further, the congestion of oil and gas activities within the area and across the pipeline (i.e., foreign line crossings) increased the potential for the need to hand-expose pipelines and use of hydro-vac excavation equipment and associated containment equipment.

Considering mitigation

For the Prentiss Project, specific topsoil stripping equipment specifications were not outlined as part of the project scope. However, due to safety concerns associated with working between two operating pipelines, Low Ground Pressure (LGP) equipment was used to strip topsoil within the corridor. The LGP equipment ensured the safe construction of the pipeline even though the distance between the two operating pipelines was too narrow (10 m) for typical topsoil stripping procedures. Further, storage space requirements at road crossings for handling spoil material required modifications to handle spoil volume. The spoil was placed on the stripped work-side and was driven on due to right-of-way constraints (Fig. 2).

Another mitigation measure applied was the use of equipment with specialized clean-up buckets (i.e., no teeth on the bucket) that could scrape stockpiled topsoil off the 8 inch and 2 inch NOVA Chemicals operating lines in cultivated fields, hay land, and pasture lands. The clean-up buckets allowed for the removal of the stockpiled topsoil without damaging the vegetation that was left in place; this was key to the successful reclamation of the right-of-way.

Developing plans

TransCanada Ventures worked with construction personnel and applied its findings from the EA to determine site-specific construction plans for the Prentiss Project. TransCanada Ventures requested a specific grade plan from the Contractor prior to construction to address the construction constraints (i.e., congested areas) and to identify the potential for significant topsoil-subsoil mixing within this area if topsoil and spoil material were not handled properly. The identification of stakeholder and environmental thresholds allowed the project team the opportunity to refine the details of construction timing, further delineate the requirements for extra temporary workspace, as well as identifying alternative construction methods (i.e. constructing backwards to further reduce concerns about space limitations).

As with the other stakeholders, TransCanada Ventures ensured that monitoring of the construction was undertaken to ensure the proper implementation of the plan and to ensure worker safety. Post-construction discussions also took place to determine areas for improvement and to identify techniques that could be applied to other projects.

RECOMMENDATIONS AND CONCLUSIONS

In this paper, the authors have identified three categories of thresholds (stakeholder, environmental, and constructability) that could potentially impact construction within a multi-pipeline corridor. It is important to identify each threshold early to determine whether or not any thresholds are at their limit. If a threshold is at its limit and it cannot be mitigated, the corridor must be considered saturated. When the saturation point of the corridor is reached, the project team must assess other potential routing options.

The early identification of issues and thresholds was invaluable to the success of the Prentiss Project as it allowed for the development of a construction plan that all stakeholders (including regulators, landowners, and construction personnel) could agree to and implement. The other key to the success of the project was the implementation of the plan in the field. The plan allowed for all field personnel to understand the issues and goals of the project, which gave them a sense of ownership of the project and accomplishment with its successful outcome. The key to the implementation of the plan was open and clear communication between the project team, who developed the plan with key stakeholders, and individuals in the field who implemented the plan.

One other way to manage thresholds may be through the development of regional land use plans. Regional land use plans aid in decision making and provide a level playing field for operators and proponents in a given region. Regional land use plans can also help determine mitigation options by providing a measurable limit to development and surface disturbance.

In the absence of regional land use plans, all stakeholders, including industry, landowners, and government, need to work together to provide solutions for managing thresholds and saturation levels within existing and proposed new corridors.

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Cumulative Effects Assessment and Linear Corridors: The Representative Areas Approach

Terry Antoniuk

Cumulative effects assessment differs from conventional project-specific impact assessment by considering larger geographic study areas, longer time frames, and unrelated projects or activities. Cumulative assessments of right-of-way proposals pose particular challenges for several reasons: (1) no prescribed or standard methods currently exist; (2) there are inherent, but frequently unrecognized, differences between project-specific cumulative effects assessments and those done for resource management or planning purposes; and (3) conventional approaches are more applicable to developments that are isolated in space rather than in long, linear corridors. The "representative areas" approach described here has been successfully used in recent federally and provincially regulated pipeline proposals in western Canada. With this approach, assessment of cumulative environmental effects is conducted for representative areas comprised of one or more 1:50,000 scale map sheets. These areas are selected to include multiple project facilities or activities and to reflect biophysical conditions and administrative boundaries. Impact analyses conducted for these representative areas consider indices of landscape conditions and compare these to established or derived thresholds for indicator species or groups. The relative merits and disadvantages of this approach are discussed from the perspective of proponents, regulators, environmental organizations, and practitioners. The use of representative areas and landscape indices is concluded to be a proven alternative for linear projects of all sizes.

Keywords: Cumulative effects, landscape indices, representative areas, thresholds, study area, impact assessment

INTRODUCTION

It is now recognized that the combined effects of unrelated individual projects or activities could result in aggregate effects that may be different in nature or extent from the effects of the individual activities (FEARO, 1994). Following passage of the *Canadian Environmental Assessment Act* in 1992 and subsequent passage of related federal, provincial, and territorial legislation, assessment of cumulative effects is now required for projects undergoing formal regulatory review (e.g., NEB, 1995). The regulatory objective of this review is to ensure that environmental effects within Canada are carefully considered and that unjustified significant adverse environmental effects do not occur. Since passage of this legislation, technical and legal developments have resulted in ongoing evolution of cumulative effects assessment (CEA) practice in Canada.

CEA differs from conventional project-specific impact assessment by considering larger geographic study areas, longer time frames, and unrelated projects or activities. In CEA, there is a requirement to draw discipline-specific information together to achieve an integrated appraisal at the larger regional or landscape scale at which most cumulative effects occur (CEARC, 1986; Sonntag et al., 1987; Cocklin et al., 1992a).

CEA of linear corridor proposals poses particular challenges for several reasons:

1. No prescribed or standard methods currently exist;
2. There are inherent, but frequently unrecognized, differences between project-specific assessments and those done for resource management or planning purposes; and

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J.W. Goodrich-Mahoney, D.F. Mutrie and C.A. Guild (editors)

3. Conventional approaches are more applicable to developments that are isolated in space rather than in long, linear corridors.

Uncertain methods

CEA is affected by a variety of technical issues such as: lack of detailed monitoring information on past development activities and key environmental parameters; absence of defined resource use or ecological thresholds; availability of credible and defensible information on present and future development activities; and difficulty in predicting synergistic, discontinuous or unanticipated resource and system effects (CEARC, 1986; Sonntag et al., 1987).

Specific guidance for evaluation of cumulative effects in Canada is provided in federal documents (CEAA, 1996, 1999; Davies, 1996; Hegmann et al., 1999). There is general agreement that given the complexity of cumulative effects, no standard method is available. Instead, selection of appropriate approaches and methods depends on the objectives and issues (Cocklin et al., 1992b; Shoemaker, 1994; Hegmann and Yarranton, 1995; Smit and Spaling, 1995; CEQ, 1997; Hegmann et al., 1999; Alberta Environment, 2000). Several court decisions also provide inconsistent legal interpretations of acceptable methods.

Due to this technical and legal uncertainty, regulators, industry, stakeholders, and practitioners are unclear about how and when CEA should be conducted for proposed linear corridors.

Project-specific CEA versus regional CEA

The most common cause of misunderstanding stems from the difference between project-specific CEAs and those done for resource management or planning purposes. Regional resource management or planning studies generally consider the effects of all past, present, and possible disturbance sources (industrial, municipal, domestic, recreational) over a large geographic area and long time frames (10–100 years). Regional studies can gather information that is available, project trends into the future, and recommend effective management measures if appropriate (e.g., Banff-Bow Valley Study, 1996). For this reason, they are the responsibility of one or more government agencies and are most successful when all interested stakeholders are involved. Regional assessments should ideally be done for resource management or planning purposes before human activities begin.

In contrast, project-specific CEAs in Canada are clearly the responsibility of the proponent; these examine the proposed project in the context of other existing and likely disturbance sources. Potential combined effects are related to available management or environmental criteria so that the significance of potential cumulative effects can be assessed. Unfortunately, most linear projects are located in areas where explicit regional management plans are not available or existing plans are mutually incompatible because they were developed in isolation for different resources or sectors. For these reasons, public stakeholders participating in linear corridor proposal reviews frequently take one of two positions:

1. No rights-of-way should be allowed until an adequate regional assessment and resource management plan has been completed; or
2. The proponent should assume the government's role and complete a comprehensive regional assessment that exceeds normal project-specific requirements.

The multi-stakeholder processes required to generate regional resource management plans are generally unpredictable and protracted. This results in delays that have obvious financial and manpower implications for both project proponents and regulatory agencies.

While completion of a project-specific CEA may be viewed as a less desirable alternative by some, it ensures that regulatory requirements are met and provides regulators and stakeholders with information on potential cumulative effects that warrant mitigation and management.

Linear corridors and CEA

Unlike facilities that are isolated in space, a right-of-way footprint consists of a relatively long and narrow corridor that can cross numerous watershed, biophysical, and administrative units. Several approaches have been adopted for linear corridor CEAs since passage of the *Canadian Environmental Assessment Act*.

The most common approach, especially where formal project review was not required, has been to avoid CEA altogether because of its perceived complexity, uncertainty, and cost. A second approach has been to restrict evaluation of cumulative effects to a cursory or qualitative discussion of potential issues without any analysis or assessment. The pervasiveness of incomplete or inadequate CEAs has also been reported for the United States (CEQ, 1997).

A third approach has been to evaluate potential cumulative effects for a single indicator or biophysical unit (often referred to as a Valued Ecosystem Component or VEC). This approach provides an analysis of cumulative effects for a species or habitat type (e.g., grizzly bear or native prairie) of social, ecological, or economic importance that is potentially affected by the right-of-way.

For most linear corridors however, consideration of a suite of indicators is more appropriate because a single indicator is not capable of assessing the pertinent factors required by legislation (Noss, 1990; Cocklin et al., 1992a,b; Cairns et al., 1993; FEARO, 1994; Smit and Spaling, 1995; Hegmann et al., 1999). While this option may be the most appropriate, it has been the least common approach, likely because it expands the complexity, duration, and cost of CEA for proposed linear corridors.

Notwithstanding progress made over the last 20 years, proponents, regulators, stakeholders, and practitioners are still searching for the CEA Holy Grail: a legally and technically accepted method (or suite of methods) that can be consistently and economically applied to linear corridor proposals to understand, assess, and manage cumulative effects.

THE REPRESENTATIVE AREAS APPROACH

The "representative areas" approach described here is not the CEA Holy Grail, but it is a proven method applicable to linear corridor proposals of all sizes. This approach has been successfully applied in CEAs of recent federally- and provincially-regulated pipeline proposals in western Canada (Alliance, 1997; Salmo Consulting Inc., 1996, 1999a,b). It involves the following steps:

1. One or more map sheets (representative areas) crossed by the proposed linear corridor are selected for evaluation of potential cumulative effects.
2. Numerical measures of human-caused disturbances (landscape indices or metrics) with and without the project are calculated for these map sheets.
3. Calculated indices are compared to management criteria or thresholds for selected biophysical or socio-economic indicators to assess potential cumulative effects.

This approach provides meaningful information about disturbance levels with and without the proposed project that can be compared to established or derived ecological and social thresholds. These data supplement project-specific impact assessment and planning and allow potential incremental project effects and cumulative effects from all existing/planned activities to be evaluated. In contrast to many other CEA methods, it is relatively quick and inexpensive (less than US $7500 per map sheet) because it is based on Geographic Information System (GIS) analysis of readily available data.

Selecting representative areas

Potential environmental effects associated with pipeline and linear right-of-way projects are well understood and include: loss of rare and endangered species; loss of terrestrial habitat and habitat effectiveness; disturbance and mortality of wildlife; and loss of productive capacity of renewable resources. These may also contribute to cumulative effects at local, regional, and landscape scales.

Identification of appropriate study area boundaries is a critical component of CEA and impact assessment in general. Selection of a large study area increases the likelihood that an impact will be judged to be of no concern because it is relatively small in comparison. In contrast, selection of a small study area prevents consideration of incremental and cumulative effects that are best evaluated over large areas. Guidance documents recommend that spatial boundaries be based on the anticipated "zone-of-influence" for selected indicators (CEQ, 1997; Hegmann et al., 1999). This may lead to complex and costly analyses covering large study areas.

With the representative areas approach, a predefined study area is used for all indicators. In most analyses conducted to date, a 1:50,000 scale map sheet was used as the basic analysis unit. This unit was selected because it is one of the primary scales for both digital and hard copy data, which facilitates GIS spatial analyses. A 1:50,000 map sheet in western Canada includes an area of approximately 900 km^2. This is consistent with the study areas used for other CEAs in North America (e.g., Lee and Gosselink, 1988; CRC, 1996, 1999) and includes sufficient area to be meaningful for the ecological and resource use indicators (VECs) that are most commonly used.

Focus on representative areas is similar to the approach used for baseline or monitoring studies where specific sampling parameters, areas, and times are systematically or randomly selected to represent overall conditions. This widely accepted method is applied because it is impractical or impossible to measure everything and sampling representative sites or areas reduces effort and associated costs.

As with any sampling program design, the number and location of representative areas selected for evaluation is critical and should be based on the location, size, and nature of the proposed linear corridor as well as existing and potential cumulative effects. Selection of representative areas is based on following criteria as described more fully below:

- size and nature of the linear corridor and potential project effects;
- nature and location of past and future projects and activities;
- availability and utility of existing data and knowledge;
- inclusion of both common and uncommon biophysical conditions (i.e., vegetation, habitat, species);
- reflection of relevant ecological boundaries (i.e., Biogeoclimatic zone, Natural Region or Ecoregion, watershed, land use); and
- reflection of relevant administrative boundaries (i.e., provincial, municipal, regional).

One approach that has been used for small pipeline projects is to select all 1:50,000 map sheets intersected by the proposed route and associated facilities. Fig. 1 shows that for smaller projects less than about 30 km in length, this may restrict the analysis area to one map sheet. Nonetheless, this study area is large enough to allow cumulative effects to be considered in the context of existing disturbance such as roads, forest harvest,

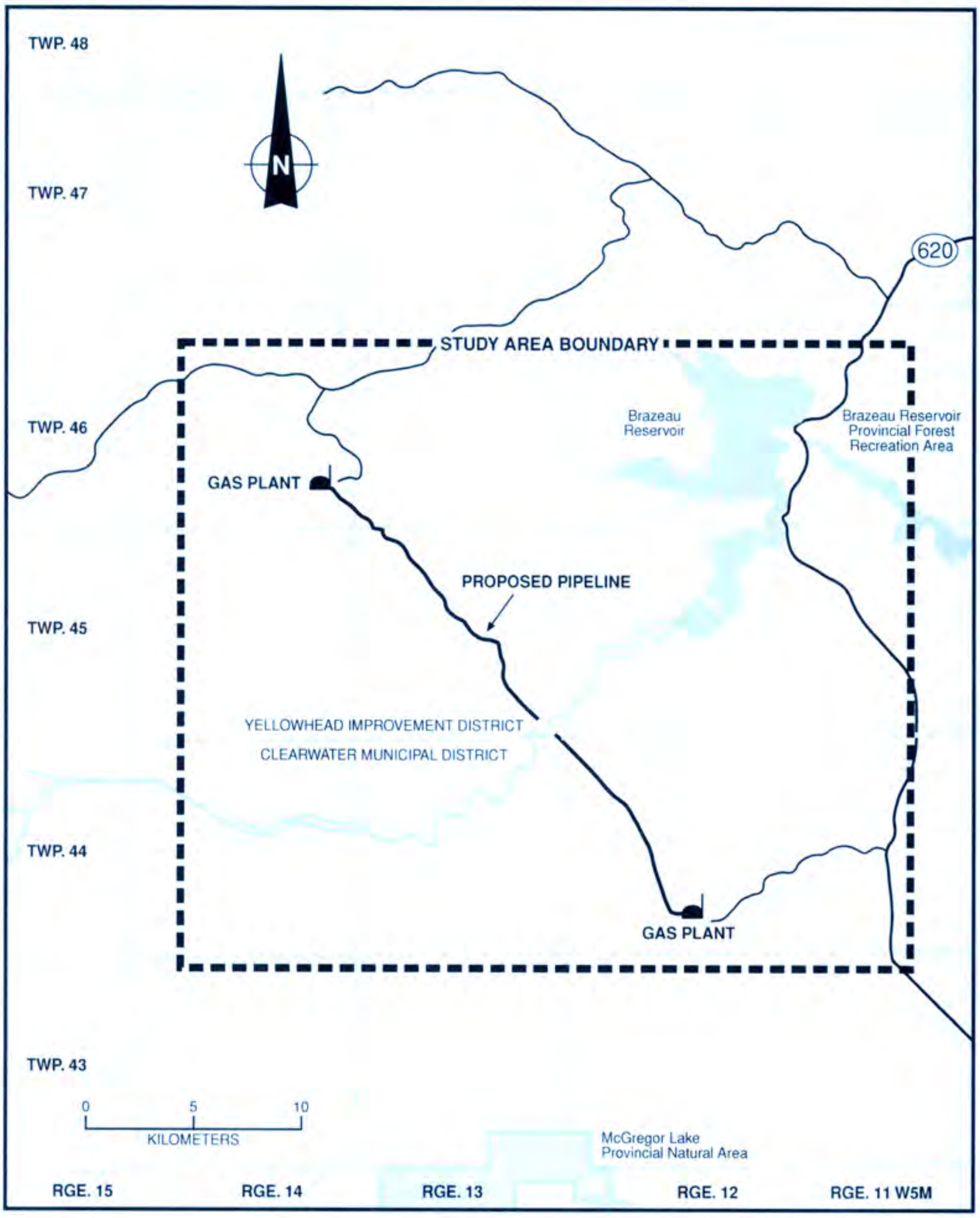

Fig. 1. CEA study area for a small pipeline project in west-central Alberta.

recreation, and urban areas (Salmo Consulting Inc., 1999a,b).

Additional map sheets can be added as needed for larger projects or those occurring in highly disturbed areas. This increases the analysis area and allows other biophysical or administrative units and existing or proposed activities to be considered.

As an example, fourteen map sheets were considered in the CEA conducted for the proposed Alliance Pipeline Project (Alliance, 1997). The Canadian portion of this project included a 1559 km long mainline, lateral pipelines totaling approximately 698 km, and associated compressors and facilities traversing three provinces and multiple ecological units. No CEA approach or method had been applied to a linear project of this scale, and conventional methods would have required evaluation of an expansive area of western Canada. For assessment purposes, the project was divided into six areas or "segments" with relatively consistent environmental, social, and project conditions. Potential cumulative effects were evaluated for a minimum of 2 1:50,000 scale map sheets for each segment. Fig. 2 shows the representative areas selected for the western half of this project. The combined evaluations for all six segments provided sufficient information to allow all cumulative effects to be evaluated (NEB, 1998).

For the Alliance Pipeline Project, comments were solicited from regulators, public stakeholders, and practitioners to evaluate the suitability of proposed representative areas. Although there was overall acceptance of the approach, a variety of concerns were expressed.

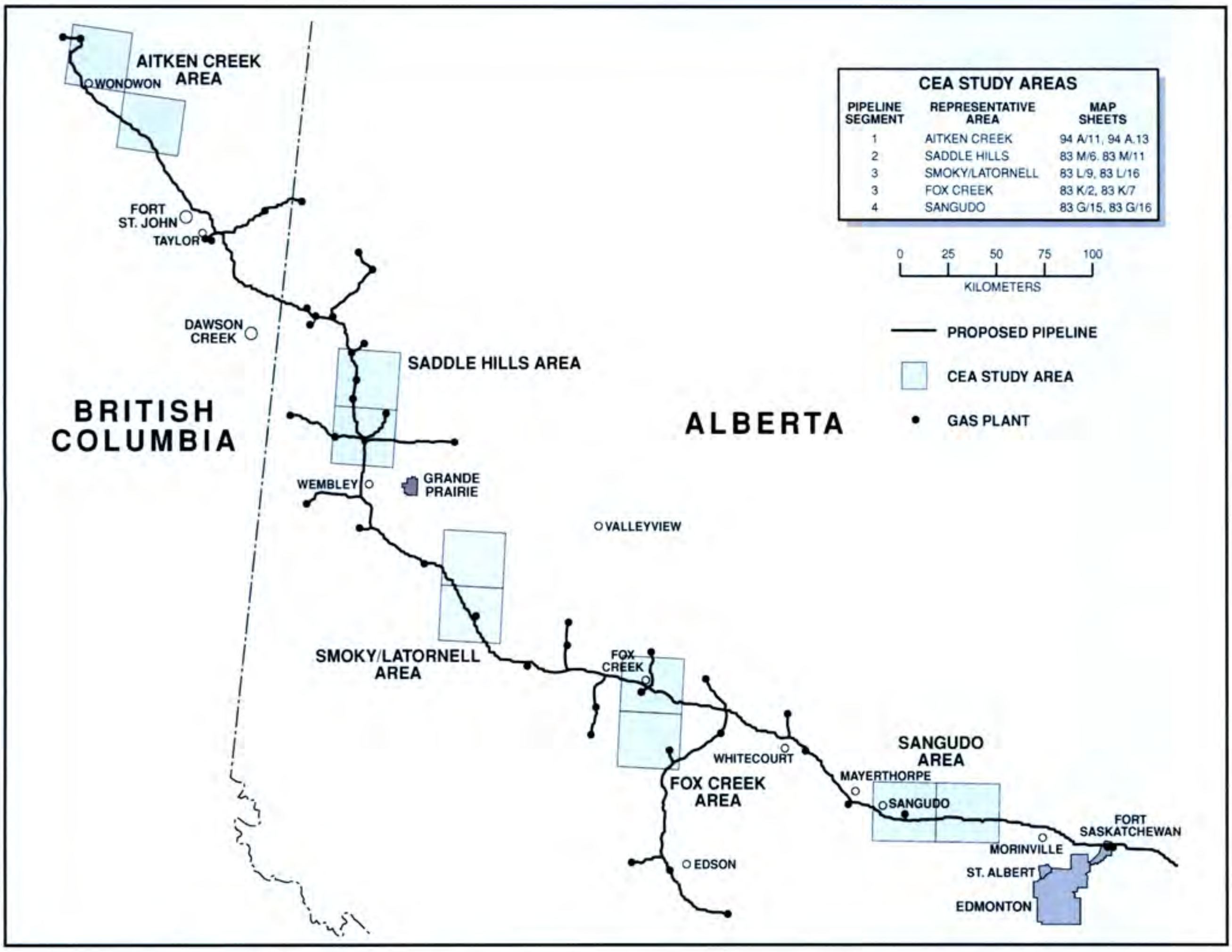

Fig. 2. Alliance Pipeline Project CEA representative areas west of Fort Saskatchewan, Alberta.

Some reviewers wondered how the analyses conducted for representative areas could be extrapolated to areas outside those selected for analysis. To address this concern, representative areas were selected to include a range of existing disturbance rates (relatively undisturbed to highly disturbed) in all major ecological units intersected by the route (boreal forest, parkland, grassland, agricultural). Others reviewers suggested that analyses should focus on areas with intensive existing development where cumulative effects were assumed to be more likely to occur. Although other activities were considered when selecting representative areas, the focus of this project-specific CEA was on activities associated with the Alliance Pipeline Project. As a result, representative areas were generally selected to include map sheets where multiple project-related activities such as mainline and gathering line construction were planned.

Calculating landscape indices

Once representative map sheets have been selected, numerical measures of human-caused disturbance (landscape indices) are calculated. Evaluation of indices is an accepted approach that provides meaningful information about existing disturbance levels and the incremental effect of the proposed linear corridor. Calculated metrics can also be compared to thresholds or management criteria to evaluate potential cumulative effects that could arise from existing, planned, and likely future activities (Beanlands and Duinker, 1983; Noss, 1990; Cocklin et al., 1992b; Noss et al., 1996).

Landscape indices used to date include access density (right-of-way km km^{-2}), stream crossing frequency (number of crossings per km of stream), total cleared area (ha), total edge area (area within a specified distance of a disturbance source), and total core area (area greater than a specified distance from a disturbance source).

Access density is used as a numerical index of habitat effectiveness and fragmentation associated with linear corridors. Research indicates that some animals avoid and are displaced by disturbances associated with roads. Relationships between access density and habitat effectiveness have been developed for some large mammals (e.g., Thomas et al., 1979, 1988; Lyon, 1984; Mace and Manley, 1993; Jalkotzy et al., 1997). Increased road density is also related to sediment transport to streams and has been correlated with declines in salmonid species including species of concern such as bull trout (USDA, 1996).

Total cleared or disturbed area is used as a numerical index of availability and fragmentation of the forest land base. Clearing, fire, and other forms of natural and man-made disturbance introduce changes into landscape patterns that affect the availability, distribution and juxtaposition of specific habitat types. Cleared or disturbed areas may also create barriers to movement of small animals (Wilcove et al., 1986) and affect stream flow and quality (e.g., Troendle and King, 1985; Nip, 1991).

Total edge and total core area are used as complementary landscape indices of terrestrial habitat suitability. Edge habitats are beneficial to many species, but excessive edge may lead to mortality or reduced populations of species such as grizzly bears and warblers that are dependent on forest interior (e.g., Reese and Ratti, 1988; Laurence and Yensen, 1991; Reijnen et al., 1995; Flather and Sauer, 1996; Gibeau et al., 1996; Reed et al., 1996a). The width of the edge zone varies with the species being considered, but in analyses completed to date, a 500-m zone of influence has been used as a representative figure applicable to a broad range of species. Minimum and maximum edge thresholds have been proposed (e.g., Thomas et al., 1979; With and Crist, 1995).

Theoretical models suggest that <40–60% core area represents an ecological threshold for interior species (Wilcove et al., 1986; Lee and Gosselink, 1988; Laurence and Yensen, 1991; With and Crist, 1995). Core area analysis is an accepted assessment technique for grizzly bear (CRC, 1996, 1999; Gibeau et al., 1996; Noss et al., 1996) and has also been applied in other physical and ecological evaluations (Laurence and Yensen, 1991; Reed et al., 1996b).

Stream crossing frequency is used as a numerical index of potential aquatic disturbance. Stream crossings represent points of access for subsistence and recreational fishermen as well as potential sources of sediment and in-stream and riparian habitat changes (e.g., Nip, 1991). A related measure, stream crossing density, is used in the British Columbia Interior Watershed Assessment Procedure (BCFS and BCE, 1995). Studies in western North America have shown that road and trail networks created for timber harvest and resource extraction can lead to direct effects on flow rates and patterns and sediment yield, and indirect effects on habitat, invertebrates and fisheries (e.g., Bosch and Hewlett, 1982; Cederholm et al., 1981; Furniss et al., 1991; McGurk and Fong, 1995).

With GIS programs, disturbance associated with the proposed linear corridor and other likely activities can be combined with existing disturbance sources to calculate cumulative impact indices at one or more points in the future. A tabular summary of indices calculated for existing and proposed disturbance in a representative area in boreal forest is provided in Table 1. Figure 3 presents a map of landscape disturbance information for a portion of the same representative area so that access corridors, edge habitat (white areas), core habitat (gray areas), and stream crossings can be visualized.

Assessing cumulative effects

Landscape indices and maps like those shown in Table 1 and Figure 3 are then used to evaluate potential cumulative effects on selected physical, chemical, biological, and socio-economic indicators using conventional assessment methods. Selection of appropriate indicators and subsequent assessment methods has received extensive discussion in CEA guidance documents and literature (e.g., Beanlands and Duinker, 1983; Noss, 1990; Cairns et al., 1993; Smit and Spaling, 1995; Banff-Bow Valley Study, 1996; Hegmann et al., 1999).

As an example, existing access density values shown in Table 1 for the Fox Creek representative area exceed thresholds proposed for sensitive species such as grizzly bear and elk (Lyon, 1984; Mace and Manley, 1993). A new linear corridor and other likely activities will add to these existing disturbance levels and thereby increase the probability or magnitude of cumulative effects on sensitive ecological and land use indicators. This indicates that all technically and economically feasible mitigative measures should be implemented to avoid or reduce potential cumulative effects. It also suggests that explicit resource management objectives or criteria should be developed and implemented.

Merits and disadvantages

A successful CEA methodology must balance the sometimes-conflicting expectations of regulators, courts, proponents, environmental organizations, other public stakeholders, and practitioners. Regulators and courts must be satisfied that all environmental effects that could cause significant adverse effects or public concern have been addressed. Environmental organizations and other public stakeholders also seek assurance that appropriate management and mitigation measures have been identified and will be implemented to ensure long-term biological and resource use viability. Project proponents want to ensure that legislated CEA requirements are complied with efficiently, economically, and with minimal risk of delay. Finally, CEA practitioners prefer to utilize proven or standardized methods that are technically defensible in public hearings or legal proceedings.

The representative areas approach has generally been well received by stakeholders. It has been accepted by federal and provincial regulatory authorities and provided them with sufficient information to assess the significance of potential cumulative effects (EAO, 1996, 1999; NEB, 1998). General issues with this approach include the seemingly arbitrary way in

Table 1. Landscape indices calculated for a representative area in the Alliance Pipeline Project CEA (Alliance, 1997)

Boreal forest segment — Fox Creek representative area		Landscape index							
		Access density[1]	Seismic line density	Stream crossing frequency[2]	Total cleared area[3]	Core area[4]			
Area in map sheets 83 K/2 and 83 K/7	Activity	Mean (km/km²)	Mean (km/km²)	(#/km)	(ha, % of total)	Total area (ha, % of total)	Number	Mean (ha)	Range (ha)
Little Smoky R. Watershed (100,691 ha)	Existing	0.77	3.19	0.45	4605 (5%)	41,296 (41%)	87	475	<1–7614
	Proposed Alliance	0.03		0.02					
	Proposed other activities			?					
	Cumulative	0.80	3.19	0.47+	4605				
Athabasca River Watershed (80,557 ha)	Existing	0.72	3.32	0.31	3611 (4%)	37,953 (47%)	81	468	<1–8667
	Proposed Alliance	< 0.01		0.02					
	Proposed other activities	?		?	850				
	Cumulative	0.72+	3.32	0.33+	4461 (6%)				
Total Area (181,248 ha)	Existing	0.72	3.25	0.53	8216 (5%)	81,649 (45%)	175	467	<1–8667
	Proposed Alliance	0.02		0.02	231	−1500			
	Proposed other activities	?		?	1040	−10,400			
	Cumulative	0.74+	3.25	0.55+	9487 (5%)	69,749 (38%)			

[1] Average total length of roads and utility corridors (pipelines, powerlines, rail lines) (km/km^2) in specified area.

[2] Stream crossing frequency represents number of road and utility corridor crossings (number/km) of stream in specified area.

[3] Total cleared area includes area cleared for roads, utility corridors, seismic lines and trails, well sites and facilities, and recreational sites in the specified area.

[4] Core Areas represent areas greater than 500 m from roads, utility corridors, well sites and facilities, and recreational sites in the specified area.

which representative area boundaries are selected and the value of landscape indices and thresholds for CEA and effects management.

A fundamental issue is whether it is appropriate to use a predefined CEA study area rather than ecologically based boundaries selected for each indicator or VEC. The ecological boundaries approach encourages a rigorous assessment of selected indicators. However, this traditional reductionist approach does not encourage an integrated assessment of all biophysical and socio-economic indicators, increases overall CEA costs, and is most applicable to large projects that are isolated in space. The complexity and cost of this approach is at least part of the reason that CEA has been qualitative or avoided altogether for most Canadian linear corridor projects.

Use of representative areas encourages an integrated assessment with consistent boundaries at lower cost. While these boundaries may appear to be arbitrary, as with any proper sampling program, the number and location of representative areas must be based on an evaluation of anticipated cumulative effects along with practical issues such as data availability. Experience has shown that when properly selected, these areas allow potential cumulative biophysical and socio-economic effects to be considered in an explicit, technically, and legally defensible way.

At present, most of the data on landscape indices and thresholds are from the United States, and the size and duration of the data sets are limited. This introduces another source of uncertainty into CEAs conducted for western Canadian linear corridor proposals and has caused some regulators and public stakeholders to question the value of landscape indices (and other accepted CEA methods). Research on the applicability of indices such as access density

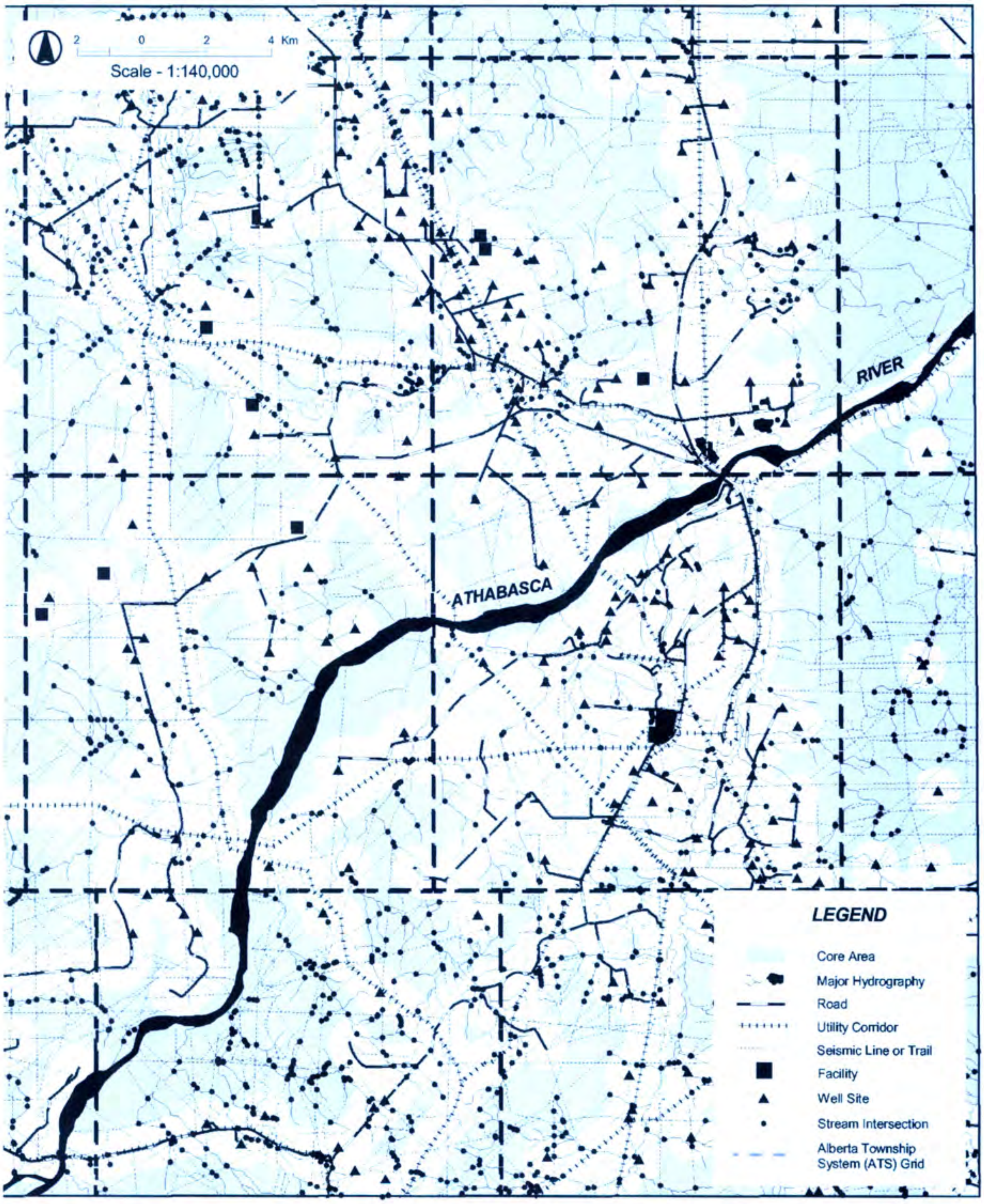

Fig. 3. Existing disturbance map generated for a representative area in the boreal forest of western Alberta.

and core area availability has begun in some areas of western Canada. Results of these studies will help refine these indices for CEA and effects management. In the meantime they provide a quantitative tool to help assess potential effects and identify the need for project-specific and regional mitigation and management measures.

Unlike other established methods, the representative areas approach can be efficiently applied to small linear projects that represent the majority of Canadian linear corridor proposals. Consistent with the intent of Canadian legislation, this will help ensure that regulators and stakeholders are provided with information on the significance of potential cumulative effects and over time will contribute to improved understanding of cumulative effects.

Use of representative areas and landscape indices is a proven and economical alternative that should be considered by practitioners and proponents for linear corridor proposals of all sizes.

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Pipeline Projects and Cumulative Effects Assessment Issues

Chris G. Finley and Dr. Richard D. Revel

By virtue of their linear nature, pipelines provide interesting dilemmas that one must face when determining how best to address project-related cumulative environmental effects. Effects from pipeline construction and operation can act in combination with other projects and activities such as resource extraction, recreational use, and other land-use practices to cause significant adverse environmental effects. The challenge is to first determine the environmental effects of the project. Three main types of disturbances stem from pipeline construction and operation: those concentrated around or emanating from a point or local area (e.g., temporary work spaces), a linear area (e.g., right-of-way), or a regional area (e.g., emissions from compressor stations). Pipeline projects can also be separated into several phases including planning, construction, operation, decommissioning, and abandonment. Each of the project phases and associated activities has the potential to adversely affect environmental values. Pipelines, being linear, provide interesting cumulative effects issues. Key cumulative effects issues include habitat loss and fragmentation, access creation and management, upstream induced effects, and watercourse crossings. To effectively assess pipeline cumulative effects stakeholders should follow an established cumulative effects assessment (CEA) framework or approach. The Canadian Environmental Assessment Agency's Cumulative Effects Assessment Practitioners Guide provides an example of a CEA framework that provides a starting point to assist the determination of the significance of cumulative effects as a result of pipeline development. As part of project-specific environmental assessments, the potential cumulative environmental effects are often identified, evaluated, mitigative measures proposed and the significance of effects assessed. Proper implementation of mitigative measures in the field is critical to the management of project-related cumulative effects. This paper argues that an overall CEA approach or framework for a pipeline project should be developed in a manner that is similar to a CEA for a non-linear project or non-pipeline project although it also recognizes that pipelines have some effects that are unique. Cumulative effects from pipelines can be managed by applying standard environmental assessment principles, using guidelines as frameworks to assist the undertaking of CEAs, and by ensuring mitigation is effectively applied.

Keywords: Linear, cumulative environmental effects, framework, mitigative measures

INTRODUCTION

The objectives of this paper are to provide information to stakeholders, namely proponents, regulators, and citizens regarding the unique features of pipelines leading to cumulative effects, identify key pipeline cumulative effects and assessment issues, and discuss mitigation options. To consider potential cumulative effects of a pipeline proposal, stakeholders should have knowledge of how pipelines and associated activities can cause environmental effects. A knowledge of cumulative effects concepts and environmental assessment principles is also essential.

Pipeline construction and operation effects can act in combination with other projects and activities such as resource extraction, recreational use, and other land-use practices to cause significant adverse environmental effects. The challenge is determining those environmental values or valued ecosystem components

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(VECs) affected, how they will be affected, determining mitigation measures, and predicting significance of effects.

ENVIRONMENTAL EFFECTS OF PIPELINE PROJECTS

Pipelines serve as transportation mechanisms that connect production sources to end-point users. Pipeline projects normally consist of: the pipeline, right-of-way, compressor stations, mainline valve sites, electrical transmission lines, temporary and permanent access roads, pigging facilities, lateral pipelines, operating centres, temporary work spaces, storage areas, and borrow pits. Installing these project facilities could result in cumulative effects to VECs when combined with other projects and activities. Pipelines and their associated facilities create a disturbance to landscapes, aquatic systems, and the atmosphere. They may have wide ranging effects on ecosystems, resources, and human communities which may be either beneficial or detrimental, or in some cases both. There are three main types of disturbances as a result of pipeline construction and operation: those concentrated around or emanating from a point or local area (e.g., temporary work spaces), a linear area (e.g., right-of-way), or a regional area (e.g., emissions from compressor stations). Project facilities have different types of disturbances associated with them, depending on the phase of the project. For instance, a compressor station during operation causes both point and area effects due to its physical presence and related emissions, whereas after decommissioning, a station may cause a point disturbance from its physical presence (assuming it is not removed). Indirect activities associated with project facilities during construction or operation are also imminent. For example, during construction, the right-of-way requires human activity that includes the use of machinery that may create area effects due to noise disturbances. This would be an indirect area impact, compounded with the linear disturbance effects of the right-of-way.

Table 1 lists typical environmental effects of pipelines linked with the project phase, activity, and facility involved. The construction phase causes environmental effects most frequently (regardless of magnitude), while operation is a close second. The magnitude, permanence, probability, duration, and frequency of environmental effects may depend on the geographic or environmental setting, proper execution of environmental mitigation, technologies employed, and interactions with other activities.

Unique and challenging features

By virtue of their linear nature, pipelines create long narrow landscape disturbances and present unique and challenging issues as they affect a multitude of stakeholders, jurisdictions, ecological regions, and cultural features. The unique features associated with pipeline projects are substantial and warrant consideration to identify how they pose a challenge to stakeholders. These challenges and barriers can represent significant time, financial and human resource commitments. If we understand the issues, we can move forward to focusing on the pertinent issues and developing solutions that have benefits for stakeholders and the environment.

Unique and challenging features of pipeline projects are diverse and can be characterized as scientific, administrative, land use, and methodological issues. Emphasis is directed at scientific issues, as they constitute the greatest hurdle to stakeholders. Administrative and land use issues have a predictable nature, and organization and coordination of information are primary concerns. Methodological issues relate to common problems encountered by practitioners. Table 2 presents the unique scientific issues and provides example considerations for each issue relevant to the challenging features associated with pipeline projects.

Land can be considered a pattern or mosaic that is composed of patches, corridors, and matrices (Forman, 1995). A pipeline project is composed of structural features predominately of the corridor landscape element, that include disturbance corridors, such as roads, electrical transmission lines, and pipeline rights-of-way. Borrow pits, compressor stations, storage areas, temporary work spaces, and valve sites all have patch-like features.

Pipelines have both internal and external structure. Three components of internal corridor structure include: width characteristics, internal entities, and plant and animal community structures (Forman, 1995). A pipeline right-of-way constructed in a forested area creates a disturbance corridor with internal structural attributes. The width of the right-of-way often corresponds to the size of the pipe, and the depth of burial. Larger pipes and increased depths generally require more space to store soil and manoeuvre equipment (Alberta Environment, 1988). Narrower corridors may be dominated by edge species, while wider corridors may support a diverse group of species, depending on the types of internal entities (Jalkotzy et al., 1997). Pipeline right-of-way widths may vary greatly in different locations. Right-of-way widths may range from less than 25 m to over 100 m where looping is practiced. In a forested landscape, where right-of-way width is excessive, internal ecological features, such as grass and shrub communities or streams or rivers that cross the right-of-way, may be common. The right-of-way may also possess linear internal entities such as recreational trails, wildlife trails, or access roads. A right-of-way may be a component of a larger corridor that includes a road or a railway. The diversity of plant and animal species within a corridor are related

Table 1. Project phase, activity, and environmental attributes affected

Project phase	Activity	Component involved	Predominate environmental attributes affected	Examples of various types of effects
Planning/Surveying	(1) Aircraft overflights	Potential rights-of-way	Wildlife	Individual disruption
	(2) Pipeline Surveyors: (a) walking	Right-of-way	Wildlife	Social disruption
	(b) All-terrain vehicle usage	Right-of-way and vicinity	Wildlife, soils, vegetation, fisheries, aquatics	Habitat avoidance
	(c) Sporadic tree clearing; right-of-way marking; significant areas marked	Right-of-way	Wildlife, habitat	Habitat disruption/loss or enhancement
	(3) Environmental surveys: wildlife, soils, vegetation, fisheries, geotechnical, archaeological, historical	Right-of-way and vicinity	Wildlife, soils, vegetation, fisheries	Direct and indirect mortality
Construction	(1) Tree clearing; tim ber salvage (fencing and bridging may precede clearing activities)	Right-of-way (mainline and laterals), all areas where future facilities to be sited	Forestry, soils, fisheries, vegetation, wildlife, habitat, aesthetics	Population effects
	(2) Establishing access; building temporary water crossing structures	Permanent and temporary access roads	Wildlife, habitat, grazing, forestry , historical or archaeological resources, soils, vegetation, fisheries	Weed introduction
	(3) Soil removal, stockpile, and grading	Right-of-way, access roads, temporary work spaces	Wildlife, habitat, grazing, forestry , historical or archaeological resources, soils, vegetation, fisheries	Disturbance or loss of rare or endangered plants/plant communities
	(4) Excavate trench (may occur after (5) toreduce open-trench time)	Pipeline trench and right-of-way, access roads, temporary work spaces	Wildlife, habitat, grazing, forestry, historical or archaeological resources, soils, vegetation, fisheries	Disturbance or loss of critical wildlife habitat Loss of merchantable timber
	(5) Hauling, stringing, bending, welding, coating, and lowering-in	Pipeline (mainline and laterals), right-of-way, valve sites, meters, access roads, temporary work spaces	Wildlife	
	(6) Back fill trench	Pipeline (mainline and laterals), right-of-way	Wildlife, fisheries	Disruption of stream flow Barriers to fish migration Habitat alteration
	(7) Set-up ancillary facilities (top-soil removal and storage)	Compressor stations, electrical transmissionlines (where required), storage areas, valve sites and meters, access roads, pigging facilities	Wildlife, soils, fisheries, vegetation, historical, archaeological resources, livestock grazing	Sedimentation of stream bed In-stream blasting mortality Fish affected by new access
	(8) Testing	Pipeline (mainline and laterals), access roads	Wildlife, water bodies, aquatic habitat	
	(9) Clean-up and reclamation of right-of-way and disturbed areas	Right-of-way and vicinity, access roads	Vegetation, fisheries, soils, wildlife, habitat	
	(10) Water crossings	Pipeline (mainline and laterals), right-of-way	Terrestrial habitat, aquatics, fisheries	
Operation	(1) Compress hydrocarbon	Compressor Station	Habitat, climate, airshed	Emissions Climate change from greenhouse gas emissions

Table 1. (continued)

Project phase	Activity	Component involved	Predominate environmental attributes affected	Examples of various types of effects
	(2) Pipeline inspection and equipment maintenance	Pipeline (mainline and laterals), permanent (temporary) access roads, right-of-way, storage areas, valve sites, meters, pigging facilities	Wildlife	
	(3) Herbicide use for plant control over pipeline, maintaining right-of-way free of woody vegetation	Pipeline (mainline and laterals), access roads	Vegetation, fisheries, habitat, aquatics	Loss of soil structure
Decommissioning	(1) Pipe cleaning, flushing, and shut-down	Pipeline (mainline and laterals), compressor stations, pigging facilities	Vegetation, water bodies, aquatic habitat	
Abandonment (a combination of these activities is common)	(1) Pipeline left in ground	Pipeline (mainline and laterals)	None	
	(2) Removal of above ground facilities	Compressor stations, meters, valves, storage areas	Wildlife, pipe acts as a conduit for water	
	(3) Pipeline removed	Pipeline (mainline and laterals), right-of-way	Same as construction, all attributes	
	(4) Excavations to ensure cleaning quality,installations of plugs and caps	Pipeline (mainline and laterals)	Same as construction, all attributes	

to width, internal entities, and external structure, such as ecological zones.

External structure refers to the corridor's relationship to its surroundings or to the surrounding matrix. Stakeholders should not ignore external landscape elements and forget about other activities and natural features such as patches, corridors, and matrices that interact with the pipeline. Documenting the environmental setting is necessary for the environmental assessment and can also be used to aid the CEA.

Disturbance corridors, such as pipeline rights-of-way, roads, or electrical transmission lines, may provide habitat for wildlife (Jalkotzy et al., 1997). Rights-of-way can provide travel corridors for wildlife that reduce energy expenditures and provide food stuffs for wildlife. Small mammals, birds, and ungulates may utilize these corridors because of the richness of plant species and communities, and this in turn, encourages corridor use by carnivores such as coyotes (Jalkotzy et al., 1997). In fragmented habitats, vegetated corridors can facilitate plant and animal movement, effectively decreasing the fragmentation effect (Henein and Merriam, 1990).

Corridors that are created from pipeline projects (roads, rights-of-way, and possibly by electrical transmission lines) may facilitate wildlife movement and act as conduits (Jalkotzy et al., 1997). Black bear may use rights-of-way as travel routes to reduce energy expenditures or improve access to prey species (Eccles and Duncan, 1986 as cited in Jalkotzy et al., 1997). In addition, large mammals, such as elk and caribou may utilize backcountry roads and seismic lines during migration (Jalkotzy et al., 1997). However, people may also use these corridors to access previously remote or inaccessible areas causing a multitude of direct and indirect cumulative environmental effects (Eccles et al., 1994). Conduits may also act as connections between fragmented patches, and thereby decrease fragmentation effects for certain species. Species such as crested wheatgrass, once commonly used in pipeline reclamation on the prairies, have taken advantage of these corridors to extend their range to invade and outcompete many native plant species. Conduits have caused fragmentation effects in those instances.

Disturbance corridors may inhibit or effectively block any plant or animal movement. When no movement occurs, the corridor constitutes a functional barrier. Marten have displayed barrier effects from a pipeline right-of-way (Eccles et al., 1985 as cited in Jalkotzy et al., 1997; Eccles and Duncan, 1986 as cited in Jalkotzy et al., 1997). Excessive rights-of-way width, or the presence of certain internal entities, such as roads, may preclude species movement across a corridor. The result may be isolation of species, populations or communities, with the extreme result of local extirpation or inbreeding depression. Population effects are a major concern, although, they are difficult to determine and require an extended study period to confirm or deny any suspicion of significant adverse effects (Jalkotzy et al., 1997). Roadways and railways with larger traffic volumes may inhibit animal and plant dispersal

Table 2. Unique and challenging features of pipeline projects

Issue	Example considerations
(1) Structural attributes of pipeline corridors (including the right-of-way, access roads, electrical transmission lines)	Width Internal entities Plant and animal communities
(2) Functional attributes of pipeline corridors (including the right-of-way, access roads, electrical transmission lines)	Habitat creation Conduit Barrier: linear habitat fragmentation, filters, isolation of communities, width of corridor Source of habitat Sink for wildlife Uncertain effects
(3) Many environmental attributes affected	Soils, hydrology, wetlands, noise levels, air quality, fisheries, wildlife, plant species and communities, agricultural, recreational, paleontological, historical, and archaeological resources, conservation areas, forestry, hunting and trapping, access creation with many direct and indirect effects, ecosystems, watersheds, ecodistricts, aesthetics
(4) Contribution to cumulative effects	Soils, hydrology, wetlands, noise levels, air quality, fisheries, wildlife, plant species and communities, agricultural, recreational, paleontological, historical, and archaeological resources, conservation areas, forestry, hunting and trapping, access creation with many direct and indirect effects, ecosystems, watersheds, ecodistricts, aesthetics, climate change
(5) Interactions with other actions within the zone of influence of the pipeline	Policies, jurisdictions, programs, Integrated Resource Plans, management plans: urban growth or species protection, legislation, regulations, by-laws, guidelines Well sites Other pipelines Other linear facilities: roads, trails, seismic lines, railways, electrical transmission lines Hydro-dams Agriculture: ranching, cultivation, irrigation districts and canals Forestry operations Human settlement: townships, villages, cities Chemical plants Coal mines, mining Processing/Manufacturing plants
(6) Route selection	Avoiding sensitive areas Minimizing stream crossings Looping where possible How wide is too wide (width) Economic considerations
(7) Type of effect	Linear Point Area Environmental media affected: air, land, water Type of disturbance activity Effect on wildlife Cumulative effects attributes/pathways

very significantly directly and indirectly as compared to pipeline rights-of-way. (Jalkotzy et al., 1997).

Animals may have the ability to move long distances, but will not disperse due to behavioural responses that inhibit this action (Saunders et al., 1991). Some bird species may not cross distances greater than 100 m in agricultural fields, and therefore a functional barrier exists (Saunders and de Rebeira, 1991 as cited in Saunders et al., 1991). Fragmentation occurs when habitats and wildlife are functionally separated. These landscapes may possess some connectivity. However, it is quite poor and corresponds to poor exchange rates (Jalkotzy et al., 1997).

Habitat fragmentation is an important feature of pipelines. The geographic expanse of pipelines may fragment many types of habitats along the route including both forested and native prairie areas. For some bird species the width of an average pipeline right-of-way of 25 m has negative fragmentation effects, as cowbirds and other nest predators adversely influence adjacent interior forest habitat (Rich et al., 1994). Additionally, species and populations may become isolated. This may lead to reduced genetic variability, causing a reduction in the reproductive fitness of populations, and in the worse case, local species extirpation. Forest fragmentation can adversely affect insects by changing the abundance and richness of species (Didham et al., 1996). Some species are attracted to the right-of-way, and as a result may face death from hunters who have gained access to previously remote areas by using the pipeline corridor as a travel route. Of particular concern in Canada are those species that are designated with a special status, meaning that they are either vulnerable, threatened, at risk, or extirpated. The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and various provincial agencies maintain databases on the locations and status of many species of Canadian wildlife.

A disturbance corridor may benefit wildlife when the corridor becomes a source of habitat and provides links for wildlife to other landscape components. Edge species and habitat generalists may thrive in a disturbance corridor, using it as a conduit, and spreading out into the matrix (Jalkotzy et al., 1997). Corridors are beneficial for enhancing biotic movement and providing foraging areas and refuges (Saunders et al., 1991). In fragmented habitats, populations of species may be sustained when individuals use corridors that connect patches.

Disturbance corridors can also become sinks when animals from the surrounding matrix are drawn into the corridor, where they subsequently die. Corridors may be a direct or indirect sink. Roads and electrical transmission lines associated with pipelines may cause direct mortality through vehicle collisions and electrocutions, while indirect mortality can result from people not associated with the pipeline using the right-of-way corridor as a conduit to affect wildlife species. In remote areas, pipeline corridors may create new access and cause further wildlife mortality. Additionally, predators attracted to the corridor because of increased prey species often become the target of people through both legal and illegal means (Jalkotzy et al., 1997).

Fish and fish habitat can be adversely affected through habitat disruption and sedimentation of watercourses. Combined with other activities such as forestry operations, the effects to fish and fish habitat can be significant.

Practitioners and scientists generally have a poor understanding of natural and social systems and this leads to difficulties in undertaking CEAs (Ross in Kennedy, 1994). For instance, they lack specific information about how a disturbance corridor will affect certain environmental attributes (i.e., will the proposed corridor contribute to significant wildlife mortality, and will it act cumulatively?). For terrestrial attributes such as wildlife, we do not have many established thresholds to assist a determination of the significance of habitat loss and other effects on wildlife. Often, we are not able to prove that a threshold has been exceeded, and that significant effects have or will occur. Best professional judgement normally must be used in the end.

Longer term environmental effects to populations may result because of the absence of solid data that identifies cause and effect relationships. For instance, practitioners often recognize information gaps regarding the identification of adverse population effects that could be attributed to a pipeline project. This has major implications for the CEA practitioner. As uncertainties unfold, they should be addressed through adaptive management, as identifying development or disturbance thresholds is not a trivial pursuit.

CUMULATIVE EFFECTS

Diverse views about cumulative effects exist, thus different ideas and definitions are common. To avoid excessive confusion on this issue the definition provided for the Canadian Environmental Assessment Agency (the Agency) by Hegmann et al. (1999) will be applied. Hegmann et al. (1999) apply a simple definition based on an important additional requirement of CEA as compared to environmental assessment: the specific consideration of effects due to other projects.

Cumulative effects generally refer to the effects of multiple human inputs to natural systems (Cocklin et al., 1992a). They develop from the incremental effect of the project or action when added to other past, present, or future actions regardless of who undertakes the activity (CEQ, 1996). These effects emerge over time and space to affect resources, ecosystems, and human populations (CEQ, 1996). Cumulative effects can have either a neutral, positive or negative effect depending on the recipient of those effects. These effects also have a duration (short, medium, long) and intensity (high, medium, low). Kalff (1995) captures the concepts of cumulative effects by identifying common elements. Three of the elements include: action, impact, and boundaries.

Actions as projects and activities are relevant to pipelines. A generic pipeline project includes five project phases, numerous facilities, and associated activities. The five phases of project development could create environmental effects, with some of them being residual and possibly acting as a source of cumulative effects. The test to determine if an effect is cumulative under the *Canadian Environmental Assessment Act* (CEAA), corresponds to examining interactions with other projects. Other actions that could interact with the pipeline to adversely affect the environment (i.e., affect a VEC) should be considered in a CEA. Cumulative effects may result from one pipeline project, several pipelines, interactions with existing projects, and interactions with past or future projects within overlapping spatial and temporal boundaries. Where reasonable and relevant, actions from the past, present and future should be examined for potential project interactions (FEARO, 1994; Hegmann, 1995; CEQ, 1996).

An environmental effect or impact occurs as a result of actions that change the status of the receiving environment. Cumulative effects can arise from either single or multiple projects. Activities in a region on their own may be individually insignificant, but when combined, cause significant cumulative effects to VECs. To illustrate this point, a wildlife population might be considered a VEC. A substantial increase in vehicular activity from an increasing number of projects in a region can effectively block migration corridors, feeding and breeding areas, and cause increased vehicle mortality. A single project in this area may cause minor effects, that would be insignificant on its own.

A boundary typically refers to the spatial (i.e., geographical) and temporal (i.e., time frame) area where environmental effects from a project or interactions with other projects can occur. For pipelines, the boundaries or zone of influence is variable and may be based on a consideration of the number of pipelines looped, local and regional environmental setting, and on any common connections or links that the pipeline possesses with other activities (e.g., when a grizzly bear home range crosses a pipeline corridor and forestry operations).

Key cumulative environmental effects

Through the identification of pipeline specific environmental effects, possible cumulative environmental effects can also be identified. Many possible types of cumulative effects exist, but only the key ones are highlighted here. Key cumulative environmental effects related to pipelines include terrestrial habitat loss and fragmentation, access creation and management, upstream induced effects, and aquatic habitat disruption through sedimentation at watercourse crossings (Finley, 1998). Each of these cumulative environmental effects has been identified as potential key issues when other developments act in combination. In areas where there may be excess pipeline capacity and where commodity prices are attractive for exploration, further development may be undertaken to meet the market demand. This would lead to an induced upstream effect that should be addressed.

To provide a basis for decision making, cumulative effects are normally evaluated to determine whether the effects are adverse, whether they are significant, and whether they are likely (FEARO, 1994). The next steps following the identification of cumulative environmental effects of pipelines is the assessment and management of those effects.

CUMULATIVE EFFECTS ASSESSMENT AND PIPELINES

CEA in simple terms means the identification, assessment, and determination of the likely significance of cumulative environmental change. Two types of approaches to CEA are commonly recognized; one scientific, and the other planning oriented (Spaling and Smit, 1993). The first type of CEA is "an information-gathering activity using principles of research and design and scientific analysis" (Smit and Spaling, 1995, p. 83). The second type of CEA utilizes "planning principles and procedures to determine an order of preference among a set of resource allocation choices" (Smit and Spaling, 1995, p. 83). These approaches, are distinctly different, in that the former applies a narrower analytical focus, whereas the latter approach applies a broader scope that includes normative evaluation and management (Smit and Spaling, 1995). These approaches, however, are not necessarily in opposition to one another, but may reflect a different scope of CEA (Smit and Spaling, 1995). The first approach has been stated as appropriate for assessing cumulative effects under the CEAA (Priddle et al., 1996). Analytical CEA approaches are normally used when the assessment is primarily focused on evaluating the effects of one project, in relation to other projects and activities. Recent CEAs have provided a further meshing of these approaches. CEAs for project-specific applications have considered land use designations, existing environmental effects monitoring programs, and acceptable use and thresholds.

Cumulative effects have largely been ignored in the past by traditional environmental assessment. Environmental assessment focuses on how the project affects the local area, and generally disregards other project interactions, and secondary activities derived from primary development (CEARC, 1988). Activities that are viewed as individually minor may have collectively significant effects, revealing the short-comings of traditional environmental assessment (Cocklin et al., 1992b), and pressing the need for the assessment of cumulative effects. CEA expands the scope of traditional environmental assessment to evaluate how multiple activities have caused cumulative effects at both local and regional scales. In general terms, it can be distinguished from environmental assessment in that it investigates a broader spatial and temporal scope of effects (Hegmann, 1995).

CEA FRAMEWORK FOR PIPELINES

The framework advocated by the Agency (Hegmann et al., 1999) for carrying out CEAs is used as a starting point for discussing generic pipeline CEAs. The framework involves the following tasks and sub-components: Scoping (Identify Regional Issues of Concern; Select Regional Valued Ecosystem Components; Identify Spatial and Temporal Boundaries; and Identify Other Actions), Analyze Effects (Collect Regional Baseline Data; and Assess Effects on Valued Ecosystem

Components), Identify Mitigation, Evaluate Significance, and Follow-up (Recommend Region-wide Monitoring) (Hegmann et al., 1999).

Based on the assessment of what a pipeline project normally entails (i.e., the physical aspects) and how it interacts with the environment through the phases of development the potential adverse environmental effects can be identified. In general, people look for a recipe list or a how-to guide that answers all CEA questions. In reality, however, CEA is complex, the process is wrought with uncertainty, and no generic guide can address all of the issues that develop in a "real world" pipeline CEA. Therefore, discussing generic pipeline CEAs can be hampered. Often, specific information is required before one can proceed to the next step. One goal in light of many uncertainties in CEA, is to address a broad range of issues and focus on the assessment process.

Scoping

Cumulative effects relevant to pipelines are diverse. This diversity challenges the practitioner to narrow the assessment to select appropriate issues and cumulative effects. In a generic sense, the impact that other actions cause on VECs are effectively the same as pipelines. However, they may occur through alternate pathways, and over different spatial and temporal scales. Several considerations are required to determine if cumulative effects are an issue:

1. Examine the potential environmental effects along the pipeline, and determine if interactions with other projects or activities are probable (e.g., use an impact checklist); and
2. Determine how the effects can be considered cumulative (i.e., examining what VECs could illustrate this interaction).

Scoping is one of the most important first steps in the assessment process. Scoping effectively reduces the number of variables that require study in a CEA by focusing on specific issues of importance (Ross, 1994 in Kennedy, 1994).

In order to examine and evaluate the potential cumulative effects of a pipeline project they must first be identified. The type, size, and location of a project are key issues with any environmental assessment, or any CEA. At the early planning stage, the type and size of a pipeline are normally known. However, the location, or the environmental setting is the main variable. No matter where pipelines are located they share common features such as their long linear nature. Therefore, we suggest that there are numerous generic cumulative effects for almost all pipelines and that certain effects could be highly relevant to a particular pipeline. Recognition that only a limited number of issues and other activities can realistically be addressed in a CEA is duly noted.

Identify issues of regional concern

The large geographic area that a pipeline encompasses and the linear nature of the project normally correspond to many more affected parties. Therefore, scoping appropriate issues takes on a new importance and challenges the practitioner to focus on non-trivial issues. Often the environmental assessment will provide clues to those issues of regional concern that should be addressed.

Select VECs

The purpose of selecting VECs for an environmental assessment or a CEA is to focus the assessment on pertinent areas of concern to the public or professionals (Beanlands and Duinker, 1983). VECs are the focus of the assessment because they integrate the effects of multiple projects (Hegmann et al., 1999).

VECs selected for a CEA may be the same as those selected for the environmental assessment (Hegmann et al., 1999). VECs that capture regional change however, may be added and required, to reflect change on a larger scale (Hegmann et al., 1999). For example, a CEA may use a watershed as a VEC, where an environmental assessment would use a fish species or fish habitat as a VEC and assess effects from watercourse crossings.

CEA study boundaries for a pipeline may be established with input from stakeholders and may require feedback from the regulating authorities. The selection of study boundaries should be based on the VECs that are being assessed. Each of the VECs can have a different relationship to the pipeline both spatially and temporally, and different project phases can affect VECs differently. Therefore, a pipeline CEA may have multiple study boundaries, with the boundaries being specific to VECs.

The study boundaries may be related to different project phases (Hegmann et al., 1999). The practitioner should disregard any boundaries when determining the other actions that could interact with the pipeline and consider anything that is a likely interaction. Other actions do not necessarily have to be in close proximity to the pipeline project. Using best professional judgement and consultation with stakeholders will aid the selection of possible project interactions. A significant criterion for selecting other actions that could interact with the pipeline is if the action causes similar effects (Hegmann et al., 1999).

Temporal boundaries

When establishing temporal boundaries, considering the type of VEC is essential. For instance, the recovery of a VEC to its original state differs greatly between VEC types. Soil can return to its productive state more rapidly than the return of vegetation to a mature forest. Thus, depending on the VECs used, time frames of assessment are quite variable.

Actions that occurred in the past in an assessment can often be incorporated into the existing background conditions. For project assessments stakeholders should be primarily concerned with assessing the incremental impact of the project in relation to other present and future activities.

Present activities to be included in an assessment can be addressed by advocating for the inclusion of those actions which cause similar effects to those resulting from pipeline development. In other words, actions that could significantly affect the VECs being studied in the assessment should be assessed.

If the temporal boundary projects too far into the future (i.e., where the uncertainty of predictions is excessive) then the boundary will not be useful for CEA predictions. Alternatively, if a fairly well known and predictable path of events is expected (e.g., vegetation succession of some communities) then extending the study boundary excessively into the future until a climax community is developing is also unnecessary.

In order to consider the inclusion of future actions, some aspects of the projects or activities must be known. The challenge is to determine what constitutes a future action that could be relevant to the pipeline project and should be considered in a CEA. Future actions must produce environmental effects that are similar in nature to the environmental effects that result from the pipeline development in order to be considered in a CEA. Under the CEAA, only those projects and activities that are relevant to the proposed project and "on the books" must be assessed in a CEA. The Agency notes three categories of future actions. These include: (1) certain actions, (2) reasonably foreseeable actions, and (3) hypothetical actions (Hegmann et al., 1999). These categories of future actions are on a continuum progressing from 1 to 3, where uncertainty increases with time and other factors. The practitioner must fulfil legal obligations and decide what one is professionally obligated to do (Hegmann et al., 1999). Future actions that are speculative should be addressed where they can not be assessed in a meaningful way because of the lack of specific data, such as a project size and location.

Spatial boundaries

When conducting a CEA for a pipeline a reasonable study boundary should be selected that addresses the zone of influence of a pipeline (which can be quite variable depending on the project). The spatial boundaries of a pipeline CEA are relevant to the types of VECs being assessed. For example, geographical patterns on the land, ecosystem type, the presence of wildlife and wildlife corridors or home ranges, watershed boundaries, and river networks among other factors should be considered. Study boundaries are also relevant to other actions that can be assessed in a CEA. For example, a VEC that is affected by the interaction of two actions (on it) may help define the size of the spatial boundary of assessment. The boundary would include the other action, and the geographical links or pathways between the action and the pipeline. In other words, the zone of influence of the pipeline assists the establishment of boundaries.

The challenge is to determine how much of the effects on the VEC is due to other actions, and how much is due to the incremental effect of the pipeline. Therefore, practitioners should be wary of choosing VECs that cause project effects to appear minimal in relation to other actions. For example, selecting an excessively wide, or large spatial boundary can cause any project related cumulative effects to appear negligible compared to other actions (Hegmann et al., 1999; Kingsley, 1997; CEQ, 1996). An excessively small boundary on the other hand may cause project related cumulative effects to appear very significant compared to other activities within the study boundary, and potentially important issues outside the established boundary may be overlooked (Hegmann et al., 1999; Kingsley, 1997; CEQ, 1996).

The scoping process in its entirety should identify other projects and activities requiring analysis. If interactions will occur between certain actions and pipelines, then a VEC should reveal the link. Determining which other actions are the most relevant to pipelines is difficult. Common actions that could combine with a pipeline to contribute to cumulative effects include: other pipelines; oil and gas development; other linear facilities (primary and secondary roads, trails, seismic lines, railways, electrical transmission lines); forestry practices; agricultural and rangeland practices; resource extraction; human settlement and community development (townships, villages, and cities); other industrial production; recreation; hydrodams; and irrigation districts (pipes and canals). Stakeholders should consider assessing projects and activities that will assist decision-makers by giving them the pertinent information on cumulative effects.

Analyze effects

Assessing the effects of multiple actions on VECs is a challenging aspect of CEA. There is no single right way to complete a CEA. Since the issues and VECs often vary from project to project, the methods used to assess the effects on VECs will also be different. In many cases, VECs determine the methods that will be used to assess the effects on them. Hegmann and Yarranton (1995) provide a comprehensive review of various approaches and methods of assessing cumulative effects.

Identify mitigation

After the CEA is completed the proposed mitigative measures must be carried into the field and properly implemented to manage potential cumulative effects. However, they must first be identified. Best management practices (BMP) implemented to mitigate project-specific effects, often also limit the potential cumulative environmental effects. For example, by selecting an appropriate route for the pipeline, which avoids environmental constraints such as watercourses, the overall net potential for cumulative environmental effects is reduced. At watercourse crossings, effective measures that minimize project-specific sedimentation will reduce the potential for interaction with other projects or activities that cause sedimentation.

Identifying local mitigation strategies for pipelines can be quite different compared with mitigation for other projects. A pipeline also creates many local environmental effects that are variable between projects and that are relevant to a project phase or activity. These local effects can normally be successfully mitigated, and they represent the best opportunity for reducing cumulative effects (Hegmann et al., 1999). Operating guidelines and company policies form standard industry practices that provide general and site-specific techniques to ameliorate environmental effects. They may be directed at the planning phase, or other phases such as construction, or operation, given their importance as possible sources of cumulative effects. Mitigation may also be directed at an environmental attribute or a VEC. Site-specific mitigation can also be noted on environmental planning maps. Specific mitigation strategies applicable to most pipelines for reducing pipeline cumulative effects are listed in Table 3.

Normally, the goal of mitigation is to attempt to reduce adverse effects to acceptable or non-significant levels. More specifically, and where feasible, mitigation strategies are aimed at returning an environmental value to its former state before the incremental disturbance from project actions. Mitigation can consist of general guidelines with broad applications or they can be very specific in nature. The goal can be to reduce local project effects, regional project effects, and regional effects from multiple projects and activities. Approaches to the management of cumulative environmental effects can occur on many different spatial and temporal scales and also involve many different jurisdictions. Mitigative measures may be localized, project-specific and immediate, or longer-term regional approaches that involve many stakeholders. Municipal, provincial and federal agencies all have a stake in the proper management of cumulative environmental effects. Effective consultation and coordination among government agencies, the public, and industry may assist in developing management plans that identify thresholds for accepted levels and types of activities in a region.

When regional mitigation is a goal and multiple jurisdictions are involved, cooperation from regional stakeholders is required to achieve success (Hegmann et al., 1999). Where CEA issues are complex and affect large areas, regional initiatives are a necessity (Hegmann et al., 1999). When approaches to mitigation are unsuccessful, techniques such as compensatory measures can be applied. Given that mitigation will not reduce all cumulative effects below significant levels in every situation, actions such as donating or directing funds to a designated regional board for conservation purposes may be warranted as a last resort. The compensation should be relevant to projects that are aimed at reducing cumulative effects that are similar in kind to those of the proposed project.

Table 3. Mitigation strategies for pipeline CEAs

Phase where mitigation is applied	Example mitigation strategies
Planning/Surveying	Route selection (minimize watercourse crossings and choose the appropriate type and location; limit habitat fragmentation; select agricultural or less valuable land; avoid ESAs; looping or using existing disturbance corridors); fly over only when necessary; key avoidance areas flagged or fenced
Construction	Timing of construction; limit sediment and run-off; only build essential roads and coordinate with other resource sectors; avoidance; notification; re-contouring topography and drainage; appropriate type of river crossing technique; limiting size of right-of-way disturbance; specific mitigation for rare species; appropriate soil handling and storage techniques; reclamation; proper citing of facilities; treat and discharge water to stable vegetated land;use gates and shooflies; firearm sanctions; control vehicle speeds
Operation	Emission reduction technologies; minimize right-of-way use by personnel and others; gates; monitor; minimize overflights; minimize herbicide use by mowing and spot-spraying with non-residuals
Decommissioning	Treating discharge water and directing to stable vegetated land; preventing water from entering the pipe
Abandonment	Only removing pipe as required; preventing water from entering the pipe
Regional Issues or Compensation	Cooperate with regional stakeholders; develop boards that address issues such as access management; participate in regional studies; donating money to conservation organizations or other resources

Management plans or regional approaches that incorporate stakeholder needs applied in combination with project-specific BMPs are seen as key requirements to properly manage potential cumulative environmental effects from pipeline projects.

Evaluate significance and implement follow-up
Practitioners should be aware that seemingly insignificant environmental effects may result in collectively significant cumulative effects (Odum, 1982), and that other activities or projects from the past, present or foreseeable future within the zone of influence of the pipeline may be considered to determine any interactions.

The significance of environmental effects from pipelines is an issue that is key to the discussion. After applying mitigation techniques and industry standards, many of the effects can be reduced and are then considered non-residual. The challenge to the CEA practitioner is to determine if non-residual (non-significant in the environmental assessment sense) or residual effects can lead to cumulative effects. Because there are no significant environmental effects, there may still persist or develop significant cumulative effects (Kingsley, 1997).

Evaluating the significance of project cumulative effects is one of the most controversial aspects of CEA. Two practitioners can carry out an assessment of cumulative effects and arrive at the same result. Depending on how results are interpreted, however, the two practitioners could easily arrive at different conclusions about the significance of the effects. Therefore, establishing proper assessment criteria for evaluating significance is essential. This may be completed before a CEA is conducted as it brings credibility to the process and provides criteria for stakeholders to evaluate the significance of project effects.

Given that the interpretation of cumulative effects is so important, the Agency provides a list of useful factors that influence the interpretation of significance. These factors include: exceeding of a threshold, effectiveness of mitigation, size of study area, incremental contribution of cumulative effects, relative contribution of effects of other actions, relative rarity of species, significance of local effects, magnitude of change relative to natural background variability, and creation of induced actions (Hegmann et al., 1999). Additional factors include how the project effects and other actions compare to plans or policies for various VECs in different jurisdictions.

The factors listed above should be considered and then described in terms of significance attributes. These significance attributes or assessment criteria can be used to aid the assessment of significance. The assessment criteria could include the following: direction, geographical extent, duration, magnitude, frequency, probability of occurrence, level of confidence, and permanence. Each of these assessment criteria uses various classifications, such as low, medium, high, or short-term, medium-term, or long-term, to describe project effects. The effects on each VEC can be determined and then the assessment criteria applied to determine significance. The determination of significance may be based on different criteria depending on the VEC being studied. Under the CEAA, the Responsible Authority must decide if the effects of the project are adverse, and if they are adverse, whether they are significant, and whether they are likely (FEARO, 1994).

All of the assessment criteria and other factors that have been discussed regarding significance should be considered in a pipeline CEA. Follow-up and monitoring are a critical part of managing cumulative environmental effects. By conducting audits and inspections, failures of mitigative measures can be identified and corrected, and their effectiveness monitored and assessed.

CONCLUSION

By properly identifying project-related residual environmental effects, stakeholders can progress to the next step of identifying potential cumulative environmental effects. To move from project-related effects to identifying cumulative environmental effects, an assessment process or framework such as that identified in the Agency's Cumulative Effects Assessment Practitioners Guide (Hegmann et al., 1999) should be applied. A defined process gives credibility and provides additional certainty in CEAs.

The proper management of cumulative environmental effects will occur through applying the appropriate mitigative measure identified during the assessment process. By ensuring that the measures are implemented cumulative effects can be managed. This may occur through monitoring conditions of approval and by carrying routine environmental inspections and audits of facilities. Approaches to the management of cumulative environmental effects can occur on many different spatial and temporal scales. Mitigative measures may be localized, project-specific and immediate, or longer-term regional approaches that involve many stakeholders. Municipal, provincial and federal agencies all have a stake in the proper management of cumulative environmental effects. Management plans or regional approaches that incorporate stakeholder needs applied in combination with project-specific BMPs are seen as key requirements to properly manage potential cumulative environmental effects from pipeline projects. Even if stakeholders cannot measure the exact cumulative effect, we should be able to take a precautionary approach and ensure to the extent possible that all commitments specifically mitigative measures are monitored and implemented. Mitigation is the key and the bottom-line to effective management of cumulative effect issues from pipeline projects.

Stakeholders can do a better job of assessing and managing cumulative effects by following accepted environmental assessment practice. Assessment methods can be improved over time. Linking project-specific cumulative effects analysis to regional initiatives should be a goal of proponents, regulators, and citizens. To improve the overall consideration of and management of cumulative effects stakeholders should be involved in carrying out follow-up and monitoring of tangible cumulative effects issues.

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Innovative Co-Location of Telecommunications Facilities within Existing Rights-of-Way

Joel M. Rinebold, Julie M. Donaldson, and Mark F. Kohler

Customer demand for new wireless telecommunications service, including cellular telephone, personal communications services, specialized mobile radio, and other wireless telecommunications services, has manifested itself in the need to construct more than 100,000 new facilities in the United States alone by 2005, many of which will require tower structures. While the demand for service is a function of the market, the need for these new facilities is a function of the technology and the competitive nature of the industry, as guided by regulators. As a consequence of this new market and regulatory scheme for competitive services, new telecommunications towers will be developed in nearly all urban and suburban locations. Use of existing telecommunications towers, originally built to provide telecommunications services for other users, is possible in many locations, but planners will be forced to identify as many as six new sites per 10 km^2 area (4 mile^2) for the development of facilities as wireless service expands. The challenge to identify tower sites has resulted in opportunities to use existing towers, buildings and other tall structures, and to co-locate antennas within existing rights-of-way. Development of facilities within existing rights-of-way is now possible and practical by attaching antennas to existing electric transmission line support structures. This technical application yields a unique opportunity to provide wireless telecommunications services without the need to construct an entirely new support structure, thus avoiding additional costs, reducing potential public opposition for the construction of such facilities, and providing revenue to support ongoing maintenance and management activities within the right-of-way. This paper will explore and test new and innovative development of co-located telecommunications facilities on existing rights-of-way, using models to assess radiofrequency propagation and signal strength within a coverage area, analyze alternatives, assess environmental effects, assess use of existing structures, and examine contractual easements to provide legal rights to use the existing rights-of-way for telecommunications service. The results of this work is relevant to state and local planners, electric utilities, and telecommunications carriers as a method to assist in the guidance and planning of telecommunications services and the efficient use of existing rights-of-way.

Keywords: Electric transmission, wireless, siting, legal, regulation, telecommunications, co-location of telecommunications facilities

INTRODUCTION

The development of new towers for wireless telecommunications services for wireless telephone and data transfer has become a difficult task for local planners. These towers may exceed 200 feet in height and can become controversial for local planning and zoning commission regulators when opposed by members of the community as unsightly, unsafe due to the possibility of tower collapse, and harmful to human health due to the exposure of radiofrequency emissions.

Propagation from wireless facilities, that include cellular telephone, personal communications services, and specialized mobile radio, is limited by frequency and low-power output. These systems require the development of dense networks to provide seamless coverage that enable users to hand off from one facility to another without an interruption of service, reuse frequency to increase overall capacity, and meet coverage

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objectives without interfering with adjacent facilities. The result has been the need to develop numerous facilities and redundant networks in nearly every urban and suburban area. Wireless carriers are developing their networks at a density that ranges from facilities less than a mile apart in urban areas to facilities several miles apart in more rural areas. The need for this dense geographic distribution of facilities severely limits the ability of the wireless industry simply to co-locate on existing towers that were developed for public safety, radio and television broadcast, and microwave transmission, without developing numerous new facilities. Furthermore, physical space on existing towers, structural capability of the tower, and potential co-channel interference from transmitting equipment will also limit opportunities for co-location of wireless antennas on existing towers.

As shown on Fig. 1, the use of existing electric transmission line rights-of-way provides a technical opportunity for the placement of wireless antennas on existing electric transmission lines support structures. However, the placement of antennas within existing rights-of-way and on existing support structures must be carefully planned and legally executed. While the regulatory requirements and jurisdiction of each location may differ, the co-location of telecommunications facilities within existing rights-of-way has been accepted by the wireless industry, and can be achieved efficiently and without significant adverse environmental effect.

WIRELESS GROWTH

The number of wireless subscribers in the United States has grown from 91,000 in 1984 to 86,047,003 in 1999 (CTIA, 2000). The estimated number of the subscribers at the present time in the United States is over 93,780,200. It is further estimated that 45,924 new subscribers are added every day in the United States, and that approximately 238.7 million Americans have access to between three and seven wireless providers (CTIA, 2000). In the United States, much of this growth is the result of changes in federal law, including the Telecommunications Act of 1996. The purpose of this new legislation was to promote competition and reduce regulation in order to lower prices, improve quality, and encourage the rapid deployment of new telecommunications technology (Krattenmaker, 1996; Kearney and Merrill, 1998). Similar growth and market development has occurred or is expected to occur in Canada, Europe, and elsewhere, as the result of similar legislation and regulatory change with an estimated 1.26 billion persons to be wireless customers worldwide by 2005 (CTIA, 2000; Campbell, 1999; Kress, 1997; Ryan, 1993).

To support this increased use of wireless technology, wireless sites in the United States have grown from 346 in 1984 to 81,698 by December 1999 (CTIA, 2000). Wireless telecommunications service providers, bolstered by this rapidly growing market, are expected to continue to develop more new towers and facilities, including more than 100,000 towers and facilities within the United States alone by 2005 (Sweet, 1998).

POLICY

In the United States, electric utilities acquired property for the establishment of rights-of-way through the powers typically granted to franchised public utility monopolies. The rates of these utilities were historically regulated on a cost-of-service basis, where the utilities were allowed a reasonable rate-of-return in exchange for the provision of universal regulated service to all customers within the utilities' franchise service areas (Phillips, 1993; Strasser and Kohler, 1987). With a regulated rate-of-return, the utility owners of network infrastructure have little incentive to share or to provide access to the right-of-way. Consequently, each utility has both opportunity and regulatory incentive to develop separate parallel networks.

However, telecommunications providers, supported by regulatory policies encouraging competition, have sought to expand their services by developing additional facilities within the existing electric transmission infrastructure. Indeed, many jurisdictions have recognized the benefits of sharing this infrastructure, including the efficient use of scarce rights-of-way, orderly expansion, coordination with many users, competition for increased innovation, and lower cost of services for consumers.

Electric utilities have often developed internal telemetry systems on existing support structures and separate towers as part of their core business of electric supply and/or transmission. However, barriers to the development of common shared networks will develop if the owners of rights-of-way establish or assign legal rights that provide unfair advantage or deny access to other carriers. This can happen if an electric utility attempts to exploit its control over the ROW. For example, the discriminatory practice of preferential pricing or over-pricing will result in anti-competitive access and impede the development of common shared networks.[1] The development of commercial wireless telecommunications services by an electric utility on electric transmission support structures may further create a significant incentive to exploit the right-of-way resource in an anti-competitive,

1 Nonetheless, the owner of the right-of-way should not be deprived of an opportunity for reasonable compensation for owning, operating, and maintaining the right-of-way and its infrastructure. The price for shared access should be the subject of private negotiation, with the availability of a regulatory process for arbitration or rate-setting should negotiation fail.

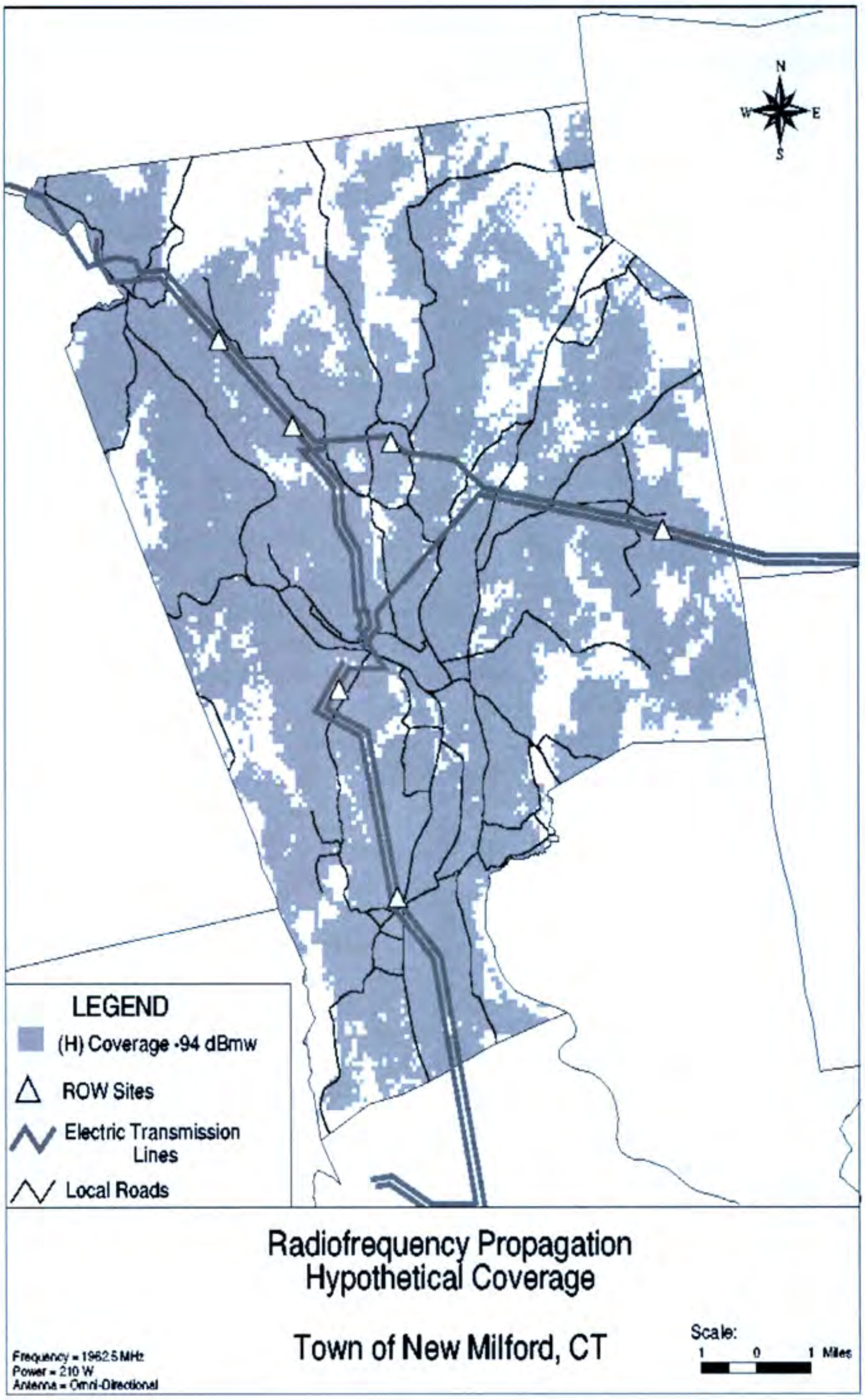


Fig. 1. Radiofrequency propagation, hypothetical ROW coverage, New Milford, Connecticut.

discriminatory fashion. Indeed, the consumer will benefit if the shared use of the right-of-way is subject to competitive pricing, nonexclusive access, proper maintenance, fair allocation of costs, reliable service, safe operations, and protection of the environment.

Physical access may be based on a first-come, first-serve basis. However, electric utilities may be faced with multiple (potentially) conflicting requests as more telecommunications carriers seek access to electric transmission lines. Any request for access or upgraded facilities should consider the needs of all existing and potential users. The resolution of these requests will likely require long-range planning with private negotiation and oversight by state or federal regulators. The right-of-way owners' denial of access should be restricted to competitively neutral grounds, including physical capacity, structural capacity, safety and reliability, radio-frequency interference, and damage to environmental resources.

Promoting the shared use of electric transmission rights-of-way does not require the elimination of the existing electric transmission monopoly held by most electric utilities. However, these rights-of-way should be considered a community resource as it may be technically unfeasible or cost prohibitive to duplicate a similar right-of-way for the development of a parallel network for telecommunications providers. The shift from potential multiple and redundant parallel networks to common infrastructure networks that serve as a platform for numerous competing carriers, sometimes referred to as lynchpin networks, will continue to gain favor as telecommunications carriers and rights-of-way owners establish master service agreements providing equal access on a non-discriminatory basis (Rosenberg, 1996). A natural symbiosis between the electric and telecommunications industries should be encouraged and could result in mutual benefit to both industries.

SITING CONSTRAINTS

All telecommunications siting must be carefully planned to provide the desired coverage within a selected service area without causing internal or external interference. System planners may test coverage using transmitting antennas located atop a crane to measure radio signal propagation, or use computer modeling to simulate coverage. Variables include frequency, power output, antenna type and gain, integration with adjacent cells, height of the support structures, and topography.

As shown on Fig. 1, placement of antennas on a transmission line support structure cannot change the physical laws which govern radio signal propagation; however, such placement can provide predictable and opportunistic locations to establish telecommunications sites. Furthermore, placement of antennas on existing support structures within maintained rights-of-way are more likely to be viewed as colocation of common infrastructure within an established utility corridor. Such established utility corridors may already be cleared of mature vegetation, served by roads, and segregated from sensitive community development. Thus, the incremental increased use of existing support structures for colocation of antennas will be less likely to affect ecological, scenic, and community resources than the development of separate towers to support such antennas. Consequently, these existing corridor locations are less likely to be publicly opposed and are more likely to be supported by regulators faced with the dilemma of telecommunications facility siting.

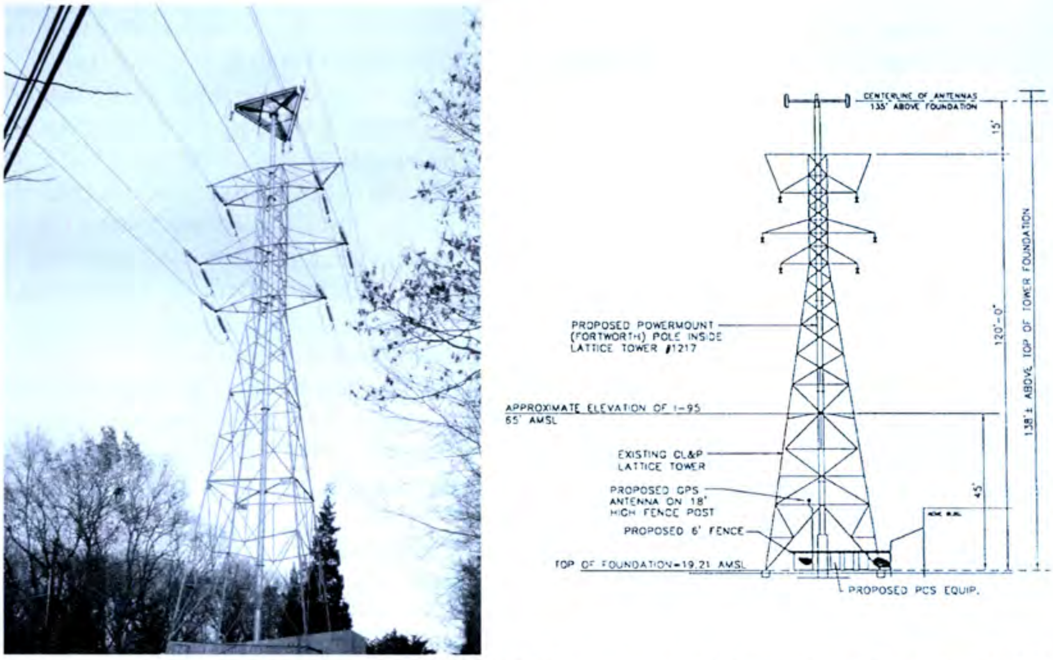
Access and utilities

Notwithstanding the legal issues associated with shared use of an existing right-of-way, to be discussed further herein, the use of an existing structure within an established right-of-way may preclude the need to develop a new facility. However, such shared use may require upgrades to the right-of-way to allow access to the telecommunications facility several times a month throughout the year. Such upgrades may include regrading, resurfacing, and drainage improvements. In general, the wireless industry will require permanent access to their facilities employing conventional four-wheel drive vehicles for facility maintenance and/or repair. Access for construction may require additional modification for delivery of equipment, structure members, and construction machinery; however, such construction access is temporary and may be limited to short-term modification to the site.

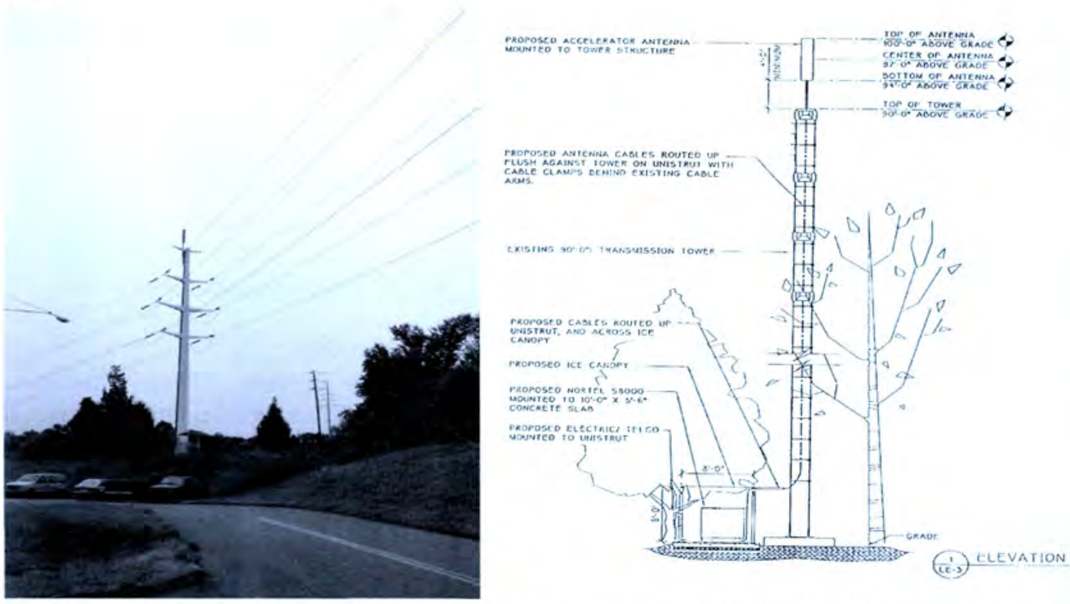
High capacity telephone connections and electric service from distribution lines may also be required for operation of a wireless facility. Such utilities may be installed either underground or overhead, at the preference of regulators and/or industry officials, but must comply with all electrical safety codes, including vertical and horizontal clearances for equipment within the right-of-way in proximity to high-voltage conductors. As a consequence of these codes, some equipment may be required to be located outside the right-of-way. In any event, the upgrade of an access road should be coordinated with the replacement of utilities and utility equipment during site construction.

Fencing, while generally not a requirement, may be preferred by some wireless providers for additional security of equipment. Such fencing must be in compliance with all vertical and horizontal separation distances and may require grounding to prevent induced static currents on metallic fence components.

Access onto the tower for maintenance and repair of antennas may be restricted. High-voltage electricity is inherently more dangerous than the lower voltage telecommunications facility, which would require telecommunications workers to have at least the same qualifications in terms of training as do electrical professionals. As a consequence of this safety issue, wireless carriers may seek to have their telecommunications technicians certified to access high-voltage structures, utility workers may seek to be certified to work on telecommunications equipment, or both industries may agree to use third-party professionals certified to work on both high-voltage electrical equipment and telecommunications equipment. Furthermore, access to antennas may be precluded unless high-voltage conductors are de-energized. Coordination between the wireless carrier and the electric utility is essential in order to de-energize conductors for scheduled maintenance and repair of antennas located in critical positions. However, it should be recognized that such coordination may be difficult during certain periods of high demand for electric dispatch, when conductors cannot be de-energized and access to antennas would be justifiably denied.



Connecticut Siting Council Petition No. 383 — Sprint PCS Compression Post Mount within a Connecticut Light & Power Company High-Voltage Electric Transmission Line Structure, Morehouse Drive, Fairfield, CT, December 18, 1997.



Connecticut Siting Council Petition No. 396 — Omnipoint Communications Direct Mast Mount on a Connecticut Light & Power Company High-Voltage Electric Transmission Line Structure, King Arthur Drive, East Lyme, CT, June 18, 1998.

Fig. 2. ROW structure modification.

Direct mast mounts

The potentially simplest method for placement of an antenna on an existing support structure is by use of a direct mast mount. In this application, as shown on Fig. 2, antennas are attached to a relatively short mast or pipe mount that in turn is attached directly to an existing support structure. Special mounting brackets, bands, and/or welding may be necessary to attach the mount to the support structure. Selection of the mounting technique is important to avoid overstressing the structure or individual members of the structure, cutting or burning critical structure members, and compromising durability of the structure by impairing galvanization or by inducing electrolysis. Although this method may allow rapid development of the facility and deployment of service, the load carrying capacity of the support structure may limit the number and size of antennas to omni-directional whip or lower capacity installations using three or less flush mount or other panel antennas. These antennas may not necessarily limit the area of coverage, but may limit the number of simultaneous signals that can be transmitted from the site, thus limiting the capacity of the proposed antenna array.

The load carrying capacity of some structures can be increased with certain structural and foundation reinforcement; however this will increase the time, cost, and complexity for the installation. Consequently, it may be more cost effective to simply reduce the antenna loading to within the capability of the tower. Nonetheless, electric utilities and regulators may seek to over design certain tower structures at key locations, such as hilltops, when installing new structures to increase the opportunity and marketability for co-location of multiple full array antennas.

Structural compression post mounts

Compression posts mounted adjacent to or within existing support structures increase load bearing capacity for mounting larger antenna arrays. As shown in Fig. 2, the use of a compression post is more involved and requires a firm foundation, construction of the compression post within or against the existing structure, and securing the post to individual members of the existing structure. However, this method offers substantially increased load bearing capacity capable of holding large arrays of nine to twelve panel antennas on a structure platform. Some compression posts are capable of being shared by multiple carriers seeking to take advantage of common infrastructure such as electric and telephone utilities, and an access road to the structure. The time, cost, complexity of development will vary with this type of construction; however, this method will provide the structural latitude for wireless carriers to develop full-sectorized arrays.

Safety

Prior to any installation, a complete structural analysis is necessary with a full description of existing utility loads; assessment of the proposed telecommunications loads for all antennas, mounting brackets, and the load of the coaxial cables routed down through the support structure; and an assessment of the structure including all bracing, bolts, and connections. Loading criteria must, as appropriate, account for wind pressure, radial ice, uneven tension from broken shield wires and conductors, and an overload factor. In addition, a geotechnical analysis must be undertaken to confirm the capability of the existing foundation to support the loads of all electric conductors, protective gear, and telecommunications equipment.

Co-location of wireless antennas may be possible on any structure; however, the structures that offer the greater structural capacity and opportunity for co-location include:

- lattice structures built with integrated structural members on multiple foundation piers;
- guyed structures where steel cables provide additional lateral support to the tower;
- dead-end structures built to withstand the tension of electric conductors arranged in a static strain configuration; and
- angle structures built to withstand the tension of electric conductors at an angle location in a line.

All construction must meet local and regional code requirements for structural stability considering mechanical and wind loading. In the United States, the Telecommunications Industry Association/Electronic Industries Association has adopted "Structural Standards for Steel Antenna Towers and Antenna Supporting Structures" (TIA, 1996) to provide "minimum criteria for specifying and designing steel antenna towers and antenna supporting structures." These standards, which are periodically updated, may be adapted for international use; however, local meteorological wind and ice loading conditions must be applied. Equivalent international system of units are used and conversion factors are provided (TIA, 1996). The content of these standards include sections on materials, loading, stresses, foundations and anchors, guy loading, operation, grounding, maintenance and inspection, and analysis of existing structures. In addition, all electrical equipment, grounding, and connections must comply with local codes including electric safety codes (IEEE, 1997). However, these standards are not intended to replace or supercede applicable codes or to be used as instruction manuals, and are not a substitution for professional design and installation with verification by licensed professional engineers.

Schedule and cost

The schedule and cost of any proposed application will vary based on the existing conditions at the site, the existing structure, and the proposed installation. Variables may include the assessment and capability of the existing structure and foundation, assessment of the proposed loading by the antennas and coaxial cable connecting the antennas to a base station, site access, availability of utility service for distribution electric and telephone service, cooperation to de-energize conductors, access to the existing structure for analysis and construction, design and construction contracts, and the legal right to use the existing rights-of-way. Should the existing tower and foundation be incapable of supporting the additional load associated with the antennas, alternatives may include modifying the structure to increase its structural capability, reducing the loading of the proposed antennas, or selecting a different structure with increased structural capability to hold the proposed antennas. These activities and analysis of alternatives may increase pre-construction costs and lengthen the schedule, but may be necessary to balance the requirements of wireless antennas with the capability of existing structures on a right-of-way. The burden of costs for these activities will likely fall upon the telecommunications carrier, unless the electric utility has entered into an arrangement to accommodate certain antennas in exchange for a fee as part of a lease agreement which can range from 10,000 to $40,000 (US) per year.

Wireless carriers and utilities have the option to assess and design applications with in-house construction crews or to coordinate with independent specialty companies that design, develop, and maintain telecommunications towers and antennas. Indeed, some specialty companies can provide detailed information on loading conditions, analysis procedures, attachment designs, fabrication procedures, construction procedures, installation, and utility references. For example, FWT, Inc. has developed proprietary specialty products including PowerMount™ compression posts for use at existing lattice structures and PowerArm™ support devices to hold antennas on existing monopoles (Wrigley, 2000). FWT, Inc. reports that most PowerMount™ sites are completed in two days, and can be operational in two to three days after construction begins, except for power and telephone connections which are affected by local issues. At one-half to two-thirds the cost of conventional network built-out, these facilities typically cost 30,000–$35,000 for a 85-foot to 110-foot unit including the costs of the foundation, standard grounding, PowerMount™, installation of the PowerMount™, and antenna/cable installation. PowerMount™ maintains that stress analysis is completed within two weeks and the PowerMount™ is shipped three weeks thereafter. To date, several hundred compression post PowerMount™ structures have been developed, as shown in Fig. 2, and have become accepted by both the electric utility and wireless industries.

Electric transmission rights-of-way — Legal nature of the property right

Electric transmission rights-of-way can be publicly or privately owned.[2] For public rights-of-way, the legal issues regarding their shared use may be governed by existing access laws or policies. The telecommunications legislation adopted in many countries to open telecommunications to competition include provisions making public rights-of-way available on a nondiscriminatory basis to all telecommunications carriers, including wireless providers (Campbell, 1999; Ryan, 1993). These provisions may already extend to publicly owned electric transmission rights-of-way or could provide a model for a future regulatory framework.

In North America, however, electric transmission rights-of-way are predominately privately owned. Electric utility companies, either through private transactions or through the exercise of the government-delegated power of eminent domain (known in Canada and other countries as expropriation),[3] have obtained private rights-of-way over the land of others to place their transmission lines. Although it is possible for the utility to obtain fee ownership of such land, more typically the property right obtained is known as an easement.[4]

An easement is a nonpossessory interest in the land of another that grants the easement holder the right to use the land, usually for a defined purpose (Bruce and Ely, 1995, ¶1.01). The easement holder does not own the land nor does it have a right to possess it; rather, the easement holder may use the land in a manner that is consistent with the grant of the easement right. Because rights of the owner of the underlying property — known as the servient estate — are involved, consideration must be given to the scope of the easement granted in evaluating whether the right-of-way may be shared without first obtaining the agreement of the owner of the servient estate. These concerns can always be avoided if the servient estate's owner consents to the shared use. Such consent, not surprisingly, is not always forthcoming and at a minimum would likely require additional compensation to the owner. In the absence of obtaining consent or additional rights from the owner, two issues in particular must be addressed: (1) whether the existing easement rights can be apportioned — that is, can they be shared with another; and (2) whether the shared use by a wireless telecommunications provider is consistent with the easement holder's existing rights.

A determination of whether an easement can be assigned or apportioned must begin with the language of the easement document. In some instances an easement may expressly preclude assignment or apportionment of the rights and benefits granted. However, in the absence of such express language, United States courts generally view commercial easements such as electric transmission rights-of-way as divisible (Bruce and Ely, 1995, ¶¶2.01, 9.04). Further, in many cases, state statute may codify the public policy favoring

2 An important caveat must be made at the outset. Property law is by its nature parochial and often varies from locale to locale not only in its details but sometimes in its broader outline. Generalizations are therefore difficult, and no effort is made to provide a complete codex of the legal rules for all jurisdictions. Instead, what is offered is a discussion of the nature of the issues that are posed, with a more focused discussion of the relevant legal principles of the United States, Canada and, to a lesser extent, other countries.

3 Eminent domain or expropriation is the power of the government to take private property for a public purpose without the owner's consent. This governmental power has often been delegated to private entities, such as public utilities, because of the essential services that they provide and the land needed for the delivery of their services (Sackman, 1999, vol. 1A, §3.03[11]; Phillips, 1993, p. 120). Although most rights-of-way have been obtained through agreement rather than the recourse to eminent domain proceedings, the threat of such recourse often provides the leverage for achieving agreement of the landowner.

4 This includes rights-of-way taken through the power of eminent domain or expropriation. The taking of property by an electric utility for transmission will generally result in an easement (Sackman, 1999, vol. 3, §11.08[20]; *Otter Tail Power v. Demchuk*, 1982).

assignment of public utility easements (Connecticut General Statutes §47-42).

Even if apportionable, the nature of the easement holder's rights must be evaluated to determine whether those rights could encompass use by a telecommunications provider. As a basic proposition of property law, an easement holder only has such rights as the grantor of the easement originally transferred to it. This would, at first blush, appear to pose an obstacle for the shared use by wireless providers given that it involves a recent technology that few could have envisioned at the time most electric transmission easements were granted. However, courts are reluctant to interpret easements in a way that preclude changes in use reflecting technological advances.

Historically, much of the existing electric transmission system was developed at the same time as the land line telephone system, resulting in a kind of symbiotic accumulation of easement rights. Electric and telephone companies, in seeking easements for their respective networks, typically also sought easement rights for the other's services. Thus, it is quite common for an electric transmission easement to include the right to use the land for telegraph and telephone as well as electric transmission lines. The question is whether such an easement can also be used for the placement of a wireless facility.

The resolution of such questions always begins with the language of the instrument creating the easement. The following is an example of the granting language in a typical electric transmission easement:

> Together with the right to enter upon said land and erect, inspect, operate, replace, repair and patrol and permanently maintain on said right of way, poles and towers, with necessary conductors, wires, cross arms, guy wires and other usual fixtures and appurtenances used or adapted for the transmission of electric current for light, heat, power or any other purpose, ***and used or adapted for telephone purposes*** (emphasis added).

The extent of the easement holder's right to use, and the corresponding right to apportion for the use of another, is determined by the language used in the grant of the easement (Bruce and Ely, 1995, ¶8.02[1]). However, the task of interpreting that language is not always simple. Courts have developed several basic rules for interpreting the language of an easement. Most fundamentally, the easement holder is entitled to reasonable use of its rights. The reasonableness of the use includes, among other things, consideration of changes in circumstances and technological developments (*Centel Cable TV v. Cook*, 1991; *Witteman v. Jack Barry Cable TV*, 1986; *Henley v. Cablevision*, 1985; *Minnkota Power Coop. v. Lake Shore Prop.*, 1980).[5] Moreover, the law presumes that advances in technology are contemplated in the grant of the easement (*Hash v. Sotinowski*, 1985). Therefore, it is not an obstacle that wireless facilities represent a new technology not specifically referenced or even imagined at the time of the grant of the easement.

Several United States and Canadian courts have evaluated the language of electric transmission easements in connection with the addition of new telecommunications technologies and have found the shared use consistent with the existing easement rights (*Stasium v. West Kootenay Power*, 1999; *Edgecombe v. Lower Valley Power & Light Co.*, 1996; *C/R TV, Inc. v. Shannondale, Inc.*, 1994; *Cousins v. Alabama Power Co.*, 1992). These courts concluded that the use of an existing electric transmission easement for new telecommunications technologies should be permitted if (a) the additional use is substantially consistent with the easement's original purpose, and (b) would not be substantially burdensome to the subservient estate. In each of these cases, the original grant of the easement was for electric transmission and telephone lines, and the proposed shared use involved the addition of fiber optic wires for a cable service provider. Even though not "telephone" service as the grantor might have recognized at the time of the original grant, the courts found cable television service to be a form of telecommunications substantially consistent with the easement's purpose and merely a natural extension of earlier technologies. The courts concluded the holder of the electric transmission easement had the right to permit the additional use without the consent of the servient estate owner.[6]

In principle, the same reasoning should pertain to wireless facilities. Wireless services are a technological advancement in telecommunications that should be considered within the scope of the reasonable use of an easement that includes telephone service as an intended purpose. However, the reasonableness of the additional burden on the servient estate must be evaluated on a case-by-case basis. As discussed above, different facilities and locations may require additional physical access or changes to the right-of-way that could rise to the level of a substantial burden on the servient estate. In most cases, the structures, equipment and activities involved will be consistent with the reasonable use associated with the existing easement rights.

Significant opportunities exist for the shared use of electric transmission rights-of-way by wireless providers. In light of the courts' approach to interpreting

5 The same rules apply in those instances in which an easement was obtained through the exercise of the power of eminent domain, except that the controlling instrument is the judgment issued by the court establishing the terms of the taking of the original easement. In all other respects, the easement holder has the same right to reasonable use including the right to take advantage of technological changes (Sackman, 1999, §11.08[2]; *Otter Tail Power Co. v. Demchuk*, 1982).

6 Similar conclusions have been reached regarding the shared use of electric transmission rights-of-way in litigation in Norway (Føyen, 2000).

easements as encompassing new telecommunications technologies, most existing electric transmission easements may already permit the addition of a wireless facility without securing additional rights or obtaining the consent of the servient estate owner.

Regulatory provisions and limitations to the promotion of shared use

The legal issues relating to shared use are not limited to the evaluation of property rights. Government regulatory policies must also be crafted to promote the shared use of electric transmission rights-of-way by wireless telecommunication providers.

Many countries have created or extended existing rules creating mandatory, nondiscriminatory access to public rights-of-way or other public properties for telecommunications providers as part of the regulatory shift to the competitive provision of telecommunications services (Campbell, 1999). Similarly, many have mandated access to existing facilities and structures of other telecommunications entities, often including the sharing of wireless facility structures (Campbell, 1999; Ryan, 1993). Less attention has been given to creating legal requirements with regard to electric transmission structures within rights-of way.

In some instances, existing laws regarding mandatory access may already be applicable to or could provide a model for mandating access to electric transmission rights-of-way. The US Pole Attachment Act provides an intriguing example. This legislation was originally enacted in 1978 as a mechanism to afford cable television providers access to the poles of electric and telephone companies. As part of the Telecommunications Act of 1996, these provisions of the Pole Attachment Act were amended to extend to telecommunications providers. Specifically, the amended legislation now requires that a "utility shall provide a cable television system or any telecommunications carrier with nondiscriminatory access to any pole, duct, conduit, or right-of-way owned or controlled by it" unless there is "insufficient capacity or reasons of safety, reliability and generally applicable engineering purposes" that justify the denial of access (47 U.S.C. §224(f)). It also gives authority to the Federal Communications Commission to establish just and reasonable rates for shared access (47 U.S.C. §224(b)–(c)).[7]

The Pole Attachment Act may have been crafted to provide access to public utility distribution structures. However, its scope is not necessarily so limited, and it could be a tool to promote the shared use of electric transmission rights-of-way. First, the Federal Communications Commission has clarified that the provisions of the Pole Attachment Act are available to wireless providers and not just wireline telecommunications carriers (FCC Report and Order, 1998, ¶¶36–42). The US Supreme Count recently upheld the FCC's rule extending mandatory access to wireless providers (National Cable v. Gulf Power, 2002). Second, by its terms the Pole Attachment Act's mandatory access requirements extend to all public utilities, including electric utilities, that own or control "rights-of-way used, in whole or in part, for any wire communications." (47 U.S.C. §224(a)(1)). If an electric transmission right-of-way is used for wire communications, a wireless provider should be able to invoke the nondiscriminatory access mandate.

Such laws may be a particularly effective mechanism for promoting shared use when an electric utility is pursuing the development of its own telecommunications business and has an inherent bias against providing access to its transmission rights-of-way to other telecommunications providers. For example, Svenska Kraftnät AB, the owner of most of the electric transmission network in Sweden, is developing a telecommunications network using its existing electric infrastructure. The Swedish Right of Way Act, as amended by the Telecommunications Act in 1993, is applicable to the development of this telecommunications infrastructure (Juhlen, 2000).

The ability of government to compel access to a private right-of-way, however, does have its limits. Under US constitutional law, for example, government-mandated access to private property such as that provided under the Pole Attachment Act is considered a taking of property (*FCC v. Florida Power Corp.*, 1987; *Loretto v. Teleprompter Manhattan CATV Corp.*, 1982). To satisfy the constitutional proscriptions against the taking of property, such access requirements must provide for the reasonable compensation of the property owner and a mechanism for judicial review of the compensation award (*Gulf Power Co. v. United States*, 1999; *Wisconsin Central Ltd. v. Public Service Comm'n*, 1996).

Interplay of public utility regulation and local land use

The proposed placement of a wireless facility in an electric transmission right-of-way may require approvals from several regulatory bodies. Particularly in a federal system, there may be multiple layers of legal regulation. For instance, in Canada, telecommunications are generally regulated at the federal level, while electric transmission rights of way are regulated at the provincial level. In the United States, the shared use of an electric transmission right-of-way may implicate federal, state and local regulation.

The US Telecommunications Act of 1996 purports to restrict state and local siting authority in several ways, including: (1) prohibiting state or local authorities from unreasonably discriminating among providers of functionally equivalent services; (2) barring state or local authorities from regulating the siting of wireless facilities in a manner that has the effect of prohibiting the provision of wireless services; and (3) preempting state

7 47 U.S.C. §224(b)–(c). The Commission has adopted rate formulas and complaint procedures that encourage resolution of rate issues by private negotiation. 47 C.F.R. §§1.1401–1.1418.

and local authorities from regulating radio frequency emissions in a manner that conflicts with federal regulations on such emissions (47 U.S.C. §332(c)(7)(B)). In most other respects, state and local authority over the siting of wireless facilities is expressly preserved (47 U.S.C. §332(c)(7)(A); Rosario and Kohler, 1996; Tuesley, 1999).

States differ, however, as to whether the regulation of wireless facility siting is within the jurisdiction of local land use agencies or of a specialized state agency. The decision of which level of government regulates siting is not in and of itself problematic for the promotion of shared use of rights-of-way. The potential for overlapping jurisdiction can arise, however, where local authorities have jurisdiction over wireless facilities. This potential exists because, in most states, the regulation of electric transmission lines is conducted at the state level, usually by either the public utilities commission or a state siting board (Williams, 1994). The rationale for state preemption of local land use control over electric transmission lines is that, given the nature of transmission and the need to cross multiple local jurisdictions, their regulation should not be the subject of conflicting municipal standards but rather a uniform state system of regulation (*East Greenwich v. O'Neil*, 1992; *Board of Supervisors v. Virginia Elec. & Power*, 1981; *Commonwealth Edison v. Warrenville*, 1997; *Preston v. Connecticut Siting Council*, 1990).

The same rationale does not necessarily extend to the siting of a wireless facility in an electric transmission right-of-way. Therefore, where local agencies regulate wireless facility siting, regulatory approvals may be necessary not only from the relevant local board but also a state agency having jurisdiction over the modification of transmission lines.

This dual, potentially conflicting or duplicative, regulatory authority does little to encourage the shared use of rights-of-way. Given the potential gains from such shared use, effort should be made to rationalize state and local siting authorities and to eliminate this otherwise unnecessary obstacle to the promotion of the use of existing rights-of-way.

SUMMARY

Electric transmission rights-of-way must be recognized as a resource with the potential to provide multiple services to customers. Although not a finite resource, these rights-of-way offer valuable options for strategic planning for both electric transmission service and wireless telecommunications providers. Government policy makers should recognize that the opportunity for sharing electric utility rights-of-way with telecommunications carriers exists, is both technically and legally possible, and is of great importance to the public. Emphasis should be placed on encouraging sharing without barriers, and discouraging opportunities for non-competitive discriminatory use. The result will be a shift from parallel networks providing discrete individual service to common shared networks acting as linear hubs deploying multiple services. Such relationships will generate revenues for the owners of the right-of-way and those who share the right-of-way; expand valuable essential services to customers; and increase siting efficiency using technological alternatives that provide better protection of environmental resources.

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8 The opinions stated in this article are the authors' own and do not necessarily reflect the opinions of the Connecticut Siting Council, the Connecticut Office of the Attorney General, or any other official or agency of the State of Connecticut.

Practical Approach to Assessing Cumulative Effects for Pipelines

George Hegmann, Ross Eccles, and Kirk Strom

This paper describes a potential approach to the assessment of cumulative effects that may be adopted for larger federally regulated pipelines in Canada. The approach is based on a process originally developed for pipelines in the Rocky Mountain foothills of western Canada; therefore, the environmental components selected reflect some that are common for that region. The approach is based on the author's experiences in conducting cumulative effects assessments in Canada. Conditions or "triggers" are discussed under which cumulative effects need to be considered for a pipeline project, establishing an effects-based approach for assessing only those portions of the pipeline potentially contributing to cumulative effects. This establishes a focused approach that clearly identifies the scope of assessment. Specific pipeline effects that typically contribute to regional cumulative effects issues are identified, and approaches for assessing the significance of project contributions to such effects are broadly discussed.

Keywords: Cumulative effects, cumulative effects assessment, pipelines, triggers

ASSESSMENT FRAMEWORK

Cumulative effects are changes to the environment that are caused by an action (i.e., projects and activities) in combination with other past, present and future human actions. A cumulative effects assessment (CEA) is an assessment of those effects (Hegmann et al., 1999).

The proposed CEA approach for pipelines follows a four-step framework (see Fig. 1):

1. Describe the project components, environmental, and land use setting.
2. Identify key, project-related contributions to cumulative effects on selected resources of concern.
3. Assess the levels of cumulative effects on the selected resources, both with and without project effects.
4. Determine if the cumulative effects are significant.

The framework is based on the premise that, under Canadian legislation, a proponent will (or should) not be required to consider cumulative effects that are not of relevance to their project. In other words, only those effects resulting from the project need to be

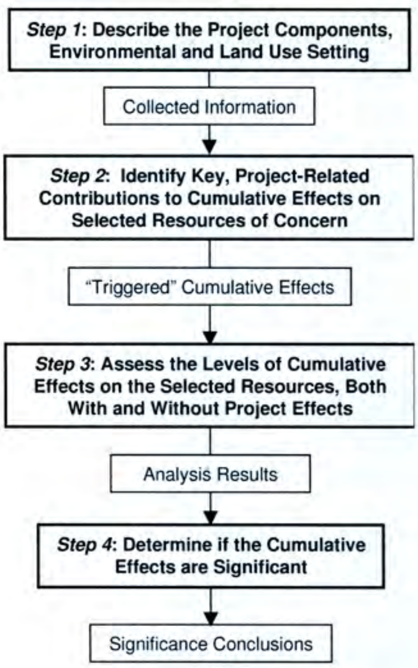

Fig. 1. CEA framework.

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considered from a CEA perspective, but they need not be significant to warrant their inclusion in the CEA. The other fundamental premise of the framework is that it is not necessary to include the entire length of the pipeline in a CEA unless justified by the nature of the project's effects. The framework instead first determines if only portions of the pipeline need to be assessed for possible contribution to cumulative effects, thereby avoiding unnecessary data collection over larger areas. Such an approach is in part a reflection of various unique attributes of pipelines in comparison to other types of projects; principally, the often considerable distance and variable land use settings traversed by the pipeline, and the limited footprint of disturbance created by such developments in any given area.

This approach is viewed as a practical and efficient application of assessment effort to meet the challenging task of assessing longer pipeline projects.

STEP 1: DESCRIBE THE PROJECT COMPONENTS, ENVIRONMENTAL AND LAND USE SETTING

In the first step, the components of the proposed project (both physical works and activities) and the project phases in which they would occur (e.g., construction, operation) are identified. Key project information requirements needed to help "scope out" important cumulative effect issues include:

- location and width of right-of-way (ROW), including laterals and access roads;
- location and dimensions of extra workspace (to the degree possible);
- location and dimensions of ancillary facilities;
- project-related emission sources and operating specifications (e.g., compressor stations, line heaters);
- location and nature of access requirements, during both the construction and operational phases of the project;
- specialized construction techniques to be used for the project (e.g., directional drilling of streams); and
- nature and scheduling of construction and operational activities.

The types of environmental setting and land use information required for Step 1 in support of a CEA generally include:

- native vegetation communities along the route;
- key wildlife habitat conditions along the route;
- streams crossed by the route, and their fisheries capability;
- opportunities for ROW and access sharing with existing operators in the area;
- other land use activities occurring in or proposed for the area;
- other industrial emission sources in the project area; and
- land use plans or resource management objectives for the area that may be relevant to the pipeline application.

STEP 2: IDENTIFY KEY, PROJECT-RELATED CONTRIBUTIONS TO CUMULATIVE EFFECTS ON SELECTED RESOURCES OF CONCERN

It is important that direct project effects with the potential of measurably contributing to regional cumulative effects issues be identified early in the scoping process. Such effects should be a subset of those identified and assessed for the projects environmental impact assessment (EIA).

Regional resource issues of concern can be identified during public and resource agency consultation sessions, and by the environmental specialists performing the assessment. Throughout much of western Canada, regional issues of concern generally include airshed quality, "at risk" vegetation and key wildlife resources, and fisheries resources. Direct pipeline effects on such resources that frequently persist after mitigation result from:

- air and noise emissions from ancillary facilities (e.g., compressor stations);
- alteration of fisheries habitat quantity and quality;
- alteration of native vegetation;
- alteration of wildlife habitat quantity and quality; and
- development of new access potential and associated increased recreational pressures on important resources.

Once important project effects have been identified, it is necessary to evaluate the potential for these effects to contribute to regional cumulative effects issues. Several basic questions need to be asked to assist in the identification of key project issues:

1. Are other land use activities in the project area having similar effects on the resource in question?
2. Do direct project effects have the potential to overlap with or incrementally add to those of other land use activities in a meaningful fashion?
3. Will project contributions to regional cumulative effects have the potential to measurably change the health or sustainability of the resource in question?

Step 2 is essential to ensure that assessment resources are not spent on irrelevant issues. For example, if a large portion of the proposed ROW will be predominantly sharing easement with or abutting to an existing road or utility corridor, that portion of the new pipeline will likely not be contributing in a meaningful manner to regional cumulative access potential; therefore, the issue of increased access need not be pursued. Conversely, where new ROW is to be developed for long stretches in a relatively remote area, then such an issue becomes more relevant.

Longer pipeline projects (e.g., 200 km) often encounter a variety of land use settings and jurisdictions, each with their own unique set of resource issues. For example, the implications of pipeline development through cleared, private agricultural land are very different from those for a pipeline in a remote forested

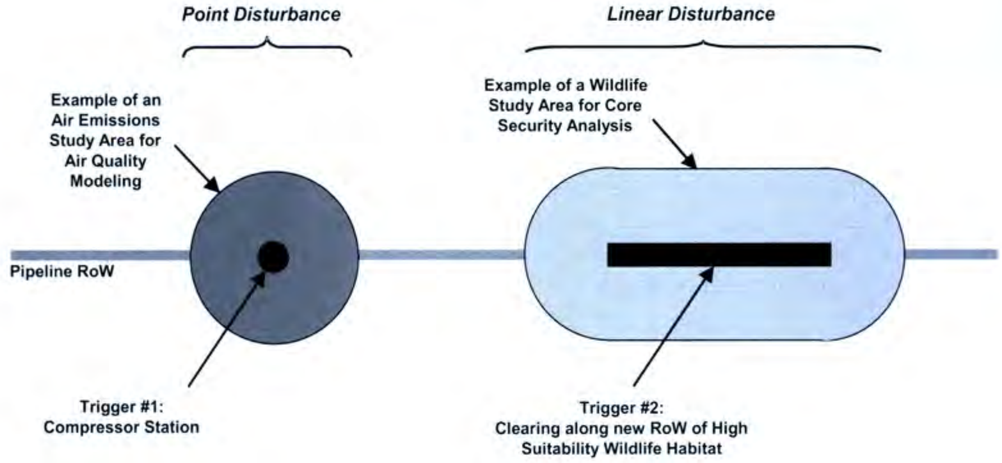

Fig. 2. Examples of use of triggers to establish location and size of study areas.

setting. Therefore, in developing an approach for a pipeline CEA, it should be recognized that different issues, study areas and assessment methods may have to be adopted for different portions of the route.

Each of the potential effects from the pipeline discussed above should be considered within the context of the various land use settings along the route. "Hotspots," where project contributions to cumulative effects are probable, should be identified. These "hotspots" serve as the geographic focus of assessment efforts, and are referred to here as CEA "triggers." Each hotspot will generally require its own unique assessment study area that reflects the nature of the project effect and the resource in question (see Fig. 2). Some discretion must be applied in the interpretation of what constitutes a study area in situations where the triggers or hotspots occur in succession for short distances but with short separations between them (i.e., triggers "on" and "off" over brief distances). In such cases, the separate study areas may be joined together to simplify the assessment.

STEP 3: ASSESS THE LEVELS OF CUMULATIVE EFFECTS ON THE SELECTED RESOURCES, BOTH WITH AND WITHOUT PROJECT EFFECTS

Methodological issues

For all resource issues, the assessment of cumulative effects requires identification of the following:

- timeframe for the assessment;
- spatial boundaries for the assessment;
- measurable parameters for the assessment; and
- inclusion list of "other activities" contributing to cumulative effects to be considered in the assessment.

Timeframe

Timeframe for the assessment refers to the periods or "slices of time" during the life of the project selected for the evaluation of cumulative effects. For a buried pipeline, timeframes could include baseline (i.e., predevelopment), construction, operations, and abandonment. Selection of the appropriate assessment timeframe for pipelines is problematic as the peak effects of a pipeline can occur at different times for different resources. For example, effects on fisheries generally peak for a relatively brief period during and immediately after construction if open cut stream crossing procedures are employed, while effects on airshed parameters will likely peak at a relatively consistent level throughout the operational phase of the project (e.g., compressor station emissions). Therefore, it is suggested that the most appropriate timeframe for assessment purposes should be selected on a resource/issue specific basis and, at the very least, should address the period of worst-case project effects for the resource in question.

Spatial boundaries

To complete a credible CEA, the study area boundaries adopted for the assessment must be resource specific. In general the study area adopted for each resource issue should:

- reflect the nature and severity of the project's contribution to cumulative effects;
- represent a defensible regional unit for the resource in question (e.g., seasonal territory for wildlife species);
- encompass the effects of other land use activities acting in a cumulative fashion with the project; and
- allow for the collection and analysis of cumulative effects data at a reasonable cost.

As previously discussed, longer pipeline projects often encounter a variety of land use settings and jurisdictions, each with their own unique set of resource issues. Cumulative effects issues along one portion of the pipeline may not be relevant along other portions of the pipeline. Therefore, it should also be recognized that the CEA study area selected for resource issues may only cover a portion of the pipeline length.

Measurable parameters
Measurable parameters are the actual units to be used for quantifying cumulative effects for the resource issues in question. For example, if grizzly bear is a resource concern, possible measurable parameters for assessing project and cumulative effects could include human-related bear deaths (i.e., total number of bears killed from hunting, road kills, and removal of "nuisance" animals per year) or habitat availability. During the selection of appropriate parameters, the proponent should consider the availability of regional data for the parameter, and the ability to generate defensible regional data at a reasonable cost.

It is important to recognize that the parameters used for the CEA should reflect those used by the proponent to identify and assess project-specific effects in the EIA, although the scale of resolution may have to change for the broader regional CEA. For example, if project-related grizzly bear deaths are predicted in the EIA, then cumulative human-caused mortality predictions should also be pursued at the regional cumulative effects level to enable the effects contribution of the project to be evaluated within the context of regional pressures. Use of parameters not addressed in the EIA simply leads to reduced credibility for the CEA, and confusion for regulatory agencies responsible for project review and approval.

Inclusion list of other activities
The identification of other projects or activities whose effects could act in an additive fashion with those of the pipeline is a critical step in a CEA. Inclusion lists should be resource/issue specific, as different resources will be influenced by different land use activities.

Candidate projects and activities for consideration in CEAs (from nearest to most distant point in time) include: approved, approved and under construction, approval imminent, in approval process, project announced and application/construction anticipated during the life of the pipeline project. Generally, only projects that have a developed footprint or design specifications at the time of the CEA are considered for quantitative analysis. Effects of projects and activities more conceptual in design can only be dealt with in a qualitative fashion, and frequently add little value to the CEA. The inclusion/exclusion of such projects should be discussed with regulators early in the assessment process.

Resource-specific approaches
In the sections below, some broad approaches to CEA are discussed for several selected resources.

Air
Triggers. During normal operations, pipelines only contribute to cumulative airshed emissions in a meaningful way where gas fired compressor stations or pump stations are required as part of a project's design. Such point emission sources can be considered as triggers for emission-related CEAs. Many transmission pipelines link into gas plants or other processing facilities that were applied for and approved under different jurisdictions by different owners. In these situations, the pipeline proponent is not responsible for assessing the cumulative contributions of the processing plant unless project-specific emissions from the pipeline project have the potential to interact with those of the processing facility.

Timeframe. As discussed, airshed issues are generally only of relevance to pipeline projects if compressor stations, pump stations or other point emission sources form part of the principal project. Airshed issues associated with equipment emissions, dust, and noise during construction are generally of short duration and too transient to be considered in a CEA. Consequently, the point in time selected for assessing airshed-related cumulative effects is generally restricted to the operational phase of the project.

Study area. The study areas selected for the CEA are centered around project-related point emission sources, and their size is heavily influenced by the emission dispersion models used for the analysis. Study areas generally reflect the area over which measurable elevated levels of project emissions are predicted, and would include areas of plume overlap resulting from project and other unrelated facilities.

Measurable parameters and analysis. Airshed-related measurable parameters commonly selected for pipeline CEAs include SO_2, NO_x, VOCs, and noise levels. However, residents in close proximity to oil and gas infrastructures are becoming increasingly concerned that an assessment of cumulative emission levels alone does not provide the complete picture of airshed cumulative effects. They argue that, while atmospheric and terrain conditions may prevent emission plume overlaps and exceeding regulatory limits from multiple emission sources, their *exposure frequency* to noticeable odors, noise events, etc. nevertheless increases with increasing facility development. This "time crowding" cumulative effects issue therefore needs to be considered where residents are located in close proximity to an expanding development infrastructure.

Fisheries
Triggers. Pipeline projects primarily affect fisheries resources through two processes, which can be viewed as triggers for considering the need for CEA:
- alteration of habitat through instream activities, sediment introductions from approach slopes, and loss of riparian cover; and
- development of new access potential and associated increased fishing pressure.

If it is determined that the project has the potential to result in such effects, a second level of screening can be employed to focus on only those issues of real concern from a cumulative effects perspective. If instream habitat is to be adversely affected, the relative sensitivity of that habitat to stream productive capacity should be evaluated before initiating a CEA. For example, damage to fall spawning areas and overwintering eggs will have a much greater potential to contribute to cumulative effects than temporary disturbance to relatively common run habitat. Similarly, new ROW being constructed across a stream near an existing all-weather road and bridge has little potential of contributing to cumulative fishing pressures in a meaningful manner, relative to a new ROW accessing a stream in a remote unroaded portion of its watershed.

The degree to which these effects will contribute to regional cumulative pressures will be largely dependent on the construction and mitigation plans proposed for the project. For example, habitat alteration and fish mortalities can be eliminated or greatly reduced through directional drilling techniques or compliance with instream work windows and best available practices. Similarly, appropriate route selection, temporary run-off controls and reclamation initiatives can largely prevent sediment introductions from ROW approach slopes both during and after construction. Nevertheless, in some circumstances, residual effects will persist and may contribute towards cumulative pressures on fish.

Timeframe. Instream effects on fisheries are most prevalent during the construction phase, while the influence of new access potential on fishing pressure will persist throughout the operational phase of the project and beyond unless adequate access control measures along the ROW are implemented. Therefore, the timeframe for assessment may include construction as well as operations, depending on the final issues pursued at a cumulative effects level.

Study area. For instream habitat effects, separate study areas will generally be required for each affected stream, unless the pipeline crosses multiple tributaries and/or reaches of the same stream. The study area of focus will generally fall between and include the riparian areas on either side of the channel over some distance along its course. The length of channel selected for the CEA should:

- at the very least, encompass the extent of project effects; and
- be bounded by obvious habitat transition zones (e.g., confluence of two major streams, transition from pool/riffle mosaic to continuous high gradient run) or seasonal habitat boundaries for resident fish wherever possible.

Measurable parameters and analysis. If pipeline development is likely to cause the harmful alteration, disruption, or destruction of habitat (HADD), then the degree of harmful effects must be evaluated within the context of existing habitat availability and existing and future disturbance from other activities. This requires the following steps:

- classification and quantification of broad habitat types (e.g., run, riffle, pool) within the reach of stream(s) selected as the study area;
- the quantification of habitats that have been or will be adversely affected by other land use activities within the study area;
- the quantification of habitats that will be adversely affected by the project in question within the study area, both from trenching operations and downstream sediment deposition; and
- evaluation of the relative contribution to cumulative habitat alteration from the project.

The focus of the assessment is to determine if project contributions to cumulative effects will adversely affect important habitats that are restricted or underrepresented as a result of past, present, and future disturbance or natural conditions. For the purposes of CEA, the above information can typically be developed from air photos or aerial reconnaissance, and need not be prohibitive from a cost or timing perspective.

Recently, the number and density of linear corridor crossings of streams (e.g., number of crossings per km of stream) has been used as a measure of cumulative effects. It is generally assumed that such crossings contribute run-off and associated sediment into water channels, or provide access for anglers, influencing both fishing distribution and pressure. In many situations, this parameter is of questionable value for assessing cumulative effects for the following reasons:

- a large percentage of linear corridors do not contribute measurable amounts of run-off and sediment into streams because of natural terrain impediments, approach slope characteristics, and vegetative cover;
- similarly, a large number of linear corridors are not accessible to motorized travel because of terrain constraints or regrowth and hence do not contribute to fishing patterns; and
- there are no credible biophysical or resource use criteria for establishing acceptable density criteria.

In the absence of information to address the first two points, a crossing-density analysis tends to overstate the potential levels of cumulative effects in the area and, as a result, understates the potential contribution of the project effects to the cumulative effects.

The value of such a parameter as an assessment or decision-making tool should be discussed with project regulators and regional resource managers early in the planning process. If such a parameter is selected for CEA, additional supplemental information will be required for the linear corridors in the study area to make the analysis of value, including the terrain and vegetation conditions on the ROW and the potential for motorized access along the ROW.

Vegetation

Triggers. Pipeline projects primarily contribute to cumulative effects on vegetation through clearing related activities in native vegetation communities. Given the long, narrow configuration of pipelines, their contributions to cumulative vegetation alteration is generally of greatest concern where there is the potential to adversely effect native species or communities of restricted occurrences. Therefore, triggers for considering a vegetation-related CEA include:

- where project clearing will occur in native vegetation communities; and
- where there is a high probability for the project to encounter species or communities of restricted status or management concern.

Timeframe. Project development effects on vegetation resources are immediately and most acutely affected during the construction phase; however, effects also persist throughout the operational phase of the project and beyond. Therefore, the timeframe for assessment may include construction as well as operations, depending on the final issues pursued at a cumulative effects level.

Study area. Spatial boundaries should be broad enough to encompass direct project effects in addition to providing an ecological context for evaluation of the significance of localized project effects. In northern boreal and prairie landscapes, it is often difficult to utilize natural ecological boundaries (e.g., ecodistricts) to define appropriate study area boundaries. Therefore, arbitrary corridors centered on the ROW (e.g., 3 or 1.5 km on either side) have been adopted for use as CEA study area. Whatever the case, the selected corridor should be wide enough to:

- allow for quantification of direct effects on vegetation resources from project development, including new access roads and ancillary facilities; and
- provide a representative picture of the vegetation community structure along the route.

With a 3 km wide study area, the project footprint typically represents only 1% of the land base within the corridor, and the diversity and relative abundance of community types typical of the region are generally represented.

Measurable parameters and analysis. Although pipeline construction is designed to minimize loss of rare or under-represented vegetation communities and species, these effects are not entirely mitigable. The assessment of any residual effects focuses on changes in community and species representation in the study area intersected by the pipeline. Consideration of community representation entails application of an approach referred to as "gap analysis," which is defined as the process of protecting biodiversity by protecting a representative system of all vegetation or habitat types (Burley, 1988 in Wilson, 1988). Warranted, therefore, is an assessment of past, current and future changes to vegetation communities as an indicative measure of probable changes in regional terrestrial biodiversity. Such an assessment evaluates the extent of existing disturbance by identifying underrepresented communities within the study area, and the significance of incremental disturbance from the pipeline in the context of simulated pristine conditions and existing disturbed scenarios. In this process, assessment of project effects to vegetation and related biota are based on the distribution and abundance of communities along the entire length of the pipeline. Analysis of cumulative effects of underrepresented communities would be undertaken in areas intersected by the pipeline in which native communities are still intact. The process includes calculation of total project clearing (ha) for each community, and calculation of total community availability in the study area (as a percentage) to indicate relative significance of clearing.

Wildlife

Triggers. Pipeline projects primarily affect terrestrial wildlife resources through four processes, which can be viewed as triggers for considering the need for CEA:

- alteration of habitat availability, which is largely incurred during project construction;
- habitat fragmentation, a spatial outcome of alteration in habitat availability;
- direct wildlife mortalities (e.g., from vehicle-wildlife collisions); and
- development of new access potential and associated loss of habitat security.

If it is determined that the project has the potential to result in such effects, a second level of screening can be employed to focus on those issues of ecological importance from a cumulative effects perspective. For example, if forested habitat is to be adversely affected through clearing and construction, the relative sensitivity of that habitat to key indicator wildlife species should be evaluated before initiating a CEA. In the case of grizzly bear, for example, damage or loss of an important, localized fen habitat could have a much greater potential to contribute to cumulative effects on the population than disturbance to relatively common habitats. Similarly, new ROW being constructed adjacent to an existing all-weather road has little potential of contributing to measurable cumulative pressures on grizzly bear habitat availability and security compared to a new ROW accessing a previously remote unroaded portion of a watershed.

The degree to which these effects will contribute to regional cumulative pressures will be influenced by the construction and mitigation plans proposed for the project. As noted with regard to fisheries and vegetation resources, certain types of project effects are unmitigable and such residual effects will persist and contribute towards cumulative pressures on wildlife.

Timeframe. Risk of direct wildlife mortality is largely limited to construction and operational phases. Habitat related effects on wildlife (i.e., changes in habitat, availability, fragmentation, and security) first occur during the construction phase, and can occur through and persist beyond the project's operational phase. Specific timeframes for assessment will depend on the success of reclamation and on the realized effectiveness of access control during and following the life of the project. Hence, the timeframe for assessment can include construction, operations and post-operational phases.

Study area. Separate study areas will generally be required to account for the differing effects and ecological context of different wildlife species. To assess the effects of alterations in habitat availability on localized wildlife species, a relatively confined study area encompassing the project footprint would suffice. This is the case, for example, for the black-throated green warbler, an arboreal passerine species that is dependent upon mature coniferous forest and minimum patch sizes of 30 ha. With a commensurate minimum patch size diameter of 600 m, this species' spatial habitat requirements allow for assessment of effects on habitat availability and fragmentation (loss of minimum patch sizes) to be undertaken and based upon the Ecological Land Classification (ELC) data compiled within the 3 km wide study area.

For larger species, such as grizzly bear, that range widely and are particularly susceptible to the effects of access proliferation, associated loss of habitat security and increased vulnerability to hunting and poaching, appropriate study area boundaries are typically much larger that that described for the warbler. Where new access is developed in an area of high quality grizzly bear habitat, an appropriate spatial scale for analysis would extend from the project footprint to a distance approximating one diameter of an average female grizzly bear's home range (~100–300 km^2).

Measurable parameters and analysis. The following discusses two types of analysis and associated parameters: habitat availability and fragmentation analysis, and core security analysis.

- *Habitat Availability and Fragmentation.* Habitat availability is defined as a measure of an area's utility to a species following the effects of human disturbance. Fragmentation of habitat occurs from human alteration of habitat, and can affect species populations by impairing their ability to move between habitats, by creation of edge effects (related to habitat security), and by loss of minimum habitat size requirements to support individuals in a population. For habitat availability and fragmentation, assessment of cumulative effects are assessed only where key restricted habitats cannot be avoided or restored during construction. Habitat availability is normally calculated based on species-specific habitat requirements for communities within a given area. The association of habitat models to community mapping links the community representation analysis to the wildlife habitat availability impact component. Assessment of habitat availability will allow, through species-specific habitat and impact models, quantification of effects of clearing and associated areas of reduced habitat availability on species dependent on relatively rare or sensitive habitats in a given project region. The presence of such key habitat features would be identified once centreline surveys have been completed for the project.
- *Core Security Habitat.* One of the key issues that often arises for pipeline projects is the concern of access proliferation and associated impacts on certain vulnerable wildlife resources due to increased potential for hunting, poaching, trapping, and natural predation. The approach suggested here is to adopt a core security habitat analysis to assess the significance of project-related effects and cumulative regional effects on wildlife security based on accepted methodologies developed in other jurisdictions for assessment on grizzly bear (USFWS, 1993; IGBC, 1994). The grizzly bear is a far-ranging species that is vulnerable to access proliferation due to associated effects from hunting and poaching. Where the project leads to creation of new access in occupied grizzly bear range, a core security analysis is undertaken with the intent of estimating existing and future levels in access density with respect to known thresholds and goals. Core secure habitat for grizzly bears are those useable areas within the species' range minus human-affected habitats. Reduced security occurs within 500 m of linear or point sources of human disturbance, and with habitat blocks too small or fragmented to accommodate a minimum female grizzly feeding radius over a 24 h period (~4.5–10.1 km^2).

STEP 4: DETERMINE IF THE CUMULATIVE EFFECTS ARE SIGNIFICANT

Two questions need to be answered to establish significance: (1) On what basis is significance to be determined? and (2) What is the contribution of the pipeline being assessed to overall cumulative effects?

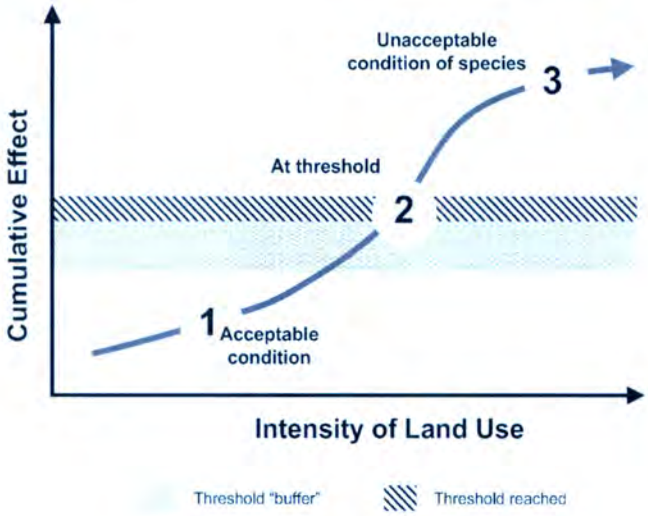

Fig. 3. Application of thresholds.

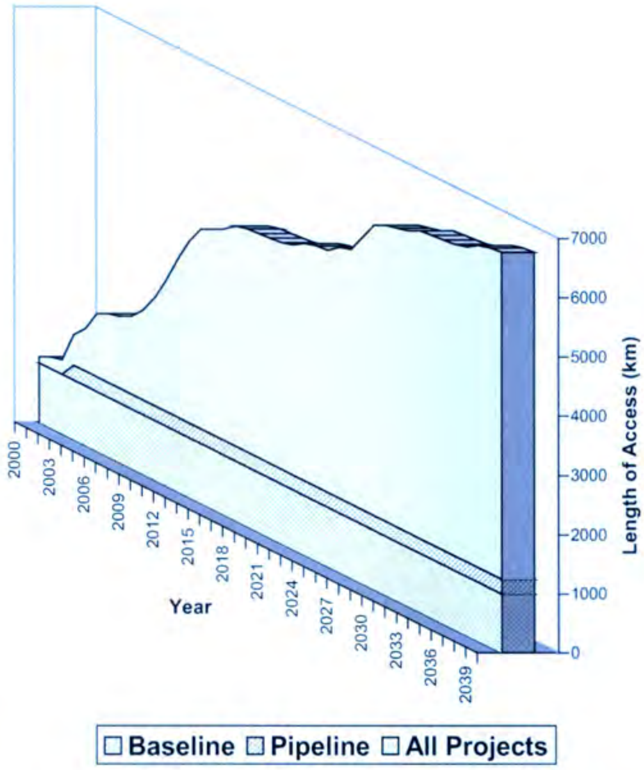

Fig. 4. Example of a relative contribution of a pipeline to cumulative effects.

A basis for establishing significance

Significance ideally is determined based on a comparison of the effect to a threshold. A threshold is a point at which a resource undergoes an unacceptable change or reaches an unacceptable level. Thresholds may be based on ecological attributes (e.g., habitat availability, wildlife populations), physical-chemical attributes (e.g., air or water contaminant concentrations), land and resource use attributes (e.g., road densities, hunting harvest) or social attributes (e.g., acceptable perceived change). As land use pressures increase, the adverse effects on a resource also increase. At relatively undisturbed conditions, the condition of the resource may be acceptable (Point 1 in Fig. 3). Eventually, some condition is reached at which a threshold is met (Point 2), after which the threshold has been exceeded (Point 3) and the condition of the resource becomes unacceptable. A "buffer" can be used as an early-warning system for management purposes to reduce or halt the advancement of the effect towards the threshold.

If thresholds are not available, qualitative conclusions can be made that rely on professional judgement, on the evaluation of a suite of effect's attributes (e.g., magnitude, geographic extent, duration), on the recognition of the degree of existing disturbances and regional trends in development, and on the contribution of project-specific and possible regional mitigation measures in ameliorating effects.

In summary, the establishment of significance can be based on the following approach:

1. Compare the residual effect to a regulatory guideline, if such a guideline exists (e.g., air quality).
2. Compare the residual effect to a government policy, if such policy exists (e.g., land use).
3. Compare the residual effect to a state of adverse environmental condition, based on scientific and/or traditional information (e.g., ecological thresholds such as wildlife core security area).
4. Make a professional judgment based on personal experience, social concerns, and best available information, with all assumptions and uncertainties clearly stated.

Establishing the contribution of the pipeline

Regulators need to know both the potential contribution alone of the pipeline to cumulative effects and the cumulative effect of all projects. Fig. 4 illustrates, for example, a situation in which a pipeline over its operational life introduces some new but relatively incremental access in a region compared to the larger contributions from other projects (e.g., as is often evident in areas undergoing rapid resource development).

The following can be used as a guide to assist in this determination, starting from first principles:

1. The pipeline has a measurable effect on a resource (i.e., there is an effect).
2. The pipeline's effect acts in a cumulative fashion with the effects of other past, present, or future projects and activities (i.e., there is a cumulative effect).
3. The pipeline's effect, in combination with those other projects and activities, shifts the resource to an unacceptable state (i.e., there is a significant effect). "Unacceptable" is defined by whatever measure is applicable and appropriate for that resource.

If (3) is true, one of two conclusions can then be reached that clarify the contribution of the pipeline to those effects:

3.1 The pipeline's contribution to cumulative effects is responsible for causing that unacceptable shift to occur. If yes, then the pipeline's contribution to cumulative effects is significant.

3.2 Other project contributions are already responsible for the unacceptable state of the resource. In this case, the pipeline is contributing incrementally to already significant cumulative effects. Contributions by the pipeline therefore may or may *not* be significant, depending on the degree of change resulting from the pipeline and/or land use priorities for the region.

For many resources, significance criteria cannot be based solely on ecological parameters, but must also consider public policy and resource priorities. Project proponents are not resource or land use managers and, as a result, are not in the position to make decisions on resource priorities. As a result, they should not be expected to make subjective decisions on significance criteria for project-specific effects or cumulative effects. Clearly, the responsibility for the development of such criteria lies with provincial and federal resource management agencies and regulators, and such criteria should be clearly identified by the responsible review authorities for the proponent early in the project's assessment phase.

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Managing Environmental Compliance on Linear Construction Projects: Strategies for Success

Jayne Battey

The cost of assessing, mitigating, and managing environmental issues on construction projects seems to rise with every passing year and, in some parts of the USA, has become a major issue in overall project scheduling and economics. This paper looks at the environmental compliance management experience of three long-distance, linear projects built in the United States between 1994 and 1999. Their stories provide valuable lessons in how to run effective environmental programs for utility construction projects. At the same time, a comparison of the projects shows that the real costs of these efforts, both financial and in terms of regulatory relationships, varied significantly.

Keywords: Inspection, regulatory, environmental compliance, environmental management programs, cost

INTRODUCTION

There is virtually no place in the United States today that you can build a long-distance utility project without facing significant regulatory and environmental hurdles. The cost of assessing, mitigating, and managing environmental issues on construction projects seems to rise with every passing year and, in some parts of the country, has become a major issue in overall project economics. The consequences of not effectively managing the environmental side of utility construction projects have also risen dramatically — projects can be delayed as permits are withheld, stopped for noncompliance actions during construction, and slowed by agency field monitors with extensive authority to impact construction progress and priorities on a daily basis.

This paper looks at the environmental compliance management experience of three utility projects built in the United States between 1994 and 1999. Although each project is a linear utility, each addresses different infrastructure needs: water, electric transmission, and natural gas. They include:

- **The Coastal Branch Phase II Project**: Owned and operated by the California Department of Water Resources (DWR) and the Central Coast Water Authority (CCWA) of Santa Barbara, California, this approximately 142-mile project was constructed between 1994 and 1997 to bring water to San Luis Obispo and Santa Barbara Counties.
- **The Alturas Intertie Project**: The Alturas Intertie Project consists of 164 miles of 345 kV electric transmission line between northern California and Reno, Nevada. The project was built in 1998 and is owned and operated by the Sierra Pacific Power Company (SPPCo).
- **The Maritimes and Northeast Phase II Pipeline Project**: The Maritimes Phase II Pipeline Project includes approximately 200 miles of 24- and 30-inch natural gas pipeline that stretches from Maine's northern border at Woodland to the southern terminus near Portland, Maine. The sponsor of the project was Maritimes and Northeast Pipeline Limited (Maritimes).

Each of these three projects faced significant regulatory hurdles, both prior to and during construction. The project proponents were all proactive, and designed and implemented extensive environmental compliance management programs to support their

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construction efforts. Their stories are illustrative in terms of how to best design and implement effective environmental programs for new construction projects. At the same time, a comparison of the projects shows that the real costs of these efforts, both financial and in terms of regulatory relationships, varied significantly.

Shortest distance between two points is not always a straight line

The focus in this paper is primarily on environmental compliance management during construction. But in order to put these construction experiences into perspective, it is important to first understand where the projects began and how the regulatory process evolved.

Coastal Branch Phase II Project

The California drought that occurred between 1987 and 1992 had people in San Luis Obispo and Santa Barbara counties installing mandatory low-flow faucets and fined for irrigating landscaping. Bringing state water to California's central coast quickly became a priority.

But as has always been the history of water management in California, the battle lines were fairly well drawn between those who viewed imported water as an absolute necessity, and those who viewed it as yet another ploy to induce growth. This battle played out during the planning and permitting of the project, and continued to make headlines in the local press throughout the project's construction.

In addition to water politics, battles over the protection of natural resources in the region also made headlines on a regular basis. San Luis Obispo and Santa Barbara Counties are home to over 40 federal or state protected species of plants and animals. It is an area rich in California history, with Native American settlements dating back over 10,000 years. With over 125 miles of mostly unspoiled California coastline, the area provides what is truly one of the most spectacular natural environments in the United States.

The project alignment, design, and approval was, to say the least, controversial. Planning and regulatory approvals for the Coastal Branch Phase II Project were initiated in 1986, and after nearly seven years of alternatives analysis, public input, and regulatory negotiations, the project moved forward to construction in early 1994.[1]

Construction took nearly four years to complete, and the project was required to comply with approximately 1445 environmental conditions of approval. During the winter of 1996, when *El Nino* rains caused wide-spread property damage throughout northern and central California, the project experienced extensive erosion and soil failure. The winter of 1997 did not provide much relief, and while the project was essentially complete by that time, a significant amount of repair work was required to meet restoration requirements.

Alturas Intertie Project

The Alturas Intertie Project was first considered by the Sierra Pacific Power Company (SPPCo) in the late 1980s. The continuing growth of the Reno-Sparks area of Nevada brought with it the need for increased electric transmission service. There was little controversy over the need for greater system reliability, and in 1993 SPPCo received authorization from the Public Service Commission of Nevada to move forward with the project. The controversy, of course, was in the actual siting of the 735 above-ground towers that would be required to transport the energy across California and Nevada to where it was needed.

The project originated in northern California, where it tied in with the Bonneville Power Administration transmission grid, and crosses southeast across the high desert towards Reno, Nevada. This area of high desert scrub (elevation 3000–4500 feet) is relatively remote and unpopulated. While environmental concerns are limited, there are areas of federally- and state-protected plant and animal species. The California Department of Fish and Game (CDFG) has had a history of being particularly sensitive to the protection of biological and water resources in this landscape. On the Alturas Intertie Project, as well as other construction projects in the region,[2] CDFG has had a track record of tough mitigation standards and the strictest regulatory enforcement in the state.

The route crossed large tracts of privately owned land, including predominately grazing and ranch lands. More than half of the route (56%) crosses federal lands managed by the US Bureau of Land Management (BLM).

The Alturas Intertie Project was controversial from the start. Property owners were understandably concerned with the thought of 75-foot-high towers located on their property. In addition, federal and state agencies conducted an exhaustive environmental review and public input process that lasted over five years. After years of analysis, at a cost estimated at nearly $5 million, the US Forest Service continued to deny the project. In early 1996, with towers and cable already at the staging yards, and crews ready to start construction, the Humboldt Toiyabe National Forest (HTNF) issued a "no project" decision for eight miles of the project on forest service land.

1 A portion of the project constructed directly by the California Department of Water Resources actually started construction in the summer of 1993, but the CCWA portion was delayed until the following spring.

2 The Tuscarora Gas Transmission pipeline was built in a parallel corridor just three years prior to the Alturas Project.

It would take another two years to identify an acceptable reroute and to complete all required permits and mitigation plans. Construction originally planned for 1996 actually began in the spring of 1998. In all, SPPCo started construction with over a dozen permits from state and federal agencies and was required to comply with approximately 1400 environmental mitigation conditions. The project was further required to support full-time monitoring by the CDFG and the California Public Utilities Commission (CPUC).

Maritimes and Northeast Phase II Project

The original concept for the Maritimes and Northeast project dates back to the early 1990s, when a consortium of companies led by Duke Energy and all Maritimes & Northeast Pipeline Ltd (Maritimes) identified an opportunity to bring natural gas from Sable Island (off the northern coast of Nova Scotia, Canada) to the New England region. Sable Island is one of the largest gas reserves in the North America. As one newspaper article put it in 1999, "(Sable Island) promises more than a generation of abundant, clean-burning energy to eastern Canada and New England."

Planning and permitting efforts for the new pipeline began in earnest in late 1996. The route, which covers nearly 200 miles of privately owned land along the state of Maine's eastern shore, was shaped by customer locations, existing utility corridors, and adjustments for local "not-in-my-back-yard" (nimby) sentiments. But while some communities in Maine protested the project, others welcomed the new construction and economic boom it would bring to northern Maine's typically quiet economy.

The final pipeline route crossed over 1700 wetlands and 325 sensitive streams. While significant environmental challenges, including the protection of both historic and biological resources, were faced, the single biggest issue for the project was ensuring the protection of the state's highly valued salmon streams. Local residents and officials, as well as state and federal regulators, all expressed significant concern over the protection of waterways and water quality. By the time the permitting process was complete, the resulting authorizations specified 12 distinct methods of stream and wetland crossing procedures.

Maritimes understood from the outset that it faced significant environmental issues and a tough regulatory climate in New England, but agency and community scrutiny on the project reached new levels of intensity during the final permitting work in 1998. Regulators and residents in the state had seen other utility construction in action, and they weren't sure they liked what they saw. Fiber optic construction in the later part of the 1990s showed a less than stellar track-record for complying with requirements to protect the state's stream and wetland habitats. Even more relevant, the Portland Natural Gas Transmission System (PNGTS) construction of approximately 240 miles of 24- and 30-inch pipeline in New Hampshire and Maine during 1998 faced one of the wettest summers on record in the region. The pipeline project had a tough time complying with permit conditions.

As one Maritimes' manager put it, "[t]he timing couldn't have been worse." Final construction planning in 1998 included a multitude of conversations with state regulators who had little reason to believe in the project's ability to comply with environmental standards. Maritimes pushed forward, however, and participated in lengthy team-building and environmental training programs internally, as well as with regulators. Maritimes committed to an aggressive and exhaustive environmental program, with clearly defined environmental protection standards and methods. Between January and May 1999, the Maritimes team, including environmental specialists, contractors, and project managers, logged over 2000 person-hours in environmental (and safety) training and team-building.

Construction began in May 1999 and was completed on schedule in October of the same year. In addition to Maritimes' internal environmental inspection program, the project supported full-time field oversight by both the State of Maine Department of Environmental Protection and the Federal Energy Regulatory Commission (FERC). At the peak, it was estimated that nearly 30 environmental and/or safety inspectors were in the field monitoring construction. The project was required to comply with over 1440 environmental protection measures.

Seven steps to environmental compliance

It's clear that all three of these projects moved into construction with significant requirements to minimize and mitigate construction impacts on the environment. They also faced ongoing, relatively intense public scrutiny, as well as on-site regulatory oversight. In all cases, the project managers understood that meeting the environmental requirements of permit approvals was critical to getting the job built and operational.

Over the last decade, the utility industry has learned a lot about how to effectively manage environmental compliance for large-scale construction projects in the unoficial United States. In some cases, new environmental management methods have developed through painful experiences. In 1993, an advisory group to the United States Sentencing Commission provided some unoficial guidance on minimizing organizational exposure related to environmental violations. It suggested seven strategies to promote effective environmental management and reduce organizational risk. To varying degrees and in varying balance, each of the three projects discussed in this paper applied these strategies.

Table 1. Environmental program elements

	Coastal branch	Alturas	Maritimes
Program Design and Organization	Clearly Defined in *Environmental Quality Assurance Program (EQAP) and Environmental Monitoring Manual*	Clearly Defined in the *Interagency Implementation Plan*	Clearly Defined in the *Environmental Compliance Management Program Plan*
Unique Program Features	Incentive Program for Contractors Environmental Task Force	Monthly Interagency Meetings	Project Leadership Training Field Reference Cards for Environmental Specifications
Training	Comprehensive and Complete • Video • Handbook • Hardhat Decal • Resource Cards • Inspector Training Program • Segment Kick-off Meetings • Ongoing Tailgate Training	Comprehensive and Complete • Handbook • Hardhat Decal • Resource Cards • Inspector Training Program • Segment Kick-off Meetings • On-going Tailgate Training	Comprehensive and Complete • Video • Handbook • Hardhat Decal • Resource Cards • Field Reference Cards • Inspector Training Program • Segment Kick-off Meetings • On-going Tailgate Training
Inspection Staffing (at peak)	Environmental Field Supervisor, Planning Assistant, 12 Field Inspectors, and Resource Specialists	Environmental Field Supervisor, Planning Assistant, 8 Field Inspectors, and Resource Specialists	Environmental Field Supervisor, Planning Assistant, 19 Field Inspectors, and Resource Specialists
Reporting/Documentation			
• Daily Reports	Paper Reports from Field Input to Database Daily	Field Computers	Field Computers
• Variance Process		Clearly Defined and Tracked	Clearly Defined and Tracked
On-site Agency Presence	Intermittent by Two State agencies	Full-time by Two State Agencies and one Federal Agency	Full-Time by one State Agency and one Federal Agency
Quality Assurance Audits	Yes/Formal	Yes/Informal	Yes/Formal

1. **Make the Commitment**: As presented in Table 1, Environmental Program Elements, each of the projects presented in this paper demonstrated a significant management commitment to environmental compliance.

   All three companies supported the development of comprehensive environmental management programs, and defined clear procedures to manage the environmental effort throughout construction. Each company assigned key line managers with distinct responsibility for environmental oversight for the respective project.
2. **Make It Part of Everyone's Job Description**: All project participants, from managers to field crews, were well informed that environmental compliance was a part of everyone's job responsibilities. At the same time, however, the project-wide sense of environmental responsibility was not equal on all three projects. Based on interviews with project staff, it is clear that this sentiment was taken more seriously on some of the projects than on others. On the Maritimes Project, for example, there seemed to be a much stronger sense that the project would not succeed unless everyone contributed to management and implementation of the environmental mandates.
3. **Inspect and Document**: Each of the projects retained well-qualified, experienced environmental inspectors or monitors. The environmental field staff was tasked with the responsibility of overseeing environmental compliance on the project, documenting daily compliance, and coordinating on a daily basis with agency representatives in the field to resolve compliance issues and concerns. It should be noted, however, that the level of environmental staffing varied significantly. Maritimes had the most, with 19 environmental inspectors assigned to the field at the peak of construction.
4. **Train Everyone**: All three projects implemented comprehensive and complete environmental training programs. Every person on the projects, from managers to field crews, was trained in regulatory conditions and key resource protection requirements. A variety of tools, including videos, handbooks, and various handouts, were used to communicate the environmental message. Both the Coastal Branch project and the Maritimes project were particularly aggressive in using training as a tool to manage compliance. Training was held on an on going basis throughout construction — as both a preventative measure (e.g., in advance of work

Table 2. Environmental program indicators and results

	Coastal Branch	Alturas	Maritimes
Total Project Cost (Estimated)	$116,000,000	$155,300,000	$650,000,000
Estimated Environmental Costs	$7,600,000	$24,200,000	$11,200,000
Environmental Costs as a Percentage of Total Costs	6.5%	15.5%	1.7%
Number of Variances Required	No data available	437	204
Average Number of Variances Written per Project Mile	No available	2.65	1.02
Number of Internally Documented Non-compliances	82	524	144
Estimated Number of Field Inspection Hours	64,000	18,000	40,000
Ratio of Non-compliances written per 1000 inspection hours	1.3	29.1	3.6
Number of Regulatory Enforcement Actions	0*	0*	0*
Number of Work Shutdowns (due to environmental)	0	3	0
Total $ in Regulatory Fines	0	0	0

*All three projects each had one non-compliance action, documented and managed internally, that was observed by regulators and nearly became an enforcement action. In all cases, the non-compliance (and near violation) was related to protection of water resources.

commencing in sensitive areas) and on occasion as a punitive measure (e.g., requiring retraining after noncompliance occurrences).

5. **Reward Positive Behavior**: While each of the projects had both penalty and incentive programs to some degree, the Coastal Branch placed a significantly higher emphasis on rewarding positive behavior than either of the other two projects. Incentives were used at nearly every level of the organization — from relatively significant financial incentives for the contractor (e.g., for avoidance/preservation of certain flagged oak trees) to smaller tokens of appreciation (e.g., hot lunch delivered to the site; free sporting events tickets) to individual workers and work crews who demonstrated a commitment to environmental compliance. There is no question that this helped to generate a more positive attitude regarding environmental compliance.
6. **Be Clear About the Consequences of Non-compliance**: The consequences of non-compliance were well communicated in construction specifications and contracts, as well as project training, for all three projects. The message was clear: environmental non-compliance would not be tolerated. Of all the projects, however, this appears to have been most acutely perceived on the Maritimes project. It is interesting to note that two of the three projects dismissed or reassigned early in project construction company and contractor individuals who seemed to have a problem (attitudinal or operational) complying with the environmental requirements. This news traveled quickly, and sent a clear message to the entire project organization (as was the intent).
7. **Review Performance and Fix What You Find**: In addition to the project's dedicated field inspectors, each of the projects provided some level of additional oversight, or quality assurance (QA). The QA program was most formalized for the Coastal Branch project, where an independent consultant provided quarterly field reviews and reports to the project manager regarding the environmental effort. The review included an assessment of field activities, as well as documentation, training, and the implementation of incentive programs.

Did it work?

For the most part, the environmental management programs for each of the three projects were successful. All of the projects discussed in this paper were completed on or near schedule, and all are currently operational. As shown in Table 2, environmental program indicators and results, none of the projects were either charged with regulatory enforcement actions or subject to regulatory fines. While all three projects experienced "close calls" related to water quality issues, only one of the three projects (the Alturas Intertie Project) experienced an environmental-related regulatory mandated work shutdown.

Evaluating the environmental results of these projects is subject to broad interpretation. In addition to the obvious considerations discussed above, there are two important questions that should be answered:

1. What did it cost?
2. How are post-project relationships with the regulators?

What did it cost?

As shown in Table 2, the environmental programs[3] ranged in cost from $7.6 million for the Coastal Branch project to $24.2 million for the Alturas Intertie. As a percentage of total project costs, the range is staggering. Maritimes, with a project cost of $650 million, shows only 1.7% for environmental planning and management. Alturas, on the other hand, comes in with

3 These figures include direct environmental program dollars, including consultant fees for planning, permitting, and compliance management; environmental mitigation costs; agency inspection program costs; and environmental document development and production costs. They do not include contractor costs for implementing environmental mitigation.

15.5% for environmental. Aside from the obvious discrepancy in total project costs (or base), this range would be attributable to a number of factors. Based on the data available, the biggest variables appeared to be off-site mitigation costs (e.g., land purchases, mitigation payments) and payments for regulatory field inspection during construction. For example, in addition to its own environmental inspection program, Alturas paid an estimated $3.4 million for on-site inspectors representing various state agencies. In addition, Alturas paid a one-time fee of $3.1 million for wildlife land purchases and a $1.75 million fee for visual mitigation.

It is important to understand that the costs discussed above do not include the contractor cost of installing environmental structures and controls. Both Alturas and Maritimes report significant environmental-related construction costs, with Maritimes being significantly higher. On the Maritimes project, contractor payments for the installation of environmental structures (primarily at streams) are estimated at over $36 million. Maritimes also estimates it spent another $7.5 million on mats used to complete construction through wetlands.

How are post-project relationships with the regulators?
All three of the projects began construction with, at best, regulatory communities that were fairly skeptical of utility construction projects. There was not necessarily much confidence (or trust) that environmental compliance was a real priority for the project proponents. While all three projects had comprehensive environmental management programs, agency relationships on Coastal Branch and the Maritimes projects ended on a significantly more positive note than on the Alturas Intertie Project. The statistics provided in Fig. 2 help tell the story:

- The Alturas environmental inspection team documented 524 environmental non-compliances during construction. That's approximately four times the amount generated on either the Maritimes project or the Coastal Branch. While internally documented non-compliance is intended to be used as a tool to internally manage compliance, the level of activity on the Alturas Project was more indicative of an inherent conflict between project construction plans and regulatory expectations.
- Alturas wrote an estimated 437 variances for the project, or nearly 2.65 variances per mile. In effect, it became apparent within the first month of construction that it would be nearly impossible to build the project as originally described and according to the permit conditions written for construction. A variance team (including contractor, environmental, and construction management staff) was assigned to scout out ahead of construction, identify project modifications, and process variance requests from the agencies. The process left regulators and project staff in constant and often heated debate. While the day-to-day work environment improved as the project switched to construction using helicopters (thereby avoiding environmental impacts), relationships between the project team and regulators did not significantly recover.

CONCLUSIONS AND RECOMMENDATIONS

Managing the environmental efforts for large-scale utility projects is a difficult and complex undertaking. It is typically a lengthy process — that begins years before construction starts. While the guidelines for effective program management have a lot to tell us in terms of setting up an organization and program to assure environmental compliance during construction, there are other factors to consider.

- As a federal regulator once put it, "Remember who's driving the bus." The project's relationships with its regulators are nearly everything in project approvals and the negotiation of environmental conditions. Regulators are typically very patient people — and they have time on their side — so do all that you can to keep relationships positive and productive from the first meeting to the last.
- Be sure to have a plan that you can actually build. It will simply not work to be planning your project while you are also building it. Nor is it wise to agree to measures that are not workable or achievable. Almost every project has a few adjustments along the way, but nothing annoys regulators more (aside from non-disclosure) than constantly going back for modifications and additional authorizations.
- Complying with today's myriad of environmental requirements is challenging for any contractor. Make sure your company and the contractor understand that the environmental specifications are non-negotiable — that they are simply part of how the project will be built.
- Unfortunately, weather can play a huge role in the track-record of environmental compliance, particularly for projects with significant stream and wetland resources. If at all possible, time construction activities for the driest part of the year. If your climate is unpredictable, hope for the best — but you must be prepared for the worst.
- Remember that *people* ultimately build your project. It really comes down to human relationships — how well people work together, how they communicate, and what tone and energy they bring to the job. Don't underestimate the power of team chemistry. Reward positive behavior and productivity, and show little tolerance for anyone who fails to understand how the environmental aspect helps meet your project objectives.

- While you will need a construction team to build your project, make every effort to maintain some continuity from the planning to the construction phase. For large, complex projects subject to multiple regulatory jurisdictions, the permitting phase is typically correspondingly complex and difficult. There are often as many unwritten understandings with regulators as there are written requirements. The people who helped get the project to construction offer an invaluable sense of perspective and understanding that will help maintain positive regulatory relationships throughout construction.

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Environmental Management System Challenge with Linear Facilities

Peter G. Prier, Daniel S. Eusebi, and David P. Wesenger

The implementation of an environmental management system based on the principles of ISO 14001 provides a unique challenge for linear facility organizations. Environmental Management Systems (EMS) have been established to control potential adverse environmental and socio-economic effects of corporate activities. A key component of an EMS is the communication framework and protocols. One of the unique features of a linear facility EMS is the need to consistently address varying external and internal stakeholder concerns across local, regional, and national regulatory jurisdictions. Linear facilities often correspond to extensive geographic areas, which may translate into cultural differences within the organization and, externally, among a greater number and diversity of stakeholders. This is less often the case with single site organizations. Internally, the management system must recognize and respond to the potential distrust by regional staff of a remote, centralized corporate headquarters, perceived to be out of touch with regional issues and management approaches. Geographic diversity may also demand mitigation and monitoring of a wider spectrum of potential environmental and socio-economic effects from facilities development and operations. To appreciate the unique interrelationships and geographic diversity of a linear facility requires a comprehensive and dynamic communication system to meet the numerous and possibly incompatible internal and external stakeholder demands. Thorough communication protocols and documentation are key to an effective linear facility EMS; stakeholder feedback on the procedures is also critical to ongoing improvement of the EMS particularly given the need for "continuous improvement within the EMS."

Keywords: Environmental management systems, communications, documentation, differences, stakeholders, linear facilities

INTRODUCTION

This paper documents the need for a more comprehensive communications framework within an Environmental Management System (EMS) for a linear facility organization. This is necessary in order to identify, respond to, and monitor the expectations of external and internal stakeholders along the length of the linear facility (NSC, 1996). Linear facilities encounter a large number and diversity of regulatory, cultural, and biophysical differences between their commencement and terminal points. The longer the linear facility is, the greater the differences are in regulatory requirements, cultural priorities, and environmental protection measures.

Stakeholders are defined as internal, within the linear facility organization, or, external to the organization. Internal communications between the various levels and functions within the organizations, and external communications for receiving, documenting, and responding to interests, need to be comprehensive and well documented. In a recent survey of the EMS status of 39, primarily manufacturing facilities, only 50–60% of the facilities had established communication protocols or procedures to receive and respond to communications from external stakeholders. For internal stakeholders (i.e., directors and employees), only 49% of the companies trained staff to be aware of the importance and operation of the EMS (Univer-

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sity of North Carolina, 2000). Clearly, communication protocols, even on single site facilities, are often not well developed. Table 1 summarizes the survey results. Examples of regulatory, cultural, and biophysical differences along a linear facility are used in the following sections to support the need for a comprehensive communications system. The need for a comprehensive communication system is critical during the planning and construction of a linear facility due to the number of issues, concerns, and permit requirements that must be addressed prior to the operation phase. During operations, effective communication among stakeholders ensures mitigation promises are kept and facilitates feedback on the EMS process.

DEFINITIONS

A linear facility, for the purposes of this paper is defined as "infrastructure used to transport, transmit, or distribute goods and services from supply to demand points." The infrastructure types encompass: railways, roads, hydro-electronic transmission lines, pipelines (gas, oil, water, sewage), and telecommunication facilities. These facilities include a network of either rights-of-way or easements interconnected to operational nodes including transformer, pump, or compressor stations, interchanges, spurs, etc.

An external stakeholder is defined as a:

- member of the public with an interest in the facility, including residents and landowners, community organizations, and other interested groups or individuals;
- federal, provincial, or municipal government agencies with a legislative mandate for any aspect of the facility's planning; construction, or operations; and,
- non-government organization (NGO) with an interest in the goods and services transported or transmitted.

An internal stakeholder is defined as any director or employee of the linear facility organization whose activities have potential to cause an environmental effect.

An interest in the facility may be identified by comments from a person, group, association, or government agency that could be potentially affected, directly or indirectly, in a positive or negative manner during the planning, construction, operation, or decommissioning stages of the facility's life.

An environmental management system (EMS) is defined as a system to support corporate environmental policies through organizational structure, planning activities, practices, procedures, processes, and resources. These components are essential for developing, implementing, achieving, reviewing, and maintaining a formal management system to minimize the environmental effects of an organization's activities and resulting products/wastes.

A communication system within an EMS structures the organization's approach to:

- facilitate internal communications between the various levels and functions of the organization; and
- receive, document and respond to communications from external stakeholders.

The following sections document the rationale and need for a more comprehensive communications system within a linear facility organization.

REGULATORY DIFFERENCES

Regulatory requirements for the construction, operation, and decommissioning of linear facilities arise from essentially three levels or tiers of government, specifically, in North America: federal, provincial or state, and local/municipal. Furthermore, within any given regulatory or government agency, linear facilities often also cross regional or district government boundaries within the same government tier. Each of these jurisdictions and potentially districts, may require environmental permits or approvals for construction of new facilities, modifications to existing facilities and for routine construction, operation, or maintenance activities and ultimately decommissioning. The longer the linear facility, the greater the likelihood of a higher number of regulatory jurisdictions and associated approval requirements.

For the planning of a 72 km pipeline in Southwestern Ontario, five federal, twenty-nine provincial and forty-three municipal government agencies were contacted, requiring more than eighty permits (ESG International, 1998). For the Tuscarora pipeline that crosses portions of Oregon, northeastern California, and Nevada, more than ninety permits were required for a 366 km, pipeline (McCullough, J.A., 1997 p. 192). For pipelines crossing the US/Canadian international boundary between Alberta and Montana, approvals from fifteen federal agencies and thirteen provincial or state agencies could potentially be required to begin construction (Mutrie, D.F. and Gilmour, K.B., 1998).

Clearly, for the planning and construction of new facilities, external contacts for approval or permits are numerous and diverse. These onerous and extensive requirements are mirrored through the operation and decommissioning phases of a linear facility. In order to ensure compliance with regulatory requirements, a comprehensive communication and documentation system must be in place internally to ensure compliance with regulatory requirements.

CULTURAL DIFFERENCES

A linear facility that crosses nations, provinces or states, and local or municipal government jurisdictions also encompasses cultural environments, both

Table 1. How companies use EMSs

Category	Feature	Percent
Training	Trained employees to be aware of the importance and operation of the EMS	49
Communications	Established procedures for receiving communications from external interested parties	60
	Documented communications received from external interested parties	54
	Responded to relevant external communications from interested parties	51
	Had documents that described the core elements of their EMS	46

Percentages based on 39 facilities studied that have active environmental management systems.
Source: "National Database on Environmental Management Systems: The Effects of Environmental Management Systems on the Environmental and Economic Performance of Facilities," University of North Carolina at Chapel Hill and Environmental Law Institute, 2000.

internally and externally. These cultural differences are most distinguishable where the international boundary between Canada and the United States is crossed, and within Canada, between provinces with different languages. Cultural priorities such as the approach to stakeholder compensation and the importance of specific cultural features such as language differences (e.g., French, English, and Spanish) also require a comprehensive communications system that recognizes these differences.

Cultural differences also occur within the corporation that owns and operates the linear facility. Communication challenges sometimes result from decisions made in the Corporate "Head Office." Those decisions can be viewed with mistrust by regional staff (internal stakeholders), since they are directions from the "ivory tower", a culturally isolated division of the same organization that could be 2000 km or more away. Continuous and frequent communication within all layers of an organization is required to ensure that "grass-roots" buy-in is acquired before EMS initiatives are released. Frequent, two-way communication and documentation minimizes the "ivory tower" nature of directives and facilitates successful EMS implementation. Local employees must be involved with the development of the EMS and its' goals and objectives.

Aboriginal priorities also underline the importance of the communication system. Aboriginal lifestyles, cultural values, traditions, and economic, social, and political aspirations are recognized as distinct enough to warrant a corporate policy for aboriginal relationships and a steering committee of four Vice-Presidents within a major electrical utility (Tennyson et al., 1993). Aboriginal people have also been incorporated into alternate route evaluations for another linear facility organization (Mohun, 1993).

The number and diversity of cultural priorities, language differences, aboriginal groups, and a remote head office, dictate the need for frequent, well documented communications.

ENVIRONMENTAL DIFFERENCES

As the length of a linear facility increases, so does the number and type of environmental features. For example, there are approximately 17 biomes in continental North America (Smith, 1974). These are essentially life zones that encompass similar plant and animal species within different climates and/or physiographic zones. Each of these biomes and sub-zones within them, often require development of site specific protection measures during planning, construction, operation, and decommissioning of a linear facility.

Agricultural and urban environments also require different protection measures. Agricultural protection measures vary based on geographic location, soil and crop types, and regional management practices. Specific protection measures for urban areas are also needed to protect public interests. Measures specific to urban areas may include: noise measures around sensitive institutions, such as hospitals; aesthetically pleasing structures ancillary to the linear facility; and separation distances from residential or institutional land uses mandated by regulatory agencies.

As best management practices are more efficiently/effectively carried out for protection of different environmental features, it is essential that regional employees and corporate environmental specialists share information through established communication channels. A communication framework must be in place to ensure that best management practices are used and their success documented, to ensure the EMS principle of "continuous improvement" is fulfilled.

CONCLUSIONS AND RECOMMENDATIONS

With increasing length, linear facilities often encounter increasingly numerous, highly diverse regulatory regimes, cultural interests and environmental features. The concerns of the equally diverse external stakeholders must be identified, documented and responded to. Internal stakeholders must be actively involved in the development of the EMS and establishment of the appropriate communication framework or system. An effective communication system that facilitates information exchange among internal and external stakeholders is critically important within a linear facility organization to ensure:

- regulatory compliance;
- the use of best management practices; and
- culturally appropriate development.

A comprehensive communication and documentation system will ensure "continuous improvement" of the EMS.

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Planning and Performance of Wildlife Crossing Structures in a Major Transportation Corridor

Anthony P. Clevenger,* Jack Wierzchowski, and Nigel Waltho

While there are few methodological approaches to determine the placement of mitigation passages along road corridors, the efficacy of these measures also is poorly known. We develop three black bear (Ursus americanus) habitat models in a GIS context to identify linkage areas across a major highway. We use an empirical model to measure the accuracy of two expert-based models and potential use in mitigation passage planning. Results showed the expert literature-based model most closely approximated the empirical model, both in the results of statistical tests and the description of the linkages. Our empirical and expert models represented useful tools for transportation planners determining the location of mitigation passages when baseline information is lacking and when time constraints are imposed. To determine the effectiveness of wildlife underpasses, we modeled species responses to 14 variables. We found that in the presence of human activity carnivores were less likely to use underpasses as compared to ungulates. Apart from human activity, carnivore performance indices were better correlated to landscape variables and ungulates performance indices were better correlated to structural variables. We suggest future underpasses designed around topography, habitat quality and location will be minimally successful if human activity is not managed.

Keywords: Banff National Park, mitigation, performance evaluation, planning, wildlife crossing structure

INTRODUCTION

Attempts to increase barrier permeability across road structures can be found in some road construction and upgrade projects. Until now few methodological approaches to determine the placement of mitigation passages along road corridors have been explored. Most have relied on techniques such as radiotelemetry or surveys along roads. But often baseline data have not been collected and time does not permit new studies to be initiated.

Modeling habitat linkages with a geographic information system (GIS) is another means of determining wildlife crossing structure placement. With increasing availability of digital biophysical and land-use data, GIS tools and applications are becoming more popular among land managers and transportation planners (Treweek and Veitch, 1996). A empirically-based model would be preferred to qualitative or conceptual models based on limited data. However, in many cases data necessary for empirical models are not available. As a substitute, expert information might be used to develop simple, predictive, habitat linkage models in a short period of time (Giles, 1998). Expert information may consist of models based on the opinion of experts or qualitative models based on information taken from the literature (Servheen and Sandstrom, 1993; Singleton and Lehmkuhl, 1999).

Aside from planning, a substantial amount of time and energy has been spent designing and building mitigation passages across roadways. Wildlife crossing structures (overpasses, underpasses, tunnels) were first constructed in the 1970s and are used as mitigation tools in many parts of the world today (Reed et al., 1975; Romin and Bissonette, 1996; Keller and Pfister, 1997). Surprisingly, few studies have assessed the efficacy of these measures (Romin and Bissonette, 1996)

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and most studies have focused on only one species (Reed et al., 1975; Singer and Doherty, 1985). Species do not function in isolation but are components of ecological systems, therefore, effective management strategies should be multi-species based (Fiedler and Kareiva, 1998).

The purpose of our study was twofold: (1) to develop three different habitat models (one empirical, two expert-based) to identify linkage areas across a major road corridor. We use the empirical model as a yardstick to measure the accuracy of the expert-based models and potential use in mitigation passage planning; and (2) to determine what underpass attributes influence passage by species, species groups, and the large mammal community.

METHODS

Study area

We collected data along the Trans-Canada highway (TCH) in Banff National Park (BNP), Alberta, Canada. The Trans-Canada highway in BNP runs along the floor of the Bow Valley (2–5 km wide), sharing the valley bottom with the Bow River, the township of Banff (population 9000), several high volume two-lane highways, numerous secondary roads, and the Canadian Pacific Railway. The TCH is the major transportation corridor through the park (length = 75 km) carrying an estimated 5 million visitors to the park per year, with an additional 5 million users en route between Calgary and Vancouver (Parks Canada Highway Services, unpubl. data). The first 45 km of the TCH from the eastern park boundary (phase 1, 2, and 3A) is four lanes and bordered on both sides by a 2.4 m high wildlife exclusion fence (phase 1 completed in 1986, phase 2 in 1988, and phase 3A late 1997). The remaining 30 km to the western park boundary (Alberta–British Columbia border, phase 3B) is two lanes and unfenced. Plans are to upgrade phase 3B to four lanes with fencing and passages within the next 5–10 years.

Planning of wildlife crossing structures

We selected black bears (*Ursus americanus*) to model habitat use and identify linkage areas across the TCH. Black bears were one of the few species we had sufficient empirical data to build a habitat model and data from crossings and mortality locations to test the model. Further, we assumed that mortality locations were crossing locations although we were unable to prove that the unsuccessful crossing locations were different from successful ones.

To develop the empirical habitat model we first determined the habitat characteristics of black bears in the study area. Location data were obtained from monitoring the movements of nine radio-collared bears between 1998 and 1999. Radiotelemetry was conducted from the ground using standard techniques (Kenward, 1987). Digital maps were in a raster format with a pixel size of 30 m × 30 m. More than 95% of all telemetry locations were <2 km from the TCH therefore we delineated the study area (16,170 ha) by buffering the road at that distance. A total of 580 radiolocations were used to determine habitat characteristics.

Nine biophysical variables were used in the analysis. *Elevation*, *slope*, and *aspect* were extracted from the 1:50,000 digital elevation model (DEM). *Terrain ruggedness (TR)* was calculated within a 250 m radius and within a 500 m radius using the formula:

$$\mathrm{TR} = \frac{[\mathrm{CD}r] \times [\mathrm{AV}r]}{[\mathrm{CD}r] + [\mathrm{AV}r]},$$

where CD is a density of contour lines within a given kernel, AV is a variability of eight cardinal aspects within a given kernel, r is a kernel size. A classified, validated habitat map did not exist for the study area, therefore we used a LANDSAT Thematic Mapper (TM) satellite image to develop a habitat map. The image was transformed into greenness and wetness bands by the tasseled cap transformation of the six TM bands designed to emphasize vegetation. Increasing values of *greenness* related to increasing amounts of deciduous, green vegetation. *Wetness* was designed to emphasize vegetation moisture content. From the hydrology theme of the digital 1:50,000 National Topographic database we obtained values for *distance to nearest drainage* (running water, i.e., streams, creeks, rivers), and *density of water bodies* (running water, ponds, lakes, reservoirs).

We used a probability function that ties the distribution of bear locations to the variables in the study area (Pereira and Itami, 1991). To account for the telemetry error, each location was buffered 175 m (the maximum average error recorded in our tests) and assigned a probability of occurrence (PO) value. We stratified the density maps into PO classes. We removed all density values less than 0.5 animals per kernel area (the null class), and calculated the 25th, 50th, and 75th percentile for each of the density distributions. These percentiles were used as the cut-out values in defining four PO categories: low (<25%), moderate (25–50%), high (50–75%), and very high (>75%). A stratified random sample of points ($n = 580$) was generated to compare with the biophysical variables in each of the PO categories. We identified explicitly directional trends in habitat selection across the full set of the PO categories, supported by the statistical analysis of the observed patterns.

To reveal the relative importance of the biophysical variables to habitat selection, we used a multivariate discriminant function analysis (DFA). We used the Mahalanobis distances criterion in the stepwise method for variables' entry and removal. Approximately 10% of the locations ($n = 68$) from the black bear telemetry database were excluded from the habitat selection analysis and reserved to test the validity of the model.

Both expert habitat models were developed as weighted linear combinations of each models' layers (biophysical variables) obtained by (a) expert opinion or (b) review of the literature on black bear habitat requirements. With a weighted linear combination approach, variables were combined by applying a weight to each followed by a summation of the results to yield a suitability map. This procedure is not uncommon in GIS and has a form similar to a regression equation (Eastman et al., 1995).

Although there are an assortment of techniques for the development of weights, one of the most promising appears to be that of pairwise comparisons developed by Saaty (1977) in the context of a decision-making process known as the Analytical Hierarchy Process (Eastman et al., 1995). In the procedure for multi-criteria evaluation using a weighted linear combination, it is necessary that the weights sum to 1. The comparisons concern the relative importance of the two criteria involved in determining suitability for the stated objective, in this study, black bear habitat Ratings were provided on a 9-point continuous scale, ranging from 1/9 (extremely less important) to 9 (extremely more important), and the midpoint 0 being equally important (Saaty, 1977). In developing the weights, a group of individuals (minimum of two) compares every possible pairing and enters the ratings into a pairwise comparison matrix.

The expert opinion-based model required the collaboration of experts in assessing the importance of variables influencing black bear habitat selection in the study area. We solicited the cooperation of five biologists with substantial experience in black bear habitat studies. Two experts committed to developing the weights for the pairwise comparison matrix. Both investigators had a combined 47 years of experience studying black bears and their habitat in the Bow River Valley. We provided the experts with a list of potential variables for the habitat model. Only variables having accompanying digital layers were considered. Initially we solicited input from the experts in regard to the variables selected for building the model and how the variables should be divided up for the pairwise comparion matrix. Once their input was received we carried out the weighting procedure using the pairwise comparison matrix.

We met with the experts to carry out the multi-criteria evaluation. The experts agreed on the variables selected and the within-variable categories to use in the model. However, they preferred to divide them into two seasons relevant to the biological needs of bears: pre-berry (den exit to 15 July) and berry (15 July to den entry). Scoring of the matrix was done within the variables and among the variables. Five habitat variables were used in the analysis: *elevation*, *slope*, *aspect*, *greenness* and *distance to nearest drainage*. Pixel and kernel sizes were kept constant throughout the analysis. The time required to perform the pairwise comparisons ($n = 12$) for both seasons was 90 min.

Literature-based expert models were developed in the same fashion as the expert opinion models. Instead of experts providing weights for the variables, the available literature on black bear habitat selection was used to assist us in weighting the variables and completing the pairwise comparison matrices. One of the authors (APC) and two other biologists carried out this part of the study. Two sources of information on black bear habitat use were selected for obtaining information for the model (Holroyd and VanTighem, 1983; Beak Associates Consulting, 1989). We used information from the study area and preferably within the same EcoProvince if possible. The same variables were scored in a pairwise comparison procedure as for the expert opinion model. All pairwise comparisons were carried out using the weight procedure in the Idrisi geographic analysis software (Eastman, 1997). The time required to conduct the 12 pairwise comparisons was 110 min. Once the comparisons were completed, criteria maps were developed by multiplying each factor map (i.e., each raster cell within each map) by its weight and then sum the results.

We based our linkage analysis model on the assumption that the probability of a bear crossing a highway increases in areas where the highway directly bisects high quality bear habitat and that the highest probability of crossings will occur in areas where a set of topographic and landscape features are conducive to lateral, cross-valley movements.

To facilitate statistical comparisons between the empirical and expert-based models, the latter being a habitat suitability index (HSI) type of model (US Fish and Wildlife Service, 1980), we reclassified the continuous empirical habitat quality surface into 20 habitat favorability (or probability) classes, indexed from low (0%) to high (100%). We then applied the same rule to the expert models. The reclassification process allowed us to express the best black bear habitat as a percentage of the maximum habitat favorability value, regardless of the unit of measurement. We defined prime black bear habitat as areas with habitat favorability values >70% for both model types.

We used the GIS environment to generate four classes of highway crossing/habitat linkage zones:

- *Class I* — Sections of TCH crossing prime black bear habitat extending up to 100 m on both sides of the highway.
- *Class II* — Sections of TCH crossing prime black bear habitat extending over 100 m on both sides of the highway.
- *Class III* — Sections of TCH, ≥250 m away from any permanent human development, nested within the Class II linkages, and within the areas conducive to cross-valley movement. This class was interactively mapped using the ortho-photographs and the DEM of the area.

- *Class IV* — Sections of TCH not directly crossing the prime black bear habitat but having the prime black bear habitat within no more than 700 m on both sides of the highway.

We tested each of the linkage models using a set of empirical black bear crossing and mortality points. Crossing locations were defined as the point on the TCH connecting a straight line between consecutive radiolocations on opposite sides of the road and obtained within 24 h. Mortality locations were obtained from the BNP wildlife mortality database (Banff National Park, Banff, Alberta). We tested whether black bear empirical crossing and mortality points were randomly distributed with respect to the distance to the linkage zones. To do this we generated a random set of highway crossings, equal in size to the empirical set, and calculated the distances from both sets of points to the Class III and IV linkage zones. We repeated these calculations for each of the habitat models. The kappa index of agreement was used to measure the similarity between models and linkage areas (p. 388–395, Campbell, 1996). The kappa index is a measure of association for two map layers having exactly the same number of categories. Indices range from 0.0 (no agreement) to 1.0 (spatially identical). Between map layers, values >0.75 indicate excellent agreement beyond chance; values between 0.4–0.75 demonstrate fair to good agreement; and values <0.4 indicate poor agreement (SPSS, 1998). We used SPSS version 8.0 statistical package for all analyses (SPSS, 1998). The software Idrisi was used to measure the kappa index of agreement (Eastman, 1997).

Performance of wildlife crossing structures

Along the fenced portion of the TCH, 22 wildlife underpasses and two wildlife overpasses were constructed. The effectiveness of such structures to facilitate large mammal movements, however, is unknown. Because no two structures are similar in all physical and ecological aspects we propose that species (i.e., large mammals) select passages that best correlate with their ecological needs and behavior. Attributes that best characterize high-use passages can then be integrated into new designs for an eventual phase 3B twinning process. We chose phase 1 and phase 2 underpasses for this study, because the recent completion of phase 3A mitigation structures did not permit sufficient time for wildlife habituation to occur at such landscape scales (first author, unpubl. data).

We chose 11 underpasses from phase 1 and 2 for this study: 9 of the 11 underpasses were cement open-span underpasses and 2 were metal culverts. We characterized each underpass with 14 variables encompassing structural, landscape, and human activity attributes (Table 1). Structural variables included underpass width, height, length (including median), openness = width × height/length; and noise level = mean of A-weighted decibel readings taken at the center point within the underpass and 5 m from each end. Landscape variables included distances to nearest forest cover, Canadian Pacific Railway, townsite, closest major drainage, and eastern-most park entrance (hereafter referred to as east gate). Human activity variables included types of human use in the underpasses characterized by counts of people on foot, bike, horseback, and a human use index calculated from the mean monthly counts of the three former variables combined.

We measured wildlife use of the underpasses using raked track pads (2 × 4 m) set at both ends of each underpass. At 3–4 day intervals each underpass was visited and species presence (wolves [*Canis lupus*], cougars [*Puma concolor*], black bears, grizzly bears [*Ursus arctos*], deer [*Odocoileus* spp.], elk [*Cervus elaphus*], and moose [*Alces alces*]), species abundance, and human activity counts were recorded. Track pads were then raked smooth in preparation for the next visit. Data were collected in this manner for two continuous monitoring periods 1 January 1995–31 March 1996 (15 months) and 1 November 1996–30 June 1998 (20 months).

We examined observed crossing frequencies in the context of expected crossing frequencies (i.e., performance indices). Expected crossing frequencies were obtained from independent data sets that included radiolocation data, relative abundance pellet transects, and habitat suitability indices. We defined our expected crossing frequencies as equal to the abundance data found at radii 1, 2, and 3 km from the center of each underpass. We used (1) radiolocation data for black bears ($n = 255$ locations), grizzly bears ($n = 221$ locations), wolves ($n = 2314$ locations) and elk ($n = 1434$ locations; Parks Canada, unpubl. data); (2) relative abundance pellet transects for deer ($n = 1579$ pellet sites), elk ($n = 26{,}614$ pellet sites), moose ($n = 43$ pellet sites) and wolves ($n = 30$ sites containing scat; Parks Canada, unpubl. data); and (3) habitat suitability indices for black bears, cougars, wolves, deer, elk, and moose (Holroyd and Van Tighem, 1983; Beak Associates Consulting, 1989). We derived species performance indices for each of the three data sets by dividing observed crossing frequencies by expected crossing frequencies. Performance indices were designed such that the higher the index the more effective the underpass appears to facilitate species crossings.

We used simple curvilinear and polynomial regression curves to optimize the fit between species performance indices and each underpass attribute (Jandel Scientific, 1994). For each species we ranked the regression models obtained according to the absolute value of each model's coefficient of determination. This three-step process allowed for the identification and ordering of underpass attributes (in order of importance) associated with each species performance

Table 1. Attributes of 11 wildlife underpasses used in analysis of factors influencing wildlife in Banff National Park, Alberta

Underpass attribute	Underpass										
	1	2	3	4	5	6	7	8	9	10	11
Structural											
Width (m)	9.8	13.4	4.2	9.8	9.5	14.9	10.0	9.8	10.3	9.0	7.0
Height (m)	2.8	2.5	3.5	2.9	2.9	3.2	3.0	2.7	2.8	2.9	4.0
Length (m)	63.0	83.2	96.1	40.0	39.7	38.0	27.1	27.2	25.6	40.1	56.0
Openness	0.43	0.4	0.15	0.71	0.69	1.25	1.1	0.97	1.12	0.65	0.5
Noise level	68.1	70.5	64.1	66.8	66.0	63.8	64.3	67.4	67.4	67.1	64.1
Landscape (distance to)											
East gate (km)	0.0	2.1	3.5	5.8	10.5	11.5	12.0	14.4	17.0	18.8	38.8
Forest cover (m)	22.3	63.3	11.9	15.2	47.3	16.1	35.9	23.3	27.5	23.9	35.4
Nearest drainage (km)	1.0	0.0	0.1	0.4	0.6	0.0	0.6	1.2	0.4	0.2	0.3
CPR[a] (km)	0.5	0.75	0.8	0.02	0.02	0.02	0.25	1.2	0.4	0.75	0.75
Nearest town (km)	1.6	3.5	5.5	6.0	1.5	0.5	0.2	1.7	5.2	7.2	0.8
Human activity											
Human use index	0.4	1.9	1.8	0.6	5.3	5.3	15.2	3.2	11.4	0.6	0.5
Bike	0	5	6	21	189	8	462	19	595	1	0
Horseback	6	3	6	5	42	138	186	12	58	10	10
Foot	7	45	14	20	34	77	129	80	241	10	29
Species passage											
Black bear	10	20	43	37	13	8	0	4	8	34	16
Grizzly bear	0	0	0	2	0	0	0	0	0	5	0
Cougar	5	29	3	30	7	0	4	4	20	15	0
Wolf	1	7	3	28	3	5	1	5	77	146	35
Deer	554	42	294	253	215	21	61	338	2882	291	54
Elk	825	201	331	1199	1062	467	1576	1522	821	683	272
Moose	1	0	1	0	0	0	0	0	0	0	0

[a]Canadian Pacific Railway track.

index, however, it failed to separate ecologically significant attributes from those that appeared significant but were statistical artifacts of the underpasses themselves. The process was repeated for each of the three scales of ecological resolution. We divided species into two groups, carnivores and ungulates.

RESULTS

Planning of wildlife crossing structures

Black bears selected for relatively gentle terrain at lower elevations, in the areas of high concentrations of and close proximity to water, and in the areas of reduced wetness index. The latter often corresponds with the valley bottom coniferous stands having the inclusions of the semi-open vegetation types. There was no selection for greenness. Bears preferred flat areas (0–3 degrees) with the southerly aspects ($X^2 = 3072.8$, d.f. = 32, $P < 0.0001$).

We generated the most parsimonious model by using eight variables, in order of importance: elevation, flat aspect, south-southeast aspect, south-southwest aspect, density of water bodies, distance to drainages, slope, and terrain ruggedness. The order of importance is that of a multivariate type and was based on the analysis of the standardized function coefficients. Overall, the DFA produced a sound statistical model. The high canonical correlation coefficient (0.755) indicated that the DFA was strong and discriminated well between the groups. Also, the Wilk's Lambda was low (0.43) denoting a relatively high discriminating power of DFA. The overall cross-validated classification accuracy was 86.5%. The model correctly classified 78.6% of the set aside radiolocations into prime black bear habitat.

We tested each of the linkage models using a set of 37 empirical black bear crossing and mortality points. With respect to the distances to the Class IV linkages the analysis showed no statistical difference between the empirical crossings and random locations ($P > 0.05$). We interpreted this as an indication that Class IV linkages were a poor predictive tool for mapping cross-highway movement. The differences between the distance from the empirical points and random locations to the Class III linkages were significantly different. There was strong statistical evidence that the empirical bear crossing and mortality locations were much closer to Class III linkages than expected by chance for the empirical model ($P = 0.018$), the expert opinion-based berry season model ($P = 0.027$), and the expert literature-based model ($P = 0.005$). Distances from the empirical points to the Class III linkages for the expert opinion-based pre-berry season model were

Table 2. Descriptive statistics for the Class III linkages of empirical and expert linkage zone models. Measurements are in km

	n	Total length	Mean length	Minimum	Maximum
Empirical model	11	8.6	0.78	0.20	2.70
Expert opinion - *Pre-berry*	17	5.7	0.33	0.13	0.93
Expert opinion - *Berry*	18	4.7	0.26	0.08	0.72
Expert literature	9	6.3	0.70	0.30	1.90

Table 3. Comparison of kappa index of agreement of the empirical black bear habitat model with expert opinion-based models and expert literature-based model. See Methods for interpretation of kappa index.

Expert models	Empirical model		
	Class II	Class III	Class IV
Expert opinion - Berry	0.3679	0.3792	0.3618
Expert opinion - *Pre-berry*	0.3243	0.4411	0.0274
Expert literature	0.4271	0.5568	0.2529

not significantly different from the random locations ($P = 0.10$).

Of the Class III linkages, both seasonal expert opinion-based models had more linkage zones and were on average smaller in length compared to the empirical and expert literature-based model linkage zones (Table 2). When compared to the empirical model, there was a relatively strong correlation with the expert literature-based model (kappa index = 0.662). The expert opinion-based pre-berry season and berry season models were only fair (0.416) to moderate (0.569) in agreement with the empirical model.

The expert literature-based model most closely approximated the empirical model, both in the results of the statistical tests and the description of the Class III linkages. To further our understanding about the similarities and differences between the models, we compared them in terms of the level of juxtaposition of both the prime bear habitat maps and the Class II, III, and IV linkage zones (Table 3). The expert literature-based model was consistently more similar to the empirical model than either of the two expert opinion-based models. Class III linkages for all three expert models had the greatest similarity with the empirical model. Class IV associations were the weakest of all. Among the expert models, the literature-based model had the strongest correlation with the empirical model. Expert opinion-based models ranged in kappa index measures from 0.02 to 0.44, while expert literature-based models varied from 0.25 to 0.55.

Performance of wildlife crossing structures

We found that for each species the rank order of significant attributes was not significantly different between performance models (paired t test, all within-species comparisons not significant at $P > 0.05$). We therefore provide mean rank scores only. The rank order of significant attributes, however, does differ between species (paired t test, Bonferroni adjusted probability values; $P < 0.05$). For example, we found that underpass distance from east gate (positive correlation) was the most significant underpass attribute affecting black bear performance indices, whereas the underpass length (negative correlation) was the most significant attribute affecting elk performance indices (Table 4). For carnivores the most significant underpass attribute influencing the group's performance was distance to townsite (positively correlated); followed by human activities in the order of hiking (negatively correlated), human use index (negatively correlated), and horseback riding (negatively correlated). Landscape and structural variables were the least significant attributes influencing the group's performance index (i.e., distance to nearest drainage, negatively correlated; underpass openness, negatively correlated; Table 5). In contrast, we found that the most significant underpass attributes influencing ungulates were structural and landscape factors. Specifically we found the rank order to be: (1) underpass openness (negatively correlated); (2) noise level (positively correlated); (3) underpass width (negatively correlated), and 5 distance to nearest drainage. Human activity attributes, although significant, were ranked lower: (4) horseback riding (negatively correlated); and (6) hiking (negatively correlated). At the third scale of resolution, the large mammal community (i.e., all species together), we found that the most significant underpass attribute influencing the community's performance index was structural openness (negatively correlated; Table 5). Distance to townsites was the second most significant attribute (positive correlation), followed by human activity (human use index, horseback riding, hiking, and biking, all negatively correlated).

DISCUSSION

Planning of wildlife crossing structures

The most noteworthy result from the exercise was not the low performance of the expert opinion-based model, but the close proximity of the expert literature-based model to the empirical model. Our findings confirmed that the expert literature-based model was consistently more similar and conformed to the empirical model better than any of the expert opinion-based

Table 4. Species level rank ordering of mean coefficient of determinations and their slope for models explaining underpass interactions in Banff National Park, Alberta

Underpass attributes	Black bear	Grizzly bear	Cougar	Wolf	Deer	Elk	Moose
Width	8−				4−	3−	5−
Height			3−	3+		10+	
Length	7+					1−	4+
Openness	4−				5−	4+	1−
Noise level	12+		1+		3+	8+	
East gate	1−			2+			3−
Forest cover	11−	3−	4+		6−	11−	6−
Nearest drainage	9−			7−	2+	2+	
CPR[a]		4−		5+	8+		
Nearest town	3+	1+	2+	1+		12+	
Human activity index	6−	2−		6−		5−	8−
Bike	10−			4−		6−	7−
Horseback	5−				1−	7−	2−
Foot	2−		5−	8−	7−	9−	9−

[a]Canadian Pacific Railway track.

Table 5. Species group and large mammal community rank ordering of mean coefficient of determinations and their slope for models explaining underpass interactions at the level of species groups and large mammal community in Banff National Park, Alberta

Underpass attributes	Carnivore	Ungulate	Large mammal community
Width		3−	6−
Height			10−
Length		8+	11+
Openness	5−	1−	1−
Noise level	7+	2+	8+
Distance to east gate		10−	13+
Distance to forest cover		7−	12−
Distance to nearest drainage	6−	5+	
Distance to CPR[a]		12+	9+
Distance to nearest town	1+	13+	2+
Human activity index	3−	9−	3−
Bike	8−	11−	7−
Horseback	4−	4−	4−
Foot	2−	6−	5−

[a]Canadian Pacific Railway track.

models. These results were based on the test of distribution of the empirical points from actual crossing and mortality locations in relation to the linkages, the descriptive characteristics of the Class III linkages, the measure of agreement between models, and measure of agreement between model linkage zones.

The poor predictive power of the pre-berry expert opinion-based model may be explained by an overestimation of the importance of riparian habitat to the pre-berry habitat model, as compared to the opinions expressed in the literature. Another possible explanation for the difference between the two expert models is that the expert literature model is based on an analytical process (data have been collected, statistically analyzed and summarized), whereas the expert opinion model is based on information taken from how experts perceive attributes from memory and experience. Further, the fact that only 35% of the empirical black bear crossing and mortality locations where those of the pre-berry season may also have influenced how well it predicted linkage areas.

There are several advantages to the expert-based techniques presented from this work. There are an assortment of GIS tools designed for model building purposes that are readily available today. GIS applications such as Idrisi (Clark University, Worcester, MA, USA), MapInfo Professional Software (MapInfo Corporation, Troy, NY, USA), and ArcView GIS (Environmental Systems Research Institute, Redlands, CA, USA) are relatively inexpensive and easy to use. Idrisi has decision support procedures as a program module built into the geographic analysis system. Remotely sensed data, digital land cover data and habitat suitability maps are increasingly accessible, frequently updated and refined for individual users or government agencies. Further, empirical data from field studies of most wildlife species, particularly game species, are obtainable in most developed countries where road mitigation practices are presently implemented. The use of the Saaty's pairwise comparison matrix requires little training and ensures consistency in developing relative weights in the development of the expert-based models. This procedure is readily available in the Idrisi software package.

Transportation planning for roads and highways has generally considered a one-dimensional, linear zone along the highway. Thus the engineering and design dimensions have been the primary concern for planners. However, the ecological effects of roads we know are many times wider than the road itself and can be immense and pervasive (Forman and Alexander, 1998). Because of the broad landscape context of road systems, it is essential to incorporate landscape patterns and processes in the planning and construction process. The results from our work should not be interpreted as a devaluation of the use of experts in developing resource management strategies. Identifying linkage areas across road corridors using both expert model types (opinion- and literature-based) we have presented can provide a useful tool for resource and transportation planners charged with determining the location of mitigation passages for wildlife when baseline information is lacking and when time constraints do not allow for pre-construction data collection. Regarding the latter, we spent approximately two months developing the four models. More than half of that time was dedicated to developing the more complex, data intensive empirical black bear habitat model. We do not advocate modeling linkage zones using exclusively expert information if empirical data are available. However, we do encourage others with empirical data for model building and testing to develop expert models concurrently so that their findings may be contrasted with ours.

Performance of wildlife crossing structures

Our results suggest that underpass attributes differentially influence species performance indices. However, depending on the scale investigated (i.e., species, species groups, large mammal community) different underpass attributes were perceived as dominant. One common thread at all resolutions was that human influence consistently ranked high as a significant factor affecting species performance indices. At the species level, for example, six of the seven species ranked at least one of these human attributes as the most or second most important attribute influencing the species performance index. At the group level carnivores showed a positive correlation between underpass performance indices and distance from town and a negative correlation to human activity. The inverse relation between the two human-related attributes occurs because the townsites serve as sources of human populations from which human use activity originates. The closer an underpass is to a townsite, the greater the human use activity observed (Mattson et al., 1987; Jalkotzy and Ross, 1993; but see Rodriguez et al., 1996).

Ungulates, however, failed to respond to human activity in the same manner. Although significant negative correlations in performance indices were observed the relative importance of human activity was ranked below that of structural attributes. Elk habituation to human presence close to town may, at least in part, have masked the performance indices of non-habituated elk further from town. At the community level, the most important attribute influencing species performance indices was structural openness. The second most important attribute, however, was distance to the townsites (positive correlation).

These results lend support to the BNP management plan that emphasizes stricter limits to human development be imposed and more effective methods of managing and limiting human use within the park be established (Parks Canada, 1997). The plan also recommends improving the effectiveness of phase 1 and 2 underpasses by "retrofitting." In this context we suggest that in such a multi-species system the most efficient approach to retrofitting is to manage human activity near each underpass. Specifically, we recommend that foot trails be relocated and human use of underpasses be restricted. Continued monitoring of wildlife passage frequencies at these structures will permit Parks Canada to evaluate how this management strategy may translate into greater permeability of the TCH and habitat connectivity for all wildlife populations in the Bow Valley.

Landscape variables other than distance to town may also be important attributes determining species performance indices. Carnivores had a greater tendency to use underpasses close to drainages, whereas ungulates tended to avoid them. Drainage are notorious travel routes for wildlife, particularly in narrow glacial valleys like Banff's Bow Valley. However, the inverse relationship between carnivores and ungulates with respect to drainages may be a result of predator-prey interactions rather than any direct effect of landscape attributes on underpass use per se. For example, deer are known to keep to the periphery of wolf territories (Mech, 1977) and reduce their feeding effort when exposed to odors of wolves and other predator species (Sullivan et al., 1985). There is some evidence that the presence of badgers [*Meles meles*] can disrupt their prey species (hedgehogs [*Erinaceus europaeus*]) use of tunnels under roads in England (C. Doncaster, unpubl. data).

The results from our analyses also suggest that structural attributes were significant in species performance indices, especially for ungulates. Ungulates preferred underpass structures with a low openness ratio, narrow width, and long tunnel dimensions. However, we doubt that such species prefer such constricted underpasses when compared to the availability of larger and more open underpasses. In a post-hoc regression analysis we found that openness was significantly correlated to length, noise, and distance to town (linear regression, $P < 0.05$). These post-hoc tests suggested that the importance of these structural attributes may be of more statistical artifacts than ecological significance.

It is possible that the overall weakness of structural attributes in explaining species performance indices could be due to species individual familiarization with the 12-year old underpasses. Individuals require time to adapt to underpass structures (Reed et al., 1975; first author, unpubl. data) and once this has occurred, the dynamics of human activity and landscape heterogeneity attributes may be more decisive in determining species performance indices than the structural attributes themselves.

The multi-scale approach we used demonstrates informational needs of a state transportation planner responsible for site-specific mitigation for deer (Reed et al., 1975; Romin and Bissonette, 1996) will likely be different from a land manager in BNP mandated to maintain ecosystem integrity of a 650,000 ha national park. However, independent of the ecological resolution used species performance indices were consistently negatively correlated to some measure of human activity. In the absence of human management the best designed and landscaped underpasses may be rendered ineffective and the barriers to habitat connectivity unmitigated.

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Part IV
Project Planning

CanCommit©: A Computerized Commitment Database for Pipeline Construction and Operations

Melissa Pockar, Paul Anderson, and Terry Antoniuk

Project managers must be aware of commitments made to regulators, landowners, communities, and other groups so that due-diligence can be properly implemented during linear facility construction and operation. In the past, commitments have been tracked by memory, or with lists and spreadsheets. These previous approaches may be insufficient where projects are large, complex, or involve large numbers of non-standard commitments. This manuscript describes CanCommit©, a computerized environmental database developed for the Canadian portion of the Alliance pipeline system. The concepts introduced and structure of CanCommit© are readily transferable to a variety of projects. CanCommit© was developed in Microsoft Access© and was designed to enable project managers and construction staff to document and track generic and location-specific environmental commitments. The documentation process, combined with the database searching and reporting capabilities, allowed conflicting conditions and commitments to be readily identified. More than 6000 records were entered into the database over a three-month period. These included commitments made by Alliance during the regulatory applications, submissions and negotiations phases of the project. Tracking of status and compliance was facilitated through user-friendly database fields, drop-down lists, and help messages. Keyword searches of commitment text and summary reports could be generated by commitment topics, source documents, responsible parties, due dates or geographic locations. The status of individual commitments were tracked and updated by Alliance during the course of construction and reported back to management and field inspectors.

Keywords: Due-diligence, environment, commitment tracking, linear construction

INTRODUCTION

The Alliance Pipeline Limited (Alliance) system extends from northeastern British Columbia, Canada, to Chicago, Illinois, USA (Fig. 1). The Canadian portion of the project includes:

- 1559 km of mainline and related facilities from a point near Gordondale, Alberta, to a point on the Canada/United States border near Elmore, Saskatchewan; and
- 698 km of lateral pipelines and related facilities in British Columbia and Alberta.

Environmental Concerns in Rights-of-Way Management: Seventh International Symposium
J.W. Goodrich-Mahoney, D.F. Mutrie and C.A. Guild (editors)

On July 3, 1997, Alliance applied to the National Energy Board (NEB) for a Certificate of Public Convenience and Necessity to construct the Canadian portion of its natural gas pipeline system. Public hearings were initiated in February 1998, followed by the release of the NEB Comprehensive Study Report (CSR) (National Energy Board, 1998a) in September 1998 that satisfied the requirements of the *Canadian Environmental Assessment Act*. The CSR incorporated the results of public participation, including advice from the NEB, Fisheries and Oceans Canada (DFO), the Prairie Farm Rehabilitation Association (PFRA), Environment Canada (EC), various government agencies from the Provinces of Alberta, Saskatchewan and British Columbia, affected landowners and other stakeholder groups. The NEB Reasons for Decision (RFD) issued in November 1998 concluded that the project

Fig. 1. Alliance Pipeline Ltd. system map.

was in the public interest (National Energy Board, 1998b). The project was subsequently approved by the Governor in Council and the Certificate of Public Convenience and Necessity (Certificate GC-98) from the NEB was issued on December 3, 1998 (National Energy Board, 1998c) (Fig. 1).

Through the consultation, negotiation, hearing and regulatory approval phases, Alliance made thousands of environmental commitments to the public and to regulators. Traditionally, these types of commitments have been tracked by memory, or with lists or spreadsheets. However, due to the size of the Alliance Project and the volume of non-standard environmental commitments, Alliance developed an electronic database tool to assist project managers and construction staff in tracking commitment implementation and status. The principal design objective was to provide identification of all environmental commitments made during the regulatory and approval processes and to document their implementation and resolution during the construction and operation of the pipeline system.

CanCommit© was designed to store and manage both non-standard and generic commitments that were gleaned from over two hundred individual documents, including the NEB application and approval documents, hearing transcripts, supporting resource assessment documents (wildlife, archaeology, soils, vegetation, aquatics, air quality, noise), regulatory correspondence, authorizations and permit conditions. CanCommit© was designed to supplement but not replace standard environmental planning documents such as the Environmental Alignment Sheets (Alliance, 1997a) and the Environmental Plans — Volume V (Alliance, 1997b) document.

The commitment information incorporated into CanCommit© included the Conditions and View of the Board as specified in the NEB RFD and Conclusions and Recommendations specified in the CSR. Also included were any proposed mitigation or commitments for issues as identified on the Environmental Issues List (Alliance, 1997c) filed with the NEB (such as sensitive watercourse crossings, land use conflicts, problem soils, unstable slopes, wildlife habitat, rare or significant plant communities, heritage, archaeological, and palaeontological sites, and traditional aboriginal use areas). Mitigative measures specified in federal, provincial, and local approvals, permits, and licenses issued during the initial regulatory phase were incorporated into CanCommit©, as were special mitigation procedures for rare plants, alternative soil handling techniques, and watercourse crossings shown on Construction and Environmental Alignment Sheets and Designed Watercourse Crossing drawings (Alliance, 1998). Proposed mitigation or commitments for unusual issues or those issues which required special attention or consideration by Alliance, environmental inspectors, contractors, or regulators were also included.

Standard (i.e., not site specific) environmental protection procedures and mitigative measures identified

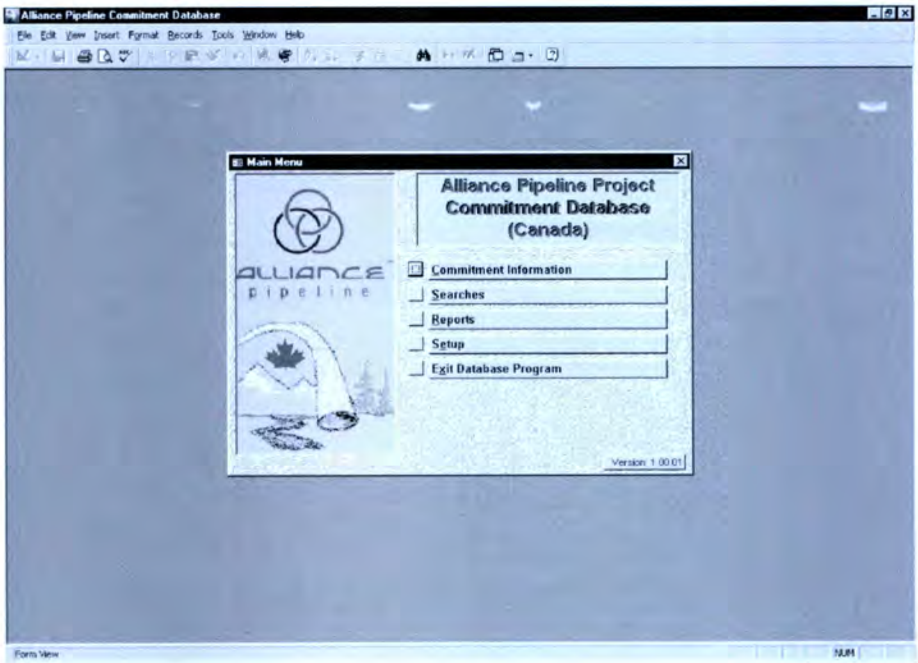

Fig. 2. CanCommit© user interface.

on Construction and Environmental Alignment Sheets, or within the Environmental Plans (Volume V) were not included in the CanCommit© database.

Design criteria methodology

Through consultation between the database programmers and Alliance environmental personnel, the scope of the database and the desired data inputs and outputs for the program were determined. Meetings were conducted with the Alliance Environmental Manager and the Supervisor of Environmental Inspection to incorporate the practical attributes from a management point of view, as well as from a field-level implementation (environmental inspector) perspective.

It was necessary to capture non-standard environmental information in a consistent format that would support keyword queries by environmental inspectors, technical specialists and project managers. Documentation of the source of the data and specific reference for each commitment was also important for additional follow-up work if required. The design of the database was to allow for conflict identification and resolution among commitments and to ultimately provide a permanent record for due-diligence purposes.

It was also necessary to track the status of these commitments in a consistent format. This capability allows outstanding and upcoming items to be identified on a regular basis for planning and compliance assurance purposes. Documentation regarding the date and specific reference for each completed commitment was also required information.

CanCommit© was programmed in Microsoft Access© through the collaborative efforts of Salmo Consulting Inc, E2 Environmental Alliance Inc., TERA Environmental Consulting (Alta.) Ltd., and Alliance (here-after referred to as the "Design Team"). In order for CanCommit© to be readily updated, it was divided into two components: a "front-end" which includes the database program, reports, and forms, and a "back-end," which includes the commitment records and tables. Data (back-end) updates were forwarded to users via e-mail or disk to ensure the most current information available from the database was utilized. When required, program changes were provided to users through "front-end" updates.

The program was designed to be user-friendly with as many drop-down menus and help messages incorporated as possible (Fig. 2). The breakdown of data into required and non-required fields ensured a base level of essential information was included for the purposes of systematic database queries and representative search results. Required fields also ensured that pertinent source and reference information were recorded for due-diligence in tracking the status of a commitment. The relevant data fields that were accessible under the "Commitment Information" tab (Fig. 2) are illustrated in the Commitment Data Form (Fig. 3). This form was for data entry or revision, and was not accessible for changes in the read-only state; only the Database (DB) Manager had the authority (and the responsibility) to maintain this information via the Commitment Data Form. A brief description of the meaning and contents in each field follows. Required fields are denoted in bold font.

Each commitment entered into the system was automatically assigned a unique number or "commitment code." The primary category for commitment data classification was "topic," which referred to a

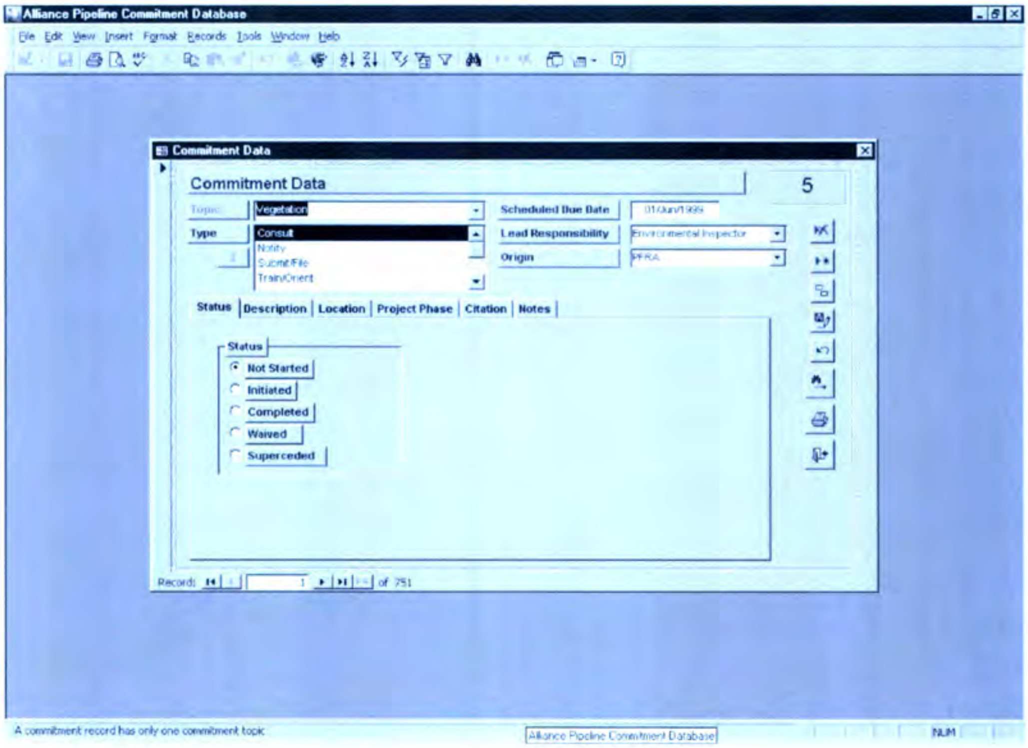

Fig. 3. CanCommit© "Commitment Data Form."

discipline or resource that required protection (such as vegetation, wildlife, heritage sites), that related to contingency measures for emergencies, or health and safety, or was associated with the handling of wastes and other hazardous materials. The "topic" was selected from a drop-down list and a record could not be saved until a topic was selected. "All" was selected if a commitment was general in nature and pertained to all topics, or "Other" if the topic was not one specified in the drop-down menu.

The commitment "type" field allowed multiple entries from the drop-down menu. The "type" of commitment indicated to the user the nature of the commitment such as notification or consultation with external groups, preparation or submission of applications or reports, and monitoring, sampling or mitigation. The number under the "type" box (Fig. 3) indicated how many "types" had been selected.

The dates entered into the "scheduled due date" field were dates that were pre-assigned to various phases of construction (for example, Winter 1999/2000 construction program, Commissioning, In-service). In many cases, one commitment would apply to various phases of construction. In these instances, the earliest possible due date was selected.

The "lead responsibility" drop-down menu consisted of various Alliance departments (for example, Alliance Environment, Alliance Land, Alliance Engineering), as well as consultants and construction personnel. The Environmental Inspector was the default selection in the "lead responsibility" field as these individuals represented Alliance's environmental presence at the construction level.

"Origin" of the commitment identified the group or regulatory agency that identified the commitment (for example, NEB, other regulators, landowners, or resource users). Alliance was the default selection in the "origin" field as most commitments were the result of promises made to regulatory agencies, specifications for environmental protection measures, or commitments made by senior Alliance representatives at the public hearings or open houses.

The status of implementation of a commitment was identified under the "Status" tab (Fig. 3). The default selection was "not started." The selection of any other "status" (for example, initiated or waived) required the input of a reference citation, which was entered into the fields located under the "citation" tab. This information included the source document reference, date, and page numbers.

The "description" tab contained the verbatim commitment text taken from the original source document. Any additional comments relevant to the commitment (such as other related commitments or other desired information to assist in database queries) was entered under the "notes" tab.

The "location" to which a commitment applied was referenced in various ways with respect to the level of detail required. For example, a commitment that referred to a specific location was identified by a Kilometer Post and pipeline segment, whereas broader commitments could be applicable to all locations within one or several provinces. Facility types and/or names as well as land features and geographic names were also used to identify the location of a specific commitment.

Multiple selections from the "project phase" field were allowed as various commitments could pertain to different phases of construction. The "activity" field allowed for multiple choices of project activities from a drop-down menu (for example, clearing, erosion control, facility construction). The default selection was "all," meaning that the commitment pertains to all construction activities.

Data-entry processes

Quality assurance

A data-entry protocol was developed for the identification and review of environmental commitments for the initial data input into CanCommit©. Commitments were initially identified and marked in source documents. This marked source document, along with any pertinent references or notes were maintained as original records in a central location.

In the initial data-entry phase, the required database fields (as denoted by bold text above) were entered and saved prior to the entry of any additional information. A commitment number was assigned by the program and was written in the source document margin. A report was then generated for each commitment, including the assigned commitment number, commitment text, source document, and topic. Data-entry forms containing location data and other non-required database fields were appended to the report, and a reviewer verified the information against the source documents.

The designated reviewer then identified the appropriate selections for each of the non-required fields on the data-entry forms. These forms were then checked by a secondary reviewer to confirm the appropriate information was identified. A note (N/A) was made where a field was deliberately left blank. The information contained on the data entry forms was then entered under the respective commitment in the database. Ideally, all fields were entered to support queries, even where not required by CanCommit© program design.

Quality control

A data-entry quality control report including all fields was printed out for independent review. Commitment summary reports were then provided to a secondary reviewer to confirm the appropriate information was identified and all required revisions were made. Final record approval for CanCommit© was designated once all required revisions from the secondary record review were completed.

Data management — Roles and responsibilities

The Database (DB) Manager was responsible for maintaining, updating, revising, and backing-up CanCommit© in the Alliance Calgary office. Sources of revisions were reports or submissions prepared by the environmental inspectors, resource specialists, or Alliance personnel, or information resulting from ongoing consultation and correspondence with regulators and stakeholders. The DB Manager was responsible for maintaining the database and forwarding updated copies of the CanCommit© back-end to the program users on a regular basis via computer disks, CDs or e-mail transmissions.

Users maintained a read-only copy of CanCommit© on their computers for reference and querying purposes. The program users were responsible to ensure that their database was current with the most recent version of the back-end and/or front-end information forwarded by the DB Manager. Typically, the users of the database were also the personnel implementing the commitments at the field level. These users (environmental inspectors, consultants, etc.) were responsible for communicating any changes in status of a commitment for which they were the "lead responsibility" to the DB Manager for incorporation into the master database. The Canadian Environmental Inspection Reporting System (CanEIRS©) included a data field for reference to a specific CanCommit© commitment code and the documentation of any pertinent information related to the status of that commitment (Fig. 4). These activity inspection reports were submitted daily to the DB Manager.

Training

A training program was implemented by the Design Team for Alliance environmental staff on the use and maintenance of CanCommit©. The Environmental Manager and Supervisor of Environmental Inspection were trained on the utilization of database searching and reporting capabilities and guided on how to implement the tool into the Environmental Inspection Program. The DB Manager was trained on the structure of the database, how to maintain the data, and how to provide technical assistance and data to the program users.

Training sessions were also conducted for approximately 22 environmental inspectors on the CanCommit© applications that related to their responsibilities at the field level. CanCommit© User Guides (Salmo et al., 1999) were provided for additional reference and trouble shooting in the field. Follow-up questionnaires were circulated to the environmental inspectors to procure their thoughts on the commitment database and its functionality at the implementation level. This survey was distributed towards the end of the construction period.

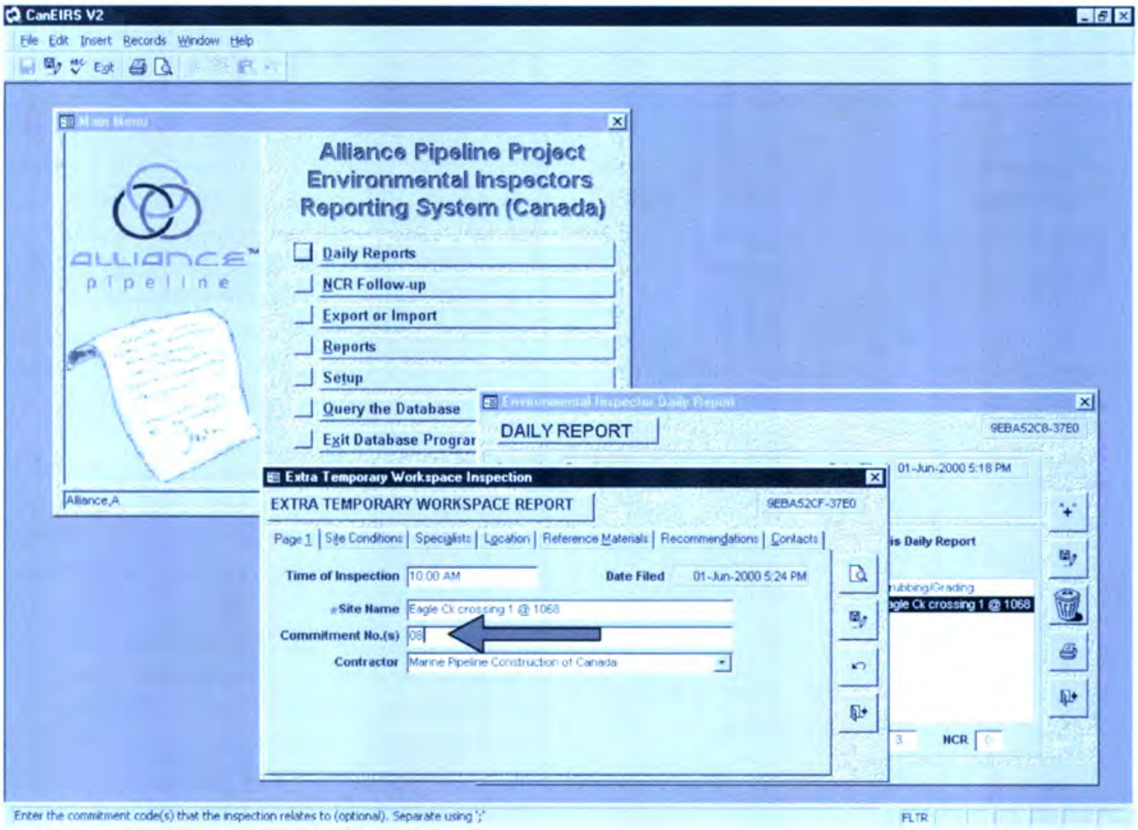

Fig. 4. CanEIRS© data entry field for communication of CanCommit© status data to database manager.

Results

The initial data entry and quality assurance/quality control (QA/QC) processes for the construction of the CanCommit© database was ongoing over a three-month period. Approximately 6000 unique records were identified and entered into CanCommit©. The back-end of the database was downsized from the master database to a working database that contained commitment information related to the Alliance environment department, the environmental inspectors, construction personnel and resource specialist consultants. This database downsize eliminated over 1500 commitments and reduced searching and reporting time.

All non-standard commitment information from the regulatory and approval process period was centrally located with searching and reporting capabilities. However, the majority of the commitments made subsequent to the initial regulatory period (i.e., during construction) were not incorporated into the database as was originally expected. The manhours required for the upkeep and maintenance of CanCommit© as a current reference tool were underestimated. As a result, the database became a compliance tool that was referenced mostly at the outset of a construction spread or phase and again as that construction phase neared its completion. The original objective of continual communication of current commitment information to and from the DB Manager and the environmental inspectors, consultants, resource specialists and construction personnel was not fully achieved due to timing constraints of all parties. The database was therefore not used as an up-to-date referenced tool.

The database was an effective searching and reporting tool for commitment information; however, searching and reporting activities often took long periods of time (at times in excess of an hour to generate a report) due to the size of the database. Reports generated from the database could be in excess of standard printer capacities. A strong understanding of the searching techniques and capabilities was required for consistent commitment results. These skills were generally acquired through practice or from prior database knowledge or familiarity. CanCommit© was found to be most useful to the environmental inspectors as they were introduced to their respective construction spreads, particularly during training periods when support was readily available. The environmental inspector feedback through the de-briefing questionnaire identified that the tool was too cumbersome and time consuming for utilization on a regular basis in the field.

CanCommit© provided an assurance level to management that the Environmental Compliance Management Program was functioning properly as commitments were being followed-up. CanCommit© provided a central and permanent record for due-diligence purposes.

DISCUSSION

The original design objectives for CanCommit© to be utilized on a regular basis by environmental inspectors and other users and maintained with current information were not fully obtained for various reasons. The underestimation of the time requirement for the upkeep of information in the database was one reason why this objective was not completely met. As many of the commitments applied to various stages of construction, the status was constantly changing. Additionally, the objective to continue with the entry of commitment data into the construction and post-construction phases was not achieved. In part, this was reflective of the type of commitment information generated during construction. These commitments were more efficiently tracked by traditional methods (such as lists or spreadsheets) as they were typically standard industry practices or special measures implemented over relatively short time frames. Also, those persons responsible for implementing the commitments at the field level were the same individuals conducting the consultation with local regulatory agencies and other stakeholders. This situation varied from the initial regulatory and approval phases that were completed prior to the involvement of any field-level personnel who would eventually be responsible for the implementation of the commitments.

A more thorough understanding of the searching and reporting capabilities of the database was attainable through practice or through general familiarity with database programs. Another reason all of the design objectives were not met was an overestimation of the computer skill levels of the environmental inspectors, and the underestimation of available field time to practice conducting database searches and becoming more familiar with the software. Basic computer skill set levels of the users should be clearly defined from the project outset and all those participating in the training of the software should have a base level of computer knowledge. The success of the program could have been enhanced by the provision of ongoing training in the field and software and hardware support.

CanCommit© was designed to complement the environmental inspection reporting system (CanEIRS©), although this objective was not sufficiently communicated and reinforced during the training and reporting phases. The transfer of commitment status information was intended to be provided to the CanCommit© database (DB Manager) via the CanEIRS© reporting window illustrated in Fig. 4. This communication of information was not consistent amongst the inspectors. Paper copies of commitment reports were distributed from the central database to the lead environmental inspectors on each spread, who in turn communicated back any relevant status information on the report sheets. This method successfully achieved the end results, although the means of information transfer were not those outlined in the objectives of the software program.

The "down-sizing" of the database to a working copy proved to benefit the management applications, but was too late into the project to benefit the environmental inspectors. Opinions were already formed regarding the utility of the database on a regular basis at the field level. The search times and the report generation times were expedited following the omission of commitments irrelevant to the Alliance Environmental department, as well as those commitments that had been waived or superceded in status.

The main objectives and the impetus behind the software development were to create a tool that would allow for the tracking of non-standard commitments, provide a permanent record of commitment implementation and identify commitments made by planning and management staff to the field level. These objectives were clearly met with CanCommit©. Although not updated and used regularly during the construction phase of the project, the database served as an assurance tool that commitments made in pre-construction phases of the project were being implemented in the field and tracked in a central location.

Future alternatives to the provision of the electronic database tool to the environmental inspectors may be to transfer pertinent site-specific commitment information into a more traditional tool (such as environmental alignment sheets). These sheets may be easily referenced on a daily basis at the field level and the changes in status may be communicated via the inspection reporting system. The database could be provided to the lead environmental inspector who would be designated as responsible to communicate the status of the commitments that are more globally related to the spread, or to the project in general.

CONCLUSION

The development of CanCommit© was a worthwhile endeavor, however, the tool was found to be more effective for use by management than by those who were implementing the commitments at the field level. These results varied from the objectives identified during the program design period; however, the desired objectives were still achieved through modified means.

The main objective of the design of the electronic tool was to provide a means of assurance that all commitments made during the regulatory and approval processes were properly implemented during the linear facility construction and operation. The design of CanCommit© certainly achieved these objectives and will continue to serve as a due-diligence tool through the construction phase and into the operations phase of the Alliance Pipeline project. It provided a sense of assurance to project managers that commitments were being consistently tracked and followed-up, which indicated the functionality of the overall Environmental Compliance Management Program. CanCommit© served well as both a planning and cross-referencing exercise, and will serve as a permanent record for Alliance.

With the implementation of modifications based on lessons learned during the original trial use of CanCommit©, the system has many applications that would be relevant to a variety of projects. Sufficient software training to individuals with a specified base level knowledge of computer systems is essential. Clear communication of expectations and protocols during the training period to those who will be using the system and implementing the commitments would enhance the utility of the database at all levels.

ACKNOWLEDGEMENTS

The authors wish to acknowledge Dr. Brian Zelt of E2 Environmental Alliance Inc. for his technical expertise and doses of originality in the CanCommit© program design. Appreciation is extended to the many members of TERA Environmental Consultants (Alta.) Ltd., in particular Jon Stuart-Smith, for the endless hours dedicated to the data entry process to transform an idea into a functional tool.

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Right-of-Way Environmental Stewardship Bibliographic Database

Susan M. Tikalsky and John W. Goodrich-Mahoney

There is now a significant body of research on environmentally sensitive approaches to right-of-way (ROW) management. Utility ROW managers would find a great use for a comprehensive reference that will compile and organize relevant ecological ROW information from a wide variety of sources. Such a reference can serve as a basis for complex technical decisions and can help prepare managers for public and regulatory information requests. Comprehensive, organized, and accessible information can assist ROW professionals in their efforts to manage environmental concerns before these concerns unduly complicate, delay, or halt ROW development. This effort will produce a comprehensive bibliographic database pertaining to environmental stewardship on ROWs. Beyond keyword searches for title and author, unique search capabilities of this database feature an ability to search the entire abstract and to search for specific subject matter by selecting among the nearly 100 ROW-specific coded fields. Each of the approximately 800 entries is coded for subjects of interest to ROW siting and maintenance professionals. Because of this extensive coding, users can refine their searches to review the available literature in a very specific area of interest. This user-friendly, searchable, and sortable database will be produced on CD-ROM.

Keywords: Bibliography, database, environment, right-of-way, stewardship

INTRODUCTION

Reliability concerns, together with an accelerating demand for energy and increasing difficulty in siting and maintaining utility rights-of-way (ROW), bring increased importance to sensitive land-management practices. Utility managers are faced with the difficult choice of siting facilities away from population centers and exerting increased pressure on natural areas, publicly-owned lands, and open space. When this occurs, the siting of a utility ROW is brought into the public arena for debate over the environmental consequences of corridor development and management. It is critical that ROW managers have the best scientific information available — to serve as a basis for their technical decisions on ROW performance and for communications with the public, company executives, and in regulatory proceedings.

Environmental Concerns in Rights-of-Way Management: Seventh International Symposium
J.W. Goodrich-Mahoney, D.F. Mutrie and C.A. Guild (editors)

METHODOLOGY

The primary sources of entries for this database are the Biological Abstracts© and Dialog© databases. The reference sections and bibliographic listings in many of the documents located through the database searches also were reviewed and additional entries identified. Following each search, the abstracts were examined to assess relevancy, and whenever possible, the full text of the selected articles was examined to produce a comprehensively coded entry.

Typically the abstract is presented as it appears with the article. When entries did not include abstracts, a brief summary was written or excerpted from the full article.

The coding hierarchy was established after review and comment by energy industry ROW professionals.

SCOPE OF THE BIBLIOGRAPHIC DATABASE

The entries for this EPRI bibliographic database encompass a vast array of studies, strategies, and approaches to the numerous issues facing those responsible for the environmental management of utility ROWs. All entries in this database address some facet of utility corridor design, siting, construction, or management with regard to environmental concerns. (Human biological or cultural impacts are not included.) Because so many topics are relevant to utility corridors and their impacts, this database contains over 800 entries. Since the needs of individual users will vary greatly, the database was made as inclusive as practicable. The extensive search capabilities of the database are designed to help users sift through entries and to assemble an individualized bibliography to meet specific needs.

Entries were limited to those references accessible to the user through the public domain. A great many of the database entries reflect work done in the past 10 years; however, age was not a filtering factor, and many important early studies and historically interesting articles are included. Most entries are from journal articles, but some relevant books, proceedings, and technical reports identified in the search process are included in the database.

SEARCH FEATURES

Users can search the database with keywords or can filter on coded fields. Each article presented as a result of a database search contains numerous identifying characteristics. In addition to having the entire abstract and title keyword-searchable, each entry in the database has been extensively coded to produce specific results from a hierarchical search request. The information displayed falls into two groupings: *Standard Citation Information and ROW Environmental Elements.*

The *Standard Citation Information* (see Table 1) includes the identifying information necessary to complete a reference: title, author(s), abstract, name of publication, date of publication, volume/issue, and page numbers. In addition, this grouping contains an indication of whether or not the article holds peer-reviewed status.

The second grouping, *ROW Environmental Elements*, (see Table 2) contains identifying information from the coding scheme developed specifically for the specialized needs of ROW professionals. The coding scheme

Table 1. Standard citation information

Category	
Author(s)	Searchable by last name
Title	Searchable in keyword search
Abstract	Searchable in keyword search
Date of publication	Searchable by year
Peer reviewed status	Searchable by status — yes, no, unknown
Name of publication	Included in output, but not searchable
Volume/issue, page numbers	Included in output, but not searchable

Table 2. ROW environmental elements — database fields (categories, subcategories, and characteristics)

Category	Subcategory	Characteristics
Environmental Subject	Wildlife	Mammals
		Birds
		Fish/aquatics
		Reptiles/amphibians
		Insects/arthropods
		Land invertebrates
		Threatened/endangered species
	Collisions and electrocutions	Yes/no
	Vegetation	Plant succession
		Invasive species
		Native/non-native species
		Threatened/endangered species
		Community composition
		Habitat (forage/cover)
		Species-specific study
		Agriculture
		Other*
	Water	Water quality — ground
		Water quality — surface
		Flow/permeation — ground
		Flow/permeation — surface
	Soil	Physical condition (compaction, density, temperature)
		Chemistry
		Disturbance/erosion
	Biodiversity	Fragmentation
		Edge effect
		Corridors as habitats
		Corridors as travel routes
Habitat		Wetland
		Forest (all woodlands)
		Riparian area/stream
		Desert (arid and semi-arid)
		Agricultural
		Tundra/permafrost
		Urban/residential
		Grassland (includes all types of prairie)
		Shrubland
		General
	Other*	
Geographic Regions		Twenty seven world-wide geographic regions, and one code for unknown/not applicable
Techniques and Impacts	Management Technique	Revegetation
		Fire
		Chemical treatment
		Mechanical treatment
		Multiple use
		Other*
	Siting/Management Issues	Cost
		Siting/design
		Public relations

Table 2. (continued)

Category	Subcategory	Characteristics
		Regulatory/legal Construction O&M/monitoring/training
Focus of Study		Quantitative Qualitative Process/Methodology Overview/Perspective

*"Other" fields are not searchable, but will appear in the output, including the text that was written in for other.

contains five primary code *categories*, which are further divided into eight searchable *subcategories*. Selecting on one or more of the 79 searchable characteristics can further refine subcategory information requests. A description of each of the primary code *categories* and *subcategories* is presented below.

CODES

A guiding principle of the coding process was to avoid inferences and allow the user to explore the implications of a study's findings. For example, the construction of any ROW is likely to disturb soil, but unless a study directly explored the nature or consequence of that disturbance, the article was not assigned the "soil disturbance" characteristic. An abstract accompanies each entry, but as originally written some were not informative enough to provide a full understanding of the article's contents. All articles that offered insubstantial abstracts, as well as most of the other database entries, have been coded following an examination of the complete document.

The following describes each of the five primary coded categories, and their subcategories. Each subcategory description identifies the number of characteristics associated with it. For further information on the characteristics, see Table 2.

Environmental study subject

All features of the ROW or study-site environment that are detailed in each article have been coded in this section of the database. An entry has been given a code for each topic it covered. For articles specific to ROWs, all coding relates to a ROW's impact or potential impact on the flora, fauna, and physical characteristics of the area.

- *Wildlife* — Six of the database's seven wildlife *characteristic* codes refer to the specific type of animal discussed. The remaining *characteristic* includes references to specific wildlife management issues for endangered/threatened species.
- *Collisions and electrocutions* — Each article was reviewed for information on bird or mammal collisions and/or electrocutions identified in the study.
- *Vegetation* — Nine *characteristic* codes were established for studies relating to floristic characteristics ranging from invasive species to wildlife habitat.
- *Water* — Studies relating to water were coded into four *characteristics* as relevant to surface water or ground water and with respect to their water quality or to flow/permeation.
- *Soil* — Entries that included soil studies were coded into three *characteristics*: physical condition, soil chemistry, or disturbance/erosion.
- *Biodiversity* — This subcategory allows the user to explore four *characteristics* of biodiversity issues that are known to significantly affect the ecology of an area. Articles coded with these *characteristics* focus on the role of ROW corridors in promoting or inhibiting biodiversity of both flora and fauna in terms of habitat (preference and avoidance behavior), movement (disease transmission and exchange of genetic material), producing edge effects, and increasing fragmentation.

Habitat

Each entry has been assigned to at least one of ten habitat *characteristics*. Because the habitat type of the ROW itself is typically that of early successional herbaceous or shrubby vegetation, it is the habitat surrounding the ROW that is coded. For non-ROW entries, the habitat type is that in which the study took place. Obviously, habitats are rarely discrete entities; to the extent that the article indicates overlap, it has been coded for all habitats mentioned.

Geographic region

Entries were assigned one of 28 geographic codes. Code numbers 1–27 correspond to geopolitical boundaries shown on the map that is built into the database. An article was assigned to the "0" category if a geographic area wasn't specified or if it discusses a concept rather than a location, voices an opinion, or presents a methodology. Occasionally, entries report the results of literature searches. In such cases, numerous locations often are only touched upon; thus, the entry is coded "0." However, if a few substantive case studies are included, the relevant geographic codes have been applied.

Techniques and impacts

Practitioners use many techniques — mechanical and chemical — to obtain the desired management goals. Additionally, ROWs are used occasionally for secondary purposes (snow storage). The following subcategories indicate the extent of the literature available on these practices.

- *Management Technique* — When an article describes an approach to managing the vegetation of a study area or ROW (hypothetical or actual), it has been assigned to this *subcategory*. The five *characteristic* fields allow the user to become more specific in the search with regard to using revegetation, fire, chemical or mechanical treatments, and multiple uses.

- *Siting/Management Issues* — Entries coded under this heading specifically address six *characteristics* that include basic areas of concern in the siting and operations of utility ROWs: cost, siting/design, O&M/monitoring/training, public relations, regulatory/legal, and construction.

Focus of study

Most entries in this database have a quantitative component. Many others offer a different approach to presenting information. To assist users who wish to isolate a particular approach, the articles have characteristics coded as quantitative, qualitative, process/methodology, and overview/perspective.

CONCLUSION

This EPRI project will produce a tool that will enable ROW environmental managers to search a wide range of scientific literature in a very efficient manner. This information will increase the credibility and effectiveness of ROW environmental stewardship efforts.

NOTE

Subsequent to this presentation, the final product for this project has been produced (EPRI, 2001).

REFERENCE

EPRI. 2001. Right-of-Way Bibliographic Database, Version 1.0. Product #1006380.

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Part V
Cultural

Off Right-of-Way Mitigation of Archaeological Sites: A Pipeline Case Study from Pennsylvania

James D. Bloemker

Mitigation of archaeological sites can be a costly endeavor in a pipeline company's effort to comply with environmental regulations. Avoiding a site is often impractical and excavating it may appear to be the only solution. Unfortunately, these traditional mitigation measures are too often the only solutions considered when dealing with archaeological sites. This paper discusses traditional mitigation measures and presents an alternative strategy to archaeological site treatment. Off-site, or off right-of-way, mitigation is a creative mitigation alternative that can be applied to some sites if conditions and circumstances permit. Within the body of this paper, an example of an alternative mitigation measure utilized by Williams Gas Pipeline–Transco on the construction of a recent gas pipeline across Pine Breeze Island in Pennsylvania is discussed.

Keywords: Section 106 compliance, creative mitigation, Clemson Island prehistoric culture

INTRODUCTION

Section 106 of the National Historic Preservation Act (NHPA) requires that federal undertakings, projects that involve a federal agency's licensing, permitting or funding, must be evaluated for their effects on significant cultural resources and take those effects into consideration when planning and constructing projects. According to the NHPA, a significant cultural resource is one that is listed on or eligible for listing on the National Register of Historic Places. Cultural resources are identified by conducting surveys, commonly called Phase I investigations, using subsurface site discovery techniques or visual observations where the ground is free of vegetative cover. Located archaeological resources are evaluated for their significance by excavating test units (Phase II investigations) and any project effects to cultural resources determined to be eligible for the National Register must be mitigated (Phase III investigations).

Thirty-four years after the NHPA was enacted, compliance with Section 106 has become routine for federal government agencies and businesses which get licenses, permits or funds from them; so too have the methods for mitigating significant cultural resources. Standard forms of mitigation for architectural resources are Historic American Building Survey/Historic American Engineering Record (HABS/HAER) documentation. For archaeological resources, mitigation routinely involves either avoidance or excavations conducted according to National Park Service regulations. Too often the decision on mitigation options is left up to agency regulators, however, they represent only a part of the Section 106 compliance process (Crisler et al., 1999).

Sometimes the standard treatment measures for mitigating cultural resources are not the best measures for the situation at hand. For example, HABS/HAER documentation often results in expensive over-documentation of historic resources. National Park Service guidelines for architectural documentation emphasize reserving this measure for resources of national significance (Barrett, 1999). In some cases neither avoidance nor excavation of an archaeological site is the right mitigation option. A better solution may be what is referred to as "mitigation banking" or "off-site mitigation." Off-site mitigation involves excavating an ar-

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chaeological site, or site portion, in place of the site (portion) affected by a federal undertaking; essentially one site is traded for another. Underlying precepts of this mitigation strategy are that the sites have comparable research values and that they are located in close proximity to one another (Bloemker, 1994).

Nonstandard solutions such as that described above have become known as "creative mitigation alternatives" or "innovative mitigation measures." The Section 106 process is meant to be flexible and allow for creative mitigation solutions. This policy was explicitly stated in the 1986 regulations implementing Section 106 [at 36 CFR 800.3(b)] and is implicitly implied in the recently revised version. In fact, Tom King (1999), the guru of Section 106, says that when complying with Section 106 almost anything is permitted beyond what is legally prohibited. What 106 participants can agree to for mitigation solutions is limited only by their imagination (King, 1999).

The following discussion examines the development of a creative mitigation alternative that was proposed by Williams Gas Pipeline–Transco (WGP–Transco) to mitigate an archaeological site affected by the construction of a buried natural gas pipeline on its Leidy Line System in Pennsylvania. The Leidy Line consists of 310.60 km of pipeline connecting the Leidy Storage Field in Clinton County, Pennsylvania to the New York City market area. The Leidy Line currently consists of three parallel pipelines: Line "A" a 60.96 cm (24-inch) diameter pipeline built in 1959; Line "B" a 60.96 cm (24-inch) diameter pipeline built in 1971; and Line "C" a 76.20 cm (30-inch) diameter pipeline built in 1991. Lines "A" and "B" were built prior to the need to comply with the NHPA and a cultural resources survey for Line "C" failed to locate site 36 Ly 263 within the right-of-way. The site was located during the cultural resources investigations required prior to the installation of Line "D." Avoidance of the archaeological site by horizontal directional drilling was not possible because of the sharp drill angles caused by the steep mountain slopes on either side of the island.

WGP–Transco proposes to increase capacity on the Leidy Line System by adding 25.75 km of 106.68 cm (42-inch) diameter pipeline in the summer of 2001 and that will be parallel to three existing pipelines on the right-of-way. The 25.75 km section of proposed construction crosses undulating terrain with average elevation peaks of 774.19 m above mean sea level (msl) and valley lows of 170.69 m msl. Pine Breeze Island, on which archaeological site 36 Ly 263 is located, lies in one such valley. Before specifics on the project are provided, a review of the background natural and cultural history of the region and the island is necessary.

THE RESOURCE BASE

Natural history

Pine Breeze Island is a long, narrow island located in Pine Creek approximately 8.05 km north of the confluence with the West Branch of the Susquehanna River in central Pennsylvania's Lycoming County. Harrisburg, the state capitol of Pennsylvania, is located 104.61 km south of the island. Pine Breeze Island is roughly 1.61 km long and 304.80 m in maximum width (Fig. 1). Archaeological site 36 Ly 263, a Late Woodland Clemson Island occupation, is located at the northern portion of the island.

Pine Breeze Island is located in an east–west trending escarpment known as the Allegheny Front. The island lies between the Ridge and Valley physiographic province to the east and the Appalachian Plateau to the west. Bedrock in the region ranges from the Lower Ordovician (oldest) to the Lower Pennsylvanian (youngest). The project area is at the southern terminus of the Wisconsin glacial advance.

The geomorphology of Pine Breeze Island (Fig. 2) was determined by mapping and profiling the sediments found in 7–6 m long trenches excavated to a depth of three meters. Examination of the sedimentological and pedological features of the main strata produced a provisional stratigraphy that indicated several cycles of alluviation, soil development and erosion that were critical to the archaeological site's interpretation.

From most recent to oldest, four layers of stratigraphic sequences were established:

- Unit I, dating from 2000 BP to the present, is found in the upper 100 cm on the west side of the island and to 50 cm on the east side. Sediments of this unit include a sod/humus horizon overlying compacted silts and fine soils. Soils of this unit have been classified by the United States Department of Agriculture (USDA) as loamy Udifluvents.
- Unit IA soils date from 2000 BP to 3000 BP. They contain the first buried surface which is between 50 and 70 cm thick with slightly thicker depths to the north. This unit contains well bedded silts and sands and thin discontinuous bands of lamellae. Lamellae are laterally thin red bands of oxidized and clay enriched soil particles that formed as episodic flood events of Pine Creek ceased.
- Unit II soils contain the second buried surface and date from 3300 BP to 5000 BP. This unit is between 1.25 and 1.75 m thick and consists of Cambic soils with impermeable gleyed clay at its base.
- The deepest soil sediments of Unit III date to 5000 BP and older. This soil consists of medium to medium coarse sands that directly overlay the basal gravels that form the base of the island (Doershuk, 1991).

Given that the top of soil sequence Units IA and II preserve an A horizon, it has been determined that the island's soils became stable around 4200 BP and 2100 BP which corresponds to the Late/Terminal Archaic and Early Woodland cultural periods of Pennsylvania prehistory.

Palynological studies are the basis for describing the paleoenvironment of the project area. Between 8000 and 6500 BC a transition from a Pleistocene to

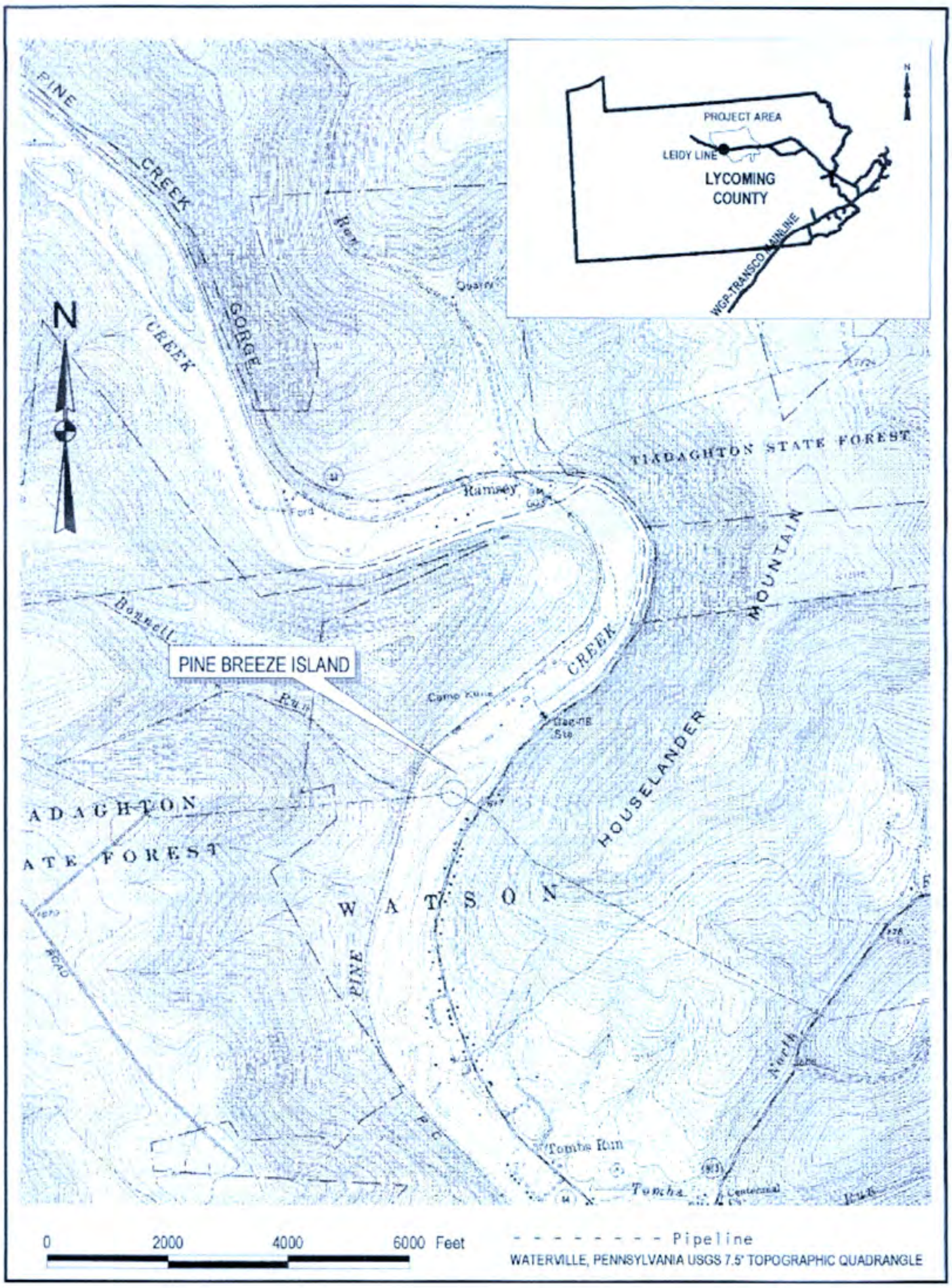

Fig. 1. Portion of the Waterville, Pennsylvania USGS 7.5 min series topographic map illustrating the proposed project area location (adapted from Doershuk, 1991).

a Holocene climate occurred. The transition resulted in the reduction of open grasslands to the expansion of boreal forests consisting of spruce and pine trees with some oaks. A warming trend called the Atlantic climatic episode occurred around 6500 to 3100 BC. Changes included an increase in precipitation and a spread of mesic forests. Mesic forests consisted of hemlock and oak trees with oak dominant by 5000 BC. The Sub-boreal climatic episode of between 3100 and 800 BC brought a warm, dry period to the region. The environment consisted of hickory forests with an expansion of grasslands. Around 810 BC to AD 1000 the region of Pine Breeze Island experienced an increase in moisture and cooler temperatures. This climatic period was known as the Sub-Atlantic episode. It more closely resembled the environmental conditions found in central Pennsylvania today. The modern climate of the project area can be described as humid continental. The project area has an average summer temperature of 21.66°C and an average winter temperature of 1.66°C. Annual precipitation in the project area averages 104.14 cm.

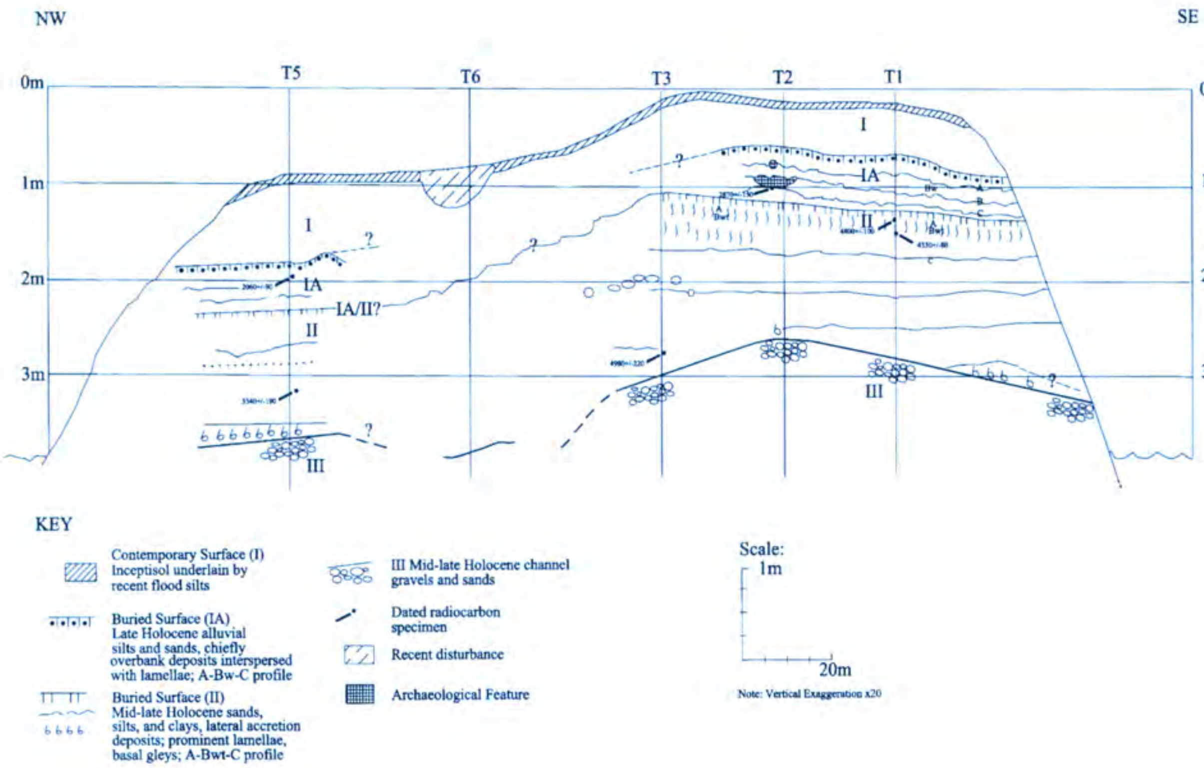

Fig. 2. Geomorphological reconstruction of sedimentary deposits of Pine Breeze Island based on data obtained from seven trenches excavated across the island (Doershuk, 1991).

Cultural history

The cultural history of central Pennsylvania follows a general pattern identified for most of the Middle Atlantic region of the United States. The earliest period of prehistory is known as the Paleoindian and dates from 14,000 BC to 8000 BC. Archaic period cultures superceded the Paleoindian around 8000 BC and lasted until around 2100 BC. A period of Transition (2100–900 BC) exists between the Archaic and Woodland periods. Like the Archaic before it, the Woodland period (900 BC–AD 1000), is subdivided into the Early, Middle and Late periods. The Late Woodland is the final period of prehistory in Pennsylvania before the arrival of Europeans into the region. It lasted from 1000 to 1600 AD and includes the Clemson Island culture whose archeological remains have been located on Pine Breeze Island.

Clemson Island cultures were composed of agriculturalists who occupied major portions of the Susquehanna River valley from approximately AD 800 to AD 1200. In addition to cultivating domesticated plants, Clemson Island people exploited resources in a manner similar to preceding cultures. Clemson Island sites are known to be present in an 18-county "core area" of central Pennsylvania and which is defined in the State Historic Preservation Office's (SHPO) management plan for this prehistoric period (Hay, 1987).

Recognized Clemson Island site types include hamlets associated with burial mounds, hamlets with no mound association, temporary camps and special purpose camps. Clemson Island hamlets are believed to be clustered according to kinship ties and associated with a single, mound-related hamlet. Later Clemson Island sites show a shift from hamlet settlements to villages at which time the use of burial mounds ceases. The Clemson Island cultural period is defined by archaeologists primarily from the excavations of village sites. The Pine Breeze Island site is unique in that it is located between the large village sites to the south and the smaller hamlet sites in the uplands to the north (Bergman, personal communication).

Toolkits used by Clemson Island folk were similar to those used by other Late Woodland cultures of the Middle Atlantic region. Artifact assemblages include broad triangular projectile points, net sinkers and fish hooks and seed grinding equipment. Pottery, however, distinguishes the Clemson Island culture from other Late Woodland period sites. The definitive pottery includes a variety of punctated ceramics with cord-marked or fabric-impressed motifs on the outer surface of the vessel (Fig. 3) (Stewart, 1988).

PROJECT SPECIFICS

The Clemson Island site was found through the initiation of Phase I investigations for WGP–Transco's proposed Leidy Line "D" expansion. Subsurface testing techniques included the excavation of 90 shovel test pits (STPs) at 15 m intervals, the placement of 14 auger probes and 7 backhoe trenches and the digging of 107 m^2 of hand dug units. The Phase I survey was

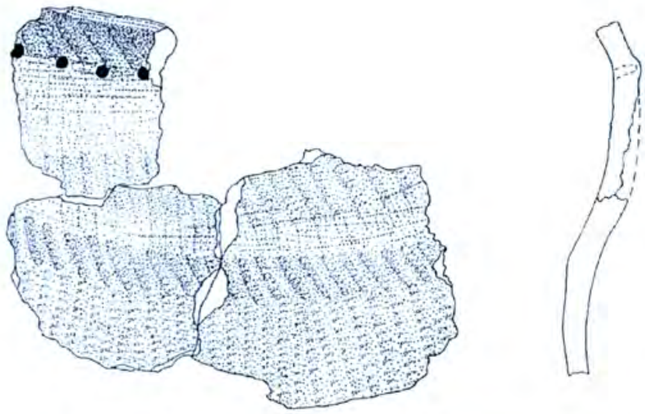

Fig. 3. Pottery is the distinguishing artifact that separates Clemson Island sites from other neighboring Late Woodland sites. Definitive Clemson Island pottery includes a variety of punctated ceramics with cord-marked or fabric-impressed motifs. An example is illustrated here (Hay, 1987).

spread over a 60.96 m wide by 198.12 m long corridor south of the existing "C" pipeline and a 60.96 m by 99.06 m work space area located at the east half of the island north of the existing "A" pipeline. The total area of Phase I survey coverage equaled 1.74 ha for a 198.12 m long by 22.86 m wide construction corridor. The corridor width was narrowed to 15.24 m after the Phase I survey results were revealed.

Survey results yielded 741 artifacts of which only one diagnostic artifact, the remnants of a Levanna projectile point, was located in the proposed pipeline trench. Additionally, only one feature was encountered and it was found to be 45.72 m south of the proposed pipeline. An additional piece of data that proved to be important in the planning of future archaeological investigations on the island was the fact that 89% of the artifacts found during the Phase I survey were located in the upper 50 cm of Unit IA soils (Doershuk, 1991). Based on the Phase I survey results that documented the site as a Clemson Island occupation, the SHPO recommended testing of the site to determine its National Register eligibility.

A plan for conducting Phase II excavations was presented to the SHPO in March 1994. The proposal had three objectives: (1) verify the low density of artifacts observed during Phase I investigations in the area southeast of the proposed pipeline by excavating 4 — 1 m × 2 m blocks within the 15 m construction right-of-way south of proposed "D" line on the eastern half of the island and east of Phase I trench 3; (2) verify the probable disturbance resulting from previous construction of pipeline "C" by excavating 3 — 1 m × 1 m test units within a 7.5 m right-of-way north of proposed line "D" between Phase I trenches 5 and 3 and (3) excavate 15 — 2 m × 2 m blocks and 15 — 1 m × 1 m test units interspersed equally between Phase I trenches 5 and 3. This field strategy was modified slightly, with SHPO permission, based on early field results and a request by WGP–Transco engineers for a slightly wider construction right-of-way of 16.76 m.

Phase II testing resulted in the recovery of 157 pieces of lithic debitage, 9 lithic tools and 670 ceramic sherds. Predominate were ceramic types related to the Clemson Island phase of occupation with Owasco and Shenk's Ferry components, neighboring Late Woodland cultures, identified less often in the ceramic assemblage. Aside from the unique setting and nature of the site, another item which made 36 Ly 263 unusual in the eyes of the SHPO was that it occupied a zone at the northern periphery of the Clemson Island culture and the southern periphery of the Owasco culture (Bergman, personal communication). Levanna points were the only diagnostic lithic artifact recovered from the excavations. Seven features were identified during Phase II testing. The features tended to be shallow and void of large artifact concentrations which was most likely due to flood water scouring that truncated the pit bottoms. Positive and negative test unit results of the Phase II excavations reinforced the Phase I survey investigations that showed the more significant portions of the site to be located south of WGP–Transco's right-of-way (Bergman et al., 1997).

Except in a small area at the southwest end, the results of the archaeological investigations in the existing pipeline and proposed construction right-of-way were disappointing from a research perspective. Testing at these locations confirmed Company representative suspicions that the site was disturbed by previous construction activity related to the installation of the three other pipelines or that the right-of-way was void of cultural material. Using data from the Phase I investigations (Doershuk, 1991) the artifact densities in the areas to be affected by the pipeline construction show reasons for the suspicions. A total of 15 — 3 m by 3 m units were dug across the island of which 7 were located in project affected areas. Artifacts from 8 of the units outside the affected areas numbered 588, whereas artifacts from the 7 units inside the affected areas equaled only 72. The numbers spoke loudly for attention to this revealing statistic.

A Phase III data recovery strategy that was based on the results of the Phase I and II investigations was developed in consultation with the SHPO in September 1997. The strategy involves excavating a single 50 m^2 block to be placed where Phase II artifacts were concentrated between coordinates N450 E460 and N465 E475 on the western side of the island (Fig. 4) (Bergman, 1997). Another key component of the data recovery plan involves donating Pine Breeze Island to a government agency of the Commonwealth of Pennsylvania for their use as an archaeological/nature preserve. WGP–Transco acquired 17 of the island's 17.4 ha (0.4 ha with three summer cabins was not purchased) specifically with the mitigation on Pine Breeze Island in mind. The donation of the island will protect the archaeological site from future development. A clause in the deed transferring the island allows for expansion

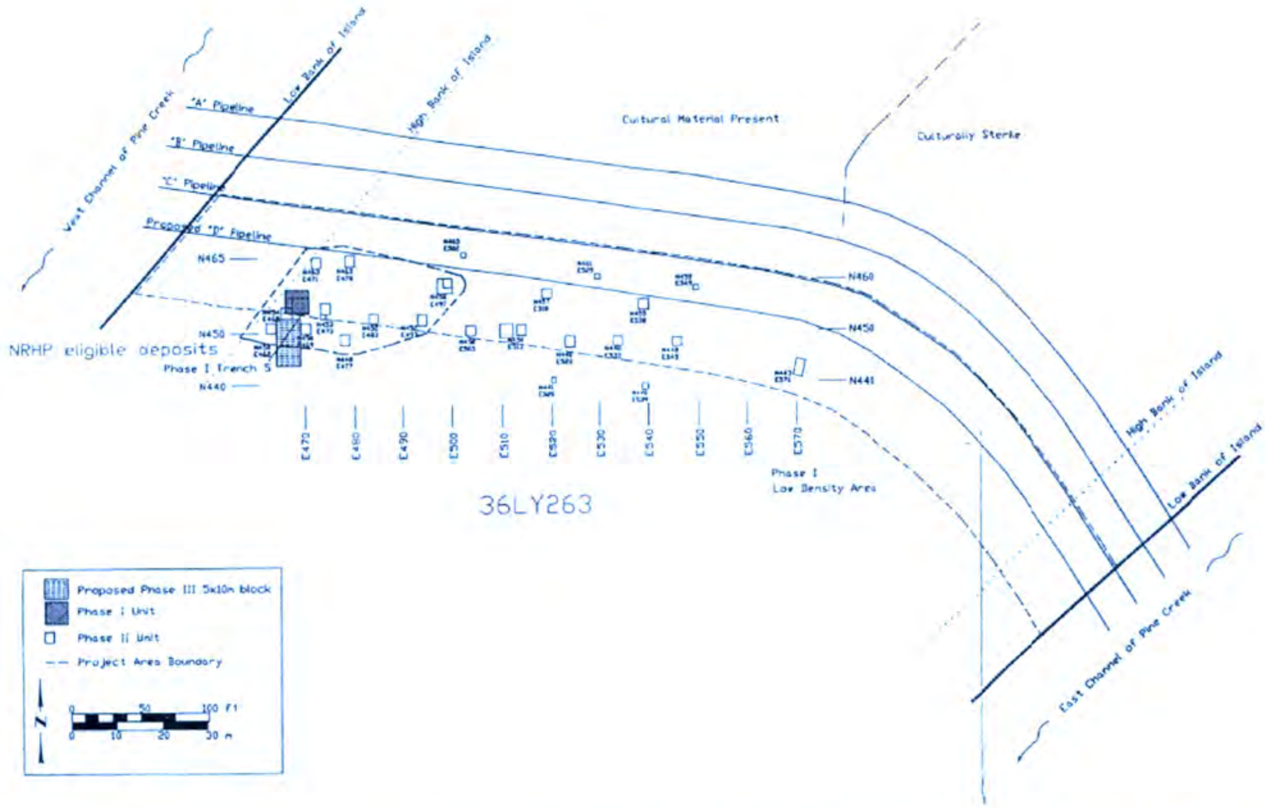

Fig. 4. The distribution of Phase I, II, and III excavation units across the construction right-of-way of Pine Breeze Island (Bergman, 1997).

of additional pipelines on the north side of the right-of-way where archaeological investigations demonstrated that little or no effects to the site would occur.

Company representatives were convinced that the better portions of the site were located to the south of the right-of-way and that any mitigation excavations to be done by the Company should be conducted there. When the island was purchased WGP–Transco was able to offer what, through Phase I and II investigations, appeared to be the better portions of the site in exchange for less excavations in the construction right-of-way. The strategy proved to be acceptable to the SHPO and the Federal Energy Regulatory Commission, the federal agency WGP–Transco must obtain a license or certificate from to build the pipeline, since a legal document (Memorandum of Agreement) was signed authorizing the strategy to be implemented.

CONCLUDING REMARKS

Circumstances for WGP–Transco at Pine Breeze Island were ideal for the employment of a creative mitigation alternative involving off right-of-way mitigation. The proposed 106.68 cm (42-inch) "D" Line crossing of the island by horizontal directional drill in order to avoid archaeological site 36 Ly 263 was not possible because of the sharp drill angles caused by the steep mountain slopes on either side of the island. The results of Phase I and II investigations demonstrated that the greater portions of the archaeological site were south of WGP–Transco's right-of-way. By offering Pine Breeze Island (the cost of the island is about third of what it will cost to excavate the 50 m^2 block) and the archaeological site it contains to the Commonwealth of Pennsylvania, WGP–Transco will be able to avoid more extensive and costly excavations in the right-of-way in exchange for the SHPO's opportunity to conduct research on a significant archaeological site at a more leisurely pace than compliance archaeology permits. It appears that this mitigation solution is a win-win situation for both the SHPO and WGP–Transco.

ACKNOWLEDGMENT

Dr. Chris Bergman of BHE Environmental, formerly 3D/Environmental, was instrumental in providing the background data on Pine Breeze Island. I would also like to thank him for taking the time to critique this paper.

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BIOGRAPHICAL SKETCH

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Part VI
Wildlife

Rights-of-Way Management in Support of Biological Conservation

Valentin Schaefer

Rights-of-way provide greenway linkages between fragments of natural areas. Within an urban context, rights-of-way provide connectivity between parks and other protected areas, creating larger breeding populations, better gene flow, larger food webs and greater opportunities for plants and animals to help each other reproduce. Managing rights-of-way to increase biodiversity produces a more effective natural network. The Green Links Project, started in 1995, focuses on strengthening ecological connectivity within Greater Vancouver. This urban area is on the Fraser River Estuary and delta, a major stopover point along the Pacific Flyway for migratory birds. The Fraser River itself is home to the world's largest salmon run. Biological conservation here is of international importance. BC Hydro and BC Gas have worked in partnership on the Green Links Project to take a regional approach to biological conservation through plantings of native vegetation and putting up bird and bat boxes with student and community participation in utility corridors, backyards, and balconies. Issues and problems that had to be addressed included ownership of lands, trees under power lines, and city maintenance crews cutting new plantings.

Keywords: Greenway, biodiversity, urban, connectivity, fragmentation

INTRODUCTION

Rights-of-way play an important role in connecting ecosystem fragments. Within British Columbia there are 71,000 km of rights-of-way, much of which can be incorporated into strategies for biological conservation. They can be used to join small areas of habitat and enable them to function as larger, more viable ecosystems.

Connectivity in biological conservation is especially important in urban areas. Cities often develop in unique and valuable natural ecosystems such as estuaries and floodplains because of their strategic importance or suitability for agriculture. In British Columbia, Canada, examples are the Fraser River estuary in Vancouver and the Garry Oak Woodland in Victoria. The location of the ecosystem fragments in cities can make them far more important than their limited size and disturbed plant life might initially suggest (Schaefer, 1994).

The loss of natural habitat due to urbanization is considerable. In the United States from 1959 to 1982, 22 million acres (8.7 million hectares), of land were converted to urban and other developed land uses, an increase of 45% (Heimlich and Anderson, 1987). In the Lower Mainland of British Columbia, about 70–80% of the original wetland habitat has been lost because of dyking in support of urban and agricultural development (Fraser River Estuary Study Steering Committee, 1978). Land that has been converted to agriculture or other similarly cultivated landscapes has only 50% of the average net primary productivity of original forested ecosystems and urban landscapes have only 13% (Healey, 1997).

Within cities the remaining natural areas exist as fragments of habitat. With fragmentation, wildlife population sizes decrease, local extinctions increase, and isolation interferes with recolonization by native species (MacArthur and Wilson, 1967; Opdam, 1991; Wilcox and Murphy, 1985).

Connectivity is one approach to solving the problem of habitat fragmentation. Connecting islands of habitat enhances species richness of breeding birds (MacClintock et al., 1977), increases seed dispersal of climax trees by wildlife (Levenson, 1981), and maximizes the

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biological diversity of fragmented habitats by promoting critical breeding densities and an increased gene pool in populations (Harris, 1984). Rights-of-way can therefore provide for larger breeding populations, better gene flow, more complex food webs and symbiotic relationships. Any degree of connectivity adds value to ecosystem fragments, with the benefits increasing with the increased degree of connection (Rudis and Ek, 1981).

The strength of network connectivity is determined by the number of networks in a region, the links within the networks and the number and sizes of the nodes of habitat fragments (Linehan et al., 1995). Utility rights-of-way can be used to form a significant part of this network. It is clear from metapopulation theory that the greater the number of patches and the closer they are, the better the colonization (Hanski and Gilpin, 1993). Seed dispersal and wildlife movements are key processes in determining the survival of metapopulations. Such movements are directly related to the connectivity of the landscape (Schippers et al., 1996). Increasing biodiversity within the connecting corridors to more closely match that of the fragments they connect increases their usefulness.

The value of connectivity in forestry conservation is generally accepted (Harris, 1984), even though it is difficult to predict if a link will function as expected (Simberloff and Cox, 1987). Wildlife movement through corridors between habitats has been demonstrated for small and large mammals (e.g., Wegner and Merriam, 1979) and for birds (e.g., Dmowski and Kozakiewicz, 1990).

In wilderness forest ecosystems, connectivity is established by deliberately leaving connections of unlogged stands between nodes. In urban systems, links usually need to be created from disturbed habitat. This can be accomplished through community stewardship and through the planning efforts of landscape architects to increase the structural complexity of vegetation. Having a corridor of adequate dimensions may in itself be insufficient (Henein and Merriam, 1990). The best wildlife corridors have good vegetation layering, a diversity of plant life and a minimum of invasive alien species (Thorne, 1993).

Greenways

Landscape architects and city planners usually refer to corridors of green space as greenways. The value of greenways to ecosystem function has been actively cultivated and several case studies have been described such as the southwestern Wisconsin environmental corridors and the Boulder greenways (Smith and Hellmund, 1993). A greenway that also serves to biologically connect two ecosystem fragments is classified as a third generation greenway (Searns, 1995).

Rights-of-way typically are used as first and second generation greenways by providing people corridors with multiuse pathways and beautifying the community. With some sensitivity to the use of native annuals, perennials, and shrubs they can act as third generation greenways, contributing significantly to the conservation of biodiversity. In urban areas the plantings can be done as a stewardship activity with the local communities and can be expanded to include backyard habitat and balconies in adjacent residential neighborhoods.

The Green Links Project

Green Links is a project of the Douglas College Centre for Environmental Studies and Urban Ecology. It was started in 1995 to establish and maintain ecological corridors in urban areas throughout Greater Vancouver. Its primary objective is to increase the ecological value and biodiversity of urban wildlife habitats and green spaces. There are two secondary objectives: to increase the value of green spaces to the community, and; to reduce ongoing maintenance, thereby decreasing monetary costs in terms of vegetation management in rights-of-way or environmental costs involving the demand for pesticides and potable water associated with managing home gardens.

Fragmentation of urban wildlife habitats is becoming a particular problem for Greater Vancouver. Over the past 10 years the region has grown to 2 million people, with the population expected to reach 3 million people by the year 2025 (GVRD, 1995). This population growth will exacerbate the already advanced state of fragmentation in the Lower Mainland's wildlife habitats.

Links are created by plantings of native vegetation (primarily shrubs and perennials). The plantings are done in partnership with schools, service clubs (e.g., Optimists, Rotary), youth groups (e.g., scouts, guides), municipal and regional governments (e.g., City of Burnaby, Greater Vancouver Regional District) and nongovernmental environmental organizations (e.g., Vancouver Natural History Society, Burns Bog Conservation Society).

METHODS

The first step in Green Links was to create a composite map of Environmentally Sensitive Areas (ESAs) in the municipalities of Greater Vancouver. The result — a regional perspective. Maps of ESAs were produced by individual municipalities without any attempt to standardize the process or the criteria. Thus, coming up with a regional map was the first step in the defragmenting process.

Three initial Green Links demonstration projects were immediately apparent from the composite map. Each offered opportunities to connect several fragments at once. In particular, rights-of-way were examined for their potential to connect several important islands of habitat with each other and the "continent," which in this case is the surrounding wilderness on the urban outskirts.

Measuring biodiversity

A baseline measure of biodiversity was established for comparison in 10 years. The 10 years seemed appropriate to provide time for the plantings to establish themselves as communities and to allow time for the wildlife populations to respond.

Two measures of biodiversity are being used to evaluate the effectiveness of Green Links. One is the Simpson's Index (D) of biodiversity where:

$$D = 1/\sum p_i^2.$$

In this formula, p represents the proportion of species i in the total sample of individuals. The arbitrary target is to use Green Links to raise the average biodiversity Simpson's index for birds (used as an indicator of overall biodiversity) by 30% over the 10-year horizon.

A second measure is the presence of indicator species. The assumption is that encouraging such species with more sensitive habitat requirements encourages more numerous species with less sensitive requirements. Examples of such indicator species may be Dark-eyed Junco (*Junco hyemalis*) for ground cover, Rufous-sided Towhee (*Pipilo erythrophthalmus*) for shrub layer, Rufous Hummingbird (*Selasphorus rufus*) for nectar-producing flowers, and Yellow Warbler (*Dendroica petechia*) for tree canopy habitat.

Increasing connectivity

The following activities are being used to increase connectivity:

1. Restore native plant species, depending on the conditions and requirements of each specific site. Various planting programs possible are:
   - *butterfly and hummingbird gardens* (herbaceous, low-growing, plants)
   - *multiple species habitats* (incorporating shrubs such as native beaked hazelnut for Steller's Jay and squirrels)
   - *green space maintenance* (ground cover and shrubs to out compete nuisance species)
2. Remove invasive species such as Scotch broom
3. Construct multiuse pathways
4. Cleanup refuse
5. Create interpretive sites
6. Conduct community workshops and erecting bird and bat boxes

Green Links is working on three demonstration sites — two are rights-of-way (Coquitlam and Surrey) and one is through a matrix of residential development (Burnaby). The Coquitlam right-of-way (Fig. 1), is the prototype and is the one being reported on here.

The Coquitlam right-of-way approximately 5 km long and 100 m wide and 128 ha in area. The land is primarily owned by the City. We work with BC Hydro to ensure plantings meet required height and species requirements for the utility. Green Links increases connectivity between five ecosystem fragments in this area:

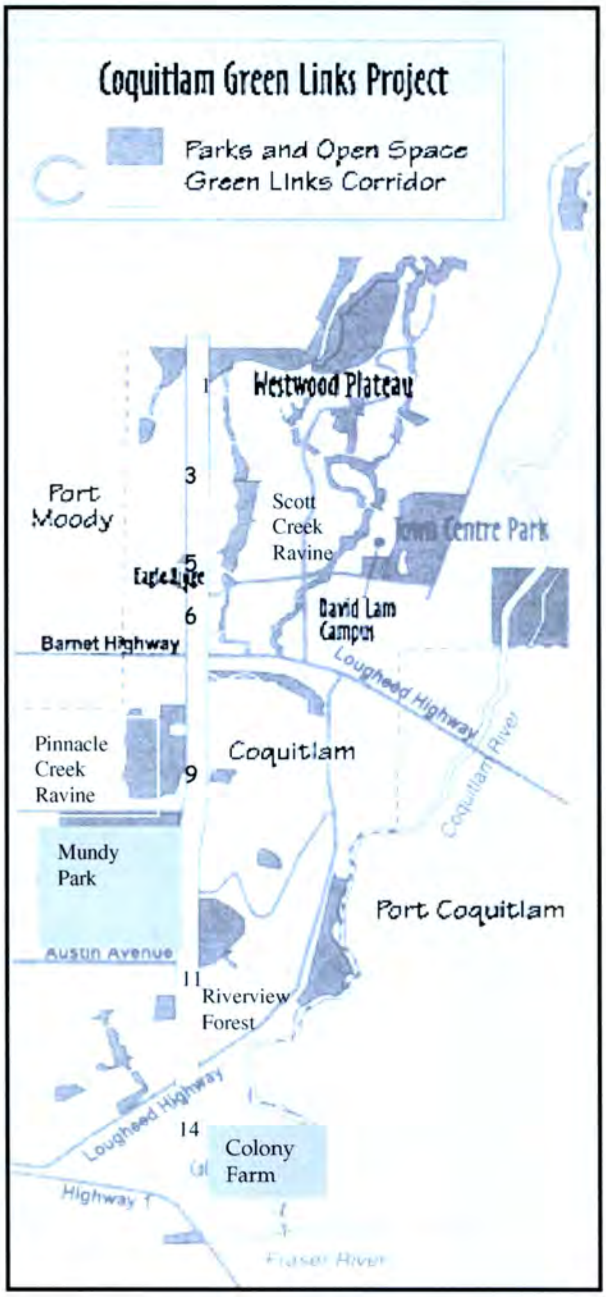

Fig. 1. The right-of-way in Coquitlam, British Columbia, used as the first Green Link Project demonstration site. The patches of green space it connects are shown in dark grey. The corridor links Scott Creek Ravine, Pinnacle Creek Ravine, Mundy Park, the Riverview Forest and Colony Farm. Sites 1, 3, 5, 6, 9, 11, and 14 are indicated as reference for the biodiversity index.

- *Colony Farm* (65 ha), a habitat of field and marsh adjacent to the Coquitlam River, was recently made into a Greater Vancouver Regional District Park in recognition of its natural value.
- *Riverview Lands* (31 ha), possesses an ecologically unique arboretum stewarded by the Riverview Horticultural Society and contains every tree species known to grow in British Columbia.
- *Mundy Park* (192 ha), a large municipal park containing a remnant forest and small lake with bog habitat, is on the top of a moraine marking the boundary

between the Burrard Inlet and Fraser River watersheds.

- *Pinnacle Creek ravine* (59 ha), part of the Chine Heights escarpment running between Coquitlam and Port Moody.
- *Scott Creek ravine* (8.5 ha), part of the Westwood Plateau and an important urban salmon stream of the Coquitlam River watershed.

RESULTS

Baseline biophysical inventories were completed for 14 sites along the right-of-way in 1996 (Schaefer and Sulek, 1997). The utility corridor supports 121 species of plants and 51 species of birds. The Simpson's biodiversity index for birds from the 14 sampling sites along the 8 km corridor (Fig. 2) ranges from 7.4–16.74, with an average of 10.7. The biodiversity index of 13.0 found at a site second closest to the wilderness fringe of the corridor was set as the 10-year target.

Implementation activities in 1996/1997 in the Coquitlam corridor included planting native vegetation at 7 locations with about 3000 plants covering approximately 6 ha, water channeling (1 location), removal of invasive species (Scotch broom, Himalayan blackberry, purple loosestrife) at 3 locations, and a plant salvage of 500 trees at 1 location.

A community survey of 2300 households resulted in 327 respondents, the majority of which appreciated the green spaces in their community and supported habitat enhancement work.

In 1996/1997, the Green Links Project as a whole, encompassing all three corridors, resulted in the planting of about 6000 plants covering about 10 ha, presentations to 2500 school children, construction of 350

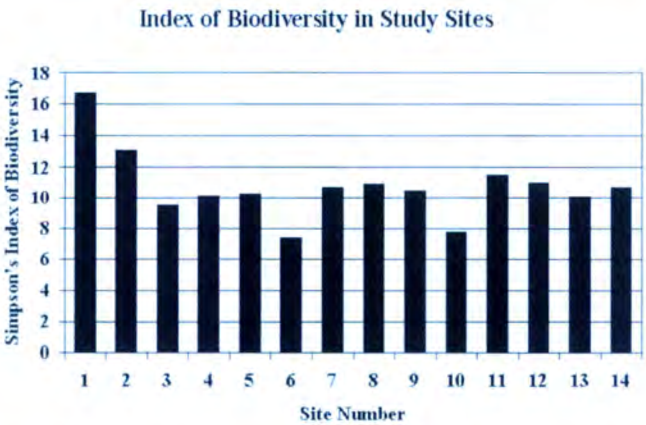

Fig. 2. Simpson's Index of biodiversity calculated for 14 sampling sites along the Coquitlam corridor. Site 1 is the farthest north next to the wilderness fringe. The five patches of green space (environmentally sensitive areas) joined by the utility corridor are represented by Sites 4, 5, and 6 adjacent to Scott Creek Ravine, Sites 7 and 8 adjacent to Pinnacle Creek Ravine, Site 10 adjacent to Mundy Park, Site 11 adjacent to the Riverview Lands, and Site 14 in Colony Farm Regional Park.

bird and bat boxes, community workshops attended by about 250 people, 70 newspaper and magazine articles, a symposium attended by 120 people representing over 30 organizations, 100,000 seeds of perennials mailed to households, over 1000 plants salvaged and the implementation of a native plant propagation program in 4 schools. About 600 people attended 12 public speaking engagements, and a Green Links Display was present at over 20 public events.

As of the year 2000, five years into the Green Links Project, 25,000 plants have been planted with the involvement of 3700 school children and community members.

Problems

The Green Links plantings were done in consultation with BC Hydro and City of Coquitlam. Unfortunately there was little or no communication with the maintenance staff who actually cut the vegetation on the sites with brush cutters or flail mowers. Such communication also proved difficult to establish because of staff changes in the mowing crews. A number of plantings were cut before we implemented a procedure to protect the perimeters of the plantings with logs. Signs are also used but are somewhat impractical because of vandalism.

DISCUSSION

Wildlife corridors are most effective if the plant species in the corridor approximate those in the green spaces they connect. Although rights-of-way are frequently "green" and perhaps even lush with vegetation, their biodiversity is typically low. The disturbance created in constructing the right-of-way favors the establishment of a few pioneer plant species. These can perpetuate themselves because the periodic cutting of the site to control the pioneers keeps the system perpetually in an early successional stage.

Planting more native species will encourage more use of the rights-of-way as a corridor by more species. In this way Green Links allows for the greater use, movement, dispersal, and interaction of plants and animals between more fragments of urban wildlife habitat. The stronger the connection, the greater the ecological value of the habitat. This should result in an increase of biodiversity to higher levels.

It will be difficult to scientifically prove a cause-and-effect relationship between the enhancement of rights-of-way and increased biodiversity. There are no controlled conditions in this natural experiment. Habitat is being destroyed, or enhanced, in other places used by the wildlife, perhaps even in wintering areas found in other countries. Conversely, positive changes may be due to conservation measures taken elsewhere. These changes may override the impacts of the Green Links project in ways which are unknown or cannot be measured Nevertheless, the relationship between increased biodiversity in corridors and its significance in connectivity is well established and should not be ignored.

ACKNOWLEDGEMENTS

The Green Links Project was established through the efforts of Gary Holisko of BC Hydro and Sharon McCarthy of BC Gas. Mart Sulek of Douglas College played an important role in building community partnerships. The Coquitlam Link is being created in partnership with Rick Daykin, David Palidwor and Mike Nihls of the City of Coquitlam Parks Department. Many thanks to the community members and participants of youth employment programs who made Green Links possible.

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BIOGRAPHICAL SKETCH

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Wildlife Use of Riparian Vegetation Buffer Zones in High Voltage Powerline Rights-of-Way in the Quebec Boreal Forest

Francis Bélisle, G. Jean Doucet, and Yves Garant

TransÉnergie operates a network of 33,000 km of high voltage powerlines. Approximately 6000 riparian vegetation buffer zones are located in these rights-of-way (ROWs), mostly to protect stream habitat. A field study was conducted in 1998 and 1999 to compare spring and summer wildlife activity in riparian vegetation buffers in rights-of-way to that in riparian habitat in adjacent forest. Vegetation structure in buffers consisted of a low stratum with a high herbaceous cover and high stem density of small DBH. Riparian vegetation in adjacent forest was characterized by higher vegetation, and a lower stem density with a higher mean DBH. A total of 49 buffer zones were sampled for vegetation, mammals, and anurans. We captured 1436 individuals from 11 species of small mammals during 10,080 trap-nights over two years. Results show a similar abundance of small mammals in buffers and adjacent forest but there were differences in species composition and species diversity. Pigmy shrew and rock vole, two uncommon species in this region, were captured in both habitats. The presence of black bear, snowshoe hare, ruffed grouse, and porcupine was detected inside vegetation buffers. Anuran and bird vocal activity was similar in buffers and adjacent forest.

Keywords: Buffer zones, small mammals, anurans, birds, biodiversity

INTRODUCTION

TransÉnergie operates a network of 33,000 km of high voltage powerlines and approximately 6000 vegetation buffer zones are located in these rights-of-way, mostly to protect stream habitat. These riparian buffers are made up of woody vegetation strips about 10 m wide, and span the width of the rights-of-way. The majority of these buffer zones were left in place when the ROWs were originally cleared. It was assumed that such buffer zones would protect streams from erosion and siltation while maintaining physical attributes of both aquatic and riparian habitats. The role of these buffer zones for terrestrial wildlife was never evaluated (Deshaye et al., 1996). In recent years, it has been postulated that forested buffer zones in ROWs in the dry boreal forest were a hazard for conductors, often resulting in outages when a forest fire ran underneath the conductors. Rights-of-way have also been suspected of presenting barriers to some species of small mammals (Schreiber and Graves, 1977). Consequently, there was some pressure to remove trees and convert forested buffer zones into permanent shrubby areas. The objective of the study was to compare wildlife activity in riparian vegetation buffers in ROWs to that in riparian habitat in the adjacent forest. Our study focused mainly on the activity and abundance of passerines, anurans, and small mammals.

STUDY AREA

Field work was carried out during two consecutive summers (1998, 1999) in the southern limit of the boreal forest, north of Baie Comeau and Forestville, Quebec (49°20′N, 68°80′W). The study area was about 10,000 km^2. It was located in the Grenville geologic province, which is dominated by igneous rocks, and where deposits are limited, thin, and more important

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in valleys. The study area is made up mainly of an uneven plateau broken by the deep valleys of the Manicouagan, Outardes and Bersimis rivers. The altitude varies between 50 and 500 m ASL. The forest vegetation is composed mainly of balsam fir (*Abies balsamea*), black spruce (*Picea mariana*), white birch (*Betula papyrifera*) and, to a lesser extent, trembling aspen (*Populus tremuloides*). Large clear-cuts and burnt areas are also common features of the landscape. Streamside vegetation was characterized mainly by alder (*Alnus* spp.), willows (*Salix* spp.) and other shrubs. Buffer zones were selected from 17 different powerlines of 315 kV (60–90 m wide) and 735 kV (120–150 m wide) based on the vegetation structure in the buffer zones and access from existing roads. A total of 2423 spans were examined to select about 50 suitable buffers contiguous to similar control sites.

METHODS

Study design

We defined buffer zones as the strip of riparian vegetation (about 10 m wide) located on each side of a stream crossing a high voltage powerline ROW (Fig. 1). In order to compare wildlife activity or abundance, each buffer was paired to a control represented by a riparian habitat of the same size located along the same stream in the adjacent and relatively undisturbed forest. Buffer zones spanned the entire width of the ROW. Controls were set at least 150 m from the buffers.

A first group of 10 sites were located north of Baie-Comeau and a second group of 39 sites were located north of Forestville. In these 49 sites, five groups were sampled: vegetation, small mammals, birds, anurans, and mid-size mammals. Sampling took place in August 1998 and 1999 for vegetation, small mammals, and mid-size mammals. Vocal activity of birds and anurans was sampled only during spring of 1999.

Vegetation structure

Vegetation structure was evaluated in 49 sites at 2 sampling stations in both buffer and control zones, using 4 variables. Circular sampling stations (40 m^2) were established on each side of riparian habitat, along small mammal trapping transects. Low vegetation composition (<0.5 m high) was measured using a modified point intercept method (Jonasson, 1988). Using this method, vegetation classes (deciduous shrubs, coniferous shrubs, herbs, bare ground, mosses, and woody debris) were identified at all intersection points within a table grid (50 × 50 cm) containing 36 intersection points. High vegetation composition (>0.5 m high) was determined by measuring diameter at breast height (DBH) of each tree in the sampling station, for 3 diameter classes (0.5–3.0; 3.1–7.0, and >7.0 cm) and 3 vegetation classes (deciduous, coniferous, and snags). Lateral vegetation density was measured using a vegetation profile board (Nudds, 1977) 2 m high by 0.3 m wide divided in 4 rectangles of 0.5 m in height. The percentage of lateral visual obstruction was estimated by an observer standing 15 m north and south of the board. Percentage of obstruction was noted by classes of 20% (0–20; 21–40; 41–60; 61–80; 81–100%) for each rectangle.

Small mammals

Small mammals were trapped in 49 sites using Museum Special traps, Victor Mouse traps (Ecko Canada), and pitfalls (2L plastic containers), distributed along linear transects, parallel to the stream, in the middle of the riparian habitat. Sampling stations were set 10 m apart in such manner as to cover the entire width of the right-of-way. In both buffer and control zones, 16 trapping stations were positioned (8 on each side of the stream) along the transects. One Museum Special trap and one Victor Mouse trap were set side-by-side at each station. One pitfall trap was also set beside

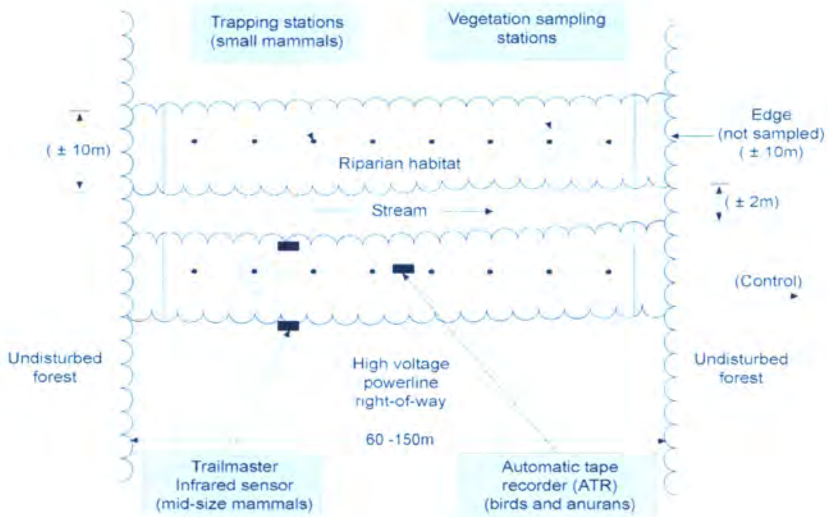

Fig. 1. Study design.

snap traps at each station in 8 sites in 1999. Traps were baited with peanut butter and oatmeal, left in place for 3 consecutive nights, and visited daily. Pitfalls were half filled with water and set with the opening at ground level. Each extremity of the buffer zone between the right-of-way and the surrounding forest was not sampled to minimize edge effect. Small mammals were identified to species level (Banfield, 1977) and total body mass (±1 g) was determined for each specimen captured. Small shrews were kept to double check identification using dental structure analysis according to Van Zyll de Jong (1983).

Birds and anurans

Vocal calls of birds and anurans were recorded at 8 sites in 1999 using automatic tape recorders (ATR) coupled to a programmable timer. An ATR was set in both buffer and control zones and left in place for 3 consecutive nights. Vocal calls were recorded synchronously in both zones during 3-minute periods distributed between 2 recording sessions, for a total of 15 minutes of listening per day. Field tests conducted in 1998 revealed that ATR registered calls only in short range so that buffer and control can be considered independent. A first recording session occurred in the morning (4h00 and 5h00) and a second one in the evening (20h00, 21h00, and 22h00). Birds and anurans were subsequently identified with their respective vocal calls using reference calls (tapes, CD).

Mid-size mammals

The presence of mid-size mammals in buffer and control zones was assessed in 2 sites in 1998 and 8 sites in 1999 using Trailmaster® infrared sensors (model TM 1500) coupled to a photographic camera (model TM-35). Infrared sensors were left in place for 4 consecutive nights and were installed on one side of riparian habitats, perpendicular to the stream, on an axis covering the entire width of the vegetation buffer zone (10 m). The infrared sensor was placed just above the ground in such a manner as to register each animal passing. A flash slave was used for better quality photography. A bait (peanut butter and oatmeal) was placed on the ground at the half way point (5 m) of the transect during sampling. Infrared sensors were visited daily and data were logged relative to passage counts and pictures taken (number of events, date, and hour).

Data analysis

Comparison analysis between buffer and control zones considered those 2 habitats to be within a complete random block. Data collected in 10 sites in 1998 were first statistically treated to adjust sampling methods and effort for sampling period of 1999. Almost all data from 1998 and 1999 were subsequently pooled and statistically treated.

Data on low vegetation structure were expressed as percent cover by vegetation classes. Data on high vegetation structure were expressed as the number of woody stems/40 m^2 for each vegetation classes and each DBH. Data on lateral visual obstruction were expressed as mean percentage (%) by height levels for north and south sides and for total height of the board using ANOVA. Data on vegetation height were compared using ANOVA (SAS Institute, 1997). Relative abundance of small mammals (captures/100 trap-nights) and total body mass of specimens captured were compared using ANOVA. The Shannon index (Zar, 1984) was used to compare vegetation and small mammal species diversity between buffer and control zones and was calculated as follow:

$$H = \frac{n \log n - \sum fi \log fi}{n},$$

where H is the Shannon index, n is the number of small mammals captured in one stratum, and f is the number of small mammals captured/species in the same stratum.

Bird and anuran calls were computed as number of 3-minute periods with at least 1 call heard for one species. This procedure was established to minimize the bias of counting a high number of individuals for a given species without knowing if calls were emitted by one or many individuals. Vocal activity was expressed as occurrence probability (% of chance for a given species to be heard during a 3-minute period). Data were analyzed for dominant species to compare vocal activity between buffer and control zones using a LOGIT model (McCullagh and Nelder, 1989). Data for mid-size mammals were limited and no statistical analysis was performed. Results are nevertheless presented and discussed on a descriptive basis.

RESULTS AND DISCUSSION

Vegetation structure

The goal of the vegetation sampling done in this study was to establish vegetation variables, relevant to rights-of-way and robust enough to support the discussion of the wildlife sampling results. Vegetation in buffers consisted of a low stratum with a high density of small woody stems and herbaceous cover (Table 1). The vegetation in the adjacent control was characterized by a high stratum with a low stem density and a high mean DBH. In the vegetation stratum >50 cm above ground, there were significantly more small trees and more deciduous cover in the buffer zones than in the forested control. There were more large snags (DBH > 7.0 cm) in the control areas than in the buffer zones. Species richness (woody species) was higher in the control zones. Vegetation ≤1 m in height was denser in the buffer than in the control zones. Overall, the vegetation available to wildlife as cover or food under 1m in height was greater in the buffer zones than in the adjacent forest.

Table 1. Comparison of vegetation structure measured in 1998–1999 (mean ± SD) between buffer and control zones; underlined values are significantly higher (ANOVA, $P < 0.01$, $n = 49$ sites). DBH = diameter at breast height.

	Buffer zones	Control	*P* value
Low vegetation stratum (<0.5 m high) (% of ground cover)			
Coniferous shrubs	1.08 ± 0.83	4.08 ± 0.83	0.0136
Deciduous shrubs	21.86 ± 3.38	20.20 ± 3.38	0.7294
Herbs	<u>55.74 ± 2.97</u>	31.79 ± 2.96	<0.0001
Mosses	7.34 ± 1.72	13.38 ± 1.72	0.0166
Bare ground	7.55 ± 1.99	14.78 ± 1.98	0.0130
Woody debris	6.44 ± 1.70	<u>15.77 ± 1.70</u>	0.0003
High vegetation stratum (>0.5 m high) (stems/40m^2)			
All species and DBH	<u>35.29 ± 2.95</u>	23.66 ± 2.95	0.0076
(0.5–3 cm DBH; all species)	<u>32.81 ± 2.93</u>	19.49 ± 2.93	0.0023
(3.1–7 cm DBH; all species)	2.24 ± 0.45	2.51 ± 0.45	0.6778
(>7 cm DBH; all species)	0.23 ± 0.14	<u>1.65 ± 0.14</u>	<0.0001
Coniferous cover (all DBH)	1.05 ± 0.27	<u>2.73 ± 0.27</u>	<0.0001
Coniferous cover (0.5–3 cm DBH)	0.64 ± 0.18	1.17 ± 0.18	0.0386
Coniferous cover (3.1–7 cm DBH)	0.24 ± 0.10	<u>0.74 ± 0.10</u>	0.0008
Coniferous cover (>7 cm DBH)	0.17 ± 0.12	<u>0.82 ± 0.12</u>	<0.0001
Deciduous cover (all DBH)	<u>33.42 ± 3.05</u>	19.53 ± 3.05	0.0023
Deciduous cover (0.5–3 cm DBH)	<u>31.45 ± 2.94</u>	17.62 ± 2.94	0.0017
Deciduous cover (3.1–7 cm DBH)	1.91 ± 0.46	1.35 ± 0.46	0.3819
Deciduous cover (>7 cm DBH)	0.06 ± 0.09	<u>0.56 ± 0.09</u>	0.0003
Snags (all DBH)	0.81 ± 0.18	1.40 ± 0.18	0.0205
Snags (0.5–3 cm DBH)	0.71 ± 0.15	0.70 ± 0.15	0.9608
Snags (3.1–7 cm DBH)	0.09 ± 0.06	<u>0.43 ± 0.06</u>	0.0003
Snags (>7 cm DBH)	0.00 ± 0.04	<u>0.28 ± 0.04</u>	<0.0001
Specific richness (Index)			
Shannon	0.60 ± 0.06	<u>1.01 ± 0.06</u>	<0.0001
Vegetation height (m)			
Visual mean height of vegetation in habitat	3.42 ± 0.64	<u>10.31 ± 0.64</u>	<0.0001
Horizontal visual obstruction (% of visual obstruction)			
From ground up to 2 m high	71.06 ± 2.48	74.13 ± 2.48	0.3876
Ground to 0.5 m high	<u>56.28 ± 2.74</u>	37.30 ± 2.74	<0.0001
From 0.5 to 1.0 m high	<u>47.44 ± 2.74</u>	36.66 ± 2.74	0.0058
From 1.0 to 1.5 m high	31.66 ± 2.74	30.64 ± 2.74	0.7909
From 1.5 to 2.0 m high	21.40 ± 2.74	23.58 ± 2.74	0.5959

Small mammals

During the summers of 1998 and 1999, we captured 1436 small mammals belonging to 11 species, for a trapping effort of 10,080 trap-nights (all trap types, Table 2). Red-backed vole, woodland jumping mouse, and deer mouse were the 3 most abundant species and accounted for 55% of the total number of small mammals captured. Red-backed vole and deer mouse are relatively abundant species in this region but the high abundance of woodland jumping mouse was unexpected since this species was relatively rare in the same area a few years ago (Bélisle, 1997).

Overall mean relative abundance of 14.36 and 14.02 small mammals/100 trap-nights were similar between buffer and control zones, respectively (ANOVA, $P =$ 0.8121). The similarity of overall relative abundance was unexpected because of the clear difference in vegetation structure between the 2 zones. O'Connell and Miller (1994) have demonstrated that the overall relative abundance of small mammals can remain high in mechanically disturbed sites where some vegetation was left in place, resembling buffer zones in our study.

A species habitat segregation seems to have occurred between the 2 zones. Buffer zones were dominated by woodland jumping mouse (2.83 captures/100 trap-nights), meadow jumping mouse (2.58 captures/100 trap-nights) and meadow vole (2.41 captures/100 trap-nights). The latter 2 species and short-tailed shrew were significantly more abundant in buffers (ANOVA,

Table 2. Comparison of small mammals relative abundance (captures/100 trap-nights) measured in 1998–1999 (mean ± SD) between buffer and control zones; underlined values are significantly higher (ANOVA, $P < 0.01$, $n = 49$ sites).

Species	Buffer zones	Control	P value
Red-backed vole (*Clethrionomys gapperi*)	1.89 ± 0.85	<u>4.97 ± 0.85</u>	0.0003
Meadow vole (*Microtus pennsylvanicus*)	<u>2.41 ± 0.45</u>	0.88 ± 0.45	0.0066
Rock vole (*Microtus chrotorrhinus*)	0.06 ± 0.03	0.02 ± 0.03	0.1679
Deer mouse (*Peromyscus maniculatus*)	1.36 ± 0.38	<u>2.59 ± 0.38</u>	0.0050
Meadow jumping mouse (*Zapus hudsonicus*)	<u>2.58 ± 0.29</u>	0.40 ± 0.29	<0.0001
Woodland jumping mouse (*Napaeozapus insignis*)	2.83 ± 0.56	2.37 ± 0.56	0.4443
Masked shrew (*Sorex cinereus*)	2.00 ± 0.40	2.39 ± 0.40	0.3178
Pygmy shrew (*Microsorex hoyi*)	0.06 ± 0.03	0.03 ± 0.03	0.1594
Water shrew (*Sorex palustris*)	0.09 ± 0.03	0.00 ± 0.03	0.0264
Short-tailed shrew (*Blarina brevicauda*)	<u>1.01 ± 0.13</u>	0.24 ± 0.13	<0.0001
Eastern chipmunk (*Tamias striatus*)	0.08 ± 0.04	0.12 ± 0.04	0.4517
All species	14.36 ± 1.28	14.02 ± 1.28	0.8121

$P < 0.01$). Adjacent control zones were dominated by red-backed vole (4.97 captures/100 trap-nights), deer mouse (2.59 captures/100 trap-nights), masked shrew (2.39 captures/100 trap-nights) and woodland jumping mouse (2.37 captures/100 trap-nights). The abundance of red-backed vole and deer mouse was significantly higher in control areas (ANOVA, $P < 0.01$).

Meadow voles are known to be relatively abundant in habitats such as grassland, herbaceous, and generally disturbed habitats (Grant, 1975, 1971; Alder and Wilson, 1989). According to our results, meadow vole and short-tailed shrew were more abundant in buffers, which contained more herbs than controls. Their relative abundance in this type of disturbed habitat was, respectively, 2.5 and 4 times higher than in a forested habitat. The presence of the short-tailed shrew has been documented in several types of habitat and can be considered a generalist species, often associated to riparian habitat (Banfield, 1977; DeGraaf and Yamasaki, 1999).

Red-backed vole and deer mouse have been associated with more woodland habitat structure (Grant, 1975; Maisonneuve and Rioux, 1998) while some authors have classified them as habitat generalists (Maisonneuve et al., 1996). Our results show that these two species were more abundant in woodland habitat like control zones when compared to a more shrubby and herbaceous habitat like buffer zones in rights-of-way. Consequently, differences in small mammal composition between buffer and control zones could be explained by differences in vegetation structure along the same riparian habitat. These results stress the importance of considering the vegetation structure when explaining species habitat segregation (Jules et al., 1999).

Three relatively rare species were captured in the buffer and control zones. Four specimens of rock vole, one of the rarest small mammals in Quebec and Canada (Banfield, 1977; Beaudin and Quintin, 1991), were captured in both habitats. Five specimens of pygmy shrew, also a very rare species in the area and sometimes mistaken for masked shrew (Banfield, 1977), were also identified in both habitats in 1999. Five specimens of the water shrew, a third relatively rare species in the area, were captured in buffers only, in 1998 and 1999. These results suggest that for rare small mammals species, composition in the buffers is similar to the one in the adjacent forested habitat.

Comparison of mean body mass of the 6 most abundant species revealed no significant difference between buffers and controls (ANOVA, $P > 0.01$). Nevertheless, a tendency can be seen for at least 2 species of voles; red-backed vole and meadow vole, for which mean body mass was higher in buffers. Red-backed vole mean body mass averaged 23.11 vs. 20.04 g in buffers and forested habitats (control) respectively. Meadow vole mean body mass was 25.86 g in buffers compared to 20.18 g in controls (Table 3). Mean body mass values of the more abundant species were similar to those found in the literature for Canada and Quebec (Banfield, 1977; Beaudin and Quintin, 1991). The higher mean body mass found in buffer zones for these 2 species could be associated to a denser herbaceous and generally low stratum vegetation, offering food source and cover for microtines (Birney et al., 1976).

Species diversity of small mammals was significantly higher in buffer than in control habitat (Table 4, ANOVA, $P = 0.002$). The Shannon index is a function of the number of species in a given habitat and the distribution of abundance between those species in the same habitat. Since overall abundance and number of species are similar between the 2 habitats, it appears that the difference is due to the distribution of abundance between species in each habitat. In control zones, 88% of the overall abundance can be explained mainly with values from 4 species while in the buffer zones, relative abundance of 6 species are required to explain the same level of abundance. From this point of view, buffer zones could be considered to have more small mammal diversity than the surrounding forest.

Table 3. Comparison of mean body mass (g) of the more abundant small mammals species captured in 1998–1999 between buffer zones and control (ANOVA, $P < 0.01$, $n = 49$ sites).

Species	Buffer zones	Control	*P* value
Red-backed vole (*Clethrionomys gapperi*)	23.11 ± 1.35	20.04 ± 0.71	0.0567
Meadow vole (*Microtus pennsylvanicus*)	25.86 ± 1.04	20.18 ± 1.88	0.0178
Deer mouse (*Peromyscus maniculatus*)	17.64 ± 0.61	17.66 ± 0.49	0.9771
Meadow jumping mouse (*Zapus hudsonicus*)	16.03 ± 0.61	14.86 ± 1.22	0.4220
Woodland jumping mouse (*Napaeozapus insignis*)	22.00 ± 0.54	22.39 ± 0.70	0.6712
Masked shrew (*Sorex cinereus*)	3.82 ± 0.39	4.12 ± 0.34	0.5766

Table 4. Comparison of small mammals specific richness (Shannon index) measured in 1998–1999 between buffer and control zones; underlined values are significantly higher (ANOVA, $P < 0.01$, $n = 49$ sites).

	Buffer zones	Control	*P* value
Specific richness	<u>1.32</u>	1.09	0.0021

Birds

Twenty-four and 23 species of birds were identified, respectively, in the buffer and control zones based on their vocal activity recorded by ATR (Table 5). Eighteen of these species were common to both zones. White-throated sparrow, Swainson's trush, and American robin were the most frequently recorded in both zones. Approximately 60% of birds were recorded 5 or more times in a given habitat (buffer or control). Most birdcalls (70%) were recorded at sunrise. Six species were found only in buffer zones: ovenbird, Lincoln sparrow, solitary vireo, northern flicker, American redstart, and northern parula. The vocal activity of the latter 3 species however was recorded in 1 period only and their presence in buffer zones was considered anecdotal. The Lincoln sparrow, an open habitat species, was detected in 4 periods in buffer zones but never in control zones (Table 6). Occurrence probability of the alder flycatcher, another early-successional habitat species, was almost 3 times greater in the buffer areas but the difference was not statistically significant (Table 6, LOGIT model, $P = 0.097$). In a northern mixed forest landscape, Morneau et al. (1999) measured significantly higher abundance of alder flycatcher in powerline rights-of-way.

If we exclude species that were detected only once, the black-throated green warbler was the only species found only in the control zones. This species is often associated with closed canopy of deciduous or coniferous stands (Thompson and Capen, 1988). The black-throated green warbler was not detected in a powerline ROW of a mixed landscape, but breeding pairs were observed in the edge and interior forest (Morneau et al., 1999).

Among the 8 most common species, the white-throated sparrow, common yellowthroat, magnolia warbler and Nashville warbler form a seral association linked with early succession (regeneration and pole stand) habitats (Thompson and Capen, 1988). Swainson's thrush is generally associated with coniferous stands but it is also observed in dense understory of younger habitat where it often breeds (Gauthier and Aubry, 1995).

Table 5. Comparison of vocal activity (number of 3-minute periods with at least 1 vocal call heard for one given species) for all birds and amphibians heard between buffer and control zones ($n = 10$ sites).

Species	Buffer	Control
Birds		
White-throated sparrow (*Zonotrichia albicolis*)	57	55
Swainson's thrush (*Catharus ustulatus*)	25	31
Common yellowthroat (*Geothlypis trichas*)	30	21
American robin (*Turdus migratorius*)	30	13
Alder flycatcher (*Empidonax alnorum*)	29	4
Magnolia warbler (*Dendroica magnolia*)	18	10
Nashville warbler (*Vermivora ruficapilla*)	17	8
Northern waterthrush (*Seiurus noveboracensis*)	13	11
Red-eyed vireo (*Vireo olivaceus*)	11	8
Winter wren (*Troglodytes troglodytes*)	8	7
Chestnut-sided warbler (*Dendroica pensylvanica*)	5	9
Veery (*Catharus fuscescens*)	5	8
Hermit thrush (*Catharus guttatus*)	5	6
Ruby-crowned kinglet (*Regulus calendula*)	1	7
Yellow-rumped warbler (*Dendroica coronata*)	2	4
Ovenbird (*Seiurus aurocapillus*)	6	0
Lincoln's sparrow (*Melospiza lincolnii*)	4	0
Common nighthhawk (*Chordeleis minor*)	2	1
Least flycatcher (*Empidonax minimus*)	2	1
Solitary vireo (*Vireo solitarius*)	3	0
Black-throated green warbler (*Dendroica virens*)	0	2
Hairy woodpecker (*Picoides villosus*)	1	1
Northern flicker (*Colaptes auratus*)	1	0
Common raven (*Corvus corvax*)	0	1
Dark-eyed junco (*Junco hyemalis*)	0	1
White-winged crossbill (*Loxia leucoptera*)	0	1
Northern parula (*Parula americana*)	1	0
Black-capped chickadee (*Parus atricapilus*)	0	1
American redstart (*Setophaga ruticilla*)	1	0
Anurans		
Spring peeper (*Hyla crucifer*)	38	17
Wood frog (*Rana sylvatica*)	9	1
American toad (*Bufo americanus*)	2	3

The vegetation profile in the buffer zones was characterized by a dense deciduous cover made of poles and saplings. This structure should theoretically provide good breeding and feeding habitat for edge and open habitat species such as the Nashville and

Table 6. Comparison of occurrence probability (percent chance to be heard per 3-minute periods) of the more abundant birds and anurans species identified between buffer and control zones (LOGIT model, $P < 0.01$, $n = 8$ sites).

Species	Buffer	Control	*P* value
Birds			
White-throated sparrow (*Zonotrichia albicolis*)	42.7 ± 8.5	40.1 ± 8.5	0.7516
Swainson's thrush (*Catharus ustulatus*)	20.1 ± 7.0	26.7 ± 11.1	0.5819
Common yellowthroat (*Geothlypis trichas*)	21.8 ± 8.9	10.3 ± 5.4	0.2433
American robin (*Turdus migratorius*)	23.6 ± 5.8	10.4 ± 3.6	0.0967
Alder flycatcher (*Empidonax alnorum*)	24.5 ± 8.8	8.8 ± 4.2	0.1170
Magnolia warbler (*Dendroica magnolia*)	6.8 ± 5.4	3.1 ± 2.9	0.3515
Nashville warbler (*Vermivora ruficapilla*)	12.7 ± 4.1	9.3 ± 3.2	0.4311
Northern waterthrush (*Seiurus noveboracensis*)	6.4 ± 3.9	3.8 ± 2.8	0.5339
Amphibians			
Spring peeper (*Hyla crucifer*)	45.0 ± 8.3	29.1 ± 7.5	0.2363

magnolia warblers. Darveau et al. (1995) observed that 20 m wide forested strips were more favorable to ubiquitous species than to forest dwelling species. We did not measure the number of breeding pairs at each site and our study does not provide precise bird abundance in each type of habitat. However, if we assume that breeding birds have a similar level of vocal activity, no matter which type of habitat they occupy, our results would then suggest that bird abundance in streamside habitat in powerline ROWs could be comparable to abundance in the adjacent control areas. In landscapes where forest harvesting is dominant, bird abundance in streamside zones can be correlated with streamside zone width (Darveau et al., 1995; Dickson et al., 1995). In our study area, the landscape was largely dominated by forest and the impact of 60–150 m wide powerline ROWs is most likely different than the impact of a large clear-cut.

Anurans

Spring peeper was the most active anuran species with respectively 38 and 17 3-minute periods with at least 1 call in the buffer and control zones (Table 5). The occurrence probability however was not statistically different (LOGIT model, $P = 0.236$, Table 6). The wood frog and the American toad were also detected in both zones: but their vocal activity was less frequent with respectively 10 and 5 periods. Vocal activity of anurans was greatest during the night recording sessions (82.9% of all periods). The American toad and the wood frog are common inhabitants of the boreal biome (Cook, 1984). Based on their specific life history information such as habitat and food requirements, mobility and reproductive strategies, these species are considered among the least vulnerable to transmission corridors and facilities (Kamstra et al., 1995). Even though our sampling effort (8 sites) was not as extensive as the effort (49 sites) for small mammals, our results suggest that anuran activity in buffer zones is comparable to the activity in the adjacent undisturbed riparian zone. We found the same species in those two habitats with a higher, although not significant, occurrence probability in the rights-of-way. A higher number of replicates would be necessary to detect any significant differences, between the 2 zones.

In the past decade, anurans and more generally, amphibians, have been the focus of increasing concern because of many reported population declines (Semlitsch, 2000). Forest fragmentation can impede juvenile dispersal and has been identified as one of the many possible causes of the decline. Vegetation in both the understory and overstory layers contributes to closure of forest canopy and are important structural elements of forest anuran habitat (deMaynadier and Hunter, 1999). Buffer zones in powerline ROWs had a different vegetation profile than control areas (Table 1). Large snags, trees (DBH > 7.0 cm), and woody debris were significantly less abundant in buffer zones. Overall stem density, herbaceous and lateral cover (height <1 m) however were highest in buffers and could possibly compensate, at least partially, for the lack of an overstory canopy. This would have to be tested in future research.

Mid-size mammals

In this study, our effort was oriented more towards testing the use of remote cameras to detect presence and activity levels of larger animals in buffer zones. We only operated 4 camera locations at a time. The data on large and mid-size mammals and grouse are presented in Table 7. Overall, black bear and snowshoe hare were most often recorded. Photographic data indicate presence (at least passage) of black bear, snowshoe hare, beaver, and ruffed grouse in buffer zones. No porcupine was photographed in buffer zones, but there was activity nearby. Porcupines likely cross rights-of-way using buffer zones but the general absence of large trees in most buffer zones make them unattractive to porcupines.

Sampling limitations

Buffer zones were sampled with the objective of assessing their use by wildlife represented by small

Table 7. Comparison of mid-size mammals species and grouse observed (pictures) between buffer and control zones in 1998–1999 ($n = 10$ sites).

Species	Buffer	Control	Total
Black bear (*Ursus americanus*)	1	2	3
Snowshoe hare (*Lepus americanus*)	2	3	5
American Beaver (*Castor canadensis*)	1	0	1
Ruffed grouse (*Bonasa umbellus*)*	1	0	1
American porcupine (*Erethizon dorsatum*)	0	1	1
All species	5	6	11

*Species not identified with other sampling method in this study.

mammals, birds, anurans, and mid-size mammals. Two sampling limitations were encountered during our study. First, a large number of sampling sites is needed to provide useful data for several taxa in order to test specific hypotheses related to birds. The second limitation was related to the relatively small size of buffer zones in rights-of-way and the difficulty of sampling for some wildlife species. In such small areas, the presence of people and/or trapping equipment could interfere with wildlife activity.

Small mammals were sampled using simple and inexpensive methods with snap traps and pitfalls that provided a great amount of data in a short time. The ATR technique used offers some advantages to researchers over other sampling techniques for birds and anurans. It is affordable and gives satisfactory results with limited manpower, for comparison between 2 sites as in this study. It does not however give any information on the abundance of anuran populations at a given site.

Infrared sensors were also used as a quick sampling method to assess mid-size mammal activity in riparian buffer zones. Infrared sensors are more expensive than the other sampling gear used but are easy to use and provided reliable data on species presence when coupled with a photographic camera. While the technique would be practical to obtain data in a given buffer zone, to sample a series of them simultaneously would require a large number of cameras, increasing costs and manpower.

CONCLUSIONS AND MANAGEMENT IMPLICATIONS

Overall, our results indicated that wildlife activity (small mammals, birds, and anurans) is somewhat similar in buffer zones and adjacent forest in wide powerline rights-of-way in the southern boreal forest. We recorded relatively high species richness and we even observed rare small mammals in right-of-way buffer zones. Differences in species richness and abundance are attributed to differences in vegetation structure in the 2 habitats. Most buffer zones in our study presented dense herbaceous cover, thick shrubby layer and absence of forested overstory canopy and were comparable to early succession habitat. Open habitat species such as the meadow vole and Lincoln sparrow were sampled more frequently in buffer zones. Right-of-way vegetation management has been shown to be favorable to the maintenance of biodversity in Sweden (Kyläkorpy and Gardenäs, 1997) and Doucet and Bider (1984) reported high small mammal, bird and amphibian activity in a narrow (20 m) experimental right-of-way. We can only speculate that buffer zones will contribute to biodiversity in rights-of-way; certainly the ecological trap issue must be considered in this context.

In 2000, amphibian populations appear to be cause for concern on a worldwide basis. In this context, perhaps rights-of-way can bring a modest contribution to the problem. Vegetation in overstory and understory layers contribute to provide cover and are important structural elements of forest amphibian habitat and the maintenance of natural vegetation buffer along streams increases the probability of amphibian persistence (Semlitsch, 2000). If powerline rights-of-way can maintain natural habitat attributes needed by amphibians along streams and wetlands (connectivity to breeding pools, woody debris, cover), we hypothesize that potential negative effects on anurans could be minimized.

Although our study did not test specifically the necessity of maintaining buffer zones in rights-of-way for wildlife in the boreal forest, data indicate that species richness was high, some rare species were present and amphibians were well represented. Therefore, we hypothesize that potential negative effects on the groups of species studied, especially amphibians, could be minimized by adopting a prudent management approach in the maintenance of vegetation buffer zones in transmission rights-of way. The average height of the vegetation in buffer zones was 3.42 m high and included some woody plants. Although our results do not permit conclusive statement on the importance of larger trees, we would advocate that buffers with a minimum of woody and herbaceous components be maintained at least in the low stratum. The structure of such buffers should include poles and saplings, along with shrubs and herbaceous species. In addition, it is only logical to recommend that the tallest tolerable arborescent vegetation should be maintained in ravines and deep narrow valleys.

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Endangered and Threatened Species and ROW Vegetation Management

Kevin McLoughlin

The electric utility industry concern for those species listed as endangered or threatened found to reside within our transmission and distribution line rights-of-way (ROW) is twofold; first we often welcome the fact that our ROW vegetation management practices have created these unique and valuable habitats that have allowed such "species of concern" to become a resident of the ROW environs. The basic objective of ROW vegetation management is to virtually eliminate, to the practical extent feasible and necessary, all the tall growing trees that could cause electrical disruptions from the ROW and conversely to facilitate the development of various low growing plant assemblages. This process, often referred to as Integrated Vegetation Management (IVM), then may provide opportunities (new ecological niches) for colonization by various endangered, threatened, rare, unique or other species of interest or concern within the confines of the limits of the ROW and/or its area of ecological influence, i.e., along the immediate ROW edge. The second concern is that due to these highly developed ROW vegetation management strategies that have promoted the floristic evolvement of the low growing shrubs, herbs, grasses, ferns, etc., the electric industry is now in some instances being "penalized" for having achieved these milestones in biodiversity in that costly studies, inventories, and surveys, are often requested/mandated when these listed endangered/threatened species (or even prospective ones) are "found" or even thought to occur on or close to our ROW. In addition, when these endangered/threatened species are actually physically detected on a ROW segment the resultant instantaneous reaction following their discovery by some members of the environmentally informed public and even some staff of environmental regulatory agencies is to immediately request a halt to all ongoing utility ROW vegetation management practices in the near vicinity of the newly discovered species of concern. This drastic "rescue" action is believed required to provide the species of concern needed "protection" and thus "preserve" it's ROW habitat from any further undue meddling by the electric utility. This paper explores the possible ramifications of the Endangered Species Act in regards to ROW vegetation management as well as some of the resulting potential consequences of regulatory programs designed to enhance the recovery of listed, proposed and even candidate species.

Keywords: Endangered species, threatened species, biodiversity, rights-of-way (ROW), vegetation management

IMPLICATIONS OF THE ENDANGERED SPECIES ACT IN REGARDS TO ROW VEGETATION MANAGEMENT

The Endangered Species Act (the Act) provides significant legal protection for those species that are listed by the Secretary of the Interior under one of two protected categories; either as an endangered or as a threatened species (E&T). An endangered species is one that is in danger of extinction throughout all or a significant portion of its range. A threatened species is one that is likely to become endangered in the foreseeable future. Both the lists for endangered species as well as threatened species stipulate the geographic range over which the species of concern is considered threatened or endangered. In addition, in some special instances, it will also specify any "critical habitat" within such a

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range that is also protected under a distinctly different regulatory criterion.

An interesting side note is that the Act prohibitions against the taking of listed fish and wildlife species apply only to endangered species and is not explicitly stated to cover those species listed as threatened. The protective language in the statute for those species to be listed as threatened is located within section 4(d) which specifies that the Secretary of the Interior is to issue regulations "as he deems necessary and advisable to provide for the conservation of such species." However, the Secretary has issued the regulations via the Fish and Wildlife Service (FWS) that apply the same section 9 prohibitions of the Act to both endangered and threatened species. Thus, from a practical application and management viewpoint, these two terms; endangered and threatened (E&T), once so legally distinct in the Act itself, are now virtually interchangeable in as far as their consequences regarding regulatory "rulemaking" restrictions apply.

One other relatively minor point to mention (at least for most ROW vegetation management scenarios) so as to insure adequate coverage of the macro issues surrounding the Endangered Species Act and its applicable regulatory requirements is that the FWS executes all the provisions of the Act, except for those provisions relating to ocean going fish, anadromous fish and marine mammals. All such provisions of the Endangered Species Act relating to maritime species are implemented by the National Marine Fisheries Service, of the National Oceanic and Atmospheric Administration (NOAA), which is located in the Department of Commerce. Interestingly, the National Marine Fisheries Service (NMFS) has not seen fit to adopt regulations that extend the same protections to threatened species as are provided to endangered species by the Interior's FWS (Jointly referred to as the "Services" in regulatory jargon.)

These listed E&T species are protected through two sections of the Act; section 7 which provides for a review and limitation of all Federal actions that may harm these listed endangered and threatened species; and section 9, which prohibits the taking of protected fish and wildlife anywhere, and forbids the destruction of protected plants on federal lands.

Section 7

Section 7 of the Act only applies to prospective Federal actions and the direct management of Federal lands. For most electric utilities, the provisions of section 7 would only be invoked by ROW vegetation management activities if a proposed federal agency action were involved. For example, the granting of a federal permit, such as a Federal Energy Regulatory Commission (FERC) license, is such a Federal action subject to section 7 review. In situations where ROW vegetation management activities are an integral part of or are by design encompassed within a pending FERC license an informal consultation with the Secretary of the Interior in concert with FERC would minimally be required. This informal contact begins when the agency or the applicant contacts the appropriate local FWS office to determine if any listed species are known to occur or possibly may occur in the project area vicinity. If the FWS provides a negative response, no further consultation is required.

However, when the applicant or Agency has reason to believe that a listed E&T species may be an occupant of the area affected by the proposed project then the Agency and the FWS must determine if the action will affect these species of concern. A "may effect determination" includes those actions not likely to adversely affect as well as those likely to adversely affect a listed E&T species. If the Agency and the FWS agree that the proposed action is not likely to adversely effect listed species (the effects are beneficial, insignificant, or discountable) no further consultation is needed.

However, when it is determined that implementation of such action will likely affect this species of concern, then the consultation process becomes formalized with specific timeframes coming into play. This request to initiate formal consultation is made by the Agency to the FWS in writing and is accompanied by a complete initiation package. With the initiation of a formal consultation process with the applicant and Agency (nominally a 90-day period) the FWS must then prepare and submit a biological opinion (within 45 days). The biological opinion is the document that states the opinion of the FWS as to whether or not the action is likely to "jeopardize" the continued existence of listed species or result in the destruction or "adverse modification" of critical habitat. If the biological opinion reaches a jeopardy or adverse modification of critical habitat conclusion, reasonable and prudent "alternatives" may be proposed for project implementation that would avoid or minimize impact to the species. Even if the FWS recognizes that a project will not jeopardize the species or adversely modify critical habitat it still may require additional reasonable and prudent "measures" be taken to minimize the impact of any potential for incidental take. If after all this, it is determined by the FWS that some unavoidable "take" will still occur then an incidental take statement must be developed to exempt such take from the section 9 prohibitions.

All Federal Agencies have a continuing obligation to contribute to the conservation of E&T species under section 7(a) (1) of the Act. The list of Federal land management actions that may activate the consultation process could conceivably entail even ordinary ROW vegetation management activities of a Federal utility such as the Bonneville Power Administration (BPA) or the Tennessee Valley Authority (TVA). In fact, any such ROW activity expected to occur in the near vicinity of E&T species by such a federal entity could, as a minimum, trigger the informal review/consultation procedures by the FWS. The potential reiterating of the informal review/consultation process activated by the annual implementation of routine ROW vegetation management actions of a Federal utility could become an incessant recurring affair to these entities as new species are added to the listings, new information emerges or fresh concern over the welfare of certain listed species appears within the FWS. It is a fact of life for such Federal Agencies; that of a reinitiating the consultation process with a constant reexamination of previous mitigation measures as well as a fresh look at all ongoing ROW vegetation management activities in regards to listed and even proposed new species listings. However, for the great majority of electric utilities contemplating vegetation management along their transmission line ROW, in the absence of any federal action, Section 7 would have very limited applicability.[1]

Section 9

Section 9 of the Act prohibits the *taking* by any *person* of any fish or wildlife species listed as endangered under the provisions of the Act. The term "person" used above refers to virtually anybody, i.e., individual, corporation, partnership, private entity, or government (federal, state, municipal or other political subdivision) employee or agent or any other entity subject to the jurisdiction of the United States. The acts that comprise a "taking" include such activities as harassing, harming, pursuing, hunting, shooting, wounding, killing, trapping, capturing, or collecting of an endangered (read threatened also) species or the attempt to engage in such conduct. Harm has also been interpreted to mean significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering.[2] Thus, significant adverse habitat modification on privately owned land can become a regulated undertaking within the purview of the Endangered Species Act if the action contemplated amounts to a taking of a listed E&T species as broadly defined above.

While listed fish and wildlife species secure ample protection under the Act (and subsequent regulations), section 9 applies a distinctly different and lesser level of protection to plants listed as endangered (including threatened[3]). Section 9(a) (2) makes it illegal to remove or damage plants endangered (or threatened) from federal lands, or from any property if it is done in knowing violation of any state law or regulation including state criminal trespass law. This prohibition is much more constrained than that provided to protect fish and wildlife species, as it only applies directly to federal lands and to those acts in contravention of state law.

Section 6

Section 6 of the Act provides a framework for the development of federal and state cooperative agreements. The Secretary of the Interior may enter into a cooperative agreement with any state, which establishes and maintains an adequate and active program for the conservation of endangered and threatened species. In order for a state program to be considered "adequate," it must be demonstrated that it is consistent with the Endangered Species Act and include all resident species of fish, wildlife and plants that are federally listed as endangered or threatened under the provisions of the Act. This arrangement for Federal and state cooperative agreements was adopted because delegation of the authority to the States was viewed as the most effective way to fulfill the provisions of the Act.[4] However, in practice executed cooperative agreements only establish a system of joint implementation and enforcement between the FWS and the reciprocating state environmental/natural resource agency.

For instance, New York State has entered into two separate cooperative agreements with the Interior's FWS, one for E&T fish and wildlife (1976) and another for E&T plants species (1983). While the primary purpose of the cooperative agreements is to provide a mechanism by which the federal government can fund a portion of the state's species conservation efforts, they also provide for the cooperation between the state's environmental/natural resource agency and the FWS in enforcing the Act and related state laws. In regards to the taking issue for E&T species, state law is specifically allowed to be more restrictive than federal law, but it is prohibited from being less restrictive.

Interim discussion

Electric utilities either own their ROW outright in fee or hold permanent easements that grant an ownership interest in the perpetuity of facility maintenance and the condition of the ROW to insure the safe and reliable transmission of electric energy. ROW vegetation management activities that involves the physical removal of incompatible vegetation or the treatment of target tree species by the judicious application of herbicides occurs either on property owned or essentially under the ownership of the utility. In New York, the state prohibitions against damaging protected plants can be waived by the landowner. Thus, the utility owner status nullifies the prohibition against damaging listed plants species at the federal level and under New York

1 For example, the consultation process for a Habitat Conservation Plan required to secure a section 10 permit is derived from section 7.

2 Babbit v. Sweet Home Chapter for a greater Oregon 1995.

3 By regulation, threatened species are afforded the same protection as endangered.

4 Senate Committee on Commerce Report on Endangered Species Act, S. Doc. No. 93-307 93rd Cong., 1st Sess. (1973).

State law, at the state level as well.[5] Therefore, in regards to all E&T plant species a violation of the Federal Endangered Species Act by the utility cannot occur in New York unless a protected plant is damaged on federal land because it is not in violation of state law.

Regarding the protection of fish and wildlife, unless essential habitat will be significantly modified to the extent that essential behavior patterns are impaired and actual species death and or injury occur, ROW vegetation management practices should not directly result in the harming or taking of any protected fish or wildlife. However, this determination is subject to a species-specific site by site resolution and assumes the vegetation management events at issue do not include the direct taking (e.g., wounding killing, trapping) of any protected fish and wildlife species. However, if a ROW segment is identified to overlap or encircle the essential habitat of E&T species of fish or wildlife, severe alteration of that habitat could be considered a taking, if essential behavioral patterns are jeopardized and actual species death or injury occurs.

Section 10

If it is determined that a taking will occur due to the ROW vegetation management operations, it is then necessary to first obtain a section 10 permit. Section 10 of the Endangered Species Act allows for the incidental taking of protected species in projects which otherwise have no Federal involvement. Section 10 permits will only be granted if a conservation plan is submitted and approved which details the incidental takings impact mitigation and offsetting strategies to be implemented. In practice, these conservation plans are referred to as Habitat Conservation Plans (HCPs) and typically require extensive involvement on the part of federal and state wildlife agencies before they are approved and the section 10 permit is granted.

Of all the various protective provisions of the Act provided to species listed as E&T, the ban against "taking" is one of the most essential. However, until 1982 there was simply no mechanism available under the Act to allow for the "take" of listed species that might occur inadvertently during the normal progression of events associated with various operations performed by private landowners. In 1982 Congress provided for such "taking" actions by amending Section 10(a)(1)(B) of the Act to allow for the issuance of "Incidental Take Permits" (ITP). An ITP authorizes the "take" of listed E&T species that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Thus, anyone who believes that his or her otherwise lawful activities will result in the "incidental take" of a listed E&T species requires a permit. Private parties wishing to conduct activities on their own lands that might result in the incidental take of a listed species cannot simply walk up to the FWS and ask for and receive an ITP. A HCP must be prepared and accompany an application for an ITP and then be approved by the FWS before a permit can be issued.

Habitat Conservation Plans and Incidental Take Permits

A HCP must include among other things, what the effects of the "taking" on the species will be and how those effects will be mitigated. HCP defines the "conserved habitat areas" which are areas explicitly designated for habitat restoration, acquisition, protection or other conservation purposes. The eventual settlement of the many issues in large HCPs can be a daunting exercise, requiring in some cases years of preparatory work. Once the HCP is completed, processing the permit application can likewise be complex and difficult undertaking requiring copious amounts of time. Publication in the Federal Register and a mandatory public comment period as was well as NEPA compliance and the possible generation of an Environmental Assessment (EA) or even a full Environmental Impact Statement (EIS) as well as other review requirements of the Endangered Species Act itself are all part of the process. While processing the application the FWS will prepare an intra-Service biological opinion under Section 7 of the Act and the ITP, and finalize any NEPA documents required. Consequently, ITPs have a number of associated documents besides the HCP.

No surprises assurances

Once completed, the HCP approach allows private development to proceed while at the same time ensuring the conservation of the species listed as E&T. As an extra incentive for landowners to go through such an arduous process, additional promises are provided by the government through what was known as the "No Surprises" assurances that provides more certainty in regards to future E&T regulatory activities. Basically, private landowners are assured that if unforeseen circumstances arise, any adjustments or modifications by the FWS will not require the commitment of additional land, water or financial compensation or additional restrictions on the use of land, water or other natural resources otherwise available for development beyond the level otherwise agreed to in the HCP with out the consent of the permittee. As noted above, there are no Federal prohibitions under the Act for the take of listed plants on non-Federal land, unless taking of those plants is in violation of State law. However, before the FWS issues an IT permit, the effects of the permit on listed plants must likewise be analyzed because section 7 of the Act requires that the approval of a HCP and issuance of an ITP must not jeopardize any listed species, including plants. Moreover, currently unlisted species can also be named on the HCP permit.

5 Since each state can pass laws and set it's own E&T species rules to be more restrictive then the federal requirements one must check the respective state laws and their subsequent rule makings in regards to the state-specific body of law.

Case studies

Two examples are available of HCPs that may have some bearing on the application of this unique partnership to electric utility ROW vegetation management programs. The Karner blue butterfly is a listed species on both the Federal and on the state level in New York. Some of the most productive Karner blue habitat is found on electric transmission line ROW that has the prerequisite host species for the butterfly larvae, the blue lupine, growing in abundance. The blue lupine is an open growing and sunloving, relatively shade intolerant species that is one of the many potential low growing species that may occupy ROW that have had the tall growing trees and shrubs selectively removed by stem specific/spot applications of herbicide. When the presence on the ROW of copious patches of blue lupine flowers was initially discovered along with the Karner blue butterfly, the clamor by environmentally organizations for eliminating the use of herbicides by the local electric utility to insure the survival of this critical host plant was tantamount to the gospel of how best to preserve this existing habitat condition. Within a few years the hand cutting of surrounding trees, particularly of black locust (a prolific stump and root suckering species) proved this advice quite shortsighted. After thorough study, selective herbicide use is now back in place on the ROW and the blue lupine plants are flourishing once again.

In Wisconsin, a state wide HCP for the protection of the Karner blue butterfly with 28 partners including utilities is in the final development stages. The HCP alleviates the need for processing multiple site-specific individual permits while allowing the Karner blue butterfly and its habitat to be conserved while it is simultaneously used and managed. This Wisconsin effort may prove to be a suitable model for other ROW habitats that engender the growth of such sun loving ROW induced E&T species.

Another HCP situation that may have applicability to electric utility ROW vegetation management from a system-wide perspective is the Potlatch Corporation approach to the HCP process. This timber products company was concerned about the impact its timber management activities had on the endangered red-cockaded woodpecker. The company believed that its current forest management programs actually benefit the woodpecker population on its landholdings and complied with the law. However, Potlatch desired some certainty in regards to their future timber harvesting plans proceeding without being hampered by the presence of the listed woodpecker. The approved HCP provides the company with flexible management options while ensuring that the red cockaded woodpeckers on the company's lands will be maintained and protected. It is anticipated that the woodpecker population will actually expand because of the forest management regime used by the company. Thus this HCP protects Potlatch's long-term investment in it timberlands and provides incentives to actively conserve the endangered woodpecker. Again, such a HCP may have applicability to an utilities system wide approach to vegetation management that demonstrates that the various Integrated Vegetation Management (IVM) techniques actually provides the needed habitat for various species of concern including those listed as E&T.

Safe Harbor Agreements

In a related effort by the Services to provide additional incentives for private property owners to restore, enhance, or maintain habitats, for listed species is the "Safe Harbor Policy." This collaborative stewardship approach to the proactive management of listed E&T species provides participating private landowners with technical assistance to develop "Safe Harbor Agreements" that manage habitat for listed species, and provide assurances that additional land, water, and/or natural resources use restrictions will not be imposed as a result of their voluntary conservation actions to benefit covered species. In addition, when the landowner meets all the terms of the agreement, the Services will authorize incidental taking of the covered species. Although this Policy sounds like a duplicative procedure for the HCP's "No Surprises" described above without having to go through the elaborate HCP process there is another interesting twist. Instead of being triggered by potentially negative "unforeseen circumstances" as in the "No Surprises," this voluntary "Safe Harbor" agreement provides its benefits if, as a result of the conservation measures implemented by the landowner, the covered species becomes even more numerous. Private property owners that implement conservation practices for certain listed species covered under a "Safe Harbor Agreement" will receive assurances from the Services that additional conservation measures will not be required and additional land, water or natural resource use restrictions will not be imposed should the covered species become more numerous as a result of the property owners actions.

Candidate species

As noted above for HCPs, the species covered by the conservation plans could include not only listed E&T species but also, unlisted species. Although technically unlisted, some species may be very close to being listed and are referred to as candidate species. Candidate species are plants and animals for which the FWS has sufficient information on their biological status and threats to propose them as endangered or threatened. NMFS defines candidate species even more broadly to include species whose status is of concern but more information is needed before they can be subject to the listing process. From the list of candidate species, those with the highest priority actually become "proposed" for listing. For instance, as of late 1999, there were 258 candidate species and another 56 species were proposed for listing. In additional there is still another slate of species that are potential future nominees that are considered "likely" to become candidates. None of these three quasi-official species rosters, i.e., proposed, candidates or those likely to become candidates receives any statutory protection under the Act.

However, the Services encourage the formation of partnerships to conserve these species since they are by definition species of concern that may warrant future protection under the Act. These partnerships are termed "Candidate Conservation Agreements" (CCA) and are formal arrangements between the Services and one or more parties to address the conservation needs of proposed, candidate and species likely to become candidates before they actually are listed. The participants, usually Federal, state, and local agencies and conservation groups, voluntarily commit to implementing certain actions that will remove or reduce threats to these species. These CCA have been expanded to private landowners with assurances that their conservation efforts will not result in future regulatory obligations in excess of those that they have agreed to at the time they entered into the agreement. In other words, the Services will provide assurances to private property owners that, in the event a species covered in the CCA is subsequently listed as endangered or threatened, the Services will not request added restrictions or require supplemental actions above those the property owner voluntarily committed to in the CCA. In return for participating in this voluntary proactive management, at the time the parties enter into the CCA, the Services would also issue a permit under section 10(a)(1) (A) authorizing the property owner to take individuals or modify habitat as specified by the terms and conditions in the agreement and consistent with the overall goal of precluding the need to list. The effective date on the permit would be set to the date any covered species becomes listed. The overall goal of the CCA is to remove enough threats to the covered species to eliminate the need for listing under the Act.

Critical habitat

Habitat considerations and concerns are an integral part of practically every procedure called for in the Act. For most listed species, the threats to their habitat are the most important consideration when determining if a species meets the requirements for protection under the Act. The FWS describes in great detail the habitat needs of these selected species, and all threats to its habitat, in all their promulgated listing rules. Habitat considerations are an essential key element in all recovery plans,[6] and recovery plans include maps and descriptions of the habitat needed to recover the species. The section 7 consultation process likewise deals with the dynamic characteristics and seasonal cycles of the habitat requirements for all listed E&T species.

When a candidate species is proposed for formal listing as either endangered or threatened under the Act, the additional consideration of whether there are specific areas of habitat that are essential to the species conservation so that these areas may also be formally proposed for designation as "Critical Habitat" must be made. Critical Habitat as used in the Act refers to specific geographic areas that are essential for the conservation of listed species, which may require special management considerations. These areas do not necessarily have to be currently occupied by the species at the time of their designation. Unlike the listing of a species, the designation of critical habitat requires that the economic impact must be taken into account when specifying any particular area as critical habitat. Setting specific boundaries is also required. Critical habitat, *if prudent and determinable*, must be proposed and designated by regulation at the time of listing and thus required to be codified in the Code of Federal Regulations. However, the FWS has long believed that, in most circumstances, the designation of "official" critical habitat is of little additional value for most listed species.

Due to these requirements, the designation of critical habitat is one of the most controversial and confusing aspects of the Act. This situation is only enhanced by the fact that all listed species and their associated habitats are already protected by the Act whether or not they are in an area officially designated as critical habitat. Thus for most listed species the designation of critical habitat is felt to be by the FWS a redundant and unnecessary procedure. The costly and time consuming process of designation of critical habitat by the FWS is a constant problem and a major drain on their limited resources (staff and funding) that the Service is still struggling with to find acceptable solutions. Seemingly, the only benefit of designating critical habitat is that of protecting suitable or even prime potential habitat in areas where the species of concern is physically not located at present in the expectation that future colonization will occur in these areas.

In recent years the FWS has been challenged on many of their "not prudent" critical habitat determinations and as a result has been inundated with citizen lawsuits for their perceived failure to complete the of Critical Habitat designation process. Many environmental groups view critical habitat as providing additional regulatory protection, thus provoking the growing number of lawsuits to prompt critical habitat designations. The consequence of all this critical habitat litigation activity is often the hasty designation of significant land areas of critical habitat (often unoccupied by the listed E&T species) resulting in a

6 A document drafted by the Service or other knowledgeable individual or group, that serves as a guide for activities to be undertaken by Federal, State, or private entities in helping to recover and conserve endangered or threatened species.

new additional regulatory layer that has the potential to significantly impede proposed projects under section 7(a)(2). Under this section all Federal agencies must, in consultation with the Service, insure that all actions they authorize, fund, or carry out are not likely to result in the destruction or adverse modification of critical habitat.

Pesticides and the Endangered Species Act

Finally, one of the last areas that the implementation of the Endangered Species Act may encroach directly upon the ROW vegetation management activities of electric utilities is the Environmental Protection Agency's (EPA) Endangered Species Protection Program (ESPP). Although the EPA Office of Pesticide Programs has included endangered species considerations in its risk assessments for many years, the Endangered Species Protection Program (ESPP), as an entity, started in 1988. It is largely voluntary now and relies on cooperation between the FWS, EPA Regions, States, and pesticide users. ESPP has its goals to simultaneously protect E&T species from harmful pesticide usage and to minimize the impact of the program on pesticide users. In order to protect listed species from detrimental effects from the use of pesticides, the EPA does the following:

1. Use's sound science to assess the risk of pesticide use to listed species.
2. Attempts to find methods to avoid concerns for listed species.
3. When the EPA cannot avoid concerns it then consults with the scientists at the FWS.
4. The FWS issues a biological opinion on the potential for adverse effects on particular species and the EPA implements pesticide use limitations that are either specified in the opinions or developed from those opinions.
5. This implementation is done by:
   - adding a generic label statement;
   - developing county bulletins that contain maps of species locations and pesticide use limitations;
   - distributing the bulletins and other materials by a wide variety of methods; and
   - providing a toll-free telephone number to assist users in determining whether they need a bulletin and where to obtain one.

The EPA encourages individual States to develop their own plans by whatever approach they determine is best for them as long as that approach meets the goals of protecting E&T species while minimizing the impact on pesticide users. States are also a part of the county bulletin review process, along with other agencies, and are encouraged to include State agencies oriented toward agriculture and those aligned with fish and wildlife as well as pesticide users and environmental groups in their review process. EPA fully realizes that it cannot adequately protect endangered species without having some impact on pesticide users. In order to minimize the impact, EPA tries to assist pesticide users in dealing with the impacts of the program. Some of the activities EPA is undertaking to do in relation to pesticide usage and protecting E&T species are:

- utilizing the minimum limitations that will protect the listed E&T species;
- recommending that States provide EPA with alternative, but protective, pesticide use limitations that are appropriate for their location and situation;
- recommending alternative pesticides;
- working with USDA to inform users about wetlands reserve and conservation reserve programs to offset impacts by offering compensation for land taken out of production; and
- occasionally the FWS will provide reimbursement for crops not harvested when the crops are important to a species.

These EPA initiated limitations on pesticide use are not law at this time, but are being provided now for application by pesticide users in voluntarily protecting E&T species from harm due to pesticide use. The EPA encourages all pesticide users to utilize this information. Once the EPA's Endangered Species Protection Program is in effect, these voluntary recommendations will undoubtedly become requirements of the program. EPA is currently soliciting comments regarding the information presented in their voluntary ESPP. The EPA particularly wants to know if the information they are disseminating about the protection of E&T species and pesticide usage is clear and correct as well as to what extent their recommended measures would affect typical pesticide use or productivity.

Potential negative consequences?

Ironically, there is now an ongoing legal case that has the potential to thwart many of the aforementioned attempts to abate the negative regulatory aspects of dealing with endangered and threatened species on ROW. An upstate New York electric utility is currently being "sued" by an underlying fee owner for having engendered a listed species to inhabit the ROW. The utility constructed a line years ago on an easement through an old field habitat that has naturally reforested on either side of the ROW. The utilities dutiful implementation of integrated vegetation management practices and over the intervening years has, as a byproduct, fostered an early succession endangered species within its transmission line ROW easement. This legal case involves a segment of ROW that through the selective removal of tall growing trees by herbicide application over the years has caused the area to become inhabited by many lower growing sun loving species. One of these lower growing species that is flourishing particularly well within the ROW is the blue lupine that is the sole host plant for an endangered insect, the Karner blue butterfly. The ROW area in question is zoned as an industrial park and the utility transmission line ROW easement cuts through a portion of this commercial property. The landowner alleges that due to the presence of the endangered species (only on the ROW) the remainder of the property cannot be accessed for development, and thus has lost a significant amount of potential commercial development. Because the endangered species host plant cannot tolerate the shaded forest area off ROW, it grows only in patches within the ROW, and thus the ROW itself cannot be developed. The utility contends that there are practical ways to accommodate the landowner's proposed development plans. Due to the presence of the endangered species (only on the ROW) the landowner can not access the remainder of the property and thus has lost a significant amount of potential commercial development. The lawsuit alleges that Federal and state laws restrict development on endangered species habitat, so the utility's actions have limited the marketing and development potential and thus lowered the value of this parcel of land zoned for industrial development! As further espoused by the plaintiff, "It is an expensive, protracted and expensive proposition to get relieve from the Endangered Species Act."

For years after finding the presence of this endangered species on its ROW this utility has had significant environmental regulatory oversight and consultation. This has resulted in site-specific studies to determine the best course of action to follow in regards to future ROW vegetation management treatments to ensure compliance with competing environmental and public service obligations. Alleging that the local utility has fostered the presence of this species through its vegetation management activities, has initiated studies and brought out experts from academia, environmental agencies and environmental groups for purposes of field research, technical advice and the use of portion of the ROW to conduct IVM research, the landowner has asserted a variety of claims including trespass.

Although, the claimants in this legal action assert this case is not about endangered species per se but is simply a trespass case, a negative court decision could have impact on other similar situations whereby an electric utility comes into possession of ROW inhabited by E&T species assisted by its vegetation management actions and then attempts to comply with the letter and spirit of the Endangered Species Act and promote and foster the welfare and recovery of these listed species. Upon seemingly complying with all applicable laws, appropriate rules and relevant guidelines in regards to the protection of listed E&T species, the utility may ultimately find itself with a disgruntled underlying fee owner, or even adjacent ROW landowner, that now claims economic loss resulting from the presence of these ROW biological assets and will resort to a lawsuit to seek redress.

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BIOGRAPHICAL SKETCH

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Evaluation of Wildlife Habitat Suitability in an Herbicide-Treated Utility Right-of-Way

J. Drew Lanham and James E. Simmons III

We investigated the effects of 8 low-volume herbicide treatments (Imazapyr, Imazapyr/Glyphosate, Imazapyr/Metsulfuron, Imazapyr/Fosamine, Imazapyr/Triclopyr, Imazapyr/Picloram, Glyphosate, and Triclopyr/Picloram) on plant species composition and wildlife habitat in a power line ROW in the lower coastal plain of South Carolina from 1996–1998. Mechanically mowed and untreated control plots were also included for comparisons. Trends in vegetative response showed increases in forb and grass groups in most herbicide-treated plots. Decreasing or stable trends were observed in soft mast, vine and woody species among most chemical treatments. Ratings from Habitat Suitability Index models using life-requisite components (Suitability Indices) for white-tailed deer (*Odocoileus virginianus*), eastern bobwhite quail (*Colinus virginianus*), wild turkey (*Meleagris gallopavo*), bobcat (*Felis rufus*), and eastern cottontail (*Sylvilagus floridanus*) showed that one year after treatment, ROW habitats were least suitable for northern bobwhite and wild turkey and most suitable for white-tailed deer, bobcat, and eastern cottontail. We suggest that herbicides may be successfully used to manage ROW habitats for some wildlife species in the Southeast. Habitat Suitability Index Models provide valuable tools for evaluating ROW wildlife management efforts.

Keywords: Habitat-Suitability Index Models, rights-of-way, wildlife

INTRODUCTION

Rights-of-way (ROW) have long been recognized as potentially valuable wildlife habitats (Egler, 1952; Bramble and Byrnes, 1972, 1974). Accordingly, the effects of different vegetation management techniques on the quality and quantity of wildlife habitat offered by utility ROW has also been a topic of interest (Arner, 1977; Mayer, 1976; Hartley et al., 1984; Huntley and Arner, 1984).

Woody vegetation that may eventually grow into electric lines and/or limit accessibility for maintenance has traditionally been controlled with rotary mowing, hand cutting or selective herbicide treatments (Johnston, 1982; Arner, 1977). However the increasing value being placed on management for multiple uses has generated interest in the efficacy of low-volume herbicide treatments for controlling woody vegetation while enhancing the value of the ROW for wildlife with a minimal effect on soil and water resources.

With increased public concerns about the way that natural resources are used, management of ROW for wildlife habitat enhancement has become a powerful public relations tool for utility companies. Many cooperative opportunities for ROW wildlife management exist among private landowners, corporate entities (including the utilities), conservation organizations and state/federal natural resource agencies. Just as importantly, these cooperative opportunities exist across a wide range of physiographic regions and habitats in the southeastern United States.

Various methods have been used to evaluate the wildlife value of ROW vegetation. These include observational data that summarize wildlife use (Mayer, 1976) as well as evaluation of vegetative structure and composition as indicators of potential wildlife use (Bramble and Byrnes, 1979). Although more emphasis is being placed upon the importance of managing ROW for wildlife, we believe that there are few if any standardized methods or consistent efforts to do so. Moreover, few efforts at evaluating ROW

Environmental Concerns in Rights-of-Way Management: Seventh International Symposium
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wildlife habitat have been conducted in the United States southeastern coastal plain. In an attempt to efficiently evaluate wildlife habitat in ROW we used Habitat Suitability Index Models (HSI) developed by the US Fish and Wildlife Service (USFWS) to rank the relative value (0.0 = low to 1.0 = optimal) of herbicide and mechanically-treated ROW vegetation for selected early-successional wildlife species including white-tailed deer (*Odocoileus virginianus*), bobcat (*Felis rufus*), eastern cottontail (*Sylvilagus floridanus*), northern bobwhite quail (*Colinus virginianus*), and eastern wild turkey (*Meleagris gallopavo*). These models are comprised of individual Suitability Indices (SI) representing habitat characteristics that also have values on a continuous scale from 0.0 to 1.0. SI values are calculated from Suitability Index Variables (SIV) that comprise the various SI's. Although HSI models are often criticized because of a lack of validation by empirical data (Cole and Smith, 1983), the habitat information contained in these models offers a coarse estimator of potential habitat value which might offer an effective means for evaluating ROW wildlife habitat.

STUDY AREA

The site for this project was 0.6 km of Santee Cooper Electric 115 kV electric line and the associated 45 m wide easement located on the Mount Holly Plantation, in Berkeley County, South Carolina USA. Elevation on the study area ranges from 5.1 to 13.8 m above sea level. Xeric plots in the area were predominately poorly drained Meggett loam (thermic Typic Albaqualf) and moderately permeable Duplin, Lenoir, or Lynchburg fine sandy loam soils (Long, 1980). Major habitat types on the property included natural stands of longleaf pine (*Pinus palustris*), loblolly pine (*Pinus taeda*) plantations, second-growth bottomland hardwoods and hardwood-cypress bays along with grassy fields, ROW and wildlife food plots.

METHODS

Vegetation sampling

Thirty 30 m × 19.2 m experimental units (EU) totaling 576 m^2 were established in August of 1996. Each of the 30 EU systematically received one of eight herbicide mixtures (Imazapyr, Imazapyr/Glyphosate, Imazapyr/Metsulfuron, Imazapyr/Fosamine, Imazapyr/Triclopyr, Imazapyr/Picloram, Glyphosate, Triclopyr/Picloram). Mechanically mowed and untreated control plots were also included for comparisons. Pre-treatment vegetation sampling was conducted during August and September of 1996. Pre-treatment sampling included obtaining plant species composition and species coverage. Composition of plant groups included woody species, vine/bramble species, grass/grass-like species and forbs. Wildlife food plant groups (as determined from Radford et al., 1964 and Martin et al., 1951) included soft mast producers, blackberries (*Rubus spp.*), desirable legumes, desirable vines, and desirable forbs. We included blackberries as a separate group because of their dual importance as both a food and cover resource. Because mechanically treated plots were mowed in June 1996 during normal ROW maintenance rotations, pre-treatment data was not available for these plots. Estimates of species composition and coverage were obtained from five randomly located 2.25 m^2 samples per EU that were delineated using a 3-sided PVC plot. Percent cover was estimated for each class and species within a class to the nearest 5% by an ocular estimate of vertical projection of ground cover before and after treatments. These data were recorded during late August and early September of 1997. Mowed plots were sampled during this period to allow for comparisons of vegetation among treatments.

Herbicide application

Herbicide treatments were applied on in late September 1996 to take advantage of hardwood nutrient translocation to roots for more efficient root kill of woody stems. Herbicides were applied using a Hy-Pro, low-volume spray gun. A $\frac{1}{4}$% non-ionic surfactant was added to all treatments to increase application effectiveness. Herbicide treatments and rates of application (l/ha) were as follows: Imazapyr (1.18); Imazapyr + Glyphosate (1.18 + 9.5); Imazapyr + Metsulfuron (1.18 + 0.15); Imazapyr + Fosamine (1.18 + 10.93); Imazapyr + Triclopyr (1.18 + 4.75); Imazapyr + Picloram (1.18 + 4.75); Glyphosate (23.75); Triclopyr + Picloram (7.13 + 4.75).

Rating wildlife habitat suitability

To evaluate the quality of wildlife habitat present on treated plots after one growing season, habitat variables related to the nature of ROW vegetation were extracted from HSI models for selected species. Habitat variables that were not affected by ROW management techniques were not used in the analysis in order to develop generalized conclusions about the value of ROW vegetation without regard for surrounding habitats (see Bramble and Byrnes, 1979).

Vegetation was evaluated according to SI variables in HSI models for bobcat (Boyle and Fendley, 1987), northern bobwhite (Schroeder, 1985b), eastern wild turkey (Schroeder, 1985a), eastern cottontail (Allen, 1984), and white-tailed deer (Short, 1986). Data corresponding to these variables were recorded from three 0.004 ha (0.01 acre) samples taken in each Experimental Unit (EU) or extracted from species composition/coverage data (Tables 1 and 2). When variables concerned percent cover, ocular estimates of these variables were used. Data for summer SI variables was collected in August and September 1997, one full growing

Table 1. Percent coverage (ocular estimation) of special plant groups on treatment plots

Treatment	Plant group	Pre-treatment		Post-treatment	
		Mean	SD	Mean	SD
Imazapyr	Soft mast species	25.0	9.2	36.7	13.9a
	Blackberry species	21.3	6.5	35.3	15.6a
	Desirable legumes	4.3	5.8	3.3	2.3b
	Desirable vines	28.0	13.0	45.3	18.8a
	Desirable forbs	17.7	10.0	24.7	20.2
Imazapyr/Glyphosate	Soft mast species	30.7	18.0	3.7	4.2c
	Blackberry species	25.0	17.8	12.3	5.5c
	Desirable legumes	3.0	1.4	3.7	1.5b
	Desirable vines	31.7	19.0	20.3	6.1bc
	Desirable forbs	26.3	9.3	21.7	12.5
Imazapyr/Metsulfuron	Soft mast species	26.7	12.1	10.7	3.2c
	Blackberry species	25.0	14.1	6.7	5.0c
	Desirable legumes	10.5	9.2	5.0	—b
	Desirable vines	27.3	1.0	13.0	4.4c
	Desirable forbs	28.3	6.8	18.7	20.2
Imazapyr/Fosamine	Soft mast species	23.3	18.8	10.7	3.2c
	Blackberry species	22.3	19.6	9.7	8.1c
	Desirable legumes	1.5	0.7	1.3	0.6c
	Desirable vines	24.0	18.2	16.3	7.4bc
	Desirable forbs	16.7	4.9	32.0	28.9
Imazapyr/Triclopyr	Soft mast species	44.7	27.4	20.3	16.4bc
	Blackberry species	41.3	29.4	15.3	18.0bc
	Desirable legumes	1.0	—	2.0	—b
	Desirable vines	44.3	25.9	22.3	15.9bc
	Desirable forbs	15.3	7.4	29.0	23.5
Imazapyr/Picloram	Soft mast species	35.3	9.6	13.3	2.3c
	Blackberry species	31.7	13.1	9.0	3.5c
	Desirable legumes	8.0	8.5	2.0	—b
	Desirable vines	36.0	10.5	15.0	3.0bc
	Desirable forbs	22.7	8.5	33.0	24.6
Glyphosate	Soft mast species	42.3	24.2	11.0	3.0c
	Blackberry species	42.0	23.8	9.3	4.5c
	Desirable legumes	3.0	2.0	4.0	1.0b
	Desirable vines	48.7	30.7	25.0	18.2bc
	Desirable forbs	17.7	7.2	27.0	11.8
Triclopyr/Picloram	Soft mast species	37.0	14.1	29.7	4.0ab
	Blackberry species	31.7	12.7	28.0	4.0ab
	Desirable legumes	4.3	3.2	2.3	1.2b
	Desirable vines	39.3	18.5	32.3	0.6ab
	Desirable forbs	13.0	6.0	14.0	7.5
Mowed	Soft mast species	—	—	17.7	6.4bc
	Blackberry species	—	—	13.7	3.8bc
	Desirable legumes	—	—	8.3	1.2a
	Desirable vines	—	—	20.0	8.7bc
	Desirable forbs	—	—	27.7	5.0
Untreated Control	Soft mast species	49.7	18.0	39.3	7.6a
	Blackberry species	42.0	23.1	32.3	7.6a
	Desirable legumes	9.5	6.4	3.0	1.0b
	Desirable vines	52.0	18.1	45.0	5.3a
	Desirable forbs	31.3	17.4	20.3	8.7

a, b, c — Categories with the same letter are not significantly different at the $P \leq 0.05$ level.

Table 2. Treatment scores for suitability index (SI) variables of bobcat, northern bobwhite, eastern wild turkey and eastern cottontail rabbit in an herbicide-treated South Carolina coastal plain ROW

Variable	I	I/G	I/M	I/F	I/T	I/P	G	T/P	M	U/C
Bobcat										
SIV 1–% area in grass/forb/shrub veg.	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
SIV 2–% grass/forb/shrub in grass/forb veg.	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
FSI–Food ≥ 4 ha	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
FSI–Food < 4 ha	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Northern Bobwhite										
SIV 1–% cover preferred herbaceous foods	0.5	0.5	0.5	0.2	0.5	0.2	0.5	0.5	0.9	0.5
SIV 2–% ground bare or w/light litter	0.5	0.2	0.2	0.2	0.2	0.5	0.2	0.2	0.2	0.2
WFSI–Winter food	0.16	0.06	0.06	0.03	0.06	0.06	0.03	0.06	0.12	0.06
SIV 6–% cover woody veg. < 2.0 m (cover)	0.5	0.2	0.5	0.5	0.2	0.5	0.2	0.2	0.2	0.5
SIV 7–% herbaceous cover	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.5	0.5
SIV 8–Avg. height of herbaceous canopy	0.9	0.2	0.2	0.5	0.0	0.2	0.2	0.2	0.9	0.0
SIV 9–% herbaceous cover in grasses	0.5	0.9	0.9	0.9	0.9	0.9	0.5	0.5	0.9	0.5
NSI–Nesting (moist soil)	0.3	0.2	0.2	0.3	0.0	0.2	0.2	0.2	0.3	0.0
Eastern Wild Turkey										
SIV 1–% herbaceous cover	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.2
SIV 2–Avg. height of herbaceous canopy	0.9	0.2	0.2	0.5	0.0	0.2	0.2	0.2	0.9	0.0
FBSI 1–Summer food/brood	0.9	0.4	0.4	0.7	0.0	0.4	0.4	0.4	0.9	0.0
FBSI 2–Summer food/brood distance to cover	0.8	0.4	0.4	0.6	0.0	0.4	0.4	0.4	0.8	0.0
SIV 6–% shrub crown cover (food)	0.9	0.9	0.9	0.9	0.9	0.9	0.5	0.9	0.9	0.9
SIV 7–% shrub crown cover (behavior)	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.2
SIV 8–% shrub cover in soft mast producers	0.9	0.9	0.5	0.5	0.9	0.9	0.9	0.9	0.9	0.9
FWSSI 2–Fall/Winter/Spring food	0.3	0.3	0.2	0.2	0.3	0.3	0.2	0.3	0.3	0.07
Eastern Cottontail										
SIV 1–% shrub closure	0.9	0.5	0.9	0.9	0.5	0.9	0.2	0.2	0.2	0.9
SIV 2–% tree canopy	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SIV 3–% cover persistent herbaceous veg.	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
WCFI–Winter cover/food	1.0	0.9	1.0	1.0	0.9	1.0	0.7	0.7	0.7	1.0

season after application of herbicide treatments. Values for winter SI variables were collected in January 1998. For ranking purposes, the continuous scale data from 0.0 to 1.0 were converted into discrete classes following methodology established by Wakeley (1988). Resulting levels included zero (SI = 0), low ($0 < SI < 0.33$), medium (0.33, SI < 0.67), and high (SI, 0.67) classes that represented relative habitat values for variables (Wakeley, 1988). Actual values of the variables measured related to these various levels is shown in Table 2. These classes facilitated habitat evaluation with less sampling effort and provided HSI scores very similar to the original models (Wakeley, 1988). For purposes of calculating HSI scores and scores for various life requisite components, values of 0, 0.2, 0.5, and 0.9 corresponded to low, medium, or high levels of these variables (Wakeley, 1988).

The primary SI variables in the bobcat HSI model (SIV 1 = the percent of the area covered in grass/forb/shrub vegetation; SIV 2 = the percent of the grass/forb/shrub portion of the area covered by grass/forb vegetation) were vegetative characteristics related to food availability. These two factors were used to determine the Food Suitability Index (FSI) that was then weighted by an area factor (Boyle and Fendley, 1987).

Variables examined for the northern bobwhite HSI (Schroeder, 1985b) included a Winter Food Suitability Index (WFSI 1 = 2/3 [SIV 1 × SIV 2], where SIV 1 = percent canopy cover of preferred herbaceous foods calculated from species composition data; SIV 2 = percent of bare ground or light litter cover). The percent canopy cover of woody vegetation <2.0 m (SIV 6) was used as an indicator of cover available. Other variables examined included the percent of herbaceous canopy cover (SIV 7), the average height of the herbaceous canopy in summer (SIV 8), and the proportion of the herbaceous canopy cover in grass (SIV 9) and soil moisture (SIV 10) as parts of the Nesting Suitability Index ($NSI = [SIV 7 \times SIV 8 \times SIV 9]^{1/2} \times SIV 10$). NSI was determined for all three moisture levels indicated in the model with wet/saturated soils representing low values (0.2), moist for medium values (0.5) and relatively dry for high values (0.9). Variables that were not examined concerned crop management and over story vegetation as well as interspersion of these different components.

Life requisite components extracted from the HSI for the eastern wild turkey included portions of the Summer Food/Brood habitat (FBSI 1 and 2) and Fall/Winter/Spring Food Suitability indices (FWSSI 2) (Schroeder, 1985a). FBSI 1 was composed of the percent herbaceous canopy closure in the summer (SIV 1) and the average height of the summer herbaceous canopy (SIV 2). This relationship was expressed as FBSI 1 =

(SIV 1 × SIV 2)$^{1/2}$. FBSI 2 (=FBSI 1 × SIV 3) incorporated the distance to forest or tree cover (SIV 3) into this relationship and was used to rank food/brood resources in ROW. For our study, SIV 3 was deemed to be high (0.9) since the lower limit of this ranking is not reached within the ROW corridor. FWSSI 2 (=SIV 6 × SIV 8)/2 × SIV 7 × SIV 3) was the Fall/Winter/Spring Food suitability index in shrub cover types where SIV 6 = percent shrub crown cover affecting food availability, SIV 7 = percent shrub crown cover affecting behavior; SIV8 = the percentage of the shrub crown cover in soft mast producers and SIV 3 = distance to forest cover.

Variables chosen from the eastern cottontail HSI model (Allen, 1984) composed the Winter Cover/Food Index; WCFI = 4 (SIV 1) + (SIV 2)/5, where SIV 1 = percent shrub crown closure; SIV 2 = percent tree canopy closure; SIV 3 = percent cover of persistent herbaceous vegetation left standing after the growing season. This relationship was equal to the maximum value between WCFI and 1.0. We chose Model IV of the white-tailed deer HSI model as a simple predictor of presence or absence of deer on a habitat block (Short, 1986). This model only considered the presence or absence of four major forage classes (leafy browse, edible fungi, cool season grasses and forbs, mast producers) as indicators of potential deer use. Suitability was conferred to habitats where one of the four major forage classes is present on 1/3 of the samples. Due to the lack of edible fungi and the presence of only soft mast producers on the study site, only leafy browse and cool season grass/forb categories were used. Cover offered to white-tailed deer was not quantified since adequate cover is usually available in coastal habitats and there is little need for thermal cover in the warm climate of coastal South Carolina (Short, 1986).

Vegetation data analysis

Percent cover estimates for both plant groupings were averaged for all five samples within each EU. ANOVA (*proc glm*; SAS Institute, 1996) was used to determine differences in coverage between EU = s for each year. Differences in coverage between sampling periods were compared using a Student's T-test. Significance levels for all tests were set at $\alpha = 0.05$.

RESULTS

Vegetative composition

Few statistically significant differences were found in coverage data by plant group or special plant group in pre-treatment or post-treatment samples (Tables 1 and 3). However, several notable patterns (pre treatment to post treatment) were observed. Forb coverage increased in all treatments except Imazapyr/Metsulfuron and untreated control plots. Grass/grass like species increased in all but Imazapyr, Imazapyr/Fosamine and Imazapyr/Triclopyr plots. In post-treatment samples, untreated controls and Imazapyr plots were the only treatments to show positive responses in vine coverage. Woody coverage decreased for all treatments except for mowed and control plots.

Differences between treatments for the coverage of special plant groups also showed limited statistical significance. Again, however we observed several patterns in response that were noteworthy. Imazapyr plots were the only treatment to show positive responses for soft mast producers like blackberry, an important food and cover resource for many wildlife species. Desirable legume responses were generally negative with only Imazapyr/Glyphosate, Imazapyr/Triclpyr, and Glyphosate showing slight positive responses. Although we had no pre-treatment data for comparison, mowed plots had the highest coverage of legume species during post treatment measurements. As in the broader vine group, the special vine class only showed positive responses in Imazapyr treated plots. Desirable forb (e.g., ragweed *Ambrosia spp.*) response was positive in Imazapyr, Imazapyr/Fosamine, Imazapyr/Triclopyr, Imazapyr/Picloram, Glyphosate, and Triclopyr/Picloram plots. The lowest desirable forb coverage was found in mowed plots.

Wildlife habitat suitabilities

Bobcat

Values contributing to the Food Suitability Index for bobcats occurred at high levels (0.9) for all treatments. When these values were used to calculate the FSI for areas of different size according to model specifications, there would be changes in quality between different sized areas, but not between treatments. For areas ≥4 ha the FSI was 0.9 for all treatments, which indicated a high value of foraging habitat. For areas <4 ha the FSI was calculated to be 0.6 for all treatments, which was at the upper end of the medium quality rating (Table 2).

Northern Bobwhite

There was limited variability among the rankings for the various components of the northern bobwhite HSI that were examined. The Winter Food Suitability Index (WFSI 1) was ranked low (0.06–0.12) for all treatments. The cover component relating to the amount of woody cover <2.0 m in height was low for most treatments with the exception of Imazapyr, Imazapyr/Metsulfuron, and Imazapyr/Fosamine which were calculated to have medium suitability, as well as the untreated control plot which had high levels of woody cover. For the nesting component (NSI) of the model, values were calculated across the three moisture gradients indicated (saturated/wet, moist, and dry). For saturated/wet and moist levels, all treatments were ranked as low quality (0.04–0.006) nesting

Table 3. Mean coverage on treatment plots by plant group (% cover by ocular estimation)

Treatment	Plant group	Pre-treatment		Post-treatment	
		Mean	SD	Mean	SD
Imazapyr	Forbs	26.7	16.7	41.3	15.9
	Grass/Grass-like	28.7	12.7	12.0	6.0
	Vine/Bramble	35.7	19.0	47.0	18.5ab
	Woody	31.7	6.7	10.3	3.8
Imazapyr/Glyphosate	Forbs	33.0	10.8	48.0	25.1
	Grass/Grass-like	18.7	13.5	31.3	23.6
	Vine/Bramble	40.0	22.1	24.0	7.2c
	Woody	37.0	9.5	20.5	19.1
Imazapyr/Metsulfuron	Forbs	39.0	5.6	36.3	21.2
	Grass/Grass-like	31.3	25.3	37.3	15.8
	Vine/Bramble	37.0	14.7	18.0	10.0c
	Woody	29.3	7.6	14.3	10.7
Imazapyr/Fosamine	Forbs	28.7	8.1	54.7	20.9
	Grass/Grass-like	30.0	21.4	26.0	16.5
	Vine/Bramble	39.7	37.2	21.0	8.7c
	Woody	28.7	8.1	31.5	13.4
Imazapyr/Triclopyr	Forbs	28.0	19.3	46.0	20.0
	Grass/Grass-like	33.0	1.4	26.0	16.5
	Vine/Bramble	56.0	36.4	27.7	18.4bc
	Woody	18.0	4.4	12.7	14.2
Imazapyr/Picloram	Forbs	31.3	7.8	51.0	21.0
	Grass/Grass-like	23.3	9.5	25.3	6.0
	Vine/Bramble	51.0	17.3	18.7	2.1c
	Woody	38.0	8.5	15.3	13.3
Glyphosate	Forbs	30.0	6.6	53.3	11.6
	Grass/Grass-like	20.0	14.9	25.3	12.5
	Vine/Bramble	57.7	37.2	30.3	19.3bc
	Woody	31.3	13.1	4.0	1.4
Triclopyr/Picloram	Forbs	27.0	3.6	34.3	9.0
	Grass/Grass-like	20.3	10.7	28.0	4.4
	Vine/Bramble	53.0	13.5	38.3	4.0bc
	Woody	27.7	14.0	5.0	2.0
Mowed	Forbs	—	—	43.0	1.0
	Grass/Grass-like	—	—	50.0	17.1
	Vine/Bramble	—	—	24.0	8.9c
	Woody	—	—	13.3	10.5
Untreated Control	Forbs	36.0	18.4	29.0	18.2
	Grass/Grass-like	9.3	4.0	12.0	4.4
	Vine/Bramble	71.0	19.1	60.7	17.0a
	Woody	18.3	5.5	29.7	15.3

a, b, c — Categories with the same letter are not significantly different at $P \leq 0.05$ level.

habitat except Imazapyr/Triclopyr and untreated control treatments which were ranked to have zero (0.0) suitability for nesting.

If this same vegetative structure had occurred on dry sites, the ranking would have increased to medium (0.4–0.6) for all treatments with low rankings in other categories. EU ranked as zero retained this ranking for dry soils. For plots within this study area, rankings relating to saturated/wet or moist soils were the most accurate representations of conditions in the field (Table 2).

Eastern Wild Turkey

There was also variability in values assigned to the various components of the eastern wild turkey HSI examined in this study. The Food/Brood Summer Index 1 (FBSI 1) was calculated as medium (0.4) for most treatments with some exceptions. High (0.7–0.9) levels of FBSI 1 were present on EU treated with Imazapyr, Imazapyr/Fosamine, and mowing. EU treated with Imazapyr/Triclopyr and controls had zero (0.0) value for summer foods. These rankings were consistent with the Food/Brood Summer Index 2, which took into account the distance from forest cover, with the exception of Imazapyr/Fosamine treatments which dropped from a high rating to a medium rating when this variable was included (0.7 to 0.6). When examining the value of ROW vegetation to the Fall/Winter/Spring food index (FWSSI 2) for shrubland habitats, all treatments were calculated to have low (0.07–0.3) values for this measure due to dense vegetation (Table 2).

Eastern Cottontail Rabbit
The variables measured for the eastern cottontail HSI were related to the Winter Cover/Food Index (WCFI). Values of this index were calculated to be high (0.7–1.0) for all treatments (Table 2).

White-tailed Deer
For model IV in the white-tailed deer HSI, habitat was determined to be adequate for use by deer if cool season grasses and forbs or leafy browse were present on $\frac{1}{3}$ of the samples taken. Cool season grasses and forbs as well as leafy browse were present on all samples taken for every treatment. These components also comprised approximately $\frac{1}{3}$ cover in all samples taken for all treatments (27% minimum). Habitat was ranked as adequate for white-tailed deer for all treatments (Table 2).

DISCUSSION

Differences in the amount of Vine/Bramble coverage on treatment EU during the post-treatment period was most likely attributable to treatment effects and environmental conditions. Greater coverage of this category on Imazapyr plots was due to an abundance of blackberry cover on these plots as compared with other treatments. Imazapyr is noted to have a minimal negative impact on blackberry species (American Cyanamid Tech. Bulletin, 1996). This was also responsible for the higher coverage of Blackberry species, Desirable Vines, and Soft Mast producing species found on Imazapyr treated plots. The presence of high Vine/Bramble coverage on untreated controls was clearly a result of these areas remaining undisturbed and the abundance of vigorous blackberry growth on these plots. Higher Vine/Bramble coverage on Triclopyr/Picloram and Glyphosate treated plots was more likely a result of proliferate growth of honeysuckle and other vine species, rather than blackberries.

High levels of Desirable Legume coverage on mowed plots was due to the low-growing cover on mechanically treated sites. Legumes present on these plots were interspersed with low-growing grass and forb cover and their presence was most likely due to the absence of dead vegetation shading the ground in the early growing season. The removal of woody and herbaceous biomass from the mowed plots allowed for greater solar penetration and most likely favored germination and establishment of a greater diversity of species on these plots. Higher levels of legumes on Imazapyr/Metsulfuron and Glyphosate treated plots were more likely a result of differential chemical coverage at the time of treatment, as well as differences in the seed bank, soil moisture and other microsite factors affecting species composition. We feel that important differences between the abundance of other plant groups in chemically treated plots will become evident in subsequent growing seasons as vegetative communities become established along the ROW. Sampling after two or three growing seasons should be more representative of conditions present during normal management rotations and will be more useful in the interpretation of differences among treatments. Additionally, we expect mowed plots to develop a denser woody component from sprouts than chemically treated areas. In addition to complicating future efforts to maintain this area with mechanical means, woody cover will likely shade forb and grass communities and prove less suitable for some valuable wildlife food plants.

Wildlife habitat suitability
The assumption that prey availability is the limiting factor concerning the quality of habitat for bobcats in the southeast (Boyle and Fendley, 1987) was the basis for using the Food Suitability Index (FSI) as an indicator of the quality of foraging habitat offered by ROW vegetation. The dense nature of native vegetation on the ROW within this study area provided the grass/forb/shrub habitat that is considered highly productive prey habitat for bobcats (Boyle and Fendley, 1987).

While all treatments were rated to have high values of the FSI for areas $\geq$4 ha and medium values for area <4 ha, we believe that the quality of foraging habitat was higher on chemically treated plots and controls than on mowed areas. Boyle and Fendley (1987) note that newly created early successional areas with qualifying levels of variables may not be as productive as older, intact areas. Chemically treated areas may provide a more consistent prey base since the structure of vegetation was not altered as drastically as on mowed areas. On chemically treated areas, there was a dense layer of residual cover from standing grasses, forbs, vines and brambles providing cover for prey species which was not present on mowed areas. ROW vegetation on an area could provide foraging habitat for bobcats even when other portions of a home range would provide unsuitable conditions for foraging. In addition, chemical treatments that lengthen or eliminate the need for traditional mowing rotations might increase the value of habitat for bobcats through time.

Habitat offered for the northern bobwhite was relatively poor for all treatments according to the factors measured in this study. Low levels of the Winter Food Suitability Index occurred due to the low to medium levels of preferred bobwhite foods on most treatments as well as the limited occurrence of bare ground. In addition to providing limited food resources, ground cover within the ROW was too dense to allow bobwhite foraging, especially for young chicks. Mowed treatments did provide high levels of preferred bobwhite foods, but due to the dense nature of the vegetation on these plots, the overall WFSI 1 was still rated as low. Treatments ranked as having a medium quality (Imazapyr, Imazapyr/Metsulfuron, and Imazapyr/Fosamine), or high quality (untreated control) cover component may have some value as escape cover for the northern bobwhite. These higher levels of woody cover, however, could conflict with the ultimate line maintenance goal of ROW managers. Woody cover on low-rated treatments would increase in subsequent years, but treatment rotations that would remove this woody cover would limit their value to quail populations. Woody cover on the chemically treated plots was mostly attributable to residual cover from low-growing, shrubby species (e.g., wax myrtle *Myrica cerifera*) that would not threaten the transmission of power, but would provide important cover for northern bobwhite and other wildlife. Low or zero values for the nesting component (NSI) for all treatments with saturated/wet or moist soils could be expected to decrease even further as the height of the herbaceous canopy continues to increase in future growing seasons after treatment. Therefore, NSI can be considered zero when considering the long-term value of ROW under these treatment regimes. Increases in the NSI under a dry moisture regime should not be viewed optimistically considering that changes in soil moisture would also lead to changes in vegetative structure.

Due to the limited presence of preferred foods, the lack of bare ground, the loss of woody cover, and moist soils in this study area, ROW treated with herbicide or mowing treatments can be considered little more than supplemental escape cover in areas already supporting northern bobwhite populations. While it has been suggested that prescribed fire could mitigate low food resources and the lack of bare ground (Arner, 1977), this is not an option that is often available to utilities considering the extensive area needing management and the liabilities associated with private landholdings and service interruption.

Habitat potential for the eastern wild turkey was also limited on ROW under most of the treatment methods examined in this study, even though high or medium rankings were given to all treatments except the control for the Food/Brood Suitability Index (FBSI) in the first year after treatment. These values are likely to decrease rapidly with successive growing seasons when the height of the herbaceous canopy would easily exceed 1 m that produces an overall HSI of zero (Schroeder, 1985a).

Low values were assigned to all treatments for the Fall/Winter/Spring Food Suitability Index (FWSSI) due to the dense layers of blackberry which would limit wild turkey visibility and limit use of these areas. These values could also be expected to approach zero as blackberry coverage becomes denser in subsequent growing seasons after treatment due to release from woody competition. According to the value determined from the HSI model, ROW under these management regimes could be expected to be of limited value for wild turkeys during the first 1–2 years after treatment.

Winter cover and food are considered to be the limiting factors determining the value of habitat for eastern cottontail rabbits (Allen, 1984). This was the basis for using the Winter Cover and Food suitability Index (WCFI) to evaluate the value of habitat offered by ROW vegetation. According to the ranking system used in this study, all treatments offered high quality habitat for use by eastern cottontails. The complete absence of a tree canopy (SIV 2) did not have a negative influence on this ranking because of the dense cover offered by blackberries, residual woody cover, and dense layers of standing herbaceous matter. Once again we suspected that chemically treated areas would provide a more stable habitat through time since mowing treatments remove almost all standing and cover for some portion of the year. The absence of this cover often coincides with the winter season when it is most needed by this species. The model predictions of optimal habitat were reinforced by frequent observations of cottontails and rabbit pellets within the study site.

Model IV of the white-tailed deer HSI did not lend itself to the ranking system used for other species. Since this model was intended to evaluate the potential presence or absence of deer on a habitat block, treatments were simply ranked as adequate or inadequate for use by white-tailed deer. Leafy browse and cool season grasses and forbs were present in all samples for all treatments within the study area. Therefore, all treatments were ranked as adequate for use by white-tailed deer. Our observations of abundant trails, pellets, beds and sightings throughout all treatment units indicated that these areas were highly suitable for white-tailed deer.

CONCLUSIONS AND MANAGEMENT IMPLICATIONS

The primary goal of ROW managers is to ensure the distribution of power and allow access for line maintenance while meeting as many secondary objectives for use of the ROW as possible. An ideal scenario for control of ROW vegetation may develop from a combination of chemical and mechanical management practices. For example, if mowing treatments were followed at the end of the following growing season with a broadcast or selective herbicide treatment, reduction in the vegetation height from mowing would increase effectiveness of chemical coverage and chemical treatments would provide some control of prolific root and sucker sprouting that consistently trouble ROW managers. At the same time such treatments would probably promote increases in many desirable wildlife plants. Alternatively, where structural diversification is the desired objective, selective application by backpack units (basal application) might encourage patchy growths of vegetation that add vertical heterogeneity within the ROW and increase wildlife habitat value.

From the model factors examined in this study, the dense vegetation occurring in our lower coastal plain ROW provides few long-term benefits to wild turkeys and bobwhite quail. However, results from this study cannot be extrapolated to evaluate ROW traversing other habitat types and environmental conditions. Habitats within this study area were most suitable for bobcats, white-tailed deer and cottontail rabbits. This is not surprising considering the abundance of food and cover offered for these species within the ROW. Hartley et al. (1984) also observed higher use of ROW by rabbits and deer in areas with more structure as opposed to less heterogeneous open grass areas. Other researchers have also found quality deer habitat on chemically treated ROW (Bramble and Byrnes, 1972, 1974).

Our study showed that no single ROW management technique served as a management panacea for all wildlife habitats in our ROW. Implementing management practices so that they are adaptive will allow managers to determine the best scenario for maintaining service and providing viable habitat in southeastern ROW. We believe that HSI models and their various components offer a valuable tool for meeting wildlife management and service goals in ROW.

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Butterflies and Skippers in Utility Rights-of-Way in the Upper Piedmont of South Carolina

J. Drew Lanham and Maria J. Nichols

Rights-of-way (ROW) are increasingly being recognized for their value to early-successional wildlife species. However, little or no information exists about diurnal Lepidopteran (butterflies and skippers) diversity in these areas. In the spring, summer, and fall of 1997 we conducted daily butterfly and skipper surveys on 6, 0.6 km transects of ROW in Greenville and Oconee counties in the Upper Piedmont of South Carolina. A total of 101 butterfly and skipper species (24,057 individuals: 14,727 butterflies and 9330 skippers) were recorded across all seasons. Overall diversity, evenness, and richness did not differ among the 6 study sites for butterflies. However, abundances of butterflies and skippers and skipper richness did differ among the six ROW. Vegetative composition assessed in the spring, summer, and fall of 1997 revealed no differences in vegetative structure among the ROW for any season. We believe that ROW may provide vital habitats for Lepidoptera in many southeastern landscapes.

Keywords: Butterflies, skippers, rights-of-way, southeastern US

INTRODUCTION

Utility rights-of-way (ROW) are ubiquitous landscape features across the United States. Although the primary function of ROW is the distribution of service (e.g., electrical, gas, communication), these areas are increasingly being enhanced for wildlife. Such actions are important since they may provide some of the only areas of early-successional habitat in human-developed or mature forest environments.

While our understanding of the importance of ROW to some vertebrate species has increased significantly, we know of no published studies that have systematically assessed the suitability of habitats for butterflies and skippers in the southeastern United States. This lack of attention is critical given the important roles Lepidoptera play as pollinators and prey in many ecosystems. Moreover, because of the declines documented for a number of butterfly and skipper species, it is important to increase our understanding of how Lepidopteran communities and species are distributed in various habitats. To address the lack of information in this area, we initiated a study to determine the species composition of butterfly and skipper fauna found on selected ROW in the Upper Piedmont of South Carolina and relate plant species structure and composition within ROW to the butterfly and skipper fauna present.

Environmental Concerns in Rights-of-Way Management: Seventh International Symposium
J.W. Goodrich-Mahoney, D.F. Mutrie and C.A. Guild (editors)

STUDY AREA AND METHODS

Study area

Six, 0.6 km transects were located on selected Duke Energy transmission rights-of-way (ROW) in the Upper Piedmont region of South Carolina. Three sites were located on the 7287 ha Clemson Experimental Forest in the Lower Foothills of Oconee County, South Carolina. Three additional sites were located in the Interior Plateau Region of Greenville County, South Carolina. Site elevations ranged from 150 to 330 m and were comprised primarily of second growth oak-hickory and mixed hardwood-pine forests growing in a transitional zone from sloping and rugged terrain to gently rolling hills (Myers et al., 1986).

Vegetation sampling and habitat evaluation

Important habitat requisites for Lepidoptera include the presence of warm, open areas, escape/protective cover, bare ground for puddling and basking, flowering plants for nectar feeding, and a diverse herbaceous component for larval target-host plants. In order to quantify these requisites, spring, summer, and fall vegetation were sampled on each ROW in 75-1 m^2 circular plots. In each plot, vegetation was placed into 1 of 6 general categories: trees >2 m, shrubs and saplings 1–2 m, herbs and forbs, woody, vines, and grasses. Percent cover estimates for the vegetation categories were measured for each plot and assigned a rank (e.g., 0 = no cover, 5 = abundant cover of 20–25%, 10 = 100% cover) following the Domin Scale (Kershaw, 1973). Nectar producing flowering plants and larval target host plants were identified to species where possible (Appendices 1 and 2). We used 2-factor analysis of variance procedures (PROC ANOVA; SAS Institute, 1996) to determine if vegetation in each of the 6 classes differed among ROW and by season. Tukey's *W* procedure (SAS Institute, 1996) was used to separate response means. Significance was determined at $P \leq 0.05$.

Lepidopteran censuses

Using the Pollard Transect Method (Pyle, 1992) to census diurnal Lepidoptera in our 6 study sites, we established a single 0.6 km transect through the longitudinal center of each ROW. Transect widths were equivalent to the width of the 6 ROW (40–80 m). Within each transect, all butterflies seen were identified to species and counted. Butterflies and skippers not positively identified in the field were either collected or photographed for later identification (Moore, 1975; Thomas, 1983a; Pollard, 1977; Pyle, 1992). Each ROW was censused 18 times with 1 survey conducted each week for each ROW. Surveys were run from 1 May to 31 October 1997. Again, 2-factor ANOVA was used to compare estimates of overall richness, butterfly and skipper richness, butterfly and skipper abundance and Shannon–Weiner Diversity (H′) and Evenness (J′) (Shannon and Weaver, 1949) by ROW and by season. Tukey's *W* Procedure was used to determine differences among means with significance determined at $P \leq 0.05$. Sorenson's Quotient of Similarity (QS; Sorenson, 1948) was also used to quantify the similarities in Lepidopteran communities among ROW.

RESULTS

ROW vegetation

All of the habitat requisites necessary for butterflies and skippers were present on all 6 ROW. This included an abundance of open habitat, bare ground and moist puddling areas. Vegetative cover was also abundant in the form of trees, shrubs, and dense areas of vines, herbs, and forbs. Eighty-two flowering nectar sources (Appendix 1) and 102 larval-target host plants (Appendix 2) were identified in the 6 ROW. Herbs and forbs dominated both nectar sources and larval target-host species. ANOVA revealed no statistically significant differences in vegetation among ROW or by season. Therefore we pooled vegetation class data (e.g., trees >2 m, shrubs, grasses, etc.) for the 6 ROW to assess seasonal differences within vegetation classes. Although, grass, herb/forb and bare ground classes had the highest numerical coverage percentages across all seasons and all ROW, ANOVA showed no statistically significant differences within vegetation classes across seasons ($P \leq 0.05$) (Table 1).

Table 1. Seasonal comparisons* of vegetative percent cover occurring on 6 rights-of-way in SC, May–Oct. 1997

Vegetation class	Spring	Summer	Fall
Trees >2 m	8.00 A	9.00 A	9.00 A
Shrubs 1–2 m	10.0 A	10.0 A	9.00 A
Grasses	18.0 B	22.0 B	24.0 B
Vines	13.0 A	14.0 A	13.0 A
Herbs and forbs	23.0 B	22.0 B	25.0 B
Other woody vegetation	5.00 C	6.00 C	6.00 C
Bare ground	23.0 B	17.0 B	14.0 B

*Values across rows with the same letter are not significantly different ($P < 0.05$).

Lepidopteran communities

One hundred and one (101) species (59 butterflies and 42 skippers) were recorded in censuses conducted across all seasons for all 6 ROW (Appendix 3). A total of 24,057 individuals (14,727 butterflies and 9330 skippers) were recorded. The five most frequently recorded species included the Eastern Tailed Blue (*Everes comyntas*), Monarch (*Danaus plexippus*), Pearly Crescentspot (*Phyciodes tharos*), Painted Lady (*Vanessa cardui*), and European Cabbage Butterfly (*Artogeia rapae*).

No statistically significant differences were reported for diversity (H′), evenness (J′), and butterfly richness (S′) among ROW. However, ANOVA did reveal some significant differences for butterfly species abundance ($F = 6.24$, $P = 0.001$, $R^2 = 0.55$), skipper abundance ($F = 5.25$, $P = 0.003$, $R^2 = 0.36$), and skipper richness ($F = 6.09$, $P = 0.001$, $R^2 = 0.44$) among some ROW (Table 2). Sorenson's index, a function that reflects the similarities in species composition between two samples, was also used to compare Lepidopteran communities among ROW.

Sorenson's index is defined as:

$$QS = \frac{2c}{(a+b)};$$

where c is the number of species common to samples 1 and 2, and a and b represents the species richness of samples 1 and 2, respectively. Estimates of QS range from 0 (no common species between samples) to 1 (identical species composition). Sorenson's estimates showed that the butterfly and skipper communities

Table 2. Lepidopteran community comparisons[a,b] on 6 rights-of-way in SC, May–Oct. 1997

ROW	H′	J′	S	Butterfly richness	Butterfly abundance	Skipper richness	Skipper abundance
1	1.50 A	0.827 A	66 A	34.0 A	360 A	16.8 B	164 B
2	1.60 A	0.866 A	71 A	34.2 A	777 B	22.0 A B	181 B
3	1.56 A	0.832 A	76 A	34.6 A	771 B	21.6 A B	211 B
4	1.57 A	0.891 A	72 A	34.2 A	346 A	17.8 A B	526 A
5	1.64 A	0.877 A	74 A	34.2 A	343 A	20.4 A B	548 A
6	1.60 A	0.856 A	74 A	35.2 A	348 A	22.8 A	233 B

[a] H′ = Shannon–Weiner diversity, J′ = Shannon–Weiner evenness, S = richness.

[b] Values in a column followed by the same letter are not significantly different ($P < 0.05$).

Table 3. Lepidopteran community comparisons[a] on 6 SC rights-of-way, May–Oct. 1997

Sites	1	2	3	4	5	6
1						
2	0.77					
3	0.77	0.82				
4	0.78	0.75	0.81			
5	0.77	0.80	0.80	0.75		
6	0.81	0.81	0.81	0.82	0.85	

[a] Comparisons reflect Sorenson's Indices ($QS = 2c/(a + b)$; where c is the number of species common to samples 1 and 2, and a and b represents the species richness of samples 1 and 2, respectively).

were more similar than dissimilar among the ROW as values for all of the pairwise comparisons ranged between 0.75 and 0.85 (Table 3).

DISCUSSION

The ROW censused in this study were botanically diverse, structurally heterogeneous, early-successional habitats. We found all of the habitat requisites for butterflies and skippers available on the utility rights-of-way that were censused. This is a result of the floristically diverse habitat found in these areas. We suggest that these areas might be critical in landscapes where quality early-successional habitats are limited and can be managed with minimal effort to provide optimal habitats for many butterflies and skippers. Given the vital role Lepidoptera play, the popularity of butterfly gardening and watching, and the increasing attention being given to ROW as wildlife habitat, one would expect that more studies would be published regarding the Lepidopteran communities in ROW. However, we found no published information regarding butterfly and skipper communities in southeastern ROW. Thus, our study provides important baseline data for further investigation of Lepidopteran habitat relationships in ROW and other habitat types.

The continuation of research investigating lepidopteran communities in ROW is critical since they play such vital roles as primary consumers, pollinators and prey in most terrestrial ecosystems. Aside from the intrinsic value of understanding the habitat relationships of Lepidoptera in ROW and other early-successional habitats, new information gained about the abundance and distribution of butterflies and skippers may ultimately increase our understanding of how other species like insectivorous passerines or native, insect-pollinated flora might respond to management that affects pollinators or prey.

Although a number of factors are associated with declines in butterflies and skippers including specimen collection, prolonged bouts of inclement weather and habitat destruction (Thomas, 1984b), habitat alteration is frequently cited as a factor in the declines observed among many Lepidopteran species (Thomas, 1984b). Efforts to recover species such as the federally endangered Karner Blue Butterfly (*Lycaeides melissa*) and the Kirtland's Warbler (*Dendroica kirtlandii*) have focused more attention on the need to manage early-successional habitats and the species dependent upon them. While the convention in conservation biology has typically been the minimization of anthropogenic disturbance, many species like the Karner Blue butterfly and other Lepidoptera may derive benefits from some anthropogenic disturbances (Swengal, 1993; Criswell, 1995). Otherwise, if the habitats on which these species depend decreases or changes in quality, then populations may continue to decline or become extinct (New, 1991).

Early-successional habitats that are important to a wide array of species may be lost or altered by urbanization, changes in agriculture, and changes in forest management practices. In urban, suburban, and rural landscapes, early-successional habitats may be altered or otherwise limited by a number of factors. Activities such as frequent, persistent mowing in urban and suburban areas and "clean-farming" in rural areas may inhibit herbaceous plant development, remove nectar-producing flowers from the stalks of grasses or other "weedy" plants and decrease the structural heterogeneity of an area. In largely forested landscapes, changes in forest management practices dictating smaller areas of disturbance or cessation of forest regeneration practices may also contribute to declines in some early-successional species (New, 1991; Pyle, 1992; Pollard and Yates, 1993).

Controversy surrounding forest management practices like clearcutting may conflict with efforts to manage some early-successional species. Additionally, the proliferation of "clean-farms" and manicured gardens and parks where desirable "weeds" and other vegetation are suppressed is unlikely to decrease as human development and demand spread. As a result, "new" means of managing for disturbance-dependent species must be investigated. Since this study and a number of other previous studies indicate that utility ROW may provide adequate early-successional habitat for a number of species, ROW may offer a legitimate management/conservation strategy for some disturbance-dependent species in some landscapes. Since the uninterrupted delivery of service to customers will continue to be priority of utility companies, ROW will continue to be managed on a consistent basis. As such these areas will become increasingly important to species dependent upon disturbed habitats in landscapes that otherwise would not support them. Current ROW wildlife habitat improvement initiatives by state, private, and industrial agencies are illustrative of the increasing desire to gain added value from ROW. However, the majority of these efforts focus almost exclusively on vertebrates. Unfortunately, while the enthusiasm for managing ROW for wildlife is increasing, our knowledge of how to do it most effectively has not. The entities responsible for managing vegetation on ROW (e.g., utility companies) should be cognizant of the potential effects that different management regimes have on *all* species. The ROW we censused had not received any treatments beyond the scheduled 2–3 year mowing. Unlike many vertebrate species that may require a great deal of time, effort, and financial input above and beyond traditional ROW maintenance, we suggest that utility companies, management agencies, and private landowners in the Southeast can, with minimal additional effort, provide important habitats for diverse Lepidopteran communities.

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APPENDIX 1. NECTARING PLANTS RECORDED ON 6 SOUTH CAROLINA ROW, MAY–OCTOBER 1997

Yarrow	*Achillea millefolium*	Common Morning Glory	*Ipomoea purpurea*
Wingstem	*Actinomeris alternifolia*	Crape-myrtle (white)	*Lagerstroemia indica*
Field Garlic	*Allium vineale*	Motherwort	*Leonurus cardiaca*
Pigweed	*Amaranthus spp.*	Wild Peppergrass	*Lepidium virginicum*
False Indigo	*Amorpha canescens*	Creeping Bush Clover	*Lespedeza repens*
Mayweed	*Anthemis cotula*	White Campion	*Lychnis alba*
Dogbane	*Apocynum spp.*	Lance-leaved Loosestrife	*Lysimachia lanceolata*
Swamp Milkweed	*Asclepias incarnata*	Whorled Loosestrife	*Lysimachia quadrifolia*
Common Milkweed	*Asclepias syriaca*	Monkey Flower	*Mimulus spp.*
Butterfly Weed	*Asclepias tuberosa*	Prickly Pear	*Opuntia humifusa*
Saint Andrew's Cross	*Ascyrum hypericoides*	Yellow Wood Sorrel	*Oxalis europaea*
Aster	*Aster spp.*	Sourwood	*Oxydendrum arboreum*
Trumpet Creeper	*Campsis radicans*	Carolina Phlox	*Phlox carolina*
Wild Sensitive Plant	*Cassia nictitans*	Garden Phlox	*Phlox panicalata*
Spurred Butterfly Pea	*Centrosema virginianum*	Phlox	*Phlox spp.*
Button Bush	*Cephalanthus occidentalis*	Clammy Ground Cherry	*Physalis heterophylla*
Bull Thistle	*Cirsium vulgare*	Pokeweed	*Phytolacca americana*
Butterfly Pea	*Clitoria mariana*	Smartweed	*Polygonum spp.*
Greater Coreopsis	*Coreopsis major*	Cinquefoil	*Potentilla spp.*
Tickseed Sunflower	*Coreopsis spp.*	Hoary Mountain Mint	*Pycnanthemum incanum*
Crown Vetch	*Coronilla varia*	Winged Sumac	*Rhus copallina*
Queen Anne's Lace	*Daucus carota*	Smooth Sumac	*Rhus glabra*
Rocket Lackspar	*Delphinium ajacis*	Rose species	*Rosa spp.*
Rocket Lackspar	*Delphinium ajacis*	Common Blackberry	*Rubus allegheniensis*
Indian Strawberry	*Duchesnia indica*	Black-eyed Susan	*Rudbeckia hirta*
Daisy Fleabane (pink)	*Erigeron annuus*	Short-styled Snakeroot	*Sanicula canadensis*
Daisy Fleabane (white)	*Erigeron annuus*	Skullcap	*Scutellaria spp.*
Horseweed	*Erigeron canadensis*	Balsam Ragwort	*Senecio pauperculus*
Sweet Everlasting	*Gnaphalium obtusifolium*	Sensitive Brier	*Shrankia microphylla*
Fine-leaved Sneezeweed	*Helenium amanum*	Common Nightshade	*Solanum americanum*
Woodland Sunflower	*Helianthus divaricatus*	Horse Nettle	*Solanum carolinense*
Sunflower species	*Helianthus spp.*	Goldenrod species	*Solidago spp.*
Jerusalem Artichoke	*Helianthus tuberosus*	Spiny-lvd. Sow Thistle	*Sonchus arvensis*
Yellow Hawkweed	*Hieracium pratense*	Venus Looking-glass	*Specularia perfoliate*
Hawkweed species	*Hieracium spp.*	Goat's Rue	*Tephrosia virginiana*
Long-leaved Houstonia	*Houstonia longifolia*	Cranefly Orchid	*Tipularia discolor*
Saint Johnswort	*Hypericum spp.*	Goat's-Beard	*Tragopogon spp.*
Yellow Star Grass	*Hypoxis hirsuta*	White Clover	*Trifoinum repens*
		Red Clover	*Trifolium pratense*
		Blue Vervain	*Verbena hastata*
		Zinnia	*Zinnia elegans*

APPENDIX 2. LARVAL TARGET-HOST PLANTS ON 6 SOUTH CAROLINA ROW, MAY–OCTOBER 1997

Trees			
River Birch	*Betula nigra*	Virginia Pine	*Pinus virginiana*
Pignut Hickory	*Carya glabra*	American Sycamore	*Platanus occidentalis*
Mockernut Hickory	*Carya tomentosa*	Chickasaw Plum	*Prunus angustifolia*
Hawthorn	*Crataegus spp.*	Black Cherry	*Prunus serotina*
American Beech	*Fagus grandifolia*	White Oak	*Quercus alba*
White Ash	*Fraxinus americana*	Southern Red Oak	*Quercus falcata*
Honey Locust	*Gleditsia triacanthos*	Water Oak	*Quercus nigra*
American Holly	*Ilex opaca*	Northern Red Oak	*Quercus rubra*
Eastern Red-cedar	*Juniperus virginiana*	Post Oak	*Quercus stellata*
Sweet Gum	*Liquiddambar styreciflua*	Black Oak	*Quercus velutina*
Yellow-Poplar	*Liriodendron tulipifera*	Black Locust	*Robinia pseudoacacia*
Shortleaf Pine	*Pinus echinata*	Black Willow	*Salix nigra*
Loblolly Pine	*Pinus taeda*	Sassafras	*Sassafras albidum*
Shrubs/Vines			
New Jersey Tea	*Ceanothus americanus*	Lowbush Blueberry	*Vaccinium vacillans*
Strawberry Bush	*Euonymus americanus*	Trumpet Creeper	*Campsis radicans*
Spicebush	*Lindera benzoin*	Japanese Honeysuckle	*Lonicera japonica*
Winged Sumac	*Rhus copallina*	Common Blackberry	*Rubus spp.*
Smooth Sumac	*Rhus glabra*	Fox Grape	*Vitaceae labrusca*
Sparkleberry	*Vaccinium arboruum*	Muscadine	*Vitis rotundifolia*
Deerberry	*Vaccinium stamineum*		
Herbs/Forbs			
Wingstem	*Actinomeris alternifolia*	Jerusalem Artichoke	*Helianthus tuberosus*
Pigweed	*Amaranthus spp.*	Wild Lettuce	*Lactuca candensis*
False Indigo	*Amorpha canescens*	Prickly Lettuce	*Lanctuca scariola*
Hog Peanut	*Amphicarpa bracteata*	Wood Nettle	*Laportea canadensis*
Pearly Everlasting	*Anaphalis margaritacea*	Motherwort	*Leonurus cardiaca*
Plantain-leaved Pussytoes	*Antennaria plantaginifolium*	Sericea	*Lespedeza cuneata*
Virginia Snakeroot	*Aristolochia serpentaria*	Partridgeberry	*Mitchella repens*
Swamp Milkweed	*Asclepias incarnata*	Prickly Pear	*Opuntia humifusa*
Milkweed spp.	*Asclepias spp.*	Panic grass	*Panicum spp.*
Aster spp.	*Aster spp.*	Passion Flower	*Passiflora incarnata*
Wild Indigo	*Baptisia tinctoria*	Clammy Ground Cherry	*Physalis heterophylla*
Beggars Tick spp.	*Bidens spp.*	English Plantain	*Plantago lanceolata*
Wild Sensitive Plant	*Cassia nictitans*	Common Plantain	*Plantago major*
Spurred Butterfly Pea	*Centrosema virginianum*	Mayapple	*Podophyllum peltatum*
Black Cohosh	*Cimicifuga racemosa*	Cinquefoil	*Potentilla spp.*
Bull Thistle	*Cirsium vulgare*	White Lettuce	*Prenanthes alba*
Butterfly Pea	*Clitoria mariana*	Short-styled Snakeroot	*Sanicula canadensis*
Coreopsis spp.	*Coreopsis spp.*	Common Nightshade	*Solanum americanum*
Tickseed Sunflower	*Coreopsis spp.*	Horse Nettle	*Solanum carolinense*
Whorled Coreopsis	*Coreopsis verticillata*	Goldenrod spp.	*Solidago spp.*
Crown Vetch	*Coronilla varia*	Spiny-lvd. Sow Thistle	*Sonchus aspen*
Queen Anne Lace	*Daucus carota*	Goat's Rue	*Tephrosia virginiana*
Wild Pea Vine	*Desmodium nudiflorum*	Goat's-Beard	*Tragopogon spp.*
Dutchman's Breeches	*Dicentra cucullaria*	Rabbit Foot Clover	*Trifolium arvense*
Horseweed	*Erigeron canadensis*	Red Clover	*Trifolium pratense*
Spurge spp.	*Euphorbia spp.*	White Clover	*Trifolium repens*
Grasses	*Poaceae*	Stinging Nettle	*Urtica dioica*
Sweet Everlasting	*Gnaphalium obtusifolium*	Blue Vervain	*Verbena hastata*
Rabbit Tobacco	*Gnaphalium spp.*	Narrow-leaved Vetch	*Vicia angustifolia*
Woodland Sunflower	*Helianthus strumosus*	Viola spp.	*Viola spp.*

APPENDIX 3. BUTTERFLIES AND SKIPPERS CENSUSED ON 6 SOUTH CAROLINA ROW, MAY–OCTOBER 1997

Sleepy Orange Sulphur	*Abaeis nicippe*	Carolina Satyr	*Hermeuptychia sosybius*
Hoary Edge	*Achalarus lyciades*	Cobweb Skipper	*Hesperia leonardus*
Sickle-winged Skipper	*Achylodes thraso*	Fiery Skipper	*Hesperia metea*
Gulf Fritillary	*Agraulis vanillae*	Brown Elfin	*Hylephila phyleus*
Lace-wing. Roadside Skipper	*Amblyscirtes aesculapius*	Eastern Pine Elfin	*Incisalia augustinus*
Bell's Roadside Skipper	*Amblyscirtes belli*	Buckeye	*Incisalia niphon*
Carolina Roadside Skipper	*Amblyscirtes carolina*	Clouded Skipper	*Junonia coenia*
Pepper and Salt Skipper	*Amblyscirtes hegon*	Eufala Skipper	*Lerema accius*
Reverse Roadside Skipper	*Amblyscirtes reversa*	Snout Butterfly	*Lerodea eufala*
Roadside Skipper	*Amblyscirtes vialis*	Northern Blue	*Libytheana bachmanii*
Least Skipperling	*Ancylophora numitor*	American Copper	*Lycaeides argyrognomon*
European Cabbage White	*Artogeia rapae*	Little Wood Satyr	*Lycaena phleas*
West Virginia White	*Artogeia virginiensis*	Olive Hairstreak	*Megisto cymela*
Great Southern White	*Ascia monuste*	Mourning Cloak	*Mitoura gryneus*
Tawny Emperor	*Asterocampa clyton*	White 'M' Hairstreak	*Nymphalis antiopa*
Sachem	*Atalopedes campestris*	Long-winged Skipper	*Panhasius m-album*
Great Blue Hairstreak	*Atlides halesus*	East. Black Swallowtail	*Panoquina ocola*
Logan Skipper	*Atrytone logan*	Spicebush Swallowtail	*Papilio polyxenes*
Dusted Skipper	*Atrytonopis hianna*	Cloudless Sulphur	*Papilio troilus*
Golden-banded Skipper	*Autochton cellus*	Common Sootywing	*Phoebis sennae*
Viceroy	*Basilarchia archippus*	Pearly Crescentspot	*Pholisora catullus*
Red-Spotted Purple	*Basilarchia astyanax*	Saffron Skipper	*Phyciodes tharos*
Pipevine Swallowtail	*Battus philenor*	Hobomok Skipper	*Poanes aaroni*
Red-Banded Hairstreak	*Calycopis cerops*	Broad-winged Skipper	*Poanes hobomok*
Spring Azure	*Celastrina ladon*	Yehl Skipper	*Poanes viator*
Large Wood Satyr	*Cercyonis pegala*	Zabulon Skipper	*Poanes yehl*
Gorgone Crescentspot	*Charidryas gorgone*	Crossline Skipper	*Poanes zabulon*
Silvery Crescentspot	*Charidryas nycteis*	Tawny-edge Skipper	*Polites origenes*
Orange Sulphur	*Colias eurytheme*	Whirlabout Skipper	*Polites themistocles*
Common Sulphur	*Colias philodice*	Comma	*Polites vibex*
Gemmed Satyr	*Cyllopsis gemma*	Question Mark	*Polygonia comma*
Monarch Butterfly	*Danaus plexippus*	Little Glassywing	*Polygonia interrogationis*
Nothern Pearly Eye	*Enodia anthedon*	Bunch-grass Skipper	*Pompeius verna*
Creole Pearly-Eye Satyr	*Enodia creola*	Tiger Swallowtail:	*Problema byssus*
Pearly-Eye Satyr	*Enodia portlandia*	Comm. Checkered Skipper	*Pterourus glaucus*
Silver-spotted Skipper	*Epargyreus clarus*	Little Yellow Sulphur	*Pyrgus communis*
Wild Indigo Duskywing	*Erynnis baptisiae*	Banded Hairstreak	*Pyrtsita lisa*
Horace's Dustywing	*Erynnis horatius*	Striped Hairstreak	*Satyrium calanus*
Dreamy Duskywing	*Erynnis icelus*	Appalachian Brown	*Satyrium liparops*
Mottled Dustywing	*Erynnis martialis*	Great Spangled Fritillary	*Satyrodes appalachia*
Sedge Skipper	*Euphyes dion*	Gray Hairstreak	*Speyeria cybele*
Dun Skipper	*Euphyes vestris*	Southern Cloudywing	*Strymon melinus*
Variegated Fritillary	*Euptoieta claudia*	Northern Cloudywing	*Thorybes bathyllus*
Fairy Yellow Sulphur	*Eurema daria*	Red Admiral	*Thorybes pylades*
Northern Hairstreak	*Euristrymon ontario*	Painted Lady	*Vanessa atalanta*
Eastern Tailed Blue	*Everes comyntas*	American Painted Lady	*Vanessa cardui*
Harvester Butterfly	*Feniseca tarquinius*	Northern Broken Dash	*Vanessa virginiensis*
Silvery Blue	*Glaucopsyche lygdamus*	Broken Dash	*Wallengrenia egremet*
Coral Hairstreak	*Harkenclenus titus*	Dogface Sulphur	*Wallengrenia otho*
Giant Swallowtail	*Heraclides cresphontes*	Leonardus Skipper	*Zerene cesonia*
Hermes Satyr	*Hermeuptychia hermes*		