Natural History Occasional Paper No. 26

Proceedings of the 7th Prairie Conservation and Endangered Species Conference

Edited by:
Garry C. Trottier
Elizabeth Anderson
Mark Steinhilber

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February 2004 at Calgary, Alberta

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A TRIBUTE TO WAYNE C. HARRIS

Dale Hjertaas

I was honored to be asked by the organizers to pay tribute to Wayne Harris and by his family and friends with their trust to do the tribute. Heather Gale arranged these images of Wayne, provided by many friends, which will cycle while I speak. I thank Heather, Sheila Lamont, Val Harris, and many friends who shared memories to help me prepare this tribute. You will note that I am not wearing a jacket and tie tonight, as I would normally when speaking to a large group. That tie habit is doubtlessly a result of my upbringing, and I confess that I feel slightly uncomfortable here without one. However as a personal tribute to Wayne, I left my tie at home. We believe Wayne owned a tie, but none of us can recall him wearing one.

Wayne had a passion for nature and a huge knowledge from both observation and books, which made him, beyond a doubt, Saskatchewan's top all-around naturalist. He knew everything from lichens to scat. He recognized the plants, birds, and butterflies and knew what to expect in any area. Thus, he found many rare species as well as new species to the province. Wayne's knowledge of nature was only exceeded by his love of it. That love led him from north to south and east to west in Saskatchewan, from early mornings to late nights. A few problems – such as abandoning his pants and boots in the mud of Big Quill Lake or emerging from a turkey vulture cave with his legs full of porcupine quills and much of him covered in turkey vulture regurgitate – may have deterred friends from getting close, but they never deterred Wayne from exploring and learning. Wayne was extremely generous in sharing his knowledge and enthusiasm for nature. He took hundreds of school children to band birds. He led countless field trips and mentored many developing naturalists, myself included. One of Wayne's lasting legacies is the interest in nature he created through his teaching of students and colleagues.

With his huge passion for nature, Wayne naturally worked hard to conserve, restore, and increase knowledge of Saskatchewan's ecosystems. Wayne believed knowledge did lead to conservation. As a university student, he was an important member of the student group that launched a vigorous, and eventually successful, lobby for the creation of Grasslands National Park. Wayne initiated spring owl surveys and Christmas mammal counts in Saskatchewan. Wayne played a major role in development of the Burrowing Owl Interpretive Centre, Chaplin Shorebird Interpretive Centre, and Morse Viewing Tower and Bird Days.

Wayne played an important role on recovery teams and recovery programs for many species. At these and other meetings, his thoughts always carried great weight because they were based on so much personal field time and observation of the species, a strength which Wayne brought to other areas besides recovery teams. In his years as Saskatchewan Environment Wildlife Specialist for Grasslands, Wayne seized an opportunity to work for environmental protection. Oil and gas development was booming, with its attendant risks. Wayne pushed a strong environmental line in dealing with industry. He was not anti-development, but rather for responsible development. He demanded setbacks from sensitive species. He demanded adequate environmental assessment and mitigation. In his enthusiasm for the environment, he sometimes demanded more than the law or his boss allowed him too! From time to time he found himself in hot water. Nonetheless, as a direct result of his work, environmental protection standards for the petroleum and mining industries in Saskatchewan are much higher today. I understand the sensitive species setbacks that he developed have also been adopted in Alberta. There are many other examples of Wayne's conservation work, like the Great Sandhills, but I have only ten minutes, not two hours.

I need to say a bit about Wayne as a person. He could appear gruff and a bit intimidating, but he was a kind, thoughtful, and totally reliable friend. He observed people well, detected the currents in a meeting, and that was effective in dealing with groups. He had a great sense of humor and was a practical joker. Wayne got on very well with landowners I think, of his ability to share his enthusiasm for the land and because he brought science and common sense together. Wayne was quite dedicated to meetings. In truth, he abhorred them; he enjoyed being in the field much more. Nonetheless, if he could influence a decision for the good of the environment, Wayne would attend the meeting.

Wayne has been my friend, colleague, and birding companion since 1971. His accidental death was a great blow, not only to his family, to me and his many friends, but to the whole naturalist and environmental community in Saskatchewan, and, I think, well beyond our provincial borders. To honor Wayne, friends have worked with the Nature Conservancy of Canada to create the Prairie Conservation Fund. Donations in memory of Wayne to the Fund will help finance research in support of prairie conservation. Information is available at the NCC web site, www.natureconservancy.ca. Tax deductible donations to the Prairie Conservation Fund may be sent to Nature Conservancy of Canada, Suite 301 - 1777 Victoria Ave., Regina, SK S4P 4K5.

In closing, I wish to share one personal experience with Wayne. I said Wayne was a great observer; but he, too, could make mistakes. We were traveling together when a mink dashed onto the road directly in front of us and we heard a thump. Naturally, we stopped to investigate and found the mink lying on the road. Wayne picked it up, saying "We might as well take it for a study skin", and tossed the dead mink into the trunk. A couple hours later we arrived at the Harris farm. On stopping the car, we heard noise and opened the trunk to find one very alive and very unhappy mink!

PRAIRIE CONSERVATION AWARDS

Dr. David Gauthier

Award presented by Greg Reimer

Dr. Gauthier is a Professor of Geography and Executive Director of the Canadian Plains Research Centre at the University of Regina in Saskatchewan. He has held numerous administrative and advisory roles with various provincial and federal science and conservation organizations, including as a founding and executive committee member of the Saskatchewan Prairie Conservation Action Plan partnership. In addition to teaching obligations and publishing and presenting research, Dr. Gauthier founded the Centre for Geographic Information Systems in Regina and was instrumental in the ultimate formation of the Prairie Adaptation Research Collaborative, funding research on all aspects of climate change across the three prairie provinces.

Ms. Dawn Dickinson

Award presented by Sandra Foss

A long-time executive member of the Society of Grasslands Naturalists, Dawn has played a major role in conservation issues. She has been actively involved in organizing workshops, open houses, and public meetings to provide the "naturalist" perspective on industrial development, as well as to provide an education forum on topics including endangered species and biodiversity. She participated in the Cypress Hills Inter-Provincial Committee, was a member of the Cypress Hills Research Steering Committee, and continues to provide her expertise to Cypress Hills Park managers. She has written conservation film scripts, provincial fish and wildlife brochures, and a wildlife and canoeing guide for the South Saskatchewan River. Dawn's writings and activities have been instrumental in helping others better understand and better manage their own activities on grassland landscapes.

McMechan Family

Award presented by Tim Sopuck

The McMechan family operates a 3000 acre mixed farm in southwestern Manitoba and has implemented conservation-oriented practices on both grain production lands and pasture lands. They were winners of the 2001 – 2002 Environmental Stewardship Award presented by the Manitoba Cattle Producers Association and participated in Manitoba's Critical Wildlife Habitat mixed-grass prairie grazing demonstration program. In addition, they promote conservation ethics at the community level, being actively involved in a school-delivered program to conserve riparian areas on pasture land. They enjoy being able to put as much back into their land as they take out and are a prime example for prairie stewardship.

PRAIRIE CONSERVATION AWARD ACCEPTANCE SPEECH

Dr. David Gauthier

It is an honour for me to be introduced by Greg Riemer for whom I have the greatest respect and admiration. He is a true champion of prairie conservation, a fact that you have recognized in choosing him as a past recipient of this award. First of all, I want to thank the organizers for pulling together an absolutely top-rate conference. I also want to congratulate the other award winners tonight on their contributions to conservation.

After 30 years of working in conservation, I am amazed that my colleagues in the conservation community can continue to surprise me, and you have certainly done that with this award. Thank you for your kindness. It means a great deal to me to receive this recognition in Calgary where I grew up as a boy and where some of my earlier work in conservation activities started, for example as a director of the Alberta Wilderness Association. It also means a great deal to me that my wife, Rita, is here with us this evening – nothing that I do has meaning without her.

I also want to give special recognition to the University of Regina and the Faculty of Arts for providing the home base for my research over the past 19 years and for their enduring and enriching commitment to fostering a supportive environment for multi-disciplinary research. Conservation objectives for the prairies can only hope to be achieved by addressing, in an integrated fashion, the full array of social, economic, political, and ideological forces that set the context for the issues. The university has provided a very supportive environment in which to focus on that array of forces.

There is a Chinese Proverb that a person should choose friends who are better than him or herself. I have had the good fortune to have such friends and the chance to get to know and work alongside a number of you and other conservationists in other countries. Many good things that have come out of the work in which I have been involved are a direct result of my association with all of you. My involvement with the conservation community has taught me many things, a couple of which I would like to briefly share with you.

The first lesson learned, and I say this with the greatest respect and affection, is that some of you can be real buggers. There are times when you go off on pathways that defy all logic. However, despite those dysfunctional moments, I have never doubted your love and passion for what you do. The most important lesson that you have taught me is that committed people working together can achieve remarkable things beyond the capacity of any individual.

We all understand that some of our friends are currently going through difficult and, in some cases, desperate times. Students of history tell us that such difficulties have always been a part of the human condition – part of what we learn from studies of the past is that humans can overcome enormous challenges, and the torch is now in our hands to address the many challenges we face. If you are feeling overwhelmed by that challenge, if you doubt the significance or impact of what you are doing to address our collective challenges, if your goals for conservation are not being reached rapidly enough for you – then try to imagine what the prairies would be like without you and your fellow conservationists. My friends, you have achieved great things against enormous odds. I wish that you could meet the people from other countries that know of your work here and hear the great regard that they have your have accomplishments.

While many of my friends are in the conservation community and represent a particular set of values, I have other friends who glory in their capitalism. They have a little capitalist joke that the person with the most money when he or she dies wins. I think that for my small part I would settle for something of a different nature. After 30 years in academia as a student and professor trying to work on conservation issues, I would like to think that by following courses of action in our lives that reduce the harm to each other and our environment, perhaps we will have left a truly valuable legacy.

I do believe that we have every reason to be confident about the future, and I hold that belief because of what I know about you. I know that each of you in your own way is a leader. You have the strength, values, and extraordinary willingness to give so much of yourselves in such ways that you are changing the world. So I take great satisfaction from this opportunity that you have given me and thank you for all that you have done for conservation and all that you will continue to achieve.

PRAIRIE CONSERVATION AWARD ACCEPTANCE SPEECH

Dawn Dickinson

I am honoured to accept this 7th Prairie Conservation Award. But in accepting, I want to acknowledge how much I owe my endeavours to the unfailing support and encouragement of the Grasslands Naturalists, to the Federation of Alberta Naturalists President, Dennis Baresco, its Board of Directors and staff, as well as to other friends and colleagues. Grasslands Naturalists members are fortunate in living in a region containing extensive areas of intact native mixed-grass prairie, a magnificent prairie river, and the beautiful fescue grasslands of the Cypress Hills. We have all worked long hours over the years to protect the lands, waters, and wildlife of this region from incremental destruction. We have also worked over the years towards a better understanding of the natural processes that drive these ecosystems. It is encouraging to see from the sessions at this conference that there is an increased focus on ecosystem research and cumulative effects.

Over the past twenty years or so, we have come a long way in our understanding of prairie grasslands, but we have not won so far in translating this understanding into decisions. In our drought-prone corner of southeastern Alberta, we are still losing drought-adapted native prairie on our public lands to cultivation for crops (most recently potatoes), crops which require irrigation from a river already stressed to the limit by demands on its waters. A public review of the process of making such decisions is badly needed.

During the past couple of decades, we have seen the evisceration of government agencies, including those responsible for environmental protection, by a policy of endless restructuring and excessive and continuing budget and staff cuts. The cumulative effects of this "slash and burn" ideology are just as alarming as the cumulative effects of unintegrated landuse practices, although the former have not yet been modelled. At the same time, growing like fireweed after a fire, there has been a proliferation of government-initiated stakeholder committees. Most of these are well intended. Some have well planned terms of reference and are effective within the limits of their mandate. Others are less so, while some are merely a public relations sham. Those members not paid by government or industry for their participation are required to donate many months of volunteer time. A hitchhiker's guide to stakeholder committees is long overdue.

As we have seen recently, audits can bring out surprising bits of information. I believe that it is vitally important to evaluate the reasons for our successes and failures – where and how we spend our limited energy and resources. There have been two major barriers to such an audit: the lack of time when we are already stretched so thinly and the perception that such evaluation may be too negative. It has become more important to justify, rather than evaluate, what we do. To quote from John Ralston Saul's *Voltaire's Bastards*, "Our society contains no method of serious self-criticism for the simple reason it is now a self-justifying system which generates its own logic." Perhaps we can demonstrate that our own segments of society are engaged in the constructive process of self-criticism in furthering our vision of prairie conservation.

I thank you for the great honour you have done me tonight and will look forward to seeing many of you again in three years time.

PRAIRIE CONSERVATION AWARD ACCEPTANCE SPEECH

McMechan Family

On behalf of my family, Debbie, and our kids, I would like to thank everyone for this honour. Our piece of ground has been in my family for three generations. My grandmother loved it for its beauty. My father saw native grass as irreplaceable and protected it through his lifetime. I know it was not always easy. The conservation practices of my father were often done at economic hardship and alone. I remember when Father passed this land to me; he said, "I've never really made any money from this ground." And it was true, but our family treasured it for its aesthetic and sentimental value. When you are standing at the pole gate on the east side, looking west as the setting sun's rays illuminate the prairie wildflowers, as the last light of a summer day casts its shadow on the old Boundary Commission Trail, as the air is filled with the sounds of the gurgling creek and the final few prairie birdsongs of the evening…you cannot help but be struck by the beauty of this piece of ground.

BUT, beauty means nothing to my banker. If we cannot make a viable return from this ground, sooner or later someone will be sowing Round-Up Ready on this section. Our partners, Manitoba Habitat Heritage Corporation, Critical Wildlife Habitat Program, and our local conservation district, have made information and resources available to us. However, it is more than just the organizations: it is the people in them. We have been fortunate to work with individuals like Roy Bullion, Curtis Hullick, Peggy Westthorpe, and many others. Their down-to-earth, common sense approach to conservation has resulted in the strengthening and regeneration of our native grass as well as making our cattle operation more profitable. So while we feel it only right to share this honour with our partners, we are keeping the award! Thanks so much.

PLENARY SESSIONS

A SHARED VISION: KEYNOTE ADDRESS

Monte Hummel
World Wildlife Fund-Canada

In the next twenty minutes, I have been challenged to present a whirlwind, big-picture assessment of how far conservation has come in the prairies since World Wildlife Fund's (WWF) Wild West program in the 1980s, and I will speculate about the future. There will also be some reflections interwoven on this morning's theme, namely a "Shared Vision". Despite some exceptional gains, which were the exception, I do not think we have come very far since Wild West and certainly not far enough from Nature's standpoint. I think that is because we ended the 1980s with what we thought was a shared vision but in reality was not, and I should probably take some personal responsibility in the matter. I also think we are going nowhere in the future, unless we do fashion a truly shared vision for prairie conservation.

Wild West was a five-year regional conservation program, financed by WWF through money raised from both the east and the west, but the finances were spent entirely by a multi-party steering committee of westerners. Think of it as "transfer payments for Nature". Some of our original steering committee members are here today, still hard at work. WWF made it clear from the very beginning that the Wild West program was a catalytic investment, intended to pick up the pace and to get things moving, but we could not be here in a big financial way forever. If anything, we have stayed much longer than we promised. We funded 50 to 60 field projects on species at risk, supported some but not enough collaborative projects with landowners to protect habitat, and finished the program in 1989 by publishing the first Prairie Conservation Action Plan which mapped out what needed to be done over the next five years. This plan had three things going for it:

1. Ten reasonably clear recommendations in the form of five-year conservation goals and implementation actions;
2. A map that indicated how much natural habitat was left and graphically served to focus the mind;
3. A head of political steam in the form of support from two prairie province Premiers and the responsible Minister from Alberta through press conferences which I attended with each of them.

While I do not have time to restate the ten goals, note the summary from our original document and observe the map on the handout provided. Do not worry if you cannot see the detail; just note the grey shading which constituted all the prairie habitat subregions with more than 50% of the native vegetation remaining in 1989. Those subregions occupied about 20% of the prairie at that time. Unfortunately, I do not have a comparable 2004 map to show you, because this map was created more or less by hand in the pre-GIS era from federal and provincial base maps. However, I did manage a few GIS Powerpoint slides to give you a general idea of where things stand now – a story familiar to all of you, I am sure.

Here is what things looked like back in the halcyon days of 1600 (Figure 1) when, as Aldo Leopold said, "The prairie tickled the bellies of the buffalo." Shown next in yellow-green is the remaining land cover that had not been subjected to the impacts of agriculture 400 years later (Figure 2). Look hard and you will see some. Incidentally, I do not mean to suggest that all lands impacted by agriculture have been trashed or that they cannot make some important contribution to biodiversity conservation. That map includes the farms of my grandparents on both sides of the family who homesteaded in Saskatchewan. Since I learned to drive a tractor at age nine, I personally disked, cultivated, sprayed, and swathed my own little patch of red on that map around Nokomis and Nipawin. Now observe the land cover map including agriculture, as well as oil and gas infrastructure (Figure 3). In 1988 (at the end of Wild West), there were about 7,500 active oil and gas wells in Canada; in 2002, there were about 20,000. Finally, the roads are layered on top of agriculture and oil and gas development (Figure 4). If this map looks alarming, even overstated, it is because the prairies are, in fact, one of the most heavily roaded ecoregions in Canada. As you have heard from other speakers, this trend is only going to intensify, especially in Alberta.

Given the state of the modern-day Canadian prairie and this room full of people who actually think they can do something positive about this state, an understandable question would be, "Are you all stark raving crazy, or are you the most courageous people on the planet?" The answer, of course, is "Yes". To add insult to injury, you are either ignored or misunderstood by the rest of the country, including by some of your conservation colleagues who should know better. For example, when arranging a visit by Prince Phillip to the clear-cuts of BC in the 1990s, I got fed up with all the west-coast activists bickering over what he should see or should not see. In frustration, I told the press that believe it or not, the most endangered ecosystem in Canada was not west-coast old-growth forest, but our own grasslands. A well-known west-coast activist was quoted the next day as saying, "Hummel seems to think we should all be more concerned about peoples' lawns."

So, there is still a big job to be done when it comes to conserving prairie Canada. I am sure there have been some important gains in the last 15 to 20 years, and I want to be the first to recognize those efforts. But we are losing. Nature is losing. The landscape is just made for a conservation martyr, for someone who feels the need

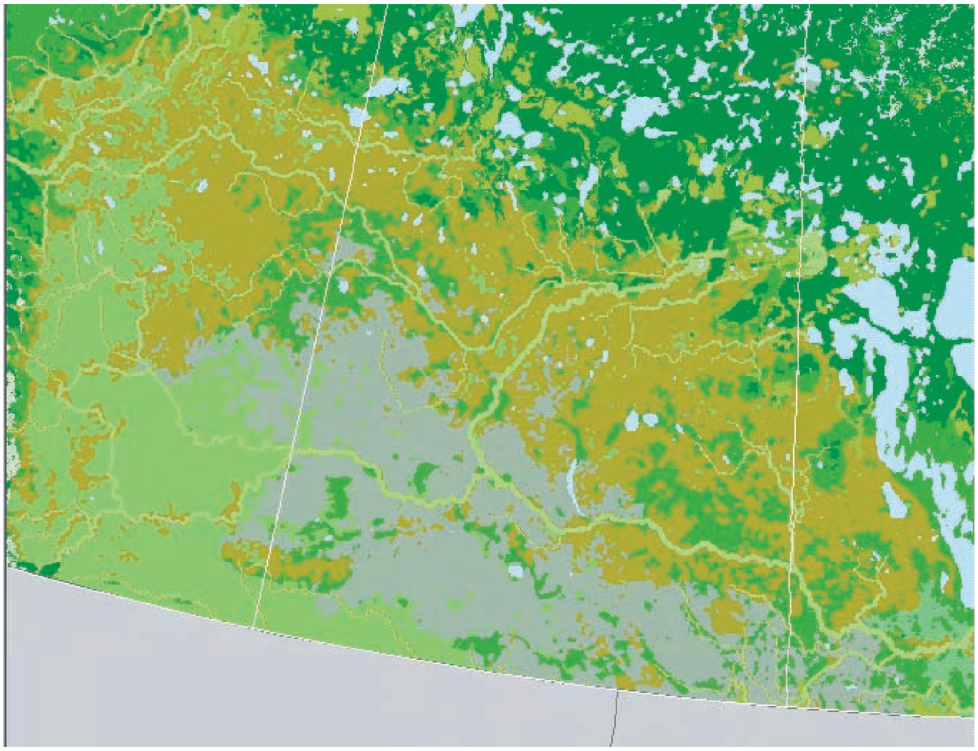

Figure 1. Prairie landscape in the 1600s. Brown shading indicates woody savanna, grey shading indicates mixed grasslands, and green shading indicates short grasslands.

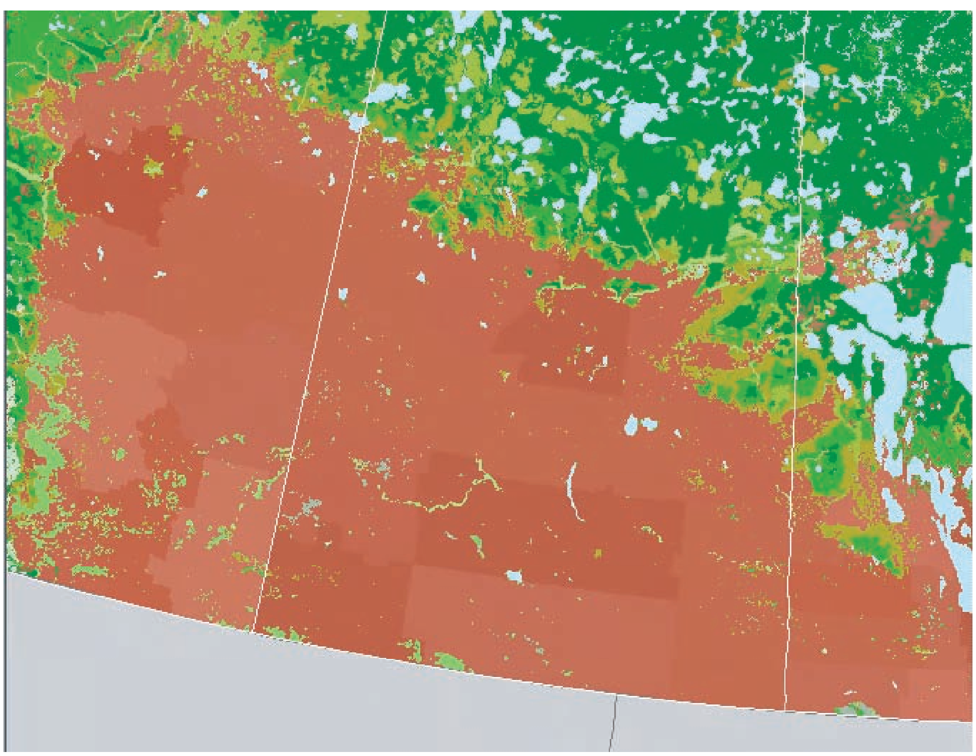

Figure 2. Current Canadian prairie landscape as impacted by agricultural activities. Red shading indicates area impacted by agricultural activities, brown shading indicates woody savanna, grey shading indicates mixed grasslands, and green shading indicates short grasslands.

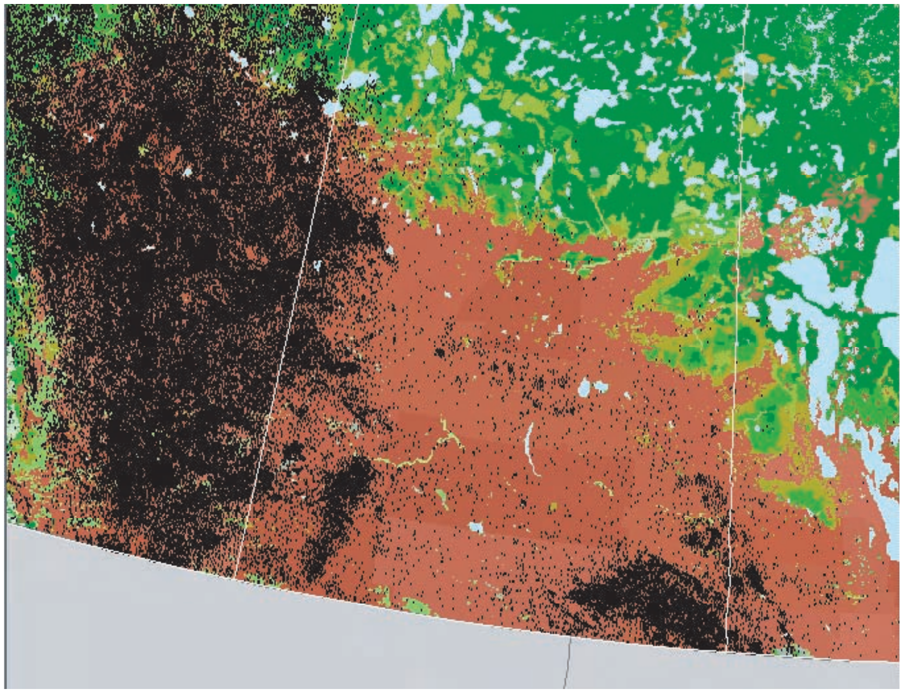

Figure 3. Current Canadian prairie landscape as impacted by agriculture and oil and gas activities. Black shading indicates area impacted by oil and gas infrastructure, red shading indicates area impacted by agricultural activities, brown shading indicates woody savanna, grey shading indicates mixed grasslands, and green shading indicates short grasslands.

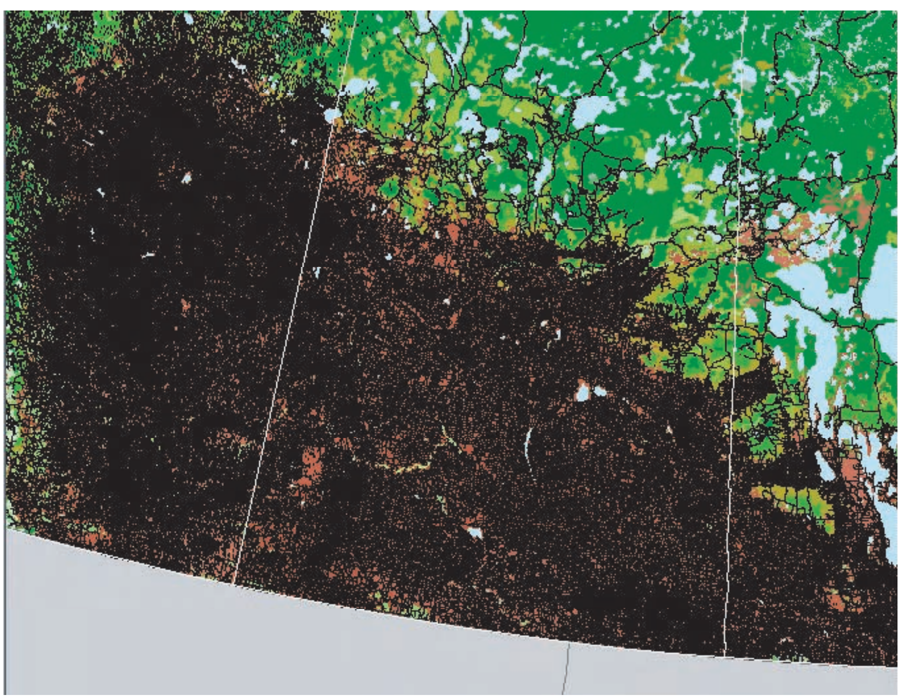

Figure 4. Current Canadian prairie landscape as impacted by agriculture activities, oil and gas infrastructure, and transportation infrastructure. Black shading indicates area impacted by oil and gas infrastructure and roads, red shading indicates area impacted by agricultural activities, brown shading indicates woody savanna, grey shading indicates mixed grasslands, and green shading indicates short grasslands.

to fight the good fight and lose. But I have got to tell you, that is not me; I am paid to fight the good fight and win. Now I am aware that there are all kinds of reasons for why we may not be winning big on the prairie, but I only have time to pick one: we do not have a truly shared vision. More specifically, the folks who are negatively impacting the prairie have not bought into the benefits of its conservation. And maybe that is our fault, not theirs. Shared conservation visions among conservationists, and only conservationists, get published and read by other conservationists, and only conservationists. They go nowhere on the ground. In the words of a cattle-raising friend of mine, "All this gum flap isn't worth a cow flap." On the other hand, a shared conservation vision among conservationists, First Nations, farmers, ranchers, landowners, energy companies, recreational users, and governments stands a chance of getting us all to where we want to go, even in this prairie landscape and especially in this prairie landscape.

Is this shared vision easier said than done? Well maybe, but I believe the most important question you can ask is, "Shared by whom?" Furthermore, the key parties needed to implement that vision must be aboard; otherwise you are relegating yourself to just declaring war and playing around the edges where you are not going to change anything of any importance. If we really mean business, the conservation movement must be much more demanding of ourselves. We are too accustomed to the self-image of "underdogs" and "watchdogs", looking in from the margins of power and commenting (usually negatively) on the decisions taken by others. At WWF, I tell my staff that we are neither underdogs nor watchdogs, we are "do-dogs", We have moved to the centre of power to actively engage the system and to be party to the decisions that draw comment from others. This has meant some controversial changes in our operating style. We must bring some real equity to the decision-making party, not necessarily in the form of money, but in the form of expertise – expertise that governments and industry genuinely need but which they currently lack. We must listen and figure out what others around the table need, not just ourselves. We must move from being a "stakeholder" to being a "partner", Stakeholder is a rather paternalistic concept, meaning one of many parties who should be consulted before someone else makes all the decisions. A partner, on the other hand, is an indispensable part of the decision-making process itself and crucial to the success of decisions which are mutually taken. As a partner, we must own the decisions we have helped make together and be loyal to our partners even in the face of criticism by others. This may mean working with a partner, for example a company or a government, who is prepared to do the right thing in one area, while they continue to under-perform in another. Waiting for them to be perfect everywhere before we will do business is a prescription for paralysis.

Accordingly, here are my suggested five ingredients for a shared conservation vision that is actually going to make a difference:

1. The vision should be inspirational.

A shared vision should set out to accomplish a goal or state of affairs that right now seems beyond reach. People should be saying, "Wow, would that ever be great! Do you really think we could achieve that?" This is what the management gurus in the U.S. call BHAGs, "big, hairy, audacious goals", In our case, we must be bold enough to target not just what is possible but what is necessary.

2. The vision must be shared by the key players needed for implementation.

I have stressed this already, but conservationists need to resist our usual temptation to write-off certain sectors as being terminally bad. "Hell hath no fury like the scorn of an environmentalist."

3. A shared vision should include shared economic interests.

Historically, conservationists have been pretty good at proposing solutions that ask landowners or business to provide public benefits at private expense. On the other hand, some landowners and industry associations also expect private benefits at public expense. Nature, of course, gets caught between these two equally unfair positions and suffers the consequences. A shared conservation vision should clearly identify both private and public benefits and reach agreement on who pays for what, in direct proportion to how much each party benefits. To put this more positively, my experience elsewhere, for example in conserving our forests, the Arctic, and marine habitats, has shown that things really start happening when those who do the right thing also benefit economically. Although this has been problematic on the prairies, especially now with BSE, I believe that the line-up of conservation-minded landowners recognized at the banquet last night testifies that it can be done. This, however, means that conservationists must have a vested interest not just in their conservation achievements but in their profitability as well.

4. Politics must be checked at the door.

Environmentalists tend to inhabit the left side of the political spectrum, which has often meant giving up on those inhabiting the right. For example, most BC activists plan to simply stem the biodiversity losses under a Gordon Campbell regime, but do not really plan for any serious gains. I believe this is a huge mistake. It is tactically naive and a disservice to Nature. It is frankly just plain stupid to think that any particular political party has a corner on environmental righteousness. We have to work with whomever we get. We must have high expectations of all politicians, no matter what their political stripe, and be prepared to fairly mete out both punishment and praise when they are deserved. In this regard, here is a provocative example for you. I am very proud of the fact that the biggest contributions made to WWF's ten-year Endangered Spaces Campaign were made by the "two Mikes" – Mike Harcourt and Mike Harris. Predictably, environmentalists saw fit to award the Harkin medal to Harcourt for doubling the amount of protected area in BC. Also predictably, no one dared to nominate Mike Harris, who by the way personally spearheaded the largest expansion of Ontario's provincial park system ever by adding 378 new protected areas totaling 6,000,000 acres with one stroke of the pen. Offhand, I would say it is a good thing for Nature that we did not give up on the other Mike, despite his disastrous performance on other parts of Ontario's environmental agenda.

5. Finally, a shared vision must stay focused on the mission, on our conservation goals, and must be disciplined in measuring progress towards those goals.

In our business, we must never confuse process with progress or progress with success. We must always measure success in terms of tangible gains for Nature, not column inches or scoring points against those we dislike. Furthermore, we cannot be satisfied with "Well, we might not have accomplished what we set out for ourselves, but we sure learned a lot trying." Either we believe our own rhetoric of urgency, or we do not. If conservation truly is a time-limited opportunity, and I believe it is, then we cannot softly accept or explain away failure to accomplish what really needs to be done.

In closing, let me summarize the ingredients for a shared vision and return to the big picture. A shared conservation vision should embrace inspirational goals, it must be shared by the key parties needed to implement it, it must fairly address mutual economic benefits, it requires checking your politics at the door, and it means being tough in measuring progress towards clearly defined goals. I honestly believe that you and I have been almost fatefully placed on this planet at a crucial moment in its natural history. We represent the last generation that will have the opportunity to do so much, to proactively protect habitats that are still largely intact, to bring about a fundamental change in how we conduct ourselves in more heavily impacted habitats, and to rescue or restore those bits and pieces of Nature that already have their backs to the wall. I further believe that it will be prohibitively expensive, effectively too late, and therefore meaningless to do this 25 years from now, because we will have lost the option by then. So, we "elders" urgently need the younger cohort at this conference, and we need you now. The Canadian prairie, as depicted on that map which has been glaring out at you throughout my talk, is instructive for the conservation movement in general. It represents where we do not want to be if at all possible, and it summons up tremendous courage to carry on. You folks truly are the bravest among us. So Godspeed, and let's carry on.

A SHARED VISION: PANEL PRESENTATION

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There has been a tremendous amount of very valuable information and perspective provided for your reflection. Speakers have asked you to focus on a number of important and necessary questions, and some speakers have emphasized the need for us to consider social and economic phenomena in terms of conservation issues. In my remarks, I will emphasize the importance of placing conservation within the context of peoples' perspectives of their quality of life and community sustainability.

First, however, I would like to remind you of the importance of scale, both spatially and temporally. Our view of the world and our assessment of its conditions are scale-dependent. This means that the problems and their possible solutions are also scale-dependent, which in turn means that single visions for conservation may not be appropriate and that single champions or single groupings of partnerships likely are not sufficient. In other words, a "shared vision" may only be possible at particular scales and may involve a focus on different issues and involve different partnerships at those scales.

"Quality of life" is a useful framing concept for consideration of the multitude of factors that affect the behaviour of people and their attitude towards conservation. When specifically questioned about their attitudes towards conservation, repeated surveys of Canadians have shown that the vast majority is supportive of conservation programs. When Canadians are questioned more broadly on the issues of greatest concern to them in their daily lives, however, conservation issues fall relatively low on their list of priorities, for example, well below concerns about employment, health, personal security, and education. This suggests that conservation of biodiversity is not the most immediate priority for most Canadians in maintaining or improving the quality of their life, possibly due to their lack of recognition of any direct link between sustaining ecosystem elements and processes and their own economic or health situation. A few examples of how other factors besides conservation weigh heavily in peoples' definition of the quality of their life may be useful. Dr. Judith Maxwell with the Canadian Policy Research Network has suggested that there are four phenomena of growing importance that influence the socio-economic characteristics of Canadian communities, and these are discussed below.

First, Dr. Maxwell refers to a growing territorial divide in which a relatively few, large, and growing metropolitan areas occur alongside many more smaller cities and rural communities with low or even declining rates of growth. There are five city-regions in Canada: Toronto, Montreal, Ottawa-Gatineau, Vancouver-Victoria, and the Edmonton-Calgary corridor. These regions captured over 83% of national population growth between 1991 and 2001. The major flows of people, ideas, and capital are converging on the largest cities, making them hubs of innovation and what some might call engines of growth. She points out that such metropolitan concentrations raise challenges for communities at risk of being left behind and for policy-makers, including an aging and less diverse population, a shrinking employment base, a limited revenue stream, and lower quality public goods and services.

Furthermore, she points out that there is a spatial segregation phenomenon. Poverty is increasingly concentrating in cities with a 22% rate of low-income people compared to 16% in rural areas. This poverty phenomenon is paralleled with a ghettoization phenomenon, that is, the tendency of visible minorities, Aboriginals, lone parent families, and disabled people to cluster in poor areas. The third point is that there is a new wage structure developing and income polarization. She points out that real minimum wages have fallen by 15 to 20% since 1975, depending on the province. One in six adult Canadians now works for less that $10/hr: if they work full-time, all year, they cannot make more than $21,000 which is well short of the income required to support a family. Those Canadians are very vulnerable and about two thirds of them are women. Finally, the fourth phenomenon is that there are significant changes in social policies aimed directly at poor people, families, and, in the case of health services, at specific health conditions which collectively have created a "poverty trap" for the working poor.

Dr. Maxwell observes that these four phenomena suggest that a large number of Canadians cannot achieve the characteristics by which they define the quality of their life; that growing areas of space are becoming distressed communities; and that it is becoming increasingly difficult for people to participate in work and civic life. This is having two kinds of costs: the loss of human capital and the monetary costs of policing, social transfers, and health care for a portion of the population that is vulnerable. She also reminds us that senior governments have a mandate to serve both urban and rural citizens, though they are not comfortable serving local needs and cannot provide local leadership. Municipal governments are also often fragmented and most have weak policy capacity, while businesses are preoccupied with the costs of doing business including issues of attracting skilled workers.

Given these pressures and characteristics, conservation issues not surprisingly fail to rank among the highest priority items facing most individuals or agencies and organizations. While conservation scientists must continue to improve understanding of species and their habitats, that understanding by itself may be insufficient to achieve conservation goals. Successful biodiversity conservation likely depends in part on an understanding and awareness of past, present, and future land uses and socio-economic conditions. It requires an understanding of what people regard as the most important factors affecting their quality of life. If, for example, most people are concerned about economic and health issues, can the conservation of biodiversity be either directly or indirectly helpful in addressing those economic and health issues? If so, then a link between conservation and individual quality of life could be effective in building community sustainability. At the beginning of my remarks, I emphasized the importance of temporal and spatial scale in addressing conservation issues. If successful conservation requires consideration of and linkage to the full array of issues by which people define their quality of life, we must remember that factors affecting quality of life vary across scale. Therefore, programs and policies to fully integrate conservation as an important component in maintaining or improving quality of life must be scale-sensitive.

OCEAN OF GRASS: A CONSERVATION ASSESSMENT FOR THE NORTHERN GREAT PLAINS

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Abstract: Grassroots, regional, and national conservation organizations formed the Northern Plains Conservation Network (NPCN) in 2000 to coordinate their mutual interests in grassland conservation. The focus of this effort is the Northern Great Plains Ecoregion (NGP), an area that World Wildlife Fund has identified among its "Global 200" – the 238 most important ecoregions on Earth for conserving biodiversity.

On behalf of the NPCN, we conducted an ecoregion-wide biodiversity and socio-economic assessment of the NGP. Global climate change, declining species trends, invasive species, and widespread fire and drought disturbance patterns unique to the grasslands suggest the need to think at larger scales than in the past. Our assessment therefore focused on those large landscapes in the NGP with high biodiversity and exceptional restoration potential. We used a decision-making model that integrated NPCN member input on how to weight various biological and socio-economic criteria. The analysis identified ten terrestrial landscapes, averaging more than one million hectares in size, where opportunities exist to restore large-scale ecological processes as well as viable populations of keystone and imperiled native species. These areas contain some of the largest blocks of untilled prairie remaining in North America. Our assessment also identified 23 outstanding reaches of NGP rivers and streams as conservation priorities. The ten large terrestrial landscapes complement more numerous, and often smaller, areas of biological importance in the NGP identified by The Nature Conservancy and others. Comprehensive conservation will require attention to the entire suite of these biologically important areas. This assessment recognizes that conserving high-priority areas will not, by itself, maintain the biological health and integrity of the ecoregion. Good stewardship of the intervening landscape is crucial. The resulting matrix of conservation and working landscapes will support the full range of biodiversity, will be more resilient to environmental change, and will provide a more diverse economic base for the people that live there.

ECOSYSTEM APPROACH TO CONSERVATION: HOW INCLUSIVE CAN IT BE?

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PREAMBLE

A goal of this presentation is to relate experiences, pertinent literature, and interpretation to 20 years of academic and practical experience in conservation. My focus includes biodiversity conservation but is broadened to include diverse disciplines and ultimately ecological, social, and economic sustainability. The area of interest includes the Northern Great Plains where agriculture is a primary economic activity and landscape modifier.

My premise is that despite considerable conservation successes and a maturing global ecology movement, the protection of ecosystem health has not kept pace with the challenges at hand. Some major resources (soils, fisheries) have been depleted worldwide; inequities and starvation among peoples are severe; and this, coupled with climate change, threatens life-sustaining processes in the biosphere. Einstein has been quoted as saying, "One can't expect to use the kind of thinking that got one into a problem, to also get one out." By extension, I suggest that in addition to the diverse disciplines and societal sectors now working toward sustainability, we would do well to devise a role in our society for a new kind of professional who is comfortable working across disciplines, who is steeped in systems theory, trained in conflict resolution, and who embraces humanism in a cooperative sense; a biosphere-sustaining professional.

My aim in this paper is not to repeat points made in the presentation verbatim, but to highlight major ideas and to provide relevant citations. Since a person's broad conceptual outlook is clearly influenced by one's education and experience, I cite three major endeavors in which I was involved and which had a transforming influence on my world view: research in conservation biology at Hanna, Alberta (e.g., Clayton and Schmutz 1999; Schmutz et al. 2001), the Prairie Ecosystem Sustainability Study (Irvine et al. 1997), and the Important Bird Areas Program (www.ibacanada.ca).

CONSERVATION SUCCESSES AND FAILURES

Since the green revolution and the technological achievements that followed, our own ability to alter the biosphere and its life-sustaining processes now threatens our existence. The potential destructiveness of this power has been recognized in some major global initiatives such as the Brundtland Commission (IUCN 1980), the Convention on Biological Diversity (Environment Canada 1995), and the Kyoto Protocol. At a smaller scale, there are successes in species protection and recovery. Through improvements in waste management, some fish can now exist in streams flowing through centuries-old cities in Europe. With regulated harvest, deer are so numerous as to cause problems in North American suburbs (Pletscher and Schwartz 2000).

In contrast to the above, many would rightly point out that these successes pale in comparison to the major systemic environmental challenges we now face. Such failures include a worldwide fish harvest that is unsustainable (Myers and Worm 2003) and water pollution that has its impact at the level of the world's seas as evidenced in coral declines (Pandolfi 2001). The estimates of expected species losses from climate change are sobering (Thomas 2004), and when considering solutions, Athanasiou (2003) cautions that the Kyoto Protocol should be saved and that even this urgent effort is nowhere near enough. Satellite monitoring of high Arctic sea ice already shows an average 9% decline since 1979.

If a continuing dismantling of the world's ecological processes is so difficult to reverse, what are the driving forces? Which sectors stand to gain and be winners? As a National Farmers Union report shows, the Canadian family farm sector is not a winner. The world's sectors and interests likely do not deliberately aim to destroy the planet; rather, collectively we are unable to comprehend the cascade effect of particular actions and programs. We are unable to comprehend the role of individual events and strategies in determining system outcomes, and when we do, it is difficult to translate this into action.

WHAT ARE SYSTEMS AND HOW COULD SYSTEMS THEORY HELP?

Systems vary in their complexity, including (1) static systems: a floor plan; (2) simple dynamic systems: clockworks; (3) cybernetic systems: a thermostat that is goal-seeking but not goal-setting; (4) open systems: self-maintaining, self-reproductive; (5) genetic-societal systems: division of labour such as in a bee hive; (6) animal systems: instinctive and goal-seeking; (7) human systems: self conscious, goal setting, planning; (8) social systems: human organization and its values, roles, history, art form; and (9) transcendental systems: un-knowables for which we have no answer (Van Gigch 1978).

Systems thinking can teach us perspectives that do not flow automatically from specialized knowledge about parts of systems. Some complexity-embracing parables can be thought provoking and instructive. Their utility does not lie in their literal prescription, but they can be useful in day-to-day problem solving as a reality check. Such statements and their complexity-theory analogs (e.g., Gleick 1987) include the following:

> "So, naturalists observe
> A flea has smaller fleas that on him prey,
> And these have smaller fleas to bite them,
> And so proceed ad infinitum."
> -- Self-similarity at ever smaller scales.

> "For want of a nail
> The shoe was lost,
> For want of a shoe
> The horse was lost.
> For want of a horse
> The rider was lost,
> For want of a rider
> The battle was lost,
> For want of a battle
> The king was lost."
> -- System sensitivity to initial conditions.

A door between two spaces, a Holon (Allen and Starr 1982), represents a structure of its own, yet also serves an integrative function between the two spaces it connects. What would endangered species protection look like if viewed as a Holon?

Scheffer et al. (2001) likened the changes in aquatic systems which they observed to such chaotic shifts between two attractors. They write,

> "All ecosystems are exposed to gradual changes in climate, nutrient loading, habitat fragmentation or biotic exploitation. Nature is usually assumed to respond to gradual change in a smooth way. However, studies on lakes, coral reefs, oceans, forests and arid lands have shown that smooth change can be interrupted by sudden drastic switches to a contrasting state. Although diverse events can trigger such shifts, recent studies show that a loss of resilience usually paves the way for a switch to an alternative state. This suggests that strategies for sustainable management of such ecosystems should focus on maintaining resilience."

-- Shifts between two different dynamic states -- Strange attractors.

NEW SCALES OF ACTION

Many scientists and non-scientists feel that more and ever better science is most promising for solving environmental problems. This is most evident by a predictable call for more science-based information when a challenge arises. More information is not an end in itself, but merely a means to an end (e.g., Kreeft 1984). Redford and Sanjayan (2003) state, "We have spent our careers pointing the finger of blame at the human race. Ours has been an accounting approach to conservation: how many, where located, how many gone… Our focus on crisis has hampered conservation biology in achieving a scale of action required to match the world's environmental problems."

During the last century, biologists have been exposed to enormous and welcome growth in ideas and approaches. A quick historical survey might begin with the 1920s wildlife management of game communities on the Arizona Kaibab Plateau that failed apparently because the intricate interaction between predators and prey was ill understood. The notion of an ecosystem was advanced in the 1930s (Bocking 1994), and the concept of sustainability was introduced in the 1960s (e.g., Jackson 1996). The Society for Conservation Biology was formed in 1986 with the express goal to transcend science and include conservation action. Costanza et al. (1997) awakened the world to the notion of ecological services. They calculated that nature's ecological services, if we had to recreate and pay for these, would amount to costs greater than the world's gross national products combined. On a challenging note, Bjorn Lomborg (2001) criticized environmentalists for overstating doom and gloom. While some of Lomborg's conclusions may be flawed, his criticism did prompt some to constructively re-examine their scales of environmental action.

Sustainability concerns have been increasingly embraced by a broad spectrum of civil society, empowered by rapid internet communication. In this context, sociologists have raised provocative questions, trying to move us from the cybernetic goal-following to goal-setting approach. Allen Hammond (Miller 2002) asked what globalization that works for everyone would look like. He distinguishes between the three following directions: a market world scenario of unfettered capitalism that may bring economic growth, but does not solve equity or environmental problems; a fortress world scenario, leading to inequalities, authoritarian oppression, and environmental destruction; or a transformed world, which is Hammond's optimistic vision for an empowered citizenry, enlightened corporate actions, and radical policy change putting preservation of the environment and social equity as their number one priorities.

Recently, Orr (2002) proposed four challenges of sustainability. He suggests that (1) we would benefit from "…more accurate models, metaphors, and measures to describe the human enterprise relative to the biosphere"; (2) that "…the transition to sustainability will require a marked improvement and creativity in the arts of citizenship and governance"; (3) that we might "…inform the public through greatly improved education"; and (4) that we would benefit from a "…higher level of spiritual awareness", as science on its own, for example, can give no reason for sustaining humankind. Akin to the future directions explored by Hammond (Miller 2002), Orr suggests that we forgive wrongs of the heart and embrace genuine concerns for social and economic justice.

Orr (2002) clearly opts for the transformed world when seeking solutions to our sustainability crisis. He invites us to seek beauty in design and in complexity rather than accounting. Holistic design may represent one of the promising new scales of action advocated by Redford and Sanjayan (2003). In agriculture, promising designs in the interest of advancing sustainability include consumer-producer linkages under the headings of community-supported agriculture, food trusts, eco-labeling, and the like. Gertler (2003) advocates a cooperative design and states that with"…their internal dynamics and logic, and given their strong links with members and communities and with other proactive organizations, cooperatives may be capable of significant progress on sustainable development initiatives …."

A CONSERVATIONIST'S TOOLBOX

Although I am attempting to make a case here for the creation of a new kind of 'biosphere-sustaining professional', it is clear that many individual people, professional and non-professionals, are conservationists at some level. While public administrators and academics believe strongly that they have a genuine influence on how public and private affairs are conducted, it has been claimed that artists have a comparatively greater influence (Stuart Hill, pers. comm.). If our environmental crisis is becoming more rather than less ominous, if the biosphere and human affairs are influenced by complex system-level mechanisms, if human population and consumption trends are rising, and if ours has been an 'accounting' approach that has not fully averted our current crisis, then a new set of tools may be needed.

Our major tools for sustainability include laws, regulations and policy, some market-based tools, and a variety of personal or funded stewardship mechanisms facilitated by a voluntary sector (Figure 1). These tools vary in their ability to benefit most or all of an ecosystem for which they are designed and in their ability to restore full or partial ecosystem function; often a holistic goal is not part of the design. Below are thought-examples of how a biosphere-sustaining professional might use systems theory as a tool to protect a given ecosystem and its function more completely. Where appropriate, these are framed in my own experiences with burrowing owl conservation. In essence, the recommendation is to create many micro-biospheres by strategically connecting and integrating the ecosystem and its function with human social and economic capital. A cooperative structure may be one option to achieve such a new scale of action called for by Redford and Sanjayan (2003) and Orr (2003).

A Holon

If burrowing owls are on the one hand a self-assertive species-entity with its own 'animal systems' level of operations, and on the other hand are integrative in a sense that they depend on and influence the system around them, then the owl-species approach may be too limited for lasting conservation. In practice, the owls *per se* have been the subject of much study and conservation action. When other elements in the owls ecosystem are included, these tend to be elements close to the owls in a systems sense. It may be more practical to set goals and actions for the owls' habitat. This approach may be more effective in the long term and will be beneficial to a host of other Great Plains species. If neither species-level nor system-level goal setting promises results, then the loss may be inevitable and should itself serve to refocus our relationship to the system.

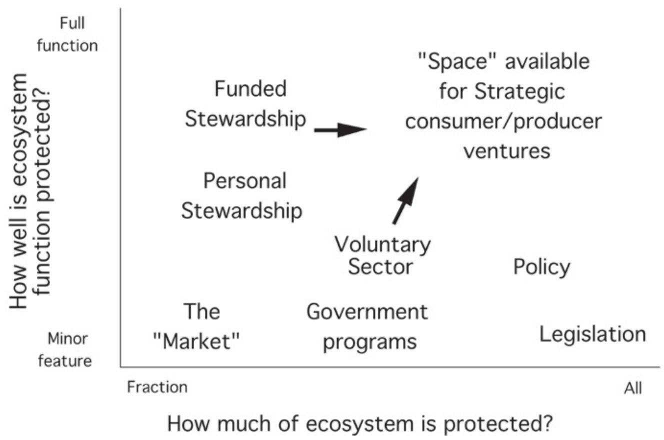

Figure 1. Concept diagram showing major institutional and personal conservation instruments, in relation to how completely they address a given agroecosystem and how well they may protect ecosystem function.

Strange Attractors

Predation emerges as a major factor in the burrowing owls' decline in Canada, and this can be linked to a fundamental change from a bison and fire disturbed ecosystem to an agricultural ecosystem (e.g., Clayton and Schmutz 1999). Other community-level studies involving rare and common species have demonstrated similar incidental predation (Litvaitis and Villafuerte 1996; Yanes and Suárez 1996). This shift to a new predation-driven attractor may have very different consequences than a pre-settlement attractor with a different dynamic (e.g., Scheffer et al. 2001). Thus, looking toward the past for clues in a so-called 'natural system' under which the owls have evolved may provide little help for conservation under our current system trajectory.

Self-Similarity and Micro-Biospheres for Sustainability Including Owls

Planning documents including conservation and recovery plans are prevalent. This approach assumes that blanket goals, objectives, and prescriptions can be devised to resolve a challenge. The notion of self-similarity and the recognition of cascades of influences invite us to consider solutions at very much smaller scales. In the food industry, studies have shown that, on average, a family spends mere minutes in the preparation of a meal. This has led to calls to produce even more genetically engineered food for shorter preparation times. In actuality, rather few families spend just minutes in food preparation; some prepare no food of their own and others spend many hours in their garden, perhaps even relishing the notion of 'slow food'. Similarly, there is likely no pair of burrowing owls and its small-scale ecosystem that are exactly alike. One set of prescriptions may not fit all or may have to be so general as to be of little value. A much more fruitful approach may be to devote more effort into much smaller subsystems, but at the same time influence the subsystem more completely.

Another metaphor for the notion of self-similarity is the concept of shores. At one scale, a line depicting a shore takes on the shape of a bay. At a smaller scale there may be a bay within a bay, leading ultimately to the shape of sand kernels, some of which repeat themselves, and so on. One could extend the notion of small scales and yet more complete units addressed at these scales to burrowing owl conservation. A unit might be a ranch or a few ranches. Information and diverse partnerships could be constructed to link ecology- or owl-conscious consumers with a ranch such that the consumer's purchasing power could enable the ranchers to operate a state-of-the-art ranch satisfying economic, social, and biosphere goals and functions. The structured economic linkage can provide reward for carefully designed action which all participants can monitor and adjust in a goal-setting sense when necessary. Food transport can be minimized and thereby the contribution to greenhouse gases. Wastes can be retained or returned to the land on the same trip when food is delivered, minimizing disruption in nutrient flows. People can have a spiritual connection to the land that sustains them and know that it also sustains the owls.

There are consumer and voluntary sector initiatives seeking such integrated goals. These initiatives exercise a market pull, instead of a market push. For example, community groups in Saskatoon (Saskatoon Food Coalition) proposed a "Saskatoon Food Charter" in 2003, consistent with the United Nations Covenant on Social, Economic, and Cultural Rights. This charter is also consistent with Canada's Action Plan for Food Security (1998) and was approved in principle by Saskatoon City Council. The Food Charter aims to build bridges between urban and rural communities, encourage environmentally sustainable food production, and support viable, sustainable, agricultural production and an equitable income distribution.

Akin to fractal geometry of shores, there are also large-scale sustainability initiatives (United Nations level) that often preclude easy interactions. A biosphere sustainer needs to have the ability to find these and other initiatives and the courage to interact with them. Operations at a micro-scale allow efficiencies which large-scale systems do not experience, and vice versa. Large-scale impact, however, can be achieved by having each unit repeated many times with each adapted to its specific setting. The consumer group can join other partnerships with other consumers in a housing co-operative that further reduces an ecological footprint and fosters a community spirit and a quality of life. The images thus portrayed are actions that are focused and revolve tightly around a small but deeply integrated system of target solutions.

CONCLUSION

The notion of cooperative- and whole-system partnerships for sustainability deserves to be highlighted. A major difficulty in our compartmentalized existence with defined and bounded roles is the notion of externalities. The prevailing construction of our (agricultural) production system is one where private benefits are monitored and protected, but public benefits are considered external to the system. This often leads to an inefficient and inadequate correction of harm, despite institutional attempts at correction. It leads to injustices as some become winners and others become losers; for some the public good is restored, for others it is not. A systematic linking of as many elements in a system as possible is desirable. For this to be achieved, we need bridges not only across disciplines but also across sectors in our society. It will be the task of the biosphere sustainer, professional and non-professional alike, to appropriately capture the internal dynamics and logic of a system and form linkages toward significant progress in sustainable development.

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THE PROTECTION OF TEMPERATE GRASSLANDS: A GLOBAL PERSPECTIVE

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INTRODUCTION

Temperate grasslands are one of the world's great biomes – or at least they used to be. They are now considered the most altered ecosystem on the planet, the result of what has been called one of the great historical convulsions of the earth's biota (Mack 1989; Parsons 1994). The temperate grasslands biome occupies about 9,000,000 km^2, or 7-8% of the earth's terrestrial surface (White et al. 2000). These grasslands occur on every continent except Antarctica and are now the most endangered ecosystem on most continents, especially the prairies of North America, the pampas of South America, the lowland grasslands of southeast Australia, and the steppes of eastern Europe (IUCN 1991; McDougall and Kirkpatrick 1994; Samson and Knopf 1996; Krapovickas and Giacomo 1998). Temperate grasslands used to be home to some of the greatest assemblages of wildlife the earth has ever known. In most cases, however, these populations exist today as only shadows of their former selves.

Temperate grasslands have been modified by human activity to such a degree that little remains today in a natural state and even less remains in some form of long-term protection (IUCN 1994; Samson and Knopf 1996; Chape et al. 2003). Globally, about 41% of temperate grasslands have been converted to intensive agriculture, another 6% to urbanization, and 7.5% to other disturbances such as commercial forestry (White et al. 2000). Grasslands in all latitudes have historically been one of the most amenable environments for human settlement and use and have provided for man's needs since early evolutionary times. The grasslands in temperate latitudes, with their more fertile soils and moderate climates, constitute some of the most productive agricultural lands on earth. Indeed,grassland landscapes and many species of grasses, including corn, wheat, rice, oats, and sugarcane, are a foundation of the world's food supply.

From a protected areas perspective, however, the opportunity to protect significant representative and ecologically viable examples of this biome has been overlooked or, in many areas, irretrievably lost. Only 4.59% of the world's temperate grasslands are currently protected within the global system of protected areas (Chape et al. 2003). Furthermore, the degree of utilization and physical alteration of grasslands, coupled with a lack of recognition of this ecosystem as one worthy of protection, has largely precluded protection as a viable landuse option in many regions of the temperate world.

This paper presents a global overview of the status of protected areas in the context of the health and remaining extent of the various temperate grassland regions of the world. The analysis will reveal the breadth of opportunities and regional priorities for increasing the levels of protection in this biome. The paper concludes with an outline of an action plan to achieve significant progress toward, and hopefully to achieve, the 10% goal over the coming decade.

THE GRASSLANDS PROTECTED AREAS TASK FORCE

Temperate grasslands were seldom visible on the global conservation agenda, although interest in the conservation and protection of grasslands has risen over the past decade. Numerous initiatives evident throughout the biome are aimed at stemming declines in habitat loss, conserving biodiversity, restoring lost or damaged ecosystems, reintroducing extirpated species, and improving grassland management practices.

These initiatives have yet to translate into significant increases in protected areas, hence the IUCN/WCPA established the Grasslands Protected Areas Task Force in 1996 to work toward raising the protection level for grassland ecosystems generally, but with a clear and immediate priority on temperate grasslands. The mission of the Task Force is to promote and facilitate the establishment of new grassland protected areas throughout the grasslands biome, with a priority on temperate grasslands, toward a goal of protecting 10% of the biome by the year 2013, and to provide for the protection, restoration, and wise use of grassland protected areas through the development of best management practices and guidelines.

The Task Force will focus on the temperate grasslands of the following areas: (1) the prairie and inter-montane grasslands of North America; (2) the pampas and the Patagonian grasslands in Argentina; (3) the steppes of eastern Europe, (4) northern Eurasia, and (5) East Asia; (6) the grasslands of southeast Australia; (7) the tussock grasslands of New Zealand; and (8) the veld of South Africa. In cooperation with WCPA's Mountains Programme, the Task Force will also pursue increased levels of protection for high elevation grasslands, particularly in (9) the Himalaya/Hindu Kush region, including the Tibetan Plateau, and (10) the Andes of Chile, Ecuador, and Peru.

To complete this mission, the Task Force will:

- undertake a comprehensive global assessment of the number, location, geographic extent, biophysical representation, and condition of protected areas in the temperate grasslands biome and produce a catalogue of this information;

- determine the gaps in the protected areas system for temperate grasslands to identify the potential candidate areas for filling those gaps and to analyse the constraints to achieving their protection;
- develop a global strategy and region-specific action plans to achieve an expanded system of protected grassland areas targeting the identified candidate areas; and
- identify the common management issues and practices that may impact the biophysical condition and the long-term maintenance of biodiversity in grassland protected areas and develop a set of best management practices.

This paper is an effort toward completing the first three tasks.

AN ASSESSMENT OF PROTECTED AREAS IN THE TEMPERATE GRASSLANDS BIOME

The UN's 1993 List of Protected Areas included an early attempt to analyse the distribution of the world's protected areas by biome, and this list first revealed the true plight of temperate grasslands, reporting that only 0.69% of the biome was protected (IUCN 1994). Based on data in the 1997 UN List of Protected Areas (IUCN 1998), a subsequent review showed a modest increase to 0.98% (Green and Paine 1997). The 2003 UN List of Protected Areas released during the World Parks Congress revealed a significant increase in temperate grasslands protection to 4.59%. Even so, aside from large lake systems, the temperate grasslands biome remains the least protected in the world. In contrast, tropical grasslands and savannas have fared much better and today have one of the highest levels of protection of all biomes, with over 15% protected (Chape et al. 2003).

While the total level of protection is perhaps the most important statistic to reveal the challenge of temperate grasslands protection, another important factor is the number and average size of the protected areas. For example, there is a recorded total of 3,533 protected areas in temperate grasslands protecting 412,000 km^2 or 4.6% of the biome. In tropical grasslands, there are only 318 protected areas, but they protect 15.34% of the biome. The average size of these protected areas in tropical grasslands is 2,058 km^2, almost 18 times larger than the average size of only 116 km^2 for temperate grasslands (Chape et al. 2003). Clearly, protecting temperate grasslands requires not only more protected areas but also larger areas. If temperate grasslands are to hold their rightful place in the world's protected areas system and reach at least the 10% target, the total area of protection should approximate 900,000 km^2, or a 120% increase over existing levels of protection. Further, the maintenance of ecological processes for long-term biodiversity persistence must prevail as a dominant criterion in new protected area selection and design given the large habitat requirements and highly migratory patterns of many temperate grasslands species. For these ecosystems, 10% may very likely not be enough.

The following section provides a regional overview of the existing situation with respect to the protection and health of the world's temperate grassland ecosystems and of the potential opportunities for increasing their level of protection.

The North American Prairie and Inter-Montane Grasslands

The original grasslands of central North America, referred to as the prairie or the Great Plains, were the second largest of the world's temperate grasslands, next to the vast steppes of Eurasia. They stretch 1,500 km north to south from southern Canada to northern Mexico and 600 km east to west, covering a vast area of over 2,700,000 km^2 (Table 1). These grasslands change in species composition and biomass along a moisture gradient that becomes more moist from west to east. The grasslands are driest in the rain shadow of the Rocky Mountains, where the short-grass prairie dominates. Further east is the mixed-grass prairie and, on its eastern margins, the

Table 1. Existing condition and levels of protection for temperate grasslands in the Americas.

Grassland Region	Original Area (km^2)	10% Target	% Remaining in Native Cover	Current % Protected	Remaining Area Required (% and km^2)
North-American Prairie	2,700,000	270,000	Overall: 28% Tall Grass: 3.0% Mixed Grass: 36% Short Grass: 34%	5.9% <0.5% 2.6% 8.0%	4.1% or 110,700
North-American Intermontane	53,300	5,300	Canada: 70-96% US: 46.3% (Wash)	5.9% No Data	4.1% or 2,185
South-American Pampas	468,260	46,800	3%	0.3%	9.7% or 45,212
Patagonian Grasslands/Steppe	63,300	6,320	No Data	No Data	Uncertain

tall grass prairie. This ocean of grass once supported an estimated 45-60 million bison and tens of millions of pronghorn antelope, deer, elk, and moose, and their ever present predators, including the prairie grizzly, gray wolf, and coyote. An incredible diversity of grassland birds, shorebirds, waterfowl, and small mammals, like the black-tailed prairie dog, numbered in the billions. In the mid-19th century, prior to European settlement, this ecosystem rivalled or exceeded the biodiversity and abundance of Africa's Serengeti.

Today, these grasslands are the most altered and endangered ecosystem on the North American continent. While estimates vary by source and region, the tall grass prairie has likely suffered losses in the range of 82.6 to 99.9% , largely through conversion to corn, soybean, and other crops. The degree of conversion in the mixed-grass prairie, which closely corresponds to North America's wheat belt, ranges from a low of 30.5% in Texas to 99.9% in Manitoba. The short-grass prairie has experienced the lowest level of conversion, with much of the area still remaining in native grass cover and used for commercial grazing purposes (Samson and Knopf 1994; Gauthier and Wiken 1998; USGS 2000). While up to 40% of the short-grass prairie remains uncultivated, the landscape is highly fragmented, and overgrazing, soil erosion, introduction of exotic species, and eradication of undesirable species have significantly impacted many areas. For example, the World Wildlife Fund estimates that of the grassland types found in Canada's prairie, less than 0.1% remains in a relatively natural condition, whether the original grass cover exists or not (WWF 2003).

As a result of this grassland loss, bison have been virtually extirpated from the wild. The population of the black-tailed prairie dog has been reduced by 98%, corresponding to similar declines in such species as the burrowing owl and the black-footed ferret. Birds dependent on grasslands have seen steeper, more consistent, and more geographically widespread declines in the Northern Great Plains ecoregion of the prairie than any other behavioural or ecological grouping in North America (Knopf 1992; NCC 2000).

These grasslands are shared among the United States (80%), Canada (16%), and Mexico (4%), and the levels of protection vary considerably among the countries. In total, there are just over 600 protected areas over 1,000 ha in size distributed throughout the Great Plains, protecting about 5.9% of this region. These protected areas are unevenly distributed among the various ecological regions within the Great Plains, with the majority of the areas (72%) occurring in the short- and mixed-grass prairie and few protected areas of substantial size occurring in the tall grass prairie, the more southern arid prairie, and the smaller coastal grassland ecosystems along the coast of Texas (Gauthier and Wiken 1998).

The Argentinean Pampas and Patagonian Grasslands

The pampas are the southern reaches of a much larger grassland region, known as the Rio de la Plata grasslands, which extends through Uruguay into the subtropical latitudes of southern Brazil and comprises one of the great grassland regions of the world. Like many grasslands, the famous pampas of Argentina are described as once being a sea of grass extending as far as the eye could see. These original Argentinean pampas once covered an extensive area of 468,260 km^2 (Table 1); however, only 1 to 3%, or 5,000 to 14,000 km^2, remains in native vegetation with the remainder producing 90% of Argentina's total agricultural production. Other estimates suggest that about 5,000 to 7,500 km^2 of these grasslands are still in relatively good conservation condition (Fundacion Vida Silvestre Argentina 2003a). Fewer than 150,000 ha, or a total of 0.2 to 0.3%, of these grasslands are under some form of protection (Krapovickas and Di Giacomo1998).

Buenos Aires Province was almost entirely grasslands, but the 67 km^2 Parque Provincial Ernesto Tornquist is now one of the largest protected patches of Argentinean pampas. Most of the remaining pampas exist in the western fringes of the ecoregion in San Luis Province where the poor soils and dry climates made even ranching less than viable (Krapovickas and Di Giacomo 1998). In the 1990s, a concerted effort by governments, academics, and non-government organizations led to the commitment to establish a new national park in the pampas grasslands of western San Luis Province. An area of about 30,000 ha was protected as Parque Nacional Los Venados (Pampas Deer National Park). This area was to have been supplemented by an additional 100,000 ha in a Provincial Reserve forming a buffer zone around the national park in which habitat would continue to be protected. Due to unfortunate delays, almost 50,000 ha of this area was converted from native grasslands to other uses in a matter of 3 years, and a proposal to build new roads through the area increases the threat to these remnant grasslands (Krapovickas and Di Giacomo 1998; Fundacion Vida Silvestre Argentina 2003b).

These remnant patches of pampas are the last stronghold of the pampas deer, which once numbered in the millions and now number about 5,000 animals. The pampas deer is not only the most endangered mammal in these grasslands, but the species is considered the most endangered of all South American deer. Of Argentina's 338 mammal species, many live in the pampas, and 20% are endangered (Fundacion Vida Silvestre Argentina 2003a).

The Patagonian steppe occupies an area of about 63,300 km^2 in southern Argentina and Chile (Table 1). This region is known for its regionally distinct communities of mammals and birds and a rich plant fauna with 30% endemism. However, Patagonia is not as pristine as is often thought: sheep were introduced to the area as early as 1865, and overgrazing was already evident by the turn of the 20th century. Today, over 30% of the Patagonian steppe is severely eroded due to overgrazing by sheep and cattle, and desertification is becoming a significant issue (GEF 2003; WWF 2003). There are no nationally protected areas in the Patagonian steppe and very few provincially protected areas. Fortunately, much of Patagonia is unpopulated, and with adequate rest from land uses, there is the potential for much of these grasslands to be restored and to support viable populations of wildlife. Efforts are currently underway, supported by the Global Environment Facility, to designate a 7,000 ha national park known as Monte Leon in a pristine area of steppe with a littoral and wetland complex (GEF 2003).

The Steppe Grasslands of Eastern Europe and Eurasia

Most of the lowland grasslands of eastern Europe and Eurasia have been highly utilized for centuries, and very few areas remain in their natural state (Table 2). Except for very limited areas protected for their special natural grasslands, Europe's grasslands are completely under some form of intensive management, with their maintenance largely dependent on grazing or cutting (IUCN 1991; Goriup 1998). While grasslands are often threatened by agricultural development in most other temperate regions, the continuation of such management practices is essential for the protection of Europe's grasslands and the species they harbour, as in Hungary's Puszta, which is among the last big grasslands in Europe. The relatively recent changes in cattle farming toward full or partial stabling in some areas and the alteration or elimination of traditional grazing regimes has led to the abandonment and disappearance of large grassland areas. The quantity of permanent grasslands in the 15 European Union countries amounted to 440,000 km^2 in 1995, after having decreased by 12% between 1975 and 1995, primarily due to conversion to commercial forestry. Up to 60% of the newly planted forest cover in Europe used to be grasslands (European Environment Agency 2003).

The eastern reaches of the Eurasian steppe (Table 2), also known as the Black Sea-Kazakh steppe, include the eastern European steppes of Hungary, Ukraine, and Romania and the even more expansive steppes of southwestern Russia and Kazakhstan. Much of these steppes persisted well into the 20th century, but between 1954 and 1960 about 41,000,000 ha of steppe was converted to arable farmland in the USSR alone (Anonymous 2002). In the Ukraine, where steppe once occupied almost half the country's area, up to 88% of the land has been converted to intensive agricultural use and only 3-5% remains in its natural state (Goriup 1998). Although 4% of the Ukraine is protected, only 0.2% of the Ukraine's steppe lies within protected areas. In Russia, only 150,000 ha, less than 0.3%, of the southwestern Siberian steppe is protected, and few remnants are greater than 200 ha in size. Only 0.3% of Kazakhstan's steppe is in protected areas, although steppe occupies 20% of its land base. In contrast to eastern Europe, however, there are still vast areas of steppe in relatively natural condition in Kazakhstan and western Siberia that could form the nucleus of an ecologically viable network of protected areas (Anonymous 2002). Such an initiative would also be critical to the conservation and protection of the endangered Saiga antelope; 80% of its remaining habitat and population are in Kazakhstan (Lushchekina and Struchkov 2001).

The Mongolian-Manchurian Steppe

Lying another 8,000 km to the east of the steppes of Kazakhstan is the Mongolian-Manchurian steppe. These grasslands span the borders of southern Siberia, Mongolia, and northern China (Inner Mongolia), a region of 2,500,000 km^2 known as Inner Asia. From a global perspective, the grasslands of Inner Asia are of special significance: they comprise over 6% of the world's grasslands and constitute the largest and least disturbed area of temperate grasslands in the world. These grasslands have been sustained over thousands of years by the large-scale and highly mobile grazing practices of nomadic pastoralism (Sneath 1998). Signs of degradation in grassland condition are, however, increasing throughout the region, especially in China's Inner Mongolia, where they have reached crisis proportions, and in southern Siberia, as a result of increased cultivation and a trend toward small-scale and less mobile grazing practices (WRI 2000). In contrast, about 90% of Mongolia's grasslands are still considered to be in relatively good condition (Sneath 1998).

Notwithstanding these trends, Inner Asia has the potential to make a major contribution to the protection of

Table 2. Existing condition and levels of protection for temperate grasslands in Europe and Asia.

Grassland Region	Original Area (km^2)	10% Target	% Remaining in Native Cover	Current % Protected	Remaining Area Required (% and km^2)
European Union Steppe	440, 000	44,000	Ukraine Steppe: 3-5%	0.2%	9.8% or 43,120
Black Sea-Kazakh Steppe	804,000	80,400	Russia: No Data Kazakhstan: 17-36%	0.3% 0.3%	9.7% or 78,000
Mongolian / Manchurian Steppe	Mongolia: 822,760 China: 3,386,000	Mongolia: 82,270 China: 338,600	Mongolia: 90% China: 10% Russia: No Data	7.9% No Data No Data	Mongolia: 2.1% or 1,329

temperate grassland ecosystems at a scale available nowhere else in the world. This is particularly the case in Mongolia, and especially in the eastern steppes of Mongolia, which are referred to as the last of the great plain ecosystems, or to use George Schaller's words, "one of the last great unspoiled grazing ecosystems in the world" (Mongolia Ministry for Nature and the Environment and UNDP 1999). Here, one can still experience the vastness of 250,000 km^2 of open, largely uninhabited expanses of grasslands and witness the migration of over one million Mongolian gazelle in herds tens of thousands strong. But even this apparent state of good health represents a highly reduced environment. The range available to the Mongolian gazelle, for example, was reduced by 50% during the last century, and their numbers have dropped accordingly (Schaller 2001).

There are approximately 822,760 km^2 of grasslands in Mongolia, of which 6.0% of the steppe zone, 6.0% of the forest steppe, and 18% of the desert steppe are protected (Table 2). In total, Mongolia has protected a total of 13.1% of its territory and has recognized the potential of protecting up to 30% of its territory, hopefully by 2020 (Myagmarsuren 2000). Resolutions from a seminar on the Protection and Conservation of Grasslands in East Asia held in Ulaanbaatar in 2000 indicated that a suitable proportion of new protected areas reflect the fact that 66-80% of Mongolia is covered in steppe and that transboundary cooperation with China and Russia would be necessary to enable sound ecosystem-based management (IUCN 2000). Existing proposals for new grassland protected areas include an additional 1,200,000 ha in the Daguur and Eastern Mongolian (Daurian) steppes (Tumurbaatar 2003).

China has 3,386,000 km^2 of grasslands covering 40% of China's land area, of which 90% is found in Inner Mongolia (Table 2). The remainder is found in Xinjiang, Uygur, Tibet, and Qinghai. In contrast to the relatively healthy grasslands in Mongolia, the adjacent grasslands of China's Inner Mongolia and Xinjiang as well as Russia's Buryatia and Chita have experienced high levels of degradation (Sneath 1998). Useable grassland in China declined by 16% between 1949 and 1990 due to increases in the development of arable land and a rapid increase in livestock, largely due to a food self-sufficiency policy implemented at the end of the 1980s. In an early bid to increase production, the nomadic herders were reorganized into farming collectives in Russia in the 1930s and in China in the 1950s, and this shift from mobile herding to more sedentary patterns of livestock husbandry, coupled with the increased numbers of livestock, led to severe overgrazing and degradation of the grasslands. In both regions, estimates from only five years ago suggested that as much as 75% of the grasslands have suffered some form of degradation, and Chinese government figures from the same period warned that as little as 44% of the grasslands in Inner Mongolia are considered useable and in good condition (Sneath 1998; WRI 2000). Official figures from China in 2002 suggested that 90% of the country's grasslands are damaged (Xinhua 2002). This degradation of the grasslands is a principal cause of desertification, now an issue of national concern.

In 2001, China announced its intention to increase the level of protection in the country from 12.8% to 18% by 2050. As part of this initiative, China's National Action Programme to Combat Desertification includes plans to create over 160 new nature preserves to protect up to 6,800,000 ha by 2010 and 9,100,000 ha by 2050. Of particular note is the restoration of the Hulun Buir grasslands, one of the more superior grasslands in northern China that borders on both Mongolia and Russia (CCICCD 2000). These grasslands cover an area of 8,360,000 ha, of which 40% has been degraded with deserts now occupying 880,000 ha. The restoration of these grasslands is a high priority, and 29 new nature reserves have been recently created in the Hulun Buir to protect 44,394 km^2. Through protection and other measures, officials hope to halt the degradation by 2005.

The Lowland Grasslands of Southeast Australia

The temperate lowland grasslands of southeast Australia are the most threatened ecosystem in that country. They once occupied approximately 20,000 km^2 and covered about one third of the state of Victoria (Table 3). Since European settlement began in 1788, the area of native grasslands in a relatively natural condition has been reduced by 99.5% to only about 10,000 ha. These grasslands have been lost primarily to crop conversion, but have also been highly degraded due to invasion by exotic species, altered fire management regimes, and overgrazing by sheep and cattle (McDougall and Kirkpatrick 1994; Taylor 1998; Government of Victoria 2003).

The remaining fragments exist as cemeteries, roadside and railway rights of way, airports, and small private grazing land. Few exceed 100 ha in size. Of the 26 lowland grassland communities found in southeastern Australia, one is now extinct and the others generally exist in small remnants accounting for less than 1% of their original range. Many are so small that their long-term viability is doubtful. Most lowland grassland communities are either very poorly reserved or totally unreserved, with the total under some form of protection approximating 2%. Furthermore, only about another 2% exist as small remnants on Crown land, severely limiting the potential for the expansion of protected areas on public land. About 75% of the remaining grasslands are on private land, and these remnants are comparatively large, but often of lower biological significance due to higher levels of disturbance. Estimates indicate that about half of the rare and endangered plant species associated with these grasslands are now only found on private land. In the long term, however, these lands will be of greater significance to the survival and restoration of certain grassland communities. Many of the smaller remnants in cemeteries and along roadsides have not been subject to disturbances such as overgrazing and ploughing and still have much to offer to long-term

Table 3. Existing condition and levels of protection for temperate grasslands in Australia, New Zealand, and South Africa.

Grassland Region	Original Area (km^2)	10% Target	% Remaining in Native Cover	Current % Protected	Remaining Area Required (% and km^2)
Lowland Grasslands of SE Australia	20,000	2,000	0.5%	2.0%[2]	8.0% or 1,600
Tussock Grasslands of New Zealand	36,372	3,630	0.1%-99%	5.9%	4.1% or 1,490
South Africa Veld	22,270	2,270	40%	2.2%	7.8% or 1,770

conservation goals (McDougall and Kirkpatrick 1994; Taylor 1998). The state of Victoria has recently made significant progress in protecting some representative examples of its grassland communities, such as the establishment of Terrick National Park and the Craigieburn Grassland Conservation Reserve (Government of Victoria 2003).

The Tussock Grasslands of New Zealand

The indigenous grasslands of New Zealand cover an area of approximately 36,375 km^2, or about 13.6% of the country's surface area (Table 3). Although this is a significant area, it represents a considerable decline from the area covered in indigenous grasslands around 1840 when European settlement began. About 84,410 km^2 or 31% of the country's area was estimated to be in grasslands at that time. Most of the current grasslands occur on the South Island where about 3,500,000 ha of short and tall tussock grasslands occupy about half of the South Island's area (South Island High Country Committee of Federated Farmers 2001; Mark et al. 2003). These grasslands are comprised of three major types, with long-lived tall tussock (bunch) grasses dominating the low-alpine zone, extensive short tussock grasslands at lower elevations and limited areas of sward grasslands in the lowland plains. Unlike most grasslands around the world, these tussock grasslands developed and evolved in the total absence of grazing mammals. Instead, the main herbivores were birds and invertebrates.

A recent assessment of the conservation status of New Zealand's grasslands revealed that approximately 27% of these grasslands are protected in national parks or conservation reserves, with an additional 45% still in public ownership in pastoral leases. As in many parts of the world, however, these statistics are skewed by high levels of protection in higher elevations and very low levels of protection in low elevations. For example, only traces of the lowland sward grasslands once found on the Canterbury plains in the rain shadow regions of the South Island now remain. As elevations increase, so does the amount of indigenous grassland remaining in relatively natural condition as well as their level of protection. In the subalpine, 24% of the short tussock remains with 3% protected; 19% of the tall red/copper tussock remains with 13% protected; 84% of the tall snow tussock remains with 31% protected; 99% of the low alpine snow tussock remains with 51% protected; and 98% of the high alpine communities remain with 62% protected (Mark et al 2003).

New Zealand is undergoing a review of its rangeland tenure arrangements, which may result in the creation of additional protected areas in indigenous grasslands. For example, the new Te Papanui Conservation Park was recently created through this review process, protecting 20,800 ha of mostly subalpine tall snow tussock (Mark et al. 2003). Priorities for the future protection of under-represented grasslands in New Zealand should focus on the subapline short tussock grasslands and the lowland sward grasslands.

The Veld of South Africa

The temperate grasslands of South Africa, known as the veld, occupy about 345,360 km^2, or almost 10% of the country (Table 3). These grasslands are found principally on the high central plateau of South Africa and the inland areas of KwaZulu-Natal and Eastern Cape provinces. South Africa's grasslands are the mainstay of the country's crop of maize, and crops such as maize, sorghum, wheat, and sunflowers are a dominant feature of the grassland landscape. At the present time, only about 2 to 2.5% of this biome is in some form of protection (Low and Robello 1996; Reyers et al. 2001).

South Africa has the third highest level of biological diversity in the world, and its grasslands host the second highest diversity of indigenous species in the country, next to the Cape Floral Kingdom. However, with only 5 to 6% of the country in protected areas, many species are threatened, and extinction rates in South Africa are high by global standards. South Africa is a semi-arid country and drought and desertification are becoming real threats to food security, with 86% of its land area used for crop cultivation or grazing of livestock (Department of Environmental Affairs and Tourism 1999). Yet, up to 79% of the country is still covered in natural woody and grassland vegetation, and South Africa has committed to expanding its protected area system to 8% of the nation; thus the potential may exist to significantly expand protected areas in the grassland biome (Department of Environmental Affairs 2001; Reyers et al. 2001).

As in many countries, South Africa's protected area system developed in an ad hoc fashion, being established in areas of high scenic beauty or tourism potential and where there were few landuse conflicts (Reyers et al. 2001). Grasslands rarely fell into these categories, and many areas of the veld were converted to agricultural use. In the northern escarpment regions of Mpumalanga and the Northern Province, exotic forest plantations replaced much of the mountain grasslands. A recent assessment of all vegetation types in South Africa revealed that the nation's grasslands and fynbos have experienced the highest levels of disturbance, and although these levels of disturbance are still relatively low compared to other temperate grasslands world-wide, several exceed 40% of their surface area, indicating the potential for significant ecological disruption. This study led to the identification of the top ten priority vegetation types requiring additional protection in South Africa, half of which are grasslands (Reyers et al. 2001). Another study specific to the vegetation of KwaZulu-Natal Province has also identified conservation priorities for five of its grassland communities, which each have levels of disturbance exceeding 60% and none of which have levels of protection approaching the 10% target (Goodman 2000).

A FRAMEWORK FOR AN ACTION PLAN FOR A DECADE OF PROGRESS IN PROTECTING TEMPERATE GRASSLANDS

The goal of the IUCN/WCPA Grasslands Protected Areas Task Force is to achieve a 10% level of protection for the temperate grasslands biome by 2013. If we are to make substantial progress toward this goal, how and where should we focus our efforts? Where can we find 10% native grasslands to protect? Can we find 10% in areas that are large enough and intact enough to remain, or through restoration to become, ecologically viable? Is 10% representative of the various types of temperate grasslands around the world?

The regional summaries above provide a basis from which to begin to answer these questions. As outlined in Table 4, the various temperate grassland regions of the world can be distinguished into three general categories of grassland landscapes according to their current levels of protection and disturbance; the remaining area in a natural state and the potential for connectivity; their current ecological condition and potential for restoration; the numbers of extirpations or extinctions and the potential for reintroductions; and the prospects for ultimate levels of protection.

In the Highly Modified and Fragmented Landscapes that typify areas like the steppes of eastern Europe, the tall grass prairie of North America, or the pampas in Argentina, ultimate levels of protection greater than 5% may be unlikely. In the Moderately Modified and Fragmented Landscapes, 10% protection may be possible as the fragments are larger with greater potential for connectivity. Examples of these landscapes can still be found in the veld in South Africa, the steppes of northern China, and western and central Mongolia. The greatest potential, however, lies in the large, relatively intact landscapes found in the grasslands of eastern Mongolia, the Kazakh steppe, the Patagonian steppe, and the mixed- and short-grass prairie of North America. In these four grassland landscapes, the potential still exists to protect large, ecologically viable grasslands, and with the required restoration and reintroduction efforts, complete with their wildlife populations and predator-prey relationships essentially intact. Three of these landscapes, all except for the Kazakh steppe, have been included in the World Wildlife Fund's Global 200; the IUCN/WCPA Grasslands Protected Areas Task Force will place its priorities here.

Table 4. Three scenarios for the protection of temperate grasslands.

Highly Modified and Fragmented Landscapes • Remain only in small, isolated remnants; little or no potential for connectivity • Restoration required • Potential for species reintroduction is limited • Extinction or extirpation is accepted • Ultimate protection levels likely cannot exceed 5%. Examples include: • The lowland sward grasslands of New Zealand • Most lowland grassland communities in south-east Australia • Most lowland grasslands in eastern Europe • Tall grass prairie in North America • The Argentinian pampas
Moderately Modified and Fragmented Landscapes • Larger, less isolated remnants; some to good potential for connectivity • Greater potential for restoration of larger areas • No or few extinctions or extirpations • High potential for species reintroduction and/or recovery • Ultimate protection levels of 5-10% possible Examples include: • Limited portions of the steppe in eastern Europe • Portions of mixed-grass prairie in North America • Intermontane grasslands of North America • The Veld of South Africa • Portions of the steppe in Kazakhstan and eastern Siberia, Russia • Portions of northern China • Portions of western and central Mongolia
Large, Relatively Intact Landscapes • Potential to protect and restore large, functional grassland ecosystems • No or few extinctions or extirpations • High potential for species reintroduction, if necessary • Ultimate protection levels potentially greater than 10% Examples include: • Eastern Steppes of Mongolia • Portions of Kazakh steppe • Patagonian steppe • Short and mixed grass prairie in North America

There are many initiatives occurring throughout the temperate grasslands biome in the Highly and Moderately Fragmented Landscape categories that the Task Force will continue to support. These include significant efforts in Europe through the Pan-European Biological and Landscape Biodiversity Strategy (i.e., Europe's response to the implementation of the Convention on Biological Diversity) and through the Natura 2000 process. China's efforts though its National Action Programme to Combat Desertification holds promise for the restoration and protection of the grasslands in Inner Mongolia. The Grasslands Programme of the Fundacion Vida Silvestre Argentina is focusing on improving protection in the pampas. Ongoing initiatives in southeast Australia, New Zealand, South Africa, and many throughout the grasslands of North America have all successfully demonstrated recent progress in furthering the protection of their grassland ecosystems.

At the World Parks Congress held in Durban, South Africa in September 2003, it was announced that the global protected area system had surpassed the 10% goal and reached 12% of the terrestrial surface of the earth. However, the protected areas system is far from finished and significant gaps remain in the protection of biomes, habitats, and species. A new focus must be brought to bear on threatened or under-represented ecosystems. The temperate grasslands biome clearly qualifies, and a new strategic approach to achieving a 120% increase over existing levels of protection is necessary. It was recognized at the Congress that future progress would require more strategic creation of new protected areas. New linkages are required among efforts to protect grassland ecosystems and other complementary objectives such as the protection of rare and endangered species, the support for traditionally mobile pastoralist cultures, and the alleviation of poverty. Biodiversity-based targets, rather than strictly numerical targets, must be used in the planning and design of these new protected areas to ensure they have the "staying power" to provide for the long-term persistence of biological diversity.

NORTH AMERICA'S ROLE IN THE GLOBAL RECOVERY OF THE TEMPERATE GRASSLANDS BIOME

North America's grasslands constitute about 17% of the global biome. They are North America's own; they are unique in the world. Only Canada and the United States can protect these grasslands and the biodiversity therein. As this paper has attempted to demonstrate, the conservation and protection of these grasslands are a continental and an international priority. The World Wildlife Fund has recognized these grasslands as one of only three regional grasslands in the world where conservation and restoration is still possible at the landscape scale. The IUCN/ WCPA Grasslands Protected Areas Task Force agrees with this recognition of their significance and includes them as one of its four international priorities for progress this decade. A new vision is emerging in North America through the Northern Plains Conservation Network for the restoration and conservation of these grasslands. If realized, the next generation of North Americans could witness at least part of the prairie as it once was. The challenge of re-wilding the North American plains is before us.

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Concurrent Sessions

COOPERATION AND SOUND SCIENCE: KEY TO CONSERVATION SUCCESS IN MANITOBA'S TALL GRASS PRAIRIE

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Abstract: Once considered a natural system that had been completely replaced by agriculture in the province, significant remnants of tall grass prairie were discovered in southeastern Manitoba by naturalists in the late 1980s. In 1989, the Critical Wildlife Habitat Program was established through a partnership of government and non-government agencies to secure and maintain representative areas of this native prairie. The Nature Conservancy of Canada (NCC) was originally involved within this partnership as the securement agency, a role that has since evolved to now include stewardship. NCC's activities in the area are characterized by a cooperative and consensus building approach, with a multiple-stakeholder management team and a local advisory committee helping to guide stewardship activities. The value of partnerships was recently evidenced with the purchase of 670,000 acres of land immediately north of the Manitoba Tall Grass Prairie Preserve. Purchased with the aid of The Nature Conservancy (TNC)'s Canada-US Partnership and a generous bequest, the Diana Wintsch Preserve marks the single largest purchase in NCC Manitoba's history.

NCC's Conservation Area Planning process follows a rigorous set of guidelines developed and tested by TNC to develop conservation strategies and a management plan that will directly affect the most critical threats to conservation targets or restore these targets to viable levels. Planning is conducted within the context of a peer-reviewed, scientifically defensible methodology, incorporating the best available knowledge and, wherever possible, working at the plant community or ecosystem level of organization. In the Tallgrass Aspen Parklands conservation landscape, an area that stretches through southeastern Manitoba and northwestern Minnesota and that includes the Manitoba Tall Grass Prairie Preserve, the conservation area planning phase is nearing completion. Implementation of the conservation strategies developed through the planning process will require the continued cooperation and goodwill of NCC's partners.

INTRODUCTION

The Tallgrass Aspen Parklands is a unique landscape located in southeastern Manitoba and northwestern Minnesota (Figure 1). It is characterized by an amazing variety of natural communities ranging from rich songbird-laden aspen woodland, to vast sedge meadows, lazily meandering streams, dry sandhill oak savannah, to awe-inspiring tall grass prairie meadows. The unique communities found here, as well as the diverse and often endangered biodiversity they support, have drawn the concern of numerous conservation-minded groups working to preserve what remains of this heavily impacted landscape. Two of these groups, the Nature Conservancy of Canada, Manitoba Region (NCC) and The Nature Conservancy, Minnesota Chapter (TNC), have been working for over a decade to conserve this special place.

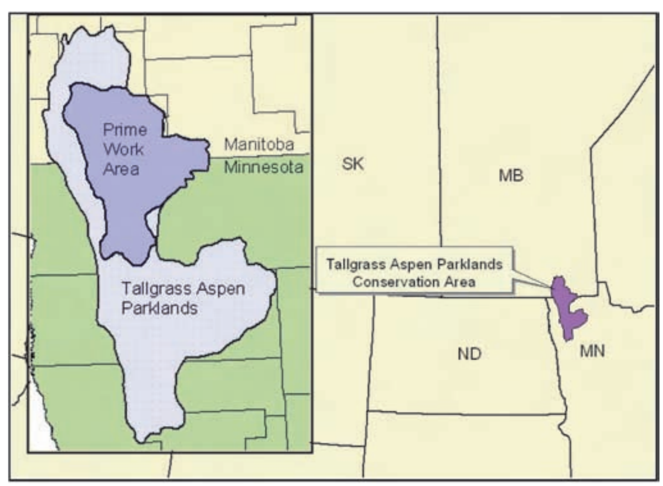

Figure 1. The Tallgrass Aspen Parklands landscape was identified as a high priority site for conservation action through an ecoregional planning process. The primary conservation focus of both NCC and TNC has been on a 2,900 km^2 portion of this landscape that is centered on the international border.

In a noteworthy example of international cooperation,NCC and TNC, in collaboration with other partners, are developing the first iteration of a conservation area plan that will provide a holistic, science- and experience-based blueprint for conservation action in the area. Following TNC/NCC's 5-S approach (Table 1), the plan will summarize conservation elements of concern, identify the threats to these elements, develop strategies to abate these threats, and establish a plan to monitor

Table 1. NCC's 5-S framework for conservation area planning.

Systems	Identifying the species and natural communities that will be the focus of observation in an area (conservation targets).
Stresses	Determining how conservation targets are threatened, such as by habitat reduction or fragmentation, changes in natural flow patterns of waterways, or changes in the number of species in a forest, grassland, or wetland.
Sources	Identifying and ranking the causes, or sources, of stress for each conservation target.
Strategies	Finding practical ways to reduce or eliminate threats through cooperative initiatives. Examples include the acquisition of interests in land and water, adaptive management or restoration of lands and waters, public policies based upon sound science, and promotion of compatible human uses.
Success	Assessing our progress in reducing threats and improving the biodiversity and ecological health of a conservation area.
	An understanding of the cultural, political, and economic situation behind the threats is essential for developing sound strategies. This human context is often referred to as a 6th "S".

success in implementing conservation action. The final plan, while concise and accessible, will be the product of extensive research and consultation. The planning process will benefit from the vast body of planning and management experience accumulated by local and national conservation organizations, governments, researchers, and residents. The Minnesota Department of Natural Resources, Manitoba Conservation, Manitoba Habitat Heritage Corporation, Canadian Wildlife Service, Manitoba Naturalists Society, university researchers, and local landowners and other residents are not only key sources of knowledge and experience, but will be crucial partners in plan implementation.

Conservation area planning in the Tallgrass Aspen Parklands was accelerated in late 2002 by the formation of a planning team and entry into the Efroymson Fellowship Program, a series of workshops that guides and informs standardized planning at high priority sites throughout the world. As the first planning iteration reaches its conclusion in early 2004, continued collaboration with conservation organizations, major landowners, and land managers will become an increasingly vital part of achieving and implementing a plan that is based on the best available knowledge, that incorporates the needs and concerns of partners, and, most importantly, that successfully and measurably conserves target species and ecological communities of concern in the Tallgrass Aspen Parklands landscape.

CONSERVATION TARGETS AT THE TALLGRASS ASPEN PARKLANDS

Five ecosystems or species guilds have been identified as conservation targets at the Tallgrass Aspen Parklands (TAP). Over forty species and communities of conservation concern, including the nationally endangered western prairie fringed orchid and the globally imperiled northern oak barrens, occur as components of these five systems. Conservation strategies designed to reduce systemic threats or restore ecological viability will also work to conserve these nested targets.

Upland Mosaic

Characterised by a complex and changing relationship between open tall grass meadows, savannah, and closed aspen forest, the TAP's upland habitat supports at least 18 species of conservation concern, including 4 nationally endangered plant species. Recurrent wildfire is the key ecological factor sustaining this system, and a lack of appropriate landscape-scale fire management is its greatest threat. Much of the upland prairie habitat was converted to agriculture in the 20th century, but the present rate of conversion is considerably slower.

Lake Plain & Beach Ridge Wetlands

Wetlands, while not supporting as many nested conservation targets as uplands, are critical to the maintenance of a functioning landscape (hydrological connectivity with uplands, rivers, etc.). Covering 30-50% of the landscape, they provide habitat for yellow rail, moose, and many other species. Two major types of wetland occur at the TAP: largely precipitation-fed Beach Ridge Wetlands occur on gravely glacial Lake Agassiz beach ridges, while Lake Plain Wetlands are found in the low-relief interbeach areas where regional groundwater flow is a key ecological factor. The conservation strategies employed to conserve these two targets will necessarily differ.

Rivers & Riparian Areas

Agricultural clearing and drainage, flood mitigation efforts, and invasive species have heavily impacted this system. Species that depend on the TAP's rivers, including a number of nationally threatened fish, will be aided by conservation strategies that work at a watershed scale to restore degraded habitat and promote more natural surface water movement.

Large, Highly Mobile Mammals

The planning team felt that the threats to certain wide-ranging large mammals, as well as the key ecological factors sustaining their populations, were so unlike the stresses facing other targets that they would require unique conservation strategies. Moose, wolves, and elk require large home ranges with appropriate habitat linkages, have particular habitat requirements, and may face considerable disease or poaching stress.

THE MANITOBA TALL GRASS PRAIRIE PRESERVE: A CRITICAL COMPONENT OF THE TALLGRASS ASPEN PARKLANDS

Background

The area had been settled by European agriculturalists during the latter half of the 19th century. This settlement resulted in the suppression of wildfire, the construction of wood frame dwellings and roadways, as well as deforestation and active cultivation of upland areas. Drainage of natural wetlands and the introduction of exotic plant and animal species followed in many areas as the domination and conversion of the land for agriculture continued. For thousands of years previous, aboriginal people had hunted the area. Periodic wildfire had maintained the highly diverse native prairies by preventing its replacement by more monotypic stands of woody species. The native faunal and floral communities coexisted in a natural harmony prior to European settlement.

Identification of Systems

Until the late 1980s, it was believed that the only native tall grass prairie sites left in Manitoba were tiny remnants of an acre or less in and around the city of Winnipeg. A group of amateur naturalists made the discovery of the century when they came upon a large tract of relatively high quality native prairie in southeastern Manitoba near the towns of Tolstoi, Gardenton, and Stuartburn. Botanists familiar with native prairie verified the find as tall grass prairie and set about to determine the extent of this natural area. The slow process of securement followed as the properties were evaluated and ranked according to their quality as native tall grass prairie. Their natural systems and stewardship needs were also identified.

The process continues today as new lands are secured and added to Manitoba Tall Grass Prairie Preserve. The Nature Conservancy of Canada acts as the major securement organization. Most of the properties that NCC secures and stewards in Manitoba have been used for agriculture at some time in the past 100 years and are in a variety of stages of recovery towards a natural state.

Stresses and Sources of Stresses

Once a property is secured, skilled technicians conduct inventories for plant communities. Natural processes that maintain the prairie as well as processes that have a negative effect on its survival are identified. Baseline reports designed to guide management decisions are developed from these inventories. Invasive species, poor grazing practices, and a lack of fire are typical stresses that can decrease the diversity of species on a native prairie by allowing undesirable species to proliferate. These undesirable species could be either native or non-native species.

Native prairies have evolved together with many interacting natural disturbances that maintain a natural equilibrium. Unfortunately, there was little opportunity to observe and study these interactions before the vast original prairie ecosystems were replaced, principally by modern agriculture. Understanding the mechanics or the biology of the stresses on this diverse natural system provides the basis for the development of the strategies for stewardship needed to maintain this system. Management plans that include proven techniques are designed so that the existing diversity is maintained. If possible, stewardship strategies will be structured to enhance existing natural areas.

Activities such as prescribed fire, brush mowing, and managed grazing are accepted tools for maintaining tall grass prairie. Properly timed fire can effectively control invading species as well as increase stem density of desirable native species. Brush mowing, managed haying, and grazing can result in the decrease of invasive woody species. Using these tools on the Manitoba Tall Grass Prairie Preserve has proven effective. Effective partnerships are essential to accomplish these costly techniques for prairie management. Fundraising for stewardship can be difficult, but must be high on the priority list.

CONSERVATION AND STATUS OF NATIVE VEGETATION IN THE PARKLAND NATURAL REGION – CENTRAL PARKLAND

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Abstract: The Parkland Natural Region is the most intensively altered natural region in Alberta, covering about 9% of the province. The area is characterized by productive soils as well as moisture, climatic, and topographic regimes that are well suited for agricultural development and human settlement. Most of the natural vegetation has been lost due to agricultural, industrial, and infrastructure development. Yet some native vegetation continues to persist, and it supports an abundance and diversity of plant and animal life. Thus, remaining native land and associated wetlands in the Parkland Natural Region represent the majority of biodiversity and associated economic, social, aesthetic, and ecological values upon which society depends.

This paper describes an initiative that used combinations of new and old and digital and hardcopy data to quantify parameters related to location, type, and size of remaining native vegetation patches and wetlands in the Parkland Natural Region – Central Parkland. This paper documents the extent of native vegetation remaining in the Central Parkland as well as details its composition, distribution, size, and land ownership.

BACKGROUND

The Parkland Natural Region covers approximately 9.5% of Alberta or 62,780 km^2. The Central Parkland covers the majority of this natural region including 53,451 km^2 or 8.1% of Alberta. This Central Parkland Natural Subregion, and the Parkland Natural Region as a whole, is a transition between drier grasslands to the south, boreal forests to the north, and montane forests to the west (Alberta Environmental Protection 1997). Historically, expansive areas of grassland with groves of aspen occurred in the south and east, gradually changing to aspen parkland in the centre of the subregion, and then changing to closed aspen forest in the north and west. However, balsam popular was common on moist sites throughout the subregion. The understories of forested areas often had dense shrub, grass, and herbaceous vegetation and were species rich. Shrub communities were dominated by snowberry, rose, chokecherry, or saskatoon and were often present in belts around forested patches. The grassland vegetation in the parkland was essentially the same as that found immediately to the south – dominated by plains rough fescue on moister sites and western porcupine grass on drier sites.

The Parkland Natural Region – Central Parkland (PNR-CP) has two major river systems, the Battle and North Saskatchewan. In addition, numerous lakes and wetlands are scattered throughout the subregion. Although wetlands cover only about 4.4% of the area, they provide important resources and essential habitats for many native biota (Alberta Environmental Protection 1996). Some of the wetlands have permanent standing water, but many, especially the smaller ones, have standing water only during part of the year or during some years (Alberta Environmental Protection 1996).

The PNR-CP is characterized by productive soils, flat or rolling topography, and a moisture/climatic regime suitable for agriculture. Thus, much of the Central Parkland of Alberta has become highly altered and fragmented by agriculture, urban expansion, and industrial development. During the last half of the 19th century, ranching was common, and unrestricted year-round grazing led to the deterioration of many range areas (Adams et al. 1994). With the encouragement of taxation and other government policies in the early 1900s (Van Tighem 1996), many homesteaders settled in the parkland and began cultivating the land (International Institute for Sustainable Development 1994). In addition, the demise of free-ranging bison and the elimination of most wildfires led to increased tree establishment and growth (Alberta Environmental

Protection 1997). Extensive drainage of wetlands and channelization of streams and rivers occurred concomitant with cultivation (Usher and Scarth 1990). This drainage has resulted in the loss of up to 70% of the original wetlands in the region (Turner et. al 1987; Prairie Habitat Joint Venture 1993), with wetland and riparian loss continuing today particularly for ephemeral wetlands (Strong et al. 1993).

At present, greater than 90% of the PNR-CP is privately owned and includes the major centres of Edmonton, Calgary, Lloydminster, Wetaskiwin, Camrose, and Red Deer. Current challenges to the PNR-CP include continued cultivation of native land for agricultural production, increased intensive livestock production, urbanization, gas and oil exploration and development, infrastructure development, wetland drainage for agricultural activities, and demands on the water resources for many purposes.

Habitat conversion in the PNR-CP has resulted in little native vegetation remaining. Based on limited data, Coupland (1973), Wallis (1987), and Alberta Prairie Conservation Forum (1995) speculated that only 10-15% of the original upland vegetation and 5% of the original native fescue grassland remains in the subregion. As a further complication, vegetation and habitat characteristics within the remaining wetland and upland fragments have been altered greatly by grazing, oil and gas extraction, transportation corridors, recreation, pollution, and the invasion of exotic species. Thus the once widespread parkland is now present in only a few, small, fragmented areas, and native parkland has become one of the most endangered ecosystems in Alberta (Alberta Environmental Protection 1997).

To effectively manage native biota in PNR-CP, we conducted a mapping project to determine three types of information:

- the amount of remaining native vegetation and water,
- the location and sizes of those native vegetation and wetlands patches, and
- the degree to which native vegetation and water are found on public versus private land.

This information can now be used to provide a scientific basis for comparing the distributions of native species, planning stewardship programs on public and private land, monitoring landuse change over time, and conducting ecological research in the PNR-CP.

PROJECT OBJECTIVES

A program to map native vegetation and wetlands in the PNR-CP was initiated in 2000 (Bjorge 2000). This program involved mapping native vegetation and wetlands from satellite images (IRS, LandSat7), air photos (scale 1:30,000), and existing provincial inventories. The present report is an analysis and discussion of the information for PNR-CP to portray the type of information that could be extracted from the native vegetation database. This report includes a description of the following:

- the amount, type, and size distribution of native vegetation patches (trembling aspen/balsam poplar, conifer, and other [grass/shrub] native vegetation) remaining in the PNR-CP;
- the number, size, and distribution of wetlands in the PNR-CP;
- the amount of remaining native vegetation and wetlands located on public versus private land; and
- baseline maps of the remaining native vegetation and wetlands so that future loss of conservation potential can be documented accurately.

RESULTS

Note that the following numbers will vary slightly as the database is updated and subsequent analysis occurs. An initial analysis of the GIS database created for this project indicated that 12.2% of the entire PNR-CP was identified as native vegetation. Water covered 4.4% of the land base, while the remaining 83.4% consisted of cultivated or otherwise disturbed land associated with agriculture, industry, infrastructure, urban development, or other uses. Of the 12.2 % of the subregion consisting of native uncultivated vegetative cover, 5.7% was deciduous, 0.2% was coniferous, and 6.3% was grass/shrub. Much of this native deciduous cover was found in about 170,000 patches smaller than 10 ha in size. However, 223 parcels of native deciduous cover larger than 100 ha were identified, and these parcels formed the majority of the land in the category. Native grass/shrub was identified in about 69,000 patches with 387 parcels larger than 100 ha. Approximately 192,000 wetlands typically smaller than 10 ha represented the majority of the land base covered by water.

Analysis of land ownership in the PNR-CP indicated only 3.0% was public land and 1.75% was a mixture of public and private land, primarily associated with riparian areas. Private land comprised more that 92% of the total area with the remaining lands taken up by major water bodies, Indian Reserves, or military land. Native vegetation was found on public land at a markedly greater frequency than on private land: although total public land constituted only 3% of the land base, 16% of all native vegetation was found here.

DISCUSSION

The Parkland Natural Region-Central Parkland GIS data set has provided a substantial amount of data that describe the amounts and configuration of both upland vegetation and wetlands. The analyses, however, proceeded slower than expected because there were some inconsistencies among GIS data layers. In addition, a multitude of analyses and presentation methods were tried to determine the most meaningful and simplest to understand.

One of the primary reasons behind the creation of the PNR-CP native vegetation database was to create a tool for use by various agencies to deliver stewardship, conservation, research, education, and other initiatives promoting wise management of our remaining native lands. However, this tool should not be utilized without an understanding of its limitations, including those associated with interpretation errors from imagery and air photos. Native grasslands were especially difficult to interpret, and this information was only derived from the interpretation of larger grass patches (usually larger than 20 ha) from air photos followed by extensive field assessments. Assessments of accuracy for LandSat interpretation indicated accuracy of 94% or greater when compared to air photos. More than 1000 known wetlands were compared with the results of our wetland inventory where 74% of these wetlands were indicated. This discrepancy is not surprising given that our protocol did not record wetlands without water or those smaller than 0.04 ha. Therefore, this database should only be used in consultation with additional databases and other information.

Finally, part of the significance of this work is to clearly demonstrate that there is very little native land remaining in the Parkland Natural Region-Central Parkland. Furthermore, most of the land is privately owned. This remaining native land is very significant as it is from this land and associated water that the majority of the biodiversity and associated economic, ecological, aesthetic, and recreational values occur. Despite the limited native land base associated with this area, these native lands are extremely productive. Sound management approaches are required to help ensure wise stewardship of these lands and sustainability of their values. Thus, all agencies and individuals involved in land management in this area are strongly encouraged to work together to this end.

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MULTISAR: A CONSERVATION STRATEGY FOR SPECIES AT RISK IN THE MILK RIVER BASIN

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Abstract: The Milk River Basin Species at Risk Conservation Strategy implements a process to provide appropriate management on critical parts of the landscape to achieve multi-species conservation. The strategy has several objectives such as conducting inventories of species at risk for which data are lacking, identifying habitat associations of selected management species and describing these associations through Habitat Suitability Index models, and evaluating range management systems for their relative value in providing habitat for species at risk. The Milk River Basin Species at Risk Conservation Strategy emphasizes voluntary stewardship activities to achieve conservation of species at risk. This paper provides an overview of the process and resulting stewardship activities. Related papers in the conference proceedings address the project wildlife inventories, fish inventories, modeling, and beneficial management practices.

INTRODUCTION

MULTISAR is a multi-partner initiative to conserve multiple species at risk at the landscape level, specifically in the Milk River Basin. This is Alberta's smallest major drainage (6,776 km^2), but it supports the highest number of species at risk (approximately 40 At Risk, May Be At Risk, or Sensitive Species) of any definable landscape in Alberta. This concentration of species at risk led to the selection of this landscape as Alberta's first venture into multi-species management of species at risk.

OBJECTIVES

There are a number of specific MULTISAR objectives:

1. To summarize existing information for species at risk in the Milk River Basin.
2. To identify data gaps and design inventories for those species for which data are lacking.
3. To carry out inventories of species at risk for which data are lacking.
4. To determine, through a species selection process, priority management species for MULTISAR.
5. To identify habitat associations of selected management species, and describe these through Habitat Suitability Index (HSI) models.
6. To produce maps of the drainage basin showing relative habitat suitability for each selected management species.
7. To develop and implement a system that identifies priority areas of the drainage basin based upon Multi-species Conservation Values (MCV).
8. To describe the natural landscape processes of importance in the Milk River Basin.
9. To evaluate current range management systems for their relative value in providing habitat for species at risk.
10. To develop beneficial management practices for Milk River Basin species at risk.
11. To implement specific conservation and stewardship measures for high priority areas of the Milk River Basin.
12. To facilitate partnerships to achieve conservation of species at risk through voluntary stewardship actions.
13. To report results of the project to Milk River Basin communities, conservation groups, and the scientific community.

WILDLIFE DATA SUMMARY AND INVENTORY

A scoping phase of the project was carried out in April 2002 to determine occurrences and distribution of species at risk (At Risk, May Be At Risk, Sensitive) within the Milk River Basin. This exercise was followed by a review to determine data gaps for both species and portions of the landscape. Wildlife surveys were designed and completed in the spring and summer of

2002 and 2003 (Quinlan et al. 2003; Quinlan et al., in press). Specific inventories completed to date include:

- inventory of the mainstem of Milk River for western silvery minnow, shorthead ("St. Mary") sculpin, and stonecat;
- search along Milk River tributaries for drought-persistent pools suitable as fish refugia, and sampling of these areas for brassy minnow;
- aerial survey of the Milk River valley for raptors (ferruginous hawk, prairie falcon, golden eagle);
- amphibian call surveys for great plains toad, plains spadefoot, and northern leopard frog;
- loggerhead shrike surveys;
- ferruginous hawk and Richardson's ground squirrel monitoring;
- roadside transects for long-billed curlew;
- searches of suitable habitat for reptiles (prairie rattlesnake, bullsnake, eastern short-horned lizard); and
- survey for olive-backed pocket mouse using owl pellets.

Results of wildlife surveys are included in Quinlan et al. (2003) and in a Year Two Project Report to be produced in March 2004. Significant findings included range extensions for amphibian and fish species, valuable information on raptor nesting habitat, and critical data on amphibian habitat associations.

SPECIES SELECTION AND HABITAT MODELING

High priority management species (At Risk, May Be At Risk, Sensitive) were selected for HSI model development based on having high ecological importance as determined by one or more criteria (Thomas and Verner 1986; Landres et al. 1988; Morrison et al. 1992). The primary criteria for species selection included the following:

- strong representative of a group of species with similar habitat associations;
- strong association with a specific major ecosystem (e.g., native grasslands);
- strong association with specific habitat structures (e.g., cliffs);
- narrow ecological tolerances;
- high sensitivity to habitat changes and human activities; or
- value as a keystone species (e.g., important prey species).

Further modification of the list of selected species was done through consideration of the information available for a given species, a desire for proportionate representation amongst major taxa, documented declines in other jurisdictions, and comparative ease of inventory and monitoring. Species that already have single-species focused stewardship projects were excluded from the list. A list of selected management species for the Milk River Basin project is included in Table 1. Additional species were considered for model development but excluded for a variety of reasons as shown in Table 2.

For each project management species, a habitat suitability index model was prepared (USDI Fish and Wildlife Service 1981). The variables used to describe habitat were based on data available in electronic map bases. A preliminary report summarizing the models was produced (Jones et al. 2003), circulated to key grassland and species at risk experts, and posted on the Alberta Conservation Association website. After a four-month review period, the models were revised and provided to the Alberta Sustainable Resource Development – Resource Information Unit for creation of maps showing relative habitat values for each species throughout the basin. A report containing all HSI models and maps will be produced in March 2004.

Table 1. Selected management species for the Milk River Basin project.

Species	Justification
Ferruginous Hawk	Native grasslands association, dependent on keystone prey, sensitive, recent inventory
Prairie Rattlesnake	Prairie coulees and grasslands association, sensitive
Great Plains Toad	Ephemeral pond association, narrow ecological tolerance, recent inventory
Eastern Short-horned Lizard	Prairie coulee and valley break associations, narrow ecological tolerance, recent inventory
Weidemeyer's Admiral	Riparian shrub association
Sharp-tailed Grouse	Grassland/shrubland association, current monitoring program
Plains Spadefoot	Ephemeral pond association, recent inventory
Loggerhead Shrike	Shrub/Grassland association
Sprague's Pipit	Native grassland association, strong species group representative
Burrowing Owl	Native grassland association, sensitive
Badger	Native grassland association, dependent on keystone prey, provide burrows for burrowing owls
Prairie Falcon	Habitat structure association (cliffs)
Olive-backed Pocket Mouse	Grassland and sandy soil association
Long-billed Curlew	Native grassland association
Swift Fox	Native grassland association, recently reintroduced
Western Small-footed Bat	Riparian association (cottonwood and cliffs)

MULTI-SPECIES CONSERVATION VALUES

A multi-species conservation value (MCV), modified from an approach used by Akcakaya (2000), was developed for each quarter section in the Milk River Basin. The MCV was developed through a weighted mean value of project management species status, distribution, habitat patch size, and habitat suitability value (Table 3). The presence of fish refugia boosted the final score for a quarter section. To calculate the MCV for each quarter section, the following formula was applied:

$$MCV=(avg \sum_{i=16}^{n} (HSIi * SSi * SDi * HPSi) + FR\ value$$

The MCV was used to develop a map showing relative conservation value of each quarter section in the Milk River Basin (Figure 1). The map is a useful tool in determining highest priority areas for conservation and stewardship initiatives for species at risk in the MULTISAR project area. The MCV process was developed for MULTISAR, but may also be suitable for application in other prairie landscapes.

Table 2. Species excluded from Milk River Basin modeling process.

Species	Reason for Excluding
Western Silvery Minnow	Riverine, key variable (flow rates) which cannot be mapped
Brassy Minnow	Tributaries and mainstem, variables cannot be mapped
Sage Grouse	U of A research project underway includes development of habitat model. Specific recovery process already underway for this species, including conservation initiatives likely to occur within Milk River Basin
Shorthead Sculpin	Riverine, key variable (flow rates) which cannot be mapped
Yucca/Yucca Moth	Very limited distribution already known, already scheduled for specific recovery planning
Western Blue Flag	Specific recovery initiatives are already underway through the Western Blue Flag Conservation Program
Piping Plover	Few, very specific locations will receive site-specific management through Piping Plover Recovery Plan
Short-eared Owl	Poor information on habitat and distribution
Long-tailed Weasel	Poor information on habitat and distribution
Pronghorn	Separate management project includes development of habitat model which can be applied in Milk River Basin
Western Hognose Snake	Poor information on habitat and distribution
Bullsnake	Poor information on habitat and distribution
Northern Leopard Frog	Extensive suitable habitat is vacant due to past declines, management recommendations will be made at known occurrence sites
Western Painted Turtle	Very limited distribution

Table 3. Multi-species conservation value weighting.

Weighting Category	Description	Value
Species Status (SS)	Endangered/At Risk	4
	Threatened/May Be At Risk	3
	Special Concern/Sensitive	2
	Special Concern/Sensitive	1
	Data Deficient	1
Species Distribution (SD)	Restricted	2
	Widespread	1
Habitat Patch Size (HPS)	Small Patches	2
	Extensive Areas	1
Fish Refugia (FR)	Present	1
	Absent	0

BENEFICIAL MANAGEMENT PRACTICES

A summary of natural processes on the landscape and current range management systems was completed (Rangeland Conservation Services Ltd. 2003). The compilation of beneficial management practices for the project management species was initiated in 2003 for inclusion in a March 2004 report. Each beneficial management practice includes a summary of ecology and habitat needs for the species, a comparative review of grazing systems for implications/suitability, and a summary of beneficial practices to enhance habitat for the wildlife species. The beneficial management practices are a resource to be used in the preparation of multi-species habitat conservation plans on the lands of cooperating ranchers.

STEWARDSHIP

Stewardship initiatives began in 2003. A brochure was produced to summarize the MULTISAR Milk River Basin project for landowners and other potential cooperators. The MULTISAR MCV process was used to prioritize the landscape for the stewardship initiatives on private and public land in the Milk River Basin. Stewardship steps to be carried out with each cooperating landowner include a multi-species wildlife and grassland habitat assessment, the completion of a multi-species habitat strategy (incorporating species beneficial management practices), and partnership-based implementation of specific improvements to benefit species at risk on private and public lands. A conservation agreement will be developed with each landowner. The involvement of Environment Canada will be sought to draft a prototype conservation agreement that satisfies the federal *Species at Risk Act* (SARA), as well as the MULTISAR objectives and needs of landowners/lessees. The MULTISAR stewardship process involves several on-site meetings between the landowner, consultant, Alberta Conservation Association, and Alberta Fish and Wildlife. MULTISAR stewardship

Multi-species Conservation Value

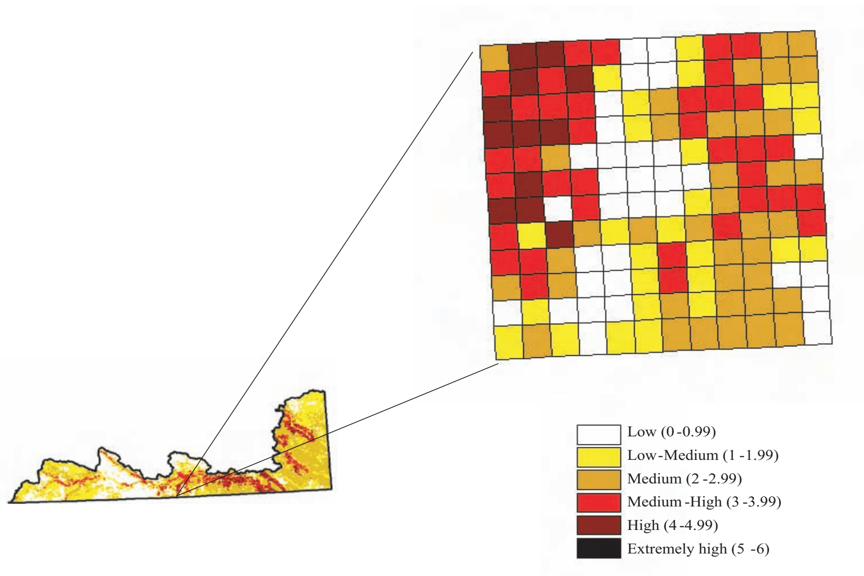

Figure 1. MULTISAR multi-species conservation value map of Milk River Basin.

includes consultation and cooperative work with other conservation organizations active in the Milk River Basin. To date, this has included participation with Operation Grassland Community, Nature Conservancy of Canada, and Alberta Riparian Habitat Management Program (Cows and Fish).

FUTURE DIRECTION

Fish and wildlife inventories of species at risk for which data are lacking, and monitoring to determine species trends, will continue in 2004-2005. Beneficial management practices and Habitat Suitability Models reports will be produced and posted on the Alberta Species at Risk website. The primary emphasis of MULTISAR will be on continued stewardship implementation in priority areas.

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USING AN ECOSYSTEM FRAMEWORK FOR ANALYZING INDICATORS AND RISKS CONCERNING HABITAT CONSERVATION ISSUES IN THE NORTH AMERICAN PRAIRIES

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Abstract: This presentation is based on a recent Central Plains of North America project that responds to conservation questions posed by an international group to the Commission on Environmental Cooperation. These included the following questions:

- What is the amount and location of 'native habitat' protection in the Central Plains?
- What are the types and relative levels of stressors that will impact native prairies?
- What are the grassland conservation responses that are associated with protected areas?

The analysis focused on issues related to the habitat/ecosystem level of biodiversity. It used the Commission's level III ecosystems (grassland and related areas) as the basis of the analysis and the means to integrate various forms of socio-economic, land use/cover, and environmental data. Various types of risk assessments were made using condition, stressor, and response indicators. For example, most of the moderate to high categories of risk for overall habitat biodiversity are associated with the eastern and central parts of the Central Plains.

The risk evaluations illustrate how analytical techniques, mapped information, knowledge, and expert opinion can be integrated both in consultations with different groups/professionals and in decision-making. The group discussions that surrounded specific parameters to be used in these risk assessments were useful in illustrating country-specific facts about baseline conditions, different views on conservation and resource management interests, quality of and standards for data, information gaps, and priorities. Data and information, as well expert opinion and knowledge, will improve over time. This form of risk analysis is not intended to be a static or one-time process. Science, socio-economic interests, conservation strategies and goals, ecosystem changes and threats, and political will are among the many factors that will change and call for an open and continued process of risk assessments into the future.

SUMMARY

This paper provides an example of how to use indicators in analyzing risks related to the conservation of natural grassland habitats. It demonstrates how different considerations, perspectives, information, and weightings could be used to guide discussions about grassland issues/concerns. Risk analysis is part of a decision-making process. The process of conducting the analysis, as well as interpreting the results can provide some sense, for example, of the gaps and opportunities that exist, what priority actions are required and the level of urgency, where the actions are most needed, which partners are best suited to implement the actions, etc.

The example of risk analysis presented in this paper is based on recently compiled data and information covering the central grasslands of North America. The topic evolved from a primary question posed by an international Commission on Environmental Cooperation (CEC) working group: What is the status of native grassland conservation across the central grasslands of North America? The answer to this question involved integrating information based on responses from a series of questions related to the following:

- amount and location of native grassland protection in the central grasslands
- types and relative levels of stressors that will impact native grassland protection, and
- range of grassland conservation activities that have taken place through protected area initiatives.

The analysis of indicators and risks in this paper focuses on habitat- or ecosystem-level biodiversity issues based on the CEC's level III ecoregion/ecosystem framework (NAEWG 1997). Under the assumptions made for this risk analysis, most of the moderate to high categories of risk to the conservation of grassland habitats are associated with the eastern and central parts of the North American prairies.

The risk evaluation illustrates, through an example, how analytical techniques, mapped information, knowledge, and expert opinion can be integrated both in consultations among different groups and professionals and in decision-making. The group discussions that surrounded what parameters to use and how to use them were helpful in illustrating essential facts about baseline conditions, different views on conservation and resource management interests, quality of data, information gaps, and priorities that exist among Canada, the United States, and Mexico.

The indicators and risk analysis related to the conservation of grassland habitats:

- used map-based information collected from many agencies and partners for the CEC's Central Grasslands Information study,
- concentrated on grassland-based conservation issues,
- focused on the central grasslands of North America,
- employed a condition-stressor-response model, and capitalized on tri-national (Canada, the United States, and Mexico) expertise derived from the following:
  - scientific and technical literature;
  - elements of the grasslands framework strategy from the Framework Document – Towards a Conservation Strategy for North America (Gauthier et al. 2002);
  - the species of common conservation concern in Biodiversity Conservation: Conservation of Migratory and Transboundary Species (CEC 2000); and
  - opinions and recommendations from an expert group of scientists and resource managers.

This risk analysis paper is a companion product for two other closely related technical reports:

- Information Analysis and Requirements for the North American Grasslands (Species and Spaces of Common Concern in the Central Grasslands of North America) (Wiken et al. 2002a) and
- Meta Data and Mapped Information for the North American Grasslands (Species and Spaces of Common Concern in the Central Grasslands of North America) (Wiken et al. 2002b).

The use of an ecosystem framework for the risk analysis contained in this document is only an example of evaluating one issue (i.e., the risks to the conservation of grasslands) using particular datasets or layers and making certain assumptions. The issue could be further analyzed using different datasets and assumptions. As well, other issues could be examined in a similar manner or on their own (e.g., a particular species-based biodiversity issue).

Risk analysis is not intended to be a static or one-time process. Data and information, expert opinion, and knowledge may improve over time. Science, socio-economic interests, conservation strategies and goals, ecosystem changes and threats, and political will are among the many factors that will change and call for an open and continued process of risk assessments into the future. The risk assessment process is illustrated in Figure 1.

INTRODUCTION

The grasslands of North America are often thought of in historical terms. These areas had a colourful natural history and culture for First Nation's people and settlers. The grasslands might now be more properly thought of as agricultural lands and ranchlands. The farming and livestock industries have played a very important role in sustaining the economies and livelihoods in Canada, the United States, and Mexico.

The values associated with the biodiversity of many landscapes and seascapes have changed greatly over the last decade. New social, cultural, and economic values pertaining to biodiversity interests (i.e., genetics, species, habitats) have been discovered, and these values have resulted in new resource management policies and commitments by governments and industries. The grasslands have been amongst the most severely altered areas in North America, and the lists of endangered species and habitats reflect these conditions. Building on ongoing conservation programs and capitalizing on new programs provide opportunities to stop habitat and species degradation and improve some conditions. This is happening in a cooperative manner where conservationists, resource management agencies, environmental non-government organizations (ENGOs), and industries have been engaged in common goals. The Prairie Conservation Action Plans in Canada's Prairie Provinces are examples of such cooperative endeavours.

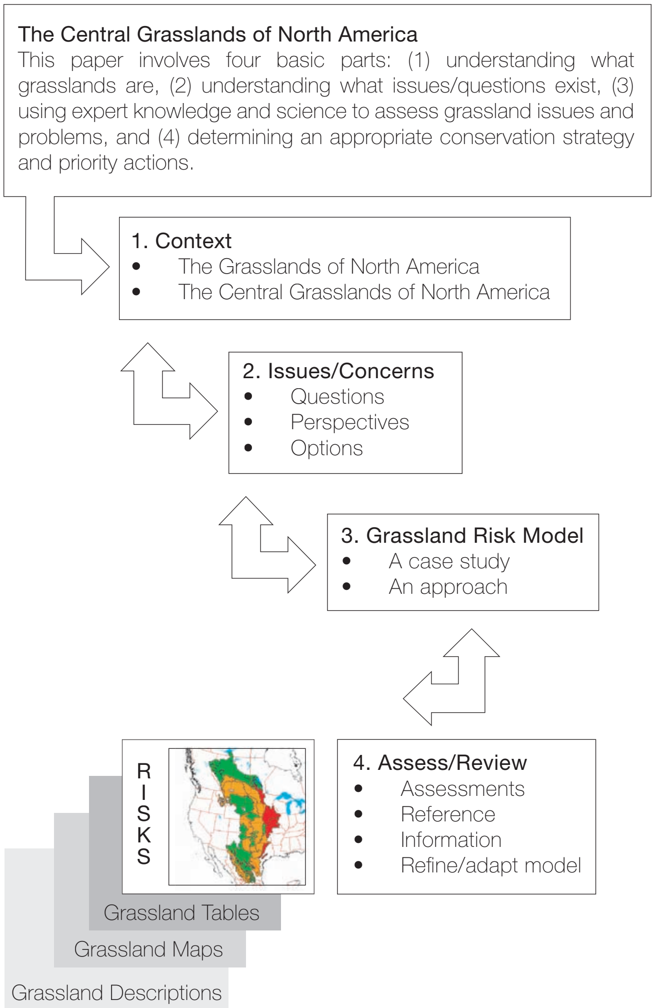

Figure 1. A summary diagram of the risk assessment process.

Under the North American Commission on Environmental Cooperation, the three countries (Canada, the United States, and Mexico) have taken a broad ecosystem perspective instead of the more narrow country, state, or provincial view. However, even this approach is not sufficient. Many grassland species require habitats in neighbouring forested or desert areas. Some species migrate through the grassland zone from arctic areas in Canada and Alaska to Latin American countries. Agricultural activities (i.e., water use, fertilizers, pesticides) in the central grasslands of the continent can also affect the water quality and habitats in the Gulf of Mexico. Thus, we must understand the range of ecosystems/habitats in North America and beyond and how habitats and species can be properly sustained.

In a complementary grassland study, various types of environmental, human activity, and landuse information were used to support the analysis of grasslands issues. This paper incorporates that information in an analysis of indicators and risks to the conservation of North American central grasslands. The material presented here is only one example of how such information can be used in decision making and planning. The basic question addressed here is "What is the current state of native grassland conservation in the central grasslands of North America?" Our example is based on four sources:

- information from the Information Analysis and Requirements for the North American Grasslands (Species and Spaces of Common Concern in the Central Grasslands of North America) (Wiken et al. 2002a),
- the baseline information assembled in the Meta Data and Mapped Information for the North American Grasslands (Species and Spaces of Common Concern in the Central Grasslands of North America) (Wiken et al. 2002b),
- the findings from the Framework Document – Towards a Conservation Strategy for North America (Gauthier et al. 2002), and
- the discussions that emerged from a small CEC Trilateral Workshop on Grassland Information Analysis held in Mexico City (April, 2002).

The analysis of concerns regarding grassland habitats is considered within the context of a risk evaluation. The notion of risk was placed in a tiered indicator model (i.e., conditions, stressors, and responses). The tiers are useful to show relationships, for instance, with current or past 'states/conditions', with types of 'factors/stressors' that adversely affect that state/condition, and with the 'responses' that have been implemented to mitigate the factors/stressors and achieve or sustain a desired state/ condition.

The results of this simplified version of risk analysis are interesting and revealing. Although the results are one form of an outcome, more importantly, the development of the indicator/risk model provided the opportunity for a group of professionals and agencies from Canada, the United States, and Mexico to analyze grassland conservation issues. The interactions among organizations and individuals fostered the ability to demonstrate:

- why views on issues differed,
- what constraints and values were associated with currently available data,
- where some critical information gaps were found, and
- how local and regional conditions and management options varied so markedly.

CONTEXT

The term 'grasslands' means many different things to people across North America, and perhaps the most popular images are based on historical events, wildlife, and conditions. People typically imagine vast rolling plains of grasslands with large herds of buffalo and other species, or simply the 'old west'. In this paper, a fairly broad definition of grasslands has been used. Specifically, to recognize the multiple biological and physical properties that sustain the grasslands and acknowledge natural and human-modified ecosystems/habitats, grasslands now refer to the native and altered landscapes in the grassland zone. This zone typically has warm dry summers and cold winters and chernozemic or prairie-type soils. In their native state, the areas are dominated by grass species and prairie dependent fauna, but many of these areas are currently associated with croplands and ranchlands.

Most people are not aware of the current state of grasslands. Human activities and agricultural land cover types – farms, croplands, ranches, and networks of roads – largely dominate the central North American grasslands. These grasslands are commonly known as the ‘agricultural areas’, ‘working landscapes’, or ‘food basket’ areas and are world-renowned for their productivity and contributions to the economy. For staunch conservationists, however, the native grasslands are now primarily the ‘has been’ landscapes. Natural grassland areas exist mainly as small and dispersed areas – remnant places of an earlier time and different ecological conditions – though these remnant areas are still home for some of the remaining native plants, birds, mammals, and other grassland dependent organisms. Many programs have been successful in protecting remaining areas of native grasslands and in blending conservation and agricultural interests.

Native grasslands occur widely in North America from Florida to Chihuahua to British Columbia. With such a wide distribution, they are often viewed from varying perspectives. Some people think about them in their native state, while others tend to think of native grasslands according to their land uses (i.e., the agricultural and ranching areas). This risk analysis concentrates on the central grasslands of North America. These plains are the largest contiguous area of grasslands that extend from the Prairie Provinces in Canada southward to Chihuahua in Mexico.

ISSUES AND CONCERNS RELATED TO GRASSLANDS

As much of the grasslands have been transformed over decades into croplands and ranching operations, the native grassland areas and associated species have become increasingly fewer in number and of greater concern for conservation. The concerns deal mainly with the scarcity of natural resources and the issues relate to the impoverishment, and ultimate loss, of species and habitats.

Along with the alterations of the landscapes, native grasslands have been extensively divided for the purposes of ownership and territorial rights. Various governments (i.e., national through to small municipalities), private landholders, Indian Reserves, and military sites divided the grasslands based on these rights and, in turn, took a role in managing these landscapes. To meet service, commercial, and socio-economic ends, the lands have been plowed up, seeded with commercial crops, fenced, set aside, partitioned by road and rail systems, irrigated or drained, fertilized, and fragmented. Less attention has been paid to managing these areas for their inherent conservation values or for multiple land resource goals in which conservation and commercial interests are considered in partnership. Disparate management aims raise concerns regarding landuse conflicts resulting from multiple land resource interests. These aims become expressed as questions about current and long-term ecosystem/habitat integrity, certainly for biodiversity and wildlife purposes. These aims can furthermore be considered within the context of the quality and quantity of the natural resources and whether the resources will continue to be sustained in a healthy state for people and wildlife, as well as for agricultural and ranching endeavours.

The structure, processes, and functions of these native grassland ecosystems and habitats have changed markedly owing to multiple decades of human activities and agricultural land uses. Many of the negative effects are most readily seen in the endangerment and loss of species and habitats; the 17 species of common conservation concern in the grasslands identified by the CEC (2000) are examples. Parallel indicators exist in related country-level studies. For example, Canada’s grasslands ecozone has the greatest number of listed endangered species and habitats/ecosystems (WHC 2001). Broader concerns were raised at the most recent Wildlife Society Conference in the form of a written conference statement.

ECOSYSTEM APPROACH

The central grasslands are one of only a few, large, and contiguous North American ecosystems that are shared among Canada, the United States, and Mexico. The forests and oceans of the continent are other examples, and these ecosystems have many connections to the grasslands. Although the forest/grassland relationships are more apparent, agricultural practices in the grasslands can also have a profound affect on seascapes (i.e., the Gulf of Mexico via the Mississippi River drainage system that threads across the grasslands). The continental connection with respect to the grasslands implies a shared responsibility among these countries to conserve this valuable ecosystem (Wiken and Gauthier 1998). The large geographic grassland area also encompasses a variety of species, habitats, and ecosystems, all functioning within a diverse mosaic of landuse activities, cultures, and political and management approaches subject to varying laws and regulations. Given such diversity and institutionalized mandates for resource management and conservation, it is not surprising that the vast majority of grassland conservation efforts occur at local or regional scales. Fewer, but equally important, conservation initiatives have been carried out at national, bi-national (especially within and between Canada and the United States), and tri-national levels.

We must continue to foster and sustain grassland conservation activities at the regional and national levels and refrain from reducing support for these activities. However, tri-national cooperation towards the conservation of the central North American grasslands is also increasingly necessary to support local, regional, and national activities. Such complementary support is required for the following reasons (Gauthier et al. 2002):

1. The full impact of human activities on species and ecosystems cannot be fully discerned at any one spatial or temporal scale. Forces impacting the sustainability of species and habitats may occur across longer time frames or originate from a larger geographic area than the scope of the local or regional conservation activity. In such cases, assessing the effectiveness of the local or regional conservation programs will be difficult, perhaps impossible, if they do not address the larger sets of driving forces. A tri-national focus provides a context for the driving forces and responses to those forces in the assessment of the effectiveness of local, regional, and national conservation activities.

2. There is a general sense of urgency towards dealing with what remains of a significantly impacted and now fairly impoverished ecosystem framework. That urgency has been recognized in numerous cooperative agreements to address conservation issues relevant to grassland ecosystems. Even existing bi-national agreements, however, tend to focus on the parts of the grassland rather than the whole, and it is very difficult to develop a comprehensive, contextual overview for any particular issue that draws the linkages among the various driving forces and responses. A tri-national strategy would help develop and sustain the broader, integrated perspective required for assessing the efficacy of approaches to landuse management and conservation in the grasslands.

3. The transboundary species, as well as parts of their life-support systems (i.e., water, air), are not limited to political jurisdictions. The Convention on Biodiversity (CBD) addressed grasslands and their biodiversity conservation during the Convention of Parties 5 sessions in February 2004 in Malaysia. The CBD recognized world grasslands, at a small spatial scale, to be the "most species-rich habitats on Earth" and that particular sites can often be of global importance for biological diversity, far out of proportion to their physical extent. The CBD recognized the potential for transboundary protected areas to help achieve the conservation of transboundary species. The development, establishment, and maintenance of a system of North American transboundary protected areas requires a strategic plan that addresses the full spectrum of central North American grassland issues.

4. Related to the above point, critical connections exist among Canada, the United States, and Mexico in terms of linkages and migratory movements among species of common conservation concern (SCCC). The 3 federal Wildlife Services of North America have agreed to work together to protect the 17 species of wild birds and mammals of common conservation concern (CEC 2000). A tri-national strategy is essential in order to ensure effective, common approaches to the development, implementation, and monitoring of management plans for SCCC that exist across organization and agency mandates and to address the full spectrum of forces impacting upon such species and their habitats.

5. Issues such as the best management use of livestock grazing and fire, sustainable wildlife harvesting, best practices to sustain agriculture, impacts of exotic species, and impacts and adaptations associated with climate change are of common concern across the geographic range of grasslands. Based on the principles of ecosystem management, a tri-national strategy can address issues that transcend the concerns, or perhaps even the capacities, of any one region or country and work towards the development and implementation of best practices to address those common issues.

Ultimately, a tri-national conservation strategy for central North American grasslands will be accomplished when

- the conservation of migratory and transboundary grassland species is addressed through initiatives that attend to their entire North American range;
- critical grassland habitats and ecosystems of North America are identified, conserved, and managed in a holistic, integrated, and intricately linked manner;
- issues pertaining to the conservation and sustainable use of grassland biodiversity are internalized by social and economic sectors of North American society;
- all potential mechanisms including those related to trade, economy and finance, bilateral and multilateral funds, law and policy as well as outreach and education are employed to successfully conserve, and sustainably use, North American grasslands; and
- all stakeholders including those from the economic sectors, private landowners, government, academia, indigenous peoples, and non-government organizations participate in initiatives for the conservation and sustainable use of North American grasslands.

DEVELOPING A RISK MODEL

Various approaches can be taken to develop a risk model, such as through sets of indicators related to conditions, stressors, and responses. The analysis is very dependent upon the key concerns, available information, opportunity and tools, and perspectives of the analysts and decision makers; therefore, the process of developing models (i.e., possible scenarios, outcomes, results) should be considered as a way to learn and share views. One example of a risk model is presented in this paper. The framework for the risk model is based on previous studies concerning a Canadian Biodiversity Risk Assessment Model and a National Wildlife Habitat Risk Model (Rubec et al. 1993; Turner et al. 1997; WHC 2001).

With so much of the native grasslands already degraded, the basic concern started with questions about the extent to which native grasslands still existed today. Thus, facts about the conditions of grasslands became the starting point in the model. This was followed by questions concerning some of the more immediate stressors that could further augment the loss of native grasslands and, subsequently, responses that have been put in place to retain native grasslands.

Basic Analytical Units

The three basic analytical components (i.e., conditions, stressors, and responses) were assessed, and the framework for analysis was developed based on the level III ecoregions identified by the Commission for Environmental Cooperation (NAEWG 1997). Twenty-four level III ecoregions/ecosystem divisions associated with the central grassland plains in North America (Figure 2) were used as the basic mapped geographical units for most of the risk analysis (i.e., 9.1.1 to 9.1.3, 9.2.1 to 9.2.4, 9.3.1 to 9.3.4, 9.4.1 to 9.4.7, 9.6.1 to 9.6. 2, 10.4.1 to 10.4.3 and 12.1.2.). As the goal is conservation of natural systems, ecosystem and habitat units were preferred rather than jurisdictional units, such as states and provinces. The ecosystem units employed based on the CEC level III ecoregions are largely grassland-dominated areas. In some mapped units, the grasslands merge with adjacent forested or desert ecosystems.

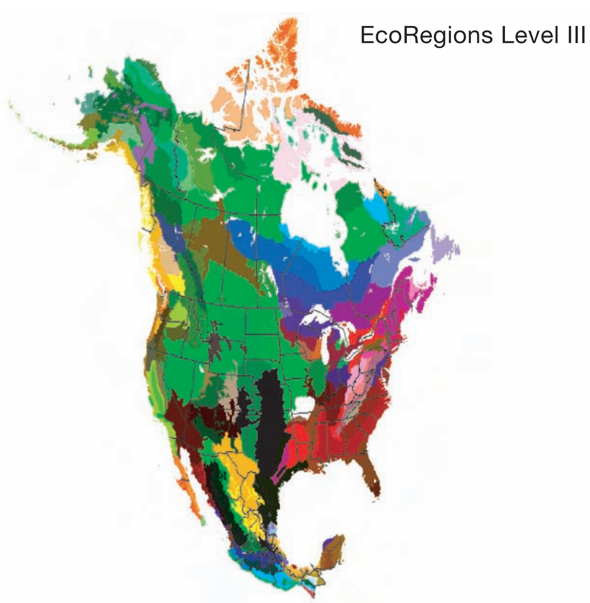

Figure 2. Commission for Environmental Cooperation level III ecoregions in North America.

Risk Indicator Model

The following condition-stressor-response indicator model (Figure 3) is used in this paper to analyze risks related to habitat conservation issues in North American grasslands.

1. The first input is the data/information that provides facts about the **conditions** of the resource being assessed. In this paper, the current conditions of the native grassland habitat types in the central grassland area of North America are addressed.
2. The second input is comprised of data that provides information on the **stressors** acting on the resource being assessed (i.e., indicators of stress factors on the conservation of natural grasslands).
3. The third input consists of data/information that measure societal **responses** implemented to protect and conserve the resource (e.g., response indicators that show how some measures of grassland conservation have been achieved).

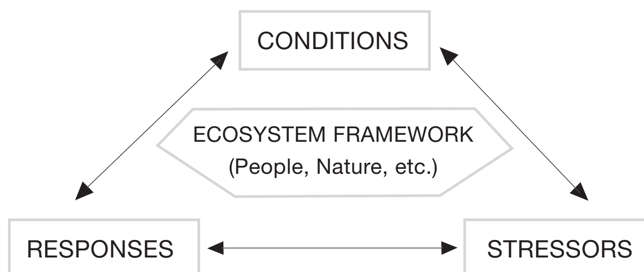

Figure 3. Risk indicator model and associated relationships between conditions, stressors, and responses.

Using all three indicators portrays a story about current assets (i.e., remaining native grasslands), the main factors (i.e., agricultural land uses, population, road densities, etc.) that may degrade their quality and abundance, and examples of conservation strategies and activities to date (i.e., Prairie Conservation Action Plans).

The data for conditions, stressors, and responses are derived from many sources. As with most compilations at the national and international levels, the metadata profiles (Wiken et al. 2000b) are not totally consistent according to the time in which they were collected, the sampling methodology, and standards; many groups have had the responsibilities to collect data and had very different levels of support to do this work. However, most of the data are relatively recent (last five to seven years) and fairly comparable for large ecosystem/area assessments. An example of specific attributes of the condition-stressor-response indicators related to the CEC level III ecosystem units for each of the three countries is shown in Appendix 1. Examples of cross-comparisons of various attributes among the level III ecosystems are presented in Appendix 2.

Conditions

To assess conditions, the risk model consists of a grassland index as a quantitative measure of native grasslands within any level III ecosystem map unit. The grassland index is derived from land cover and landuse data that have been used to characterize the CEC level III ecosystem units for the central grasslands of North America (CCEA 1999). The types of land cover and land uses contained in each level III ecosystem unit can be variable depending on how that area was developed and managed for agriculture and other commercial and urban land uses and what has been done to conserve areas or to limit human interventions on the landscape. Approximately 30 land cover/use classes are identified. The classes attempt to account for different grassland types (e.g., short-grass prairies, tall grass prairies), grass cover mixes (e.g., grasses and shrubs, grasses and woodlands), and land uses (e.g., grasses and croplands). The compilation of land cover/use classes for North America (CCEA 1999) is based on a very high resolution radiometer (AVHRR) remote sensing analysis and on the comparisons of AVHRR spectral signatures and ground reference sites (http://edcdaac.usgs.gov/glccc/glcc.html; see metadata profiles in Wiken et al. 2002b). Owing to the general accuracy of AVHRR (e.g., 1 x 1 km grid cells and the 1992/1993 coverages), the results of particular land cover/use classes are designed more for regional assessments and descriptions.

Each level III ecosystem unit may have several land cover/use classes, and each type has to be ranked according to how it may indicate the presence of native grasslands. The use of an index was a way to sum the relative amounts or areas in native grassland conditions. As some land cover/use classes are not pure grasslands, a weighted value was given to each type. For instance, the land cover type might be a pure grassland type or a cropland/grassland mix type, with the former type having more weight. The formula used to generate the grassland index (i.e., the relative amount of grasslands and non-grasslands in each level III ecosystem unit) was the following:

Grassland Index = Area of pure grassland cover type X 1.0 + area of grassland/natural cover type X 0.66 + area of grassland/cropland cover type X 0.33 + area of natural cover/grassland cover type X 0.25 + area of cropland/grassland cover type X 0.20.

In general, each weighting reflects the relative importance of each land cover/use type for determining the amount (not quality) of native grasslands that may be present. These values were a matter of 'first-order expert opinion' assigned by the authors and were intended to represent the relative significance of the grassland condition for each land cover/use type. A pure grassland cover type within a map unit/ecosystem type was thought to have a greater value in terms of significance to native grassland (i.e., a multiplier value of 1.0 was used). A grassland/cropland cover type had less value because of the mix of crops (i.e., a lesser multiplier value of 0.33 was used in this case). These weightings that were given to a particular land cover/use class type contained within a map unit can be modified through expert input, knowledge of particular geographical areas and grasslands types, personal on-the-ground studies, etc.

Stressors

In discussions during the development of the risk model, a number of measures of stress were considered. They included assessments of croplands, human population numbers, road network densities, and fragmentation. [Although fragmentation was thought to be important, a fragmentation index was not included due to uncertainties about how to assess these values for general purposes as opposed to specific species or habitat types and implications relative to particular species, life-cycle needs.]

To limit the number of stressors, only the amount of croplands and human population densities were used. A high density of roads typically indicates a higher population density. This assumes that areas with extensive cropland cover and higher levels of human populations place many stresses on conserving native grasslands. Croplands compete with efforts to conserve natural areas on the basis of land allocation (i.e., what lands are allocated to agriculture, ranching, etc.) and economics, and wilderness and natural area conservation goals often conflict with preferred locations for housing and industrial developments.

In compiling the grassland index, the cropland data were tallied according to the different land cover/use types. The AVHRR data were also used here. A cropland index was developed using the following formula:

Cropland Index = Area of pure cropland cover type X 1.0 + area of cropland/other cover types X 0.5 + area of other cover types/cropland X 0.25.

A pure cropland cover type represented a greater danger/stress to the conservation of native grasslands than did other land cover types that contained cropland mixes. Pure croplands were multiplied by 1.0 and other mixed cropland types were ranked lower. The population as well as road densities (contained in the metadata report by Wiken et al. 2002b) have inherent numeric values and each was ranked into a ten-class system. Values for each level III ecosystem unit were then calculated.

Responses

As a measure of societal response, the risk model uses the percentage of area in each ecosystem that has been designated as 'protected' for formal conservation purposes. The list of conservation areas was very inclusive, covering wildlife areas, migratory bird sanctuaries, parks, nature reserves, and wilderness areas. Much of this information was derived from the North American Conservation Areas Database (CCEA 1999). A few of the protected areas in the United States lacked figures concerning the percentage of the area encompassed. The North American Conservation Areas Database data were largely used as point file locations (as polygon or boundary files were not available). Conservation areas were assigned to the level III ecosystem unit in which the point location was found. However, there may be some cases in which a conservation area straddles one or more level III ecosystem units.

Synthesis of Results

The synthesis of results from the first level assessment of the condition-stressor-response risk model provides an index of the risk to the conservation of the level III grassland ecosystems within the central grasslands of North America. The condition-stressor-response model was built upon expert group sessions, previous risk studies, specific assumptions, and types of information that were available, and the results need to be understood within this context. By linking conditions, stressors, and responses, the analysis breaks away from the traditional 'silo' or singular interest approach to conservation actions.

The final model of risks to grassland conservation is the product of a simple formula (briefly described below), although other more complicated models could have been used. For each level III ecosystem unit, the formula used was based on calculating the sum values as noted below:

1. Presence of potential native grasslands weighting X 'Condition' class weight;
2. Cropland index weighting X 'Stressor' class weight;
3. Human population density weighting X 'Stressor' class weight; and
4. Conservation area percentage weighting X 'Response' class weight
5. Sum the four into the overall unit risk index.

The risk model uses unbiased weightings amongst the conditions, stressors, and responses – each element/map was given a 0.25 class weight to produce a sum for the overall ranked level III ecosystem units. A maximum possible risk value was ten. The model's elements and weightings can be modified by expert/specialist input to change either the map or class weightings for the model. The model can be enhanced at any time by adding or changing input layers/weightings.

This particular risk model integrates several inputs to measure the current relative risk to the conservation of North American central grasslands, based on the following assumptions:

1. When the grassland index is high, the risk is low.
2. When the cropland index is high, the risk is high.
3. When the population density is high, the risk is high.
4. When the area in conservation lands is high, the risk is low.

These assumptions are based on CEC studies (CEC 2000, 2002; Gauthier et al. 2002), country-level studies (INEGI 1994; Government of Canada 1996; WHC 2001), and the CEC Trilateral Workshop on Grassland Information Analysis that was held in Mexico City in 2002.

The process of obtaining the results of the risk analysis is significant in terms of decision making and planning. When the management of a resource, such as grasslands (e.g., the habitats, the species, the ecosystem services), is shared among so many groups, disciplines, and jurisdictions, perspectives and values regarding management approaches may differ. Although the reasons behind the differences are not clear to all interested parties, these differences may not preclude a basis for compatible interests (e.g., tourism and wildlife conservation interests may have different perspectives but they can undertake compatible endeavours). Discussions leading to risk assessments allow for varying perspectives to be illustrated. For example, the selection and testing of indicators show the relationship between different inputs and the attributes that characterize them. Information used in the risk analysis process can be used for future planning purposes (e.g., as a guide for developing elements of a conservation strategy, and for screening what additional data must be collected and monitored).

Sometimes currently available data or information are not suitable for risk analysis, and their use could lead to poor results. In the short term, it is extremely difficult and costly to change the data and information to conduct risk analyses and all the supporting inventory and monitoring studies. Therefore, the data and information need to be considered in a mid- and long-term context. At present, evaluations using risk models are perhaps more important in fostering the development of suitable questions (i.e., it is pointless in having an answer if the initial question was wrong or was addressed based on irrelevant data/information) and in shaping the overall decision process. The risk analysis process is adaptive. As newer, more detailed datasets become available or as grassland conservation knowledge improves, for instance, they can be added to the model(s) for a more complete representation of the risks to North American central grasslands.

GRASSLAND RISK MAP

The grassland risk map (Figure 4) shows the levels of risk to the conservation of North American grasslands (the notion of risk is dependent upon the map layers and weightings that were used in the risk indicator model). The map is based on the rankings of risks (i.e., high, medium, and low) associated with the 24 level III ecosystem units presented in Table 1. A collection of maps illustrating the risks to the conservation of grasslands was completed for each level III ecosystem unit. Overall, about 11.4% of the grassland areas are considered to be at high risk for requiring conservation interventions, and approximately 46.4% fall within the medium risk category.

High risk: The grasslands in the eastern margins of the Central Plains show the greatest level of risk to the conservation of grasslands. Four level III ecosystem units fall into this category (i.e., 9.2.2, 9.2.3, 9.2.4, and 9.4.7).

Medium risk: These areas tend to occupy the core sections of the Central Plains, from Alberta/Saskatchewan through to Texas/Chihuahua. Eleven level III ecosystem units fall into this category (i.e., 9.2.1, 9.3.1, 9.3.2, 9.4.1, 9.4.2, 9.4.6, 9.6.1, 9.6.2, 9.4.5, 10.4.2, and 12.1.2).

Low risk: The areas that were designated as having a low risk are located towards the western edges of the plains, near the mountain ranges, and on the northern ends of the Central Plains where they merge into the boreal forest. Nine level III ecosystem units fall into this category (i.e., 9.1.1, 9.1.2, 9.1.3, 9.3.3, 9.3.4, 9.4.3, 9.4.4, 10.4.1, and 10.4.3.).

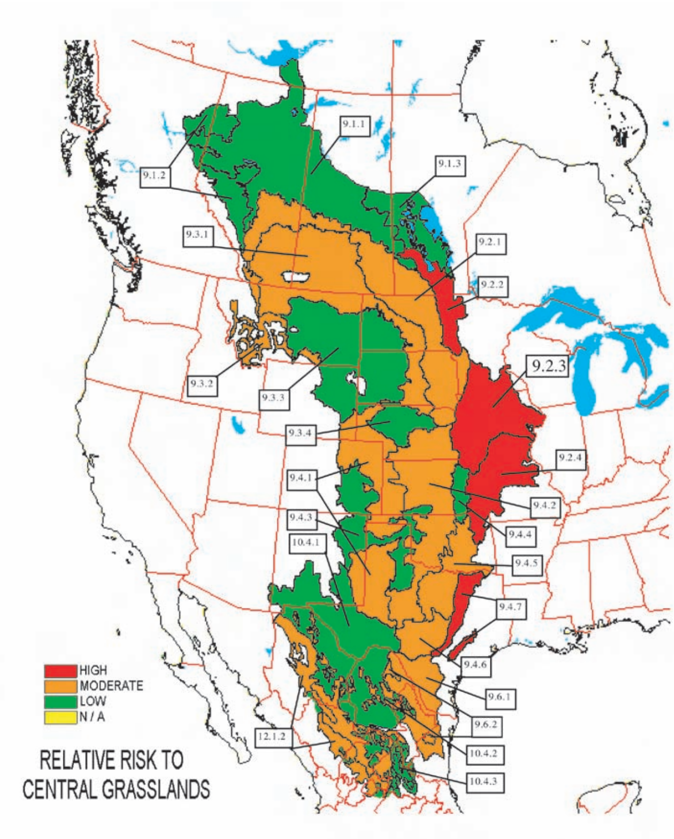

Figure 4. Grassland risk map for the 24 level III ecosystem units.

CONCLUSION

Terms such as ecosystem management, environmental management, sustainable resource use, integrated planning, etc. represent new objectives in landscape/seascape planning. Addressing these objectives often means having to invoke a broader assessment and decision-making process that involves diverse values, resources, priorities, considerations, agencies, and people – each having their own social, economic, and environment biases. There are also different timelines involved in these objectives which currently embrace the traditional near-term planning horizons. However, they are increasingly being considered in longer-term planning time frames.

Table 1. Level III ecosystem units ranked according to risk.

Grassland Areas of North America			
High Risk	**Level III**	**Area in Km²**	**Percentage**
Temperate Prairies	9.2.2	77,701	1.87
Temperate Prairies	9.2.3	198,960	4.8
Temperate Prairies	9.2.4	145,671	3.51
South-Central Semi-arid Prairies	9.4.7	50,439	1.22
		472,771	
Medium Risk			
Temperate Prairies	9.2.1	358,852	8.65
West-Central Semi-arid Prairies	9.3.1	388,121	9.36
West-Central Semi-arid Prairies	9.3.2	74,444	1.79
South-Central Semi-arid Prairies	9.4.1	281,026	6.78
South-Central Semi-arid Prairies	9.4.2	283,065	6.82
South-Central Semi-arid Prairies	9.4.5	114,994	2.77
South-Central Semi-arid Prairies	9.4.6	61,936	1.49
Tamaulipas-Texas Semi-Arid Plain	9.6.1	131,827	3.18
Tamaulipas-Texas Semi-Arid Plain	9.6.2	7,741	0.19
Chihuahuan Desert	10.4.2	113,514	2.74
Western Sierra Madre Piedmont	12.1.2	108,006	2.6
		1,923,526	
Low Risk			
Boreal Plains	9.1.1	486,365	11.73
Boreal Plains	9.1.2	121,316	2.93
Boreal Plains	9.1.3	105,499	2.54
West-Central Semi-arid Prairies	9.3.3	361,053	8.71
West-Central Semi-arid Prairies	9.3.4	61,285	1.47
South-Central Semi-arid Prairies	9.4.3	154,945	3.74
South-Central Semi-arid Prairies	9.4.4	28,157	0.68
Chihuahuan Desert	10.4.1	410,473	9.9
Chihuahuan Desert	10.4.3	21,926	0.53
		1,751,019	
	TOTAL	**4,147,316**	**100**

Although attempts to implement these objectives throughout the three Prairie Provinces (i.e., Alberta, Saskatchewan, and Manitoba) have been difficult, initiatives such as the Prairie Conservation Action Plans have created new and effective mechanisms to bring environmental non-government organizations, governments, industry, and private land-owners together. However, Canada is just one of three key stewards responsible for the care and management of the central grasslands of North America; the perspectives and values of many individuals and agencies within the United States and Mexico must also be taken into account. The perspectives, values, available resources, and priority needs often differ greatly among the three countries, resulting from historical differences in land use and culture. One approach that has been taken to sharing views, values, and considerations regarding the conservation of North American grasslands has been the use of indicators and risk assessments.

Risk assessments may be conducted using a condition-stressor-response indicator model. This type of model is iterative, and any of the three stages (i.e., conditions, stressors, or responses) may be used as a beginning point when assessing an issue. As well, specific environmental, social, or economic indicators that are relevant to an issue can be used in association with each of these stages. For example, the issue being addressed may be a condition of a resource, a particular type of stressor, or a response/means taken to mitigate the adverse impacts of the stressor or to sustain or improve the condition.

This paper provides an example of using the condition-stressor-response indicator model to analyze the risks related to a habitat conservation issue (i.e., the risks to the conservation of grassland ecosystems in North America) based on an ecosystem framework (i.e., the Commission on Environmental Cooperation level III ecoregions). The risk analysis began with a concern regarding the conditions of natural grasslands (i.e., locations and quantities of natural grassland habitats). The assessment revealed the areas that still had these grassland assets and to what degree. These natural grassland areas were examined in the context of a series of stressors (i.e., density of population and roads, intensive farm land uses) that would likely further deteriorate these regions. Finally, a response (i.e., the designation of protected areas) that had been taken to protect these areas was considered. An example of specific attributes of the condition-stressor-response indicators related to the CEC level III ecosystem units for each of Canada, the United States, and Mexico is shown in Appendix 1. Examples of cross-comparisons of various attributes among the level III ecosystems are presented in Appendix 2.

The intent of using a condition-stressor-response indicator model was to encourage participants (i.e., stakeholders, interest groups, resource managers, etc.) involved in the environmental management process to consider a broad range of environmental, social, and economic indicators concerning the effects, causes, and solutions associated with various grassland conservation issues. Rather than simply producing conclusive values or rankings, the goal in conducting risk assessments is to use the results as a means to evaluate data and information; act as a focal point in discussions regarding issues and concerns; test the validity and gaps in current day knowledge; and outline requirements for incorporation into, and implementation of, conservation strategies and policies.

The results of the risk analysis presented in this paper using an example based on the condition-stressor-response indicator model and the Commission on Environmental Cooperation level III ecoregions are presented in Table 1 and the grassland risk map (Figure 4). The trends throughout all three countries are similar in that the greater levels of risk are mainly associated with the more productive agricultural and ranching lands along the eastern edges of the central grasslands. The partnerships and biophysical attributes that would have to be considered in the eastern ecoregions of the Central Plains could differ greatly from those related to the western ecoregions. For example, stressors (such as cropland farming and cattle production), as well as the loss of natural grasslands, are highest in the eastern ecoregions of the plains in the United States, whereas ranching and natural grasslands are more prevalent in the western ecoregions. Therefore, in the eastern ecoregions, partnerships and agreements with farmers and farm associations are important responses to restore medium- to high-risk grassland areas and to sustain the remaining critical areas. Overall, about 11.4% of the central North American grasslands are within the high risk category with respect to requiring conservation intervention, and about 46.4% falls within the medium risk category. These results provide valuable information regarding priority areas and direction for decision making and the allocation of human and economic resources in terms of grassland conservation planning and management activities by all parties (i.e., Canada, the United States, and Mexico).

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Appendix 1: Examples of Specific Attributes for Particular Level III Ecosystem Units

LEVEL I 9.0 GREAT PLAINS

LEVEL II 9.2 TEMPERATE PRAIRIES

LEVEL III 9.2.1 Area 358,852 Sq. km.

CONDITIONS	Value	Units
Grasslands	0	%
Grasslands / Natural Cover	1	%
Grasslands / Cropland	4	%
Natural Cover / Grasslands	0	%
Cropland / Grasslands	66	%
Grassland Index	15.2	Max. 100
STRESSORS		
Cropland	14	%
Cropland / Other Cover	77	%
Other Cover / Cropland	6	%
Cropland Index	54	Max. 100
Population	1234354	People
Population Density	3.4	People /km^2
Road Density	12.107	Km. / km^2
Fragmentation (see note)		
RESPONSES		
No. of Conservation Sites	284	No.
Conservation Area	716074	ha
Percent protected	2.02	%
RISK INDEX	7	Max. 10

Attributes for selected conditions, stressors, and responses for Level III Ecoregion 9.2.1.

LEVEL I 9.0 GREAT PLAINS

LEVEL II 9.4 SOUTH-CENTRAL SEMI-ARID PRAIRIES

LEVEL III 9.4.2 Area 283,065 Sq. Km.

CONDITIONS	Value	Units
Grasslands	4	%
Grasslands / Natural Cover	9	%
Grasslands / Cropland	31	%
Natural Cover / Grasslands	0	%
Cropland / Grasslands	16	%
Grassland Index	23.4	Max. 100
STRESSORS		
Cropland	20	%
Cropland / Other Cover	24	%
Other Cover / Cropland	48	%
Cropland Index	44.0	Max. 100
Population	1112299	People
Population Density	3.9	People /km^2
Road Density	10.271	Km. / km^2
Fragmentation (see note)		
RESPONSES		
No. of Conservation Sites	16	No.
Conservation Area	59929	ha
Percent protected	0.21	%
RISK INDEX	7	Max. 10

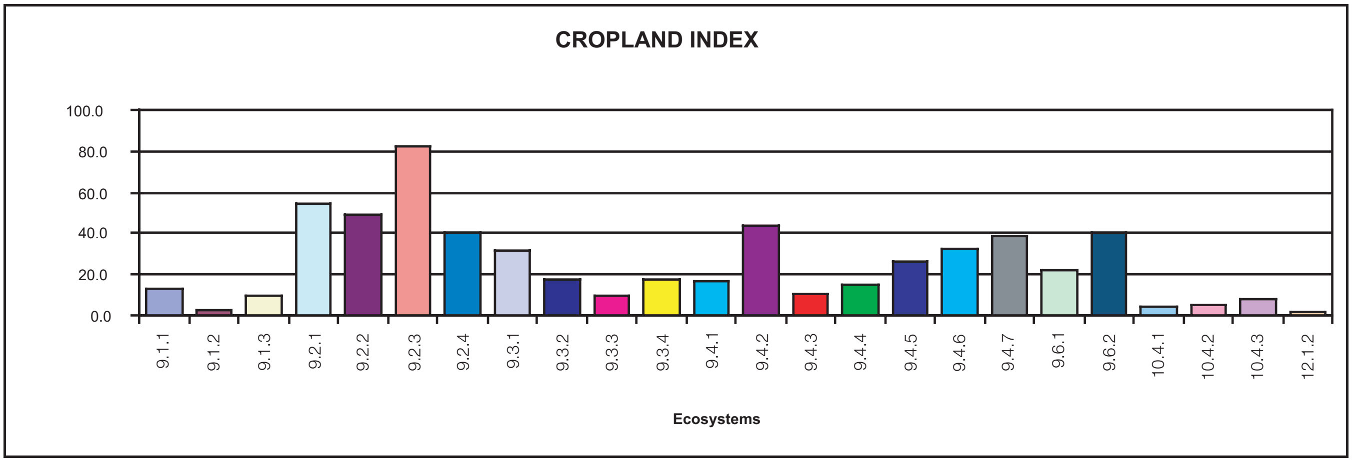
Attributes for selected conditions, stressors, and responses for Level III Ecoregion 9.4.2.

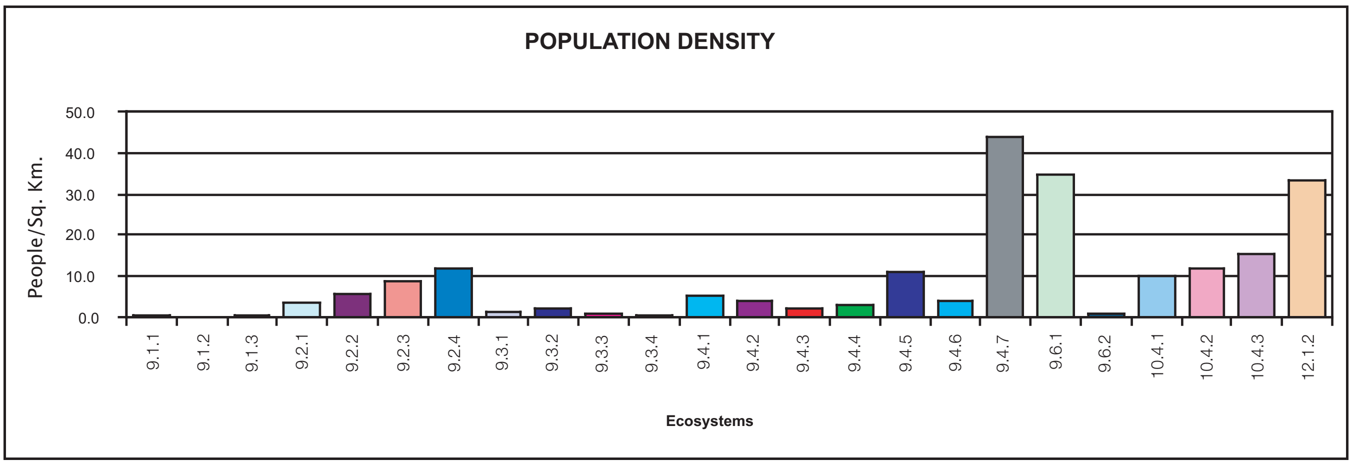
LEVEL I 10.0 NORTH AMERICAN DESERTS		
LEVEL II 10.4 CHIHUAHUAN DESERT		
LEVEL III 10.4.1 Area 410,473 Sq. Km.		

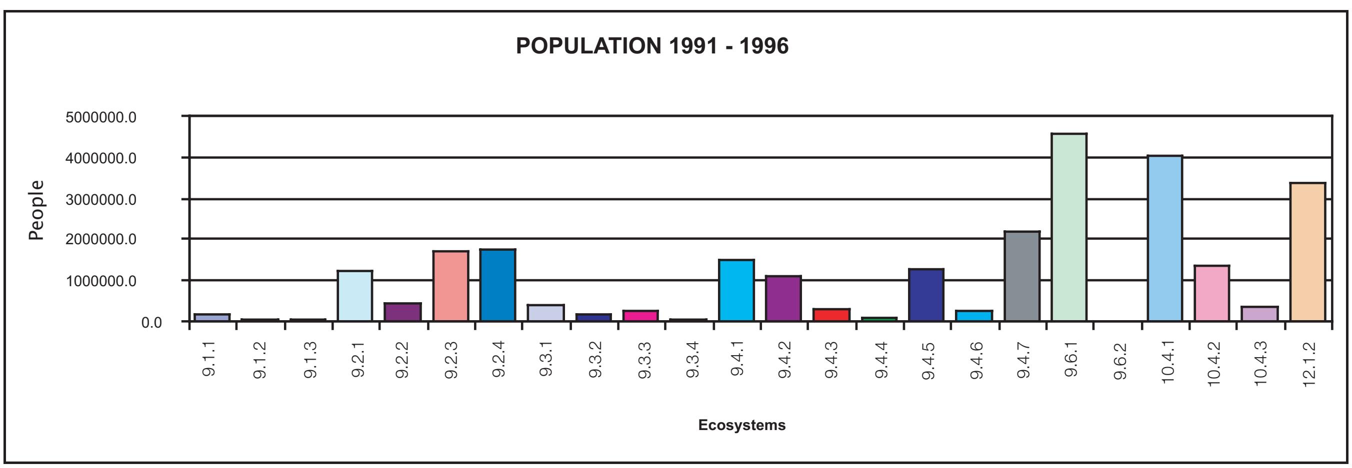
CONDITIONS	Value	Units
Grasslands	1	%
Grasslands / Natural Cover	21	%
Grasslands / Cropland	3	%
Natural Cover / Grasslands	50	%
Cropland / Grasslands	2	%
Grassland Index	28.8	Max. 100
STRESSORS		
Cropland	2	%
Cropland / Other Cover	3	%
Other Cover / Cropland	3	%
Cropland Index	4.3	Max. 100
Population	4049328	People
Population Density	9.9	People /km^2
Road Density	6.178	Km. / km^2
Fragmentation (see note)		
RESPONSES		
No. of Conservation Sites	42	No.
Conservation Area	1012576	ha
Percent protected	2.47	%
RISK INDEX	5	Max. 10

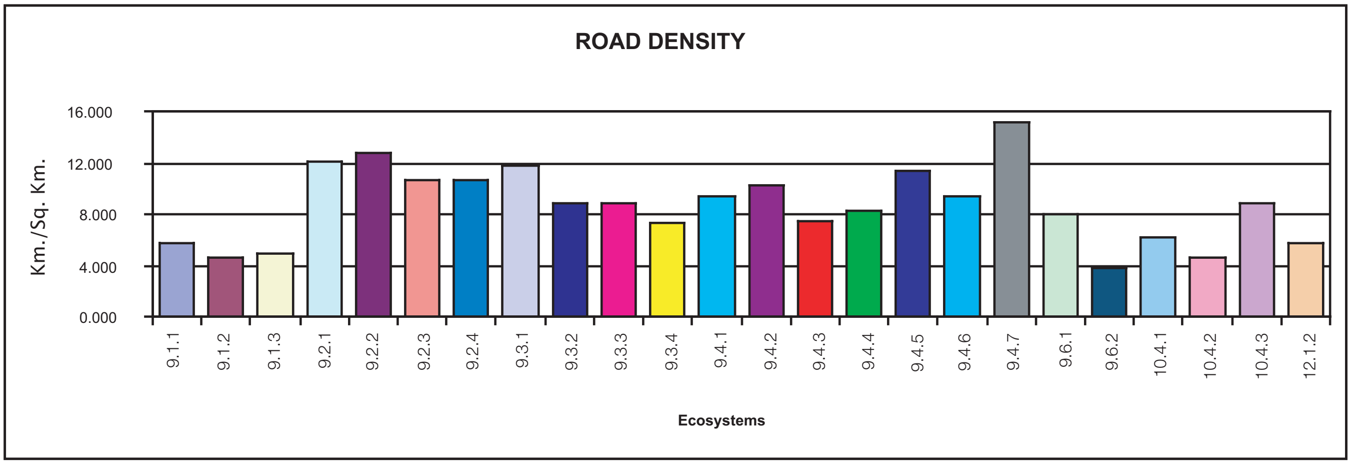
Attributes for selected conditions, stressors, and responses for Level III Ecoregion 10.4.1.

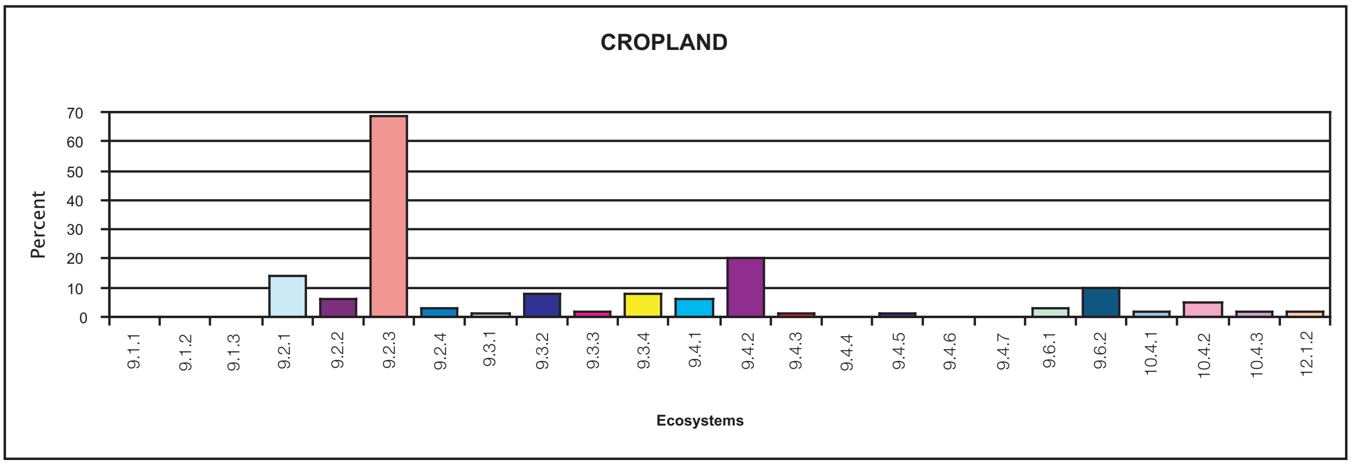
Appendix 2: Examples of Cross Comparisons of Attributes Among the Level III Ecosystem Units

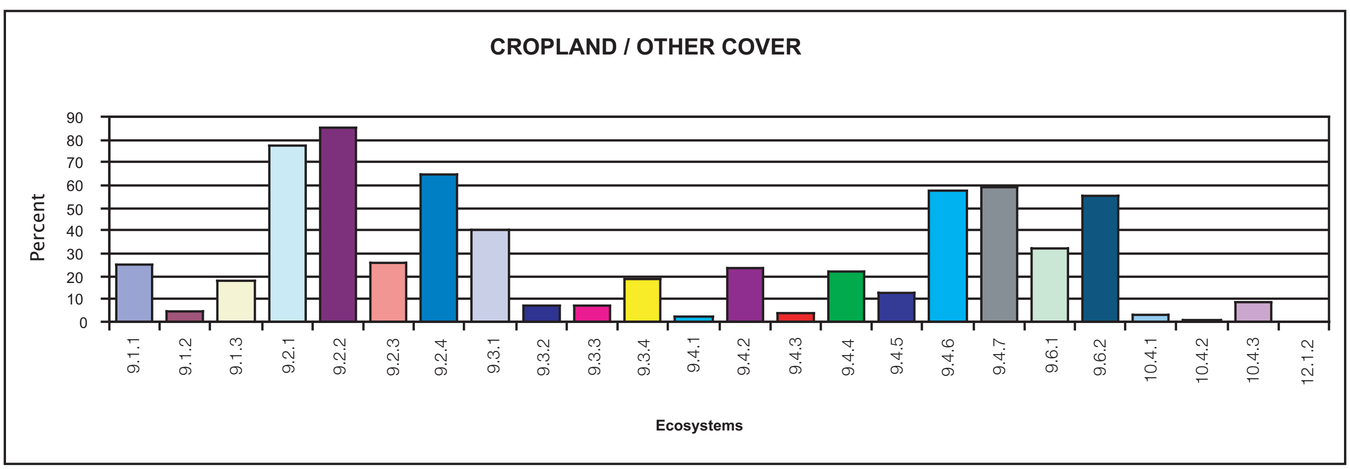







ROAD DENSITY
Km./Sq. Km.
16.000
12.000
8.000
4.000
0.000
9.1.1
9.1.2
9.1.3
9.2.1
9.2.2
9.2.3
9.2.4
9.3.1
9.3.2
9.3.3
9.3.4
9.4.1
9.4.2
9.4.3
9.4.4
9.4.5
9.4.6
9.4.7
9.6.1
9.6.2
10.4.1
10.4.2
10.4.3
12.1.2
Ecosystems


CROPLAND
Percent
70
60
50
40
30
20
10
0
9.1.1
9.1.2
9.1.3
9.2.1
9.2.2
9.2.3
9.2.4
9.3.1
9.3.2
9.3.3
9.3.4
9.4.1
9.4.2
9.4.3
9.4.4
9.4.5
9.4.6
9.4.7
9.6.1
9.6.2
10.4.1
10.4.2
10.4.3
12.1.2
Ecosystems


CROPLAND / OTHER COVER
Percent
90
80
70
60
50
40
30
20
10
0
9.1.1
9.1.2
9.1.3
9.2.1
9.2.2
9.2.3
9.2.4
9.3.1
9.3.2
9.3.3
9.3.4
9.4.1
9.4.2
9.4.3
9.4.4
9.4.5
9.4.6
9.4.7
9.6.1
9.6.2
10.4.1
10.4.2
10.4.3
12.1.2
Ecosystems

CONSERVATION OF NATIVE PRAIRIE IN CANADA – THE PRAIRIE CONSERVATION ACTION PLAN EXPERIENCE

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Abstract: Grassland conservation in Canada has been mobilized and directed through the development of Prairie Conservation Action Plans (PCAP) and PCAP Committees in the three Prairie Provinces of Alberta (45 partner agencies and organizations), Saskatchewan (26 partners), and Manitoba (26 partners). In Alberta, 43% of the native prairie remains, while in Saskatchewan and Manitoba, less than 20% of mixed-grass prairie remains. Tall grass prairie in Manitoba has been reduced to less than 1%. Although there are many similarities in the approaches taken to conserve remnant prairie in each province, there are many contrasts due to differences in jurisdictional, political, cultural, climatological, industrial, and agricultural backgrounds. Moreover, the differences in size and total area of remaining prairie have stimulated differences in programs, projects, and methods for conserving this natural resource. The Alberta vision is "to conserve the biological diversity of native prairie and parkland ecosystems for the benefit of current and future generations", focusing strongly on biodiversity and landscapes. The native prairie in Saskatchewan is "to be sustained in a healthy state in which natural and human values are respected", with a strong focus on supporting sustainable livestock production and working landscapes. Finally, the stated objective of the Manitoba PCAP is "identifying and implementing economic activities that go hand-in-hand with the restoration and maintenance of healthy prairie ecosystems", with attention on deriving economic benefit from the land in a sustainable fashion. The success of the PCAPs as well as the successful projects, programs, and activities by the PCAP partners will be examined.

SASKATCHEWAN'S PRAIRIE CONSERVATION ACTION PLAN

Greg Reimer
Saskatchewan Environment

Karyn Scalise and Allen Patkau
Saskatchewan Prairie Conservation Action Plan

David A. Gauthier
Canadian Plains Research Center, University of Regina

Abstract: The Prairie Conservation Action Plan (PCAP) Partnership launched Saskatchewan's second five-year action plan for native prairie conservation in June 2003. The 2003-2008 plan builds on the 1998-2003 Saskatchewan plan and the 1989-1994 plan for Prairie Canada. The five goals of the 2003-2008 plan are: (1) to sustain a healthy native prairie grazing resource; (2) to conserve the remaining prairie resource; (3) to maintain native prairie biological diversity; (4) to promote complementary sustainable uses of native prairie; and (5) to increase awareness and understanding of native prairie and its values. Relative to these goals, the PCAP Partnership developed 25 objectives and 78 direct actions deemed necessary to advance native prairie conservation in Saskatchewan. The 18-month plan renewal process involved 19 of PCAP's 25 partner groups. The 2003-2008 plan was modeled closely after the 1998-2003 plan due to its success in advancing progress on many of its 85 actions, including its ability to deliver effective, on-the-ground conservation strategies for native aquatic and terrestrial habitats within Saskatchewan's Prairie Ecozone. Although well-written and visionary, the 1989-1994 plan lacked key mechanisms, partners, resources, and other features that contributed greatly to success of the 1998-2003 plan. This presentation compares and contrasts the Canadian and Saskatchewan plans and highlights some of the accomplishments made by the PCAP Partnership since 1998.

PRAIRIE HABITAT JOINT VENTURE – MAKING A DIFFERENCE THROUGH PARTNERSHIPS

Deanna Dixon
Prairie Habitat Joint Venture

Brett Calverly
Ducks Unlimited Canada

Abstract: The Prairie Habitat Joint Venture (PHJV) has been a leader in habitat conservation for waterfowl and other migratory birds since the mid-1980s. To date, over 3,500,000 acres of upland and wetland habitat has been secured through a variety of approaches. This habitat securement, coupled with on-the-ground management initiatives, has allowed partners to make serious contributions to bird conservation in western Canada. While many significant gains have been made, PHJV partners continue to face challenges on the Canadian prairies. A unique blend of opportunities is being explored to meet these challenges. The need continues for direct habitat programs as well as innovative, landscape- and policy-based initiatives that have far-reaching benefits across the prairie landscape.

USING GEOGRAPHIC INFORMATION SYSTEMS TO PLAN FOR NON-WATERFOWL CONSERVATION WITHIN THE PRAIRIE HABITAT JOINT VENTURE

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Canadian Wildlife Service

Abstract: Through a series of increasingly sophisticated uses of GIS, we have produced two mapable products to assist in conservation planning within Alberta NAWMP's priority areas. We also created PHJV-wide models based on bird data from the Breeding Bird Survey and on a series of habitat and environmental characteristics from the same locations generated with GIS technology. Information from the validated models will be used to generate maps of the probability of occurrence of priority species. These map products assist in conservation planning by targeting areas where conservation of habitat will benefit multiple species groups. However, the on-the-ground conservation tool chosen for target areas will ultimately determine how many species groups benefit.

INTRODUCTION

The Prairie Habitat Joint Venture (PHJV) was originally founded as the delivery mechanism for the North American Waterfowl Management Plan (NAWMP). The PHJV has since expanded its focus to include all birds, as expressed in the new PHJV vision statement, "prairie and parkland landscapes capable of sustaining bird populations in harmony with human use of the environment."

NAWMP has long used a Decision Support System (DSS) to direct its waterfowl conservation efforts. The DSS was developed through the analysis of a variety of habitat and environmental attributes in a geographic information system (GIS) format. The resulting digital map shows the areas of highest probability of use by priority waterfowl species and conservation efforts are focused therein. To work towards the PHJV's expanded vision, similar DSS products must be developed for non-waterfowl species using GIS. By overlaying priority areas for waterfowl and non-waterfowl, it is hoped the PHJV will be able to identify areas where their work may result in the maximum multi-species benefits.

METHODS

Identifying Priority Species

All areas within the PHJV are important to one or more of the over 300 non-waterfowl species. To focus our efforts, we began with the same initial step as was used in developing the waterfowl DSS; we identified priority species (Table 1). We utilized priority species lists generated by Prairie Partners in Flight for landbirds, Prairie Canada Shorebird Working Group for shorebirds, and the Northern Prairie and Potholes Waterbird Conservation Working Group of Waterbird Conservation for the Americas for waterbirds. In the latter case, we used only those priority species known to occur regularly in prairie Canada. For shorebirds, we used only the Species of High Conservation Concern. Priority landbird and waterbirds were mainly breeding species, while shorebirds included some passage migrants for which prairie wetlands are vital during migration. In the international priority-setting system used for landbirds, a point total for each species is developed based on trend, geographic responsibility, and known or possible threats. The shorebird and waterbird priority setting was not done in such a formal manner, but experts who set the priorities did consider the same three factors of trend, responsibility, and threat.

Identifying Priority Areas

For some priority species (Priority Group I), we only had information on which waterbodies they had been known to use, but we did not necessarily know what waterbodies had not been used. Thus we developed a Waterbody DSS. The known Priority Group I species locations were first filtered to retain only those that fell within the PHJV boundaries. The basins used by one species in one province (i.e., piping plover in Saskatchewan) had already been delineated and were available as a GIS product. For the remainder of the species and for piping plover in the other two provinces, we had only point coordinates. These coordinates were intersected with the National Topographic System wetland layer, and the boundaries of the appropriate wetland were selected for use in our Waterbody DSS. The boundaries of all the waterbodies known to be used by Priority Group 1 species were then overlaid with the boundaries of the Waterfowl DSS, and the proportion of priority waterbody area falling within the Waterfowl DSS area was calculated.

For the remainder of the priority species (Priority Group II), we had considerably more information because these species were regularly monitored by the Breeding Bird Survey (BBS). The Breeding Bird Survey is jointly managed by the United States Geological Survey and the Canadian

Table 1. Priority species by group

Bird Group	Species Name	Priority Group
Shorebird [1]	Five passage migrants	I
	Piping Plover	I
	Upland Sandpiper	II
	Long-billed Curlew	II
	Marbled Godwit	II
	American Avocet	II
	Willet	II
	Wilson's Phalarope	II
Waterbird [2]	Western Grebe	I
	Franklin's Gull	I
	Black Tern	II
	Horned Grebe	II
	American Bittern	II
	Yellow Rail	II
Landbirds [3]	Greater Sage Grouse	II
	Sharp-tailed Grouse	II
	Northern Harrier	II
	Swainson's Hawk	II
	Ferruginous Hawk	II
	Golden Eagle	II
	Prairie Falcon	II
	Black-billed Cuckoo	II
	Snowy Owl	II
	Burrowing Owl	II
	Long-eared Owl	II
	Short-eared Owl	II
	Loggerhead Shrike	II
	Sedge Wren	II
	Sprague's Pipit	II
	Bohemian Waxwing	II
	Clay-colored Sparrow	II
	Lark Bunting	II
	Grasshopper Sparrow	II
	Baird's Sparrow	II
	LeConte's Sparrow	II
	Nelson's Sharp-tailed Sparrow	II
	McCown's Longspur	II
	Chestnut-collared Longspur	II
	Bobolink	II

1. Shorebird priorities set by Prairie Canada Shorebird Working Group
2. Waterbird priorities set by Northern Prairie and Parkland Waterbird Conservation Working Group.
3. Landbird priorities set by Prairie Partners In Flight

Wildlife Service (CWS). More than 400 randomly selected, 24.5 km-long routes are surveyed, largely by volunteers, in Canada each year. All birds seen or heard are recorded at 50 stops along the route once a year under prescribed temporal, environmental, and observer conditions. This has created a valuable long-term database that has been used for many conservation purposes. The potential of the BBS to examine the connection between bird and habitat data has been unexplored until recently because the stop locations were not mapped and bird data were entered on a ten-stop level. Beginning in 2000, the CWS collected Global Positioning System (GPS) locations for stops on most routes within the prairie and parkland portions of the three Prairie Provinces. The CWS in Ottawa made entering the old prairie data on a stop-by-stop basis a priority.

We took BBS stop-by-stop presence/absence bird data from the period 1992-1998 for 135 routes that fell within the PHJV boundaries. Habitat characteristics within 400 m and 800 m of each stop location were generated for a series of variables available as GIS data layers. These included percent cover of grass, trees and shrubs, forage, wetland, roads, and three categories of soil drainage (excessive, rapid, and well-drained). Non-cover variables included northing, easting, measures of accumulated moisture from February to May, and average 100 m digital elevation model value. Several GIS variables were the product of formulas combining multiple data sources such as the class category under the Waterfowl Canada Land Inventory (which combines soil, slope, moisture, wetlands, and other factors) and Conserved Soil Moisture (which uses all moisture in the previous two years with more weight given to recent moisture). We then used Generalized Estimating Equations to generate models. Models were also generated using back selection, and Information Criterion was used to select the best model to describe the relationship between each individual Priority Group II bird species and the habitat variables. Once a model was selected, a map showing the probability of occurrence of the species was generated. Some bird species occurred too infrequently on the Breeding Bird Survey to generate useful individual models.

RESULTS AND DISCUSSION

We were able to generate a map of priority wetland areas for Priority Group I species. There was 63.5% overlap of those wetlands within the PHJV priority area for waterfowl work. Many areas important to water-related non-game birds are already under focus for waterfowl conservation. The percentage overlap may be even higher since the Waterbody DSS included only those wetlands known to harbour priority wetland birds. Many other wetlands have not been surveyed and could contain priority wetland species. Given the degree of overlap, challenges still remain to integrate the needs of the non-waterfowl waterbirds into PHJV conservation efforts within the priority area. Many Priority Group I species require different types of wetlands or different kinds of wetland conditions and management than do waterfowl.

The modeling for Priority Group II was not yet complete at the time this paper was presented, but many species in this group of birds are so closely associated with grasslands that we speculated the eventual model may bear a strong resemblance to the grassland layer. The grassland layer had very little overlap (23.5%) with the PHJV priority area.

Between the conference and the publication of these proceedings, the modeling was completed. As expected, the final models for many Priority Group II species were largely influenced by the presence of grass, and the overlap between individual priority species and the PHJV priority area was very low. Many priority landbirds were much less likely to occur in grassland in parkland situations, which meant that the areas of highest probability were well outside waterfowl priority areas. Many challenges exist to integrate conservation for Priority Group II birds into PHJV activities, although the overlap between priority landbirds and northern pintail was far better than for waterfowl in general. Within the priority areas, there are differences in habitat types and management preferred by waterfowl and Priority Group II birds. The majority of important habitat for Priority Group II birds is outside of PHJV focus areas, so new partners and strategies will be needed to generate effective conservation for this bird group.

ACKNOWLEDGMENTS

The Alberta Biodiversity Advisory Group and Canadian Wildlife Service funded this exercise. We thank Gerard Beyersbergen for providing names of priority waterbirds and shorebirds and locations of waterbodies used by priority waterbirds and shorebird passage migrants. The Saskatchewan Watershed Authority delineated the boundaries of piping plover waterbodies. The Piping Plover Recovery Team provided the remainder of piping plover waterbody locations. Bev Gingras formatted GPS and bird data to prepare them for analysis. Manitoba Provincial coordinator Ken DeSmet and Manitoba Conservation Data Centre assisted CWS in obtaining BBS stop locations in that province during fall 2003. Saskatchewan BBS coordinator Al Smith had already collected many stop locations and assisted us in obtaining the rest in summer 2003. National BBS coordinator Connie Downes directed entry and checking of the stop-by-stop bird data. We thank the many volunteers who annually devote one or more days to collect BBS data.

A NATURE CONSERVANCY OF CANADA AND DUCKS UNLIMITED CANADA PARTNERSHIP INITIATIVE: THE CYPRESS UPLANDS

Margaret Green
Nature Conservancy of Canada

Abstract: The Cypress Uplands surrounding the Cypress Hills Provincial Park in southeastern Alberta has been designated as a priority in the grasslands by both The Nature Conservancy of Canada (NCC) and Ducks Unlimited Canada (DUC). The large tracts of relic grasslands, numerous wetlands, and conglomerate rock outcrops provide habitat for a variety of wildlife including breeding birds and species at risk. As a result, NCC and DUC have forged a partnership to conserve and enhance environmentally significant land in the Cypress Uplands. The partnership involves planning and implementing a program that works with landowners to help them conserve and manage their land. To date, over 14,000 acres have been conserved, primarily through conservation easements.

INTRODUCTION

The Cypress Uplands surrounding Cypress Hills Provincial Park is located within the mixed-grass ecoregion of Alberta, covering approximately 3262 km^2. The plateau within the Cypress Hills Provincial Park gives way to rolling hills that undulate from the park and further give way to rolling grasslands rich in wetlands. This gently to strongly rolling terrain was created by the ground moraine left by glaciation 20,000 years ago (Hildebrandt and Hubner 1994). The Cypress Hills formation was formed by sands and gravels transported by large rivers from the Rocky Mountains while they were formed in the Eocene time period (Sauchyn 1999). The Cypress Hills themselves survived the Pleistocene glaciation, while the surrounding plains have been rounded and carved by ice numerous times in the past. The prairies are situated on a lowland glacial lake basin (Hildebrandt and Hubner 1994).

The mixed-grass ecoregion is predominately comprised of mixed-grass prairie (Coupland 1950). The most common grasses are porcupine grass *(Stipa spartea)*, needle-and-thread grass *(Stipa comata)*, blue gramma grass *(Bouteloua gracilis)*, June grass *(Koeleria cristata)*, and wheat grass (*Agropyron* spp.). Shrub species found in coulees and wet areas include snowberry *(Symphoricarpos albus)*, red osier dogwood (*Cornus stolonifera*), silverberry *(Elaeagnus commutata)*, wild rose *(Rosa acicularis)*, and chokecherry *(Prunus virginiana)*.

The Cypress Hills and the surrounding area are extremely abundant in wildlife. The area north and west of the Cypress Hills is very productive waterfowl habitat, with numerous wetlands and sufficient upland nesting cover provided by the native prairie. Up to 207 species of birds have been observed in the Cypress Hills themselves due to the availability of diverse habitats (Hildebrandt and Hubner 1994). The surrounding prairies are home to sharp-tailed grouse, Baird's sparrows, meadowlarks, red-tailed hawks, golden eagles, and many other species. Numerous ungulates including elk, moose, and mule deer use the Cypress Hills extensively and the surrounding prairie for feeding and calving grounds. Pronghorn are plentiful further from the treed Cypress Hills. Predators such as lynx, bobcat, coyote, and fox can also be found in and around the Cypress Hills as well as numerous smaller mammals including squirrels, raccoons, and porcupines (Hildebrandt and Hubner 1994).

THE ORGANIZATIONS

The Nature Conservancy of Canada (NCC) and Ducks Unlimited Canada (DUC) have forged a partnership to conserve and enhance environmentally significant land in the Cypress Uplands. The NCC is a non-profit, Canada-wide organization dedicated to preserving biodiversity by working with landowners. This work is done on a volunteer basis, and NCC helps landowners preserve their land in perpetuity. NCC prefers to work with partner organizations whenever possible. Any project completed by NCC is a result of much fundraising – over 60% of the funding comes from individual donations across Canada. DUC is also a non-profit, Canada-wide conservation organization who works in partnerships with landowners. DUC's work involves conserving, restoring, and managing wetlands and associated habitats as well as active participation in environmental education, research, and land and water management.

THE PREMISE

NCC and DUC have both identified the Cypress Uplands as a priority landscape for conservation. The Cypress Uplands is designated a nationally environmentally significant area, and numerous species at risk are found therein. This area also has many wetlands important for northern pintail production. In the spring of 2002, a partnership was born to work towards a common goal in the Cypress Uplands: NCC had the experience in completing conservation easements, while DUC could bring restoration and water development expertise to the table when partnering with landowners in the area. Furthermore, both organizations could make their conservation dollars ultimately go further by sharing costs for all projects.

MAPPING PROCESS

A detailed mapping initiative was the first step in devising a plan for the area, and the moist mixed-grass ecoregion was chosen as the boundary. The mapping process involved compiling different information layers into a GIS platform and weighting the various information layers on importance. The result was a quarter-section-based priority map. The information layers used included the following:

- Native Prairie Vegetation Inventory – a quarter-section-based classification of native prairie vegetation cover within the Grassland Natural Region in southern Alberta.
- Environmentally Significant Areas – areas with provincial and national environmental significance based on several criteria including relatively undisturbed and sizable remnants of upland and valley habitats, important waterfowl production and shorebird staging areas, critical wildlife ranges, staging habitat with high concentrations of waterfowl, National Parks, habitats for endangered species, and rare plant and animal species.
- Riparian Information – a buffering system was used to ensure that riparian areas were taken into consideration.
- DUC Pintail Decision Support System – the Pintail Decision Support System map assists DUC in focusing resources on areas with the greatest potential for increasing waterfowl recruitment in the prairie and parkland ecoregions of western Canada.
- Species at Risk Information – these data were obtained from the provincial government's tracking program for species at risk, the Biodiversity/Species Observation Database. Due to the sensitive nature of these data, only general locations were given and species were not specified.
- Land Tenure – these data included information on Crown versus private land ownership.

A weighted overlay map was developed due to the fact that not all the layers incorporated into the analysis needed the same weight or influence on the resultant map. High priority areas highlight areas on the landscape where model inputs were ranked high (weighted between 6 and 9). The steps followed to produce this map are described below.

1. Data were gathered from various agencies and converted to shapefiles (projected to Geographic, NAD 83).
2. ArcView 3.2a, Spatial Analyst 2.0, and Model Builder were utilized in the modeling process. Vector shapefiles were added to an ArcView project and classified for display.
3. Themes were added to the Model Builder layout as vector themes. Each theme was converted to a raster dataset with a cell size of 25 m, and raster themes were overlaid using the weighted overlay operation.
4. Model inputs were assigned a percent influence affecting the overall model and scale values between 1 and 9 were applied within each variable. Restricted values were excluded from the modeling process due to existing protective status.
5. Weights were applied to raster themes based on each theme's importance to conservation. Once weighted, a conservation priority map was produced to assist in determining areas with the highest value for conservation within the mixed-grass ecoregion.

PROGRAM DELIVERY

Landowners in high priority areas were identified and were invited to an open house held in the spring of 2003. Information packages were also sent out to landowners. There are several options available to landowners wishing to conserve their land, specifically conservation easements (purchased, donated, or a combination), land purchase or land donation, land donation through estate, or land donation with a life interest. Conservation easements are voluntary, legal agreements that run with the land. Under an easement, a portion of the landowner's rights are donated or sold (e.g., restrictions would include no subdivision and no cultivation of native grasslands); however, easements also enable the landowner to continue using the land to the highest use. Easement management costs for DUC and NCC are typically minimal. NCC prefers to keep land in private stewardship, therefore the goal is 90% easements and 10% land purchase in most areas, including Cypress Uplands.

To date, there are nine projects completed or currently in negotiation. This represents 19,560 acres, with the majority in conservation easements. NCC and DUC would like to acknowledge the landowners working with the organizations. Without the ranching families and their personal conservation ethics, Cypress Uplands would not look as it does now.

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PRAIRIE FARM REHABILITATION ADMINISTRATION: PROVIDING PASTURE FOR MORE THAN JUST COWS

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Abstract: In addition to providing a grazing and breeding service for some 220,000 cattle and horses each year, the 2,300,000 acres of pasture land within the Prairie Farm Rehabilitation Administration's (PFRA) Community Pastures are home to 57 prairie species at risk. It is a success story that proves that livestock and species at risk can coexist, even thrive, when managed using a landscape approach. Nashlyn Community Pasture in southwest Saskatchewan is an excellent example of how landscape management is collectively beneficial. In the 65-year history of this 61,700 acre pasture, range management practices have improved the condition of the rangeland significantly; stocking rates have increased from less than 1,000 head in the 1930s to 1,600 head in the 2000s, the range condition is currently rated as excellent, and the pasture provides suitable habitat for multiple species at risk. This presentation provides an in-depth case study of land management practices used at Nashlyn and across PFRA, which have been proven over almost seven decades. The critical role of partnerships with local producers, pasture patrons, non-government organizations, and other levels of government will be highlighted as pasture improvement techniques and practices are examined and discussed.

STEWARDSHIP AT WORK: OPERATION GRASSLAND COMMUNITY'S BURROWING OWL MANAGEMENT PLANS

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Operation Grassland Community (OGC), a habitat stewardship program coordinated by the Alberta Fish and Game Association, has been active in the Grassland Natural Region since 1989. Currently, we have a membership of over 250 landowners, managing more than 64,000 hectares of native prairie and other wildlife habitats such as sagebrush communities, coulees, and cottonwood forests. Through our recruitment and partnership with landowners, our goal is to recognize good stewards for maintaining healthy native prairie that will help benefit the recovery of species at risk. Our program provides a variety of extension materials and on-the-ground stewardship initiatives to assist farmers and ranchers in achieving sound land management and sharing a common vision of a healthy environment and productive agricultural landscape.

OGC undertook a new initiative in the spring and summer of 2003 working with landowners to create management plans for their burrowing owl habitat. Since fewer members have been reporting nesting owl pairs over the years, we wanted to examine what habitat and management practices characterized landowners who still have breeding pairs. The goal was to assess what type of habitat was being used for nesting, offer positive feedback for compatible land management, as well as offer recommendations to improve existing or historical burrowing owl habitat. We also hoped to offer insight to those landowners who have not seen owls recently.

We began by contacting members who had reported burrowing owl activity in the 2002 and 2001 censuses. Twenty-five landowners participated in the Burrowing Owl Management Plans, and twenty-three were OGC members. In May 2003, 18 active nests were found, successfully fledging approximately 70 young. Many landowners helped search for pairs in areas where they suspected activity as well as areas used in the past. When a landowner was unable to accompany us, permission was obtained along with directions to the previous year's locations. Active nest sites were visited at least twice between May and August 2003, and a GPS location was taken of the burrows. At each visit, owl sightings, gender, age (adult or juvenile), and presence of pellets and prey remains were recorded. Information collected around the nest site or last year's burrow included land use (e.g., native or tame pasture), availability of roosts, distance to wetlands, distance to prey habitat, cattle grazing, timing and stocking rates, ground squirrel and badger activity, and availability of predator perches. Landowners were also queried on subjects such as land management, pest management, and grazing practices.

A report was created specific for each farmer/rancher (e.g., Burrowing Owl Management Plan: prepared for the Smith family). The title page included photos of their nest site(s) and owls where possible. The report was divided into 4 sections, ranging from 10 to 11 pages. Section I outlined the purpose of the project, illustrated the owls' shrinking range and declining numbers, and provided a brief summary of current research. Section II, "The Decline", attempted to address the many reasons for decreased numbers in Alberta. It listed causes such as increased number of predators, prey availability, low productivity, pesticides, rodent control, road kill, habitat loss, and the potential challenges faced on wintering grounds. Section III was called "Burrowing Owl Facts", reminding landowners how to identify a burrowing owl and providing an illustration of their annual life cycle as it applies to Alberta owls. The latter page was designed to be a calendar of events, outlining week by week what a typical pair and their young would experience if they started nesting in May. Section IV was the actual management plan, entitled "Your Burrowing Owl Habitat". In table format, this final section was broken into eight elements of habitat management, specifically, cattle grazing, wetlands, prey habitat, burrowing rodent activity, predator activity, grasshoppers and pesticides, cultivated lands, and human activity. Burrowing owl needs were presented adjacent to what the landowner's habitat provides and a set of management recommendations. Individual reports varied depending on the habitats where nests were found, adjacent land uses, and current landuse practices. The report was tied together with a complimentary air photo delineating various habitats available to owls, as well as roads, well sites, and other landscape features.

The reports serve as a reference tool for participating landowners, as well as a thank-you for their participation. Upon delivering the reports, many expressed their appreciation for the personal touch. This pilot project helped both the program and individual landowners identify good places to look for burrowing owls next year and offered positive feedback as to what management practices were working and why owls may be observed in some areas and not others. Our hope is to complete reports for additional landowners in 2004 and re-visit the 25 participants from 2003 to determine if owls returned to the management area.

WHEN A WORD LOSES MEANING: DEFINING WHAT IS AND IS NOT ENDANGERED SPECIES STEWARDSHIP

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Abstract: 'Stewardship' is a popular word in endangered species circles; however, there is a danger that the meaning of this word may be lost with liberal use. Since 1994, Saskatchewan Wetland Conservation Corporation (now part of the Saskatchewan Watershed Authority) has been delivering stewardship programming with agricultural producers on species such as piping plovers and burrowing owls. Landowners have readily adopted land management changes to benefit badly needed endangered species habitat. Such success has driven us to reflect on the essential features of a 'stewardship' approach to conservation.

Stewardship activities are those that mediate the tension between private rights to control over resources and responsibility to the public good that comes with these rights. For Saskatchewan Watershed Authority, this has meant demonstration projects, voluntary conservation agreements, workshops, and on-farm visits. With the necessary information and support, landowners can make responsible land management decisions that benefit both themselves and the environment. The success of this programming has depended on the conviction that stewardship hinges on the rights and actions of individual landowners.

INTRODUCTION

'Stewardship' is a popular word in endangered species circles; however, there is a danger that the meaning of this word may be lost with liberal use. Current usage of the word seems to be broad or have multiple meanings. If 'stewardship' is so inclusive as to simply mean 'conservation', then stewardship has little utility as a specific tool for endangered species recovery.

Since 1994, the Saskatchewan Wetland Conservation Corporation (now part of the Saskatchewan Watershed Authority, SWA) has been delivering stewardship programming with agricultural producers to conserve habitat for species at risk such as piping plovers and burrowing owls. Landowners have readily adopted land management changes to benefit endangered species habitat. Such success has driven us to reflect on the essential features of a 'stewardship' approach to conservation.

EXISTING DEFINITIONS

Both government and non-government agencies have proposed many working definitions of stewardship. A few examples are as follows:

Stewardship is defined as a land ethic where people care for our land, water, and air as parts of a natural system and in a way that enhances it for generations to come. (Environment Canada)

Stewardship refers to the wide range of voluntary actions that Canadians take to care for the environment. (Wildlife Habitat Canada)

Stewardship is voluntarily taking responsibility for the patch of land over which you as a landowner have some influence. (Ducks Unlimited Canada)

Stewardship is an ethic based upon individual and community values derived from an understanding of the need to protect, conserve, and restore ecosystems for current and future generations. Stewardship is not a technique – but a philosophy – that goes beyond legal obligations to encompass moral obligations of responsible care. (Department of Fisheries and Oceans Canada)

SWA has been engaged in stewardship programming for a decade through the Prairie Stewardship Program. This involves working with private landowners on a voluntary basis to participate in habitat conservation and make land management decisions that benefit habitat. A driving force behind this programming has been respect for private management of habitat. The purpose of this paper is to establish a basis for defining endangered species stewardship. Thus, we suggest a useful definition will exclude some activities, will pertain directly to actions that assist the recovery of endangered species, and will apply to an agricultural landscape where land is privately managed.

CHARACTERISTICS OF STEWARDSHIP

Based on existing agency definitions and the SWA experience, we would suggest that 'stewardship' can be defined by three main characteristics:

- Landowner activities – Stewardship is something that landowners do since they manage the habitat.
- Landowner control – Stewardship is voluntary. It is seldom confrontational.
- Self-interest – Because landowners have control over habitat, they have a strong self-interest in it as a resource.

The next logical question is what types of programming pertain to stewardship. That is, what programming addresses the needs of endangered species through a stewardship approach (landowner activities, landowner control, and self-interest)?

TESTING THE DEFINITION

The utility of our proposed definition can be tested by examining how it applies to a wide range of activities sometimes referred to as stewardship programming. While land purchase is a potentially important conservation/environmental activity, the central issue of stewardship is sidestepped. It eliminates the private interest by placing control of the land simply in the public sphere. Regulation can also be an important conservation tool. However, regulation again avoids finding a resolution to the private/public conflict. This does not exclude regulators from stewardship involvement; however, coercion violates private control and the voluntary component of stewardship. At times, habitat creation projects (e.g., stream restoration, wetland creation, tree planting) are labeled as stewardship. These activities are more appropriately identified as conservation, even if they do involve local volunteers. If a project does not involve private control or interests, then this project is not stewardship. Extension and technical help give landowners the tools, encouragement, and recognition to employ beneficial practices that help endangered species. This sort of activity would constitute stewardship programming since the potential conflict between the private and public interest is addressed. Finally, grant or incentive programs that help producers manage their operations in a more environmentally friendly way are obvious examples of activities that would meet our definition of stewardship programming.

PROBLEMS WITH THE DEFINITION

We are aware of three problems with this definition to date. First, it is unclear whether this definition addresses temporal aspects and responsibilities to future generations. Community pastures are also an important component of endangered species stewardship; however, this definition may exclude activities in such areas. Finally, this definition is necessarily tailored towards an agricultural context. Its usefulness in an industrial or suburban context is unclear.

SUMMARY

The goal of this paper was to present stewardship as a specific kind of endangered species conservation activity. Stewardship hinges on the rights and actions of individual landowners and avoids the pitfalls of regulation, land purchase, and confrontation. Many conservation activities are not stewardship because they fail to mediate the tension between public and private rights.

THE HABITAT STEWARDSHIP PROGRAM: SPECIES AT RISK RECOVERY THROUGH NATIVE PRAIRIE CONSERVATION

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Abstract: The Habitat Stewardship Program for Species at Risk (HSP) is a federal program established in 2000 to help Canadians protect species at risk and their habitats. As one of the three pillars under the National Strategy for the Protection of Species at Risk, the HSP fosters land and resource use practices that contribute to the recovery of COSEWIC-listed Endangered, Threatened, and Special Concern species, as well as prevent other species from becoming a conservation concern. The program also fosters partnerships among organizations interested in the recovery of species at risk and thus supports organizational and individual efforts in meeting the requirements of the National Recovery Program and the new *Species at Risk Act.*

The HSP focuses most of its Prairie and Northern Region resources towards priority landscapes within the Prairie Ecozone since the majority of COSEWIC-listed species at risk in the region rely on native prairie for at least a portion of their life cycle. As habitat loss is the primary factor for the decline of many prairie species at risk, and a significant proportion of remaining native prairie is in private hands, a stewardship approach to species at risk conservation in this ecozone is sensible. Through priority activities including habitat securement, enhancement, and restoration and landowner education, HSP-funded programs assist individual landowners and resource industries in managing their native prairie in an economically and environmentally sustainable manner. More importantly, these activities demonstrate to a larger audience the social, economic, and environmental value of native prairie conservation. The HSP also fosters cooperation among partners who can collaboratively deliver integrated species at risk programming at a landscape level.

This paper will summarize the government's overall strategy for protecting species at risk. It will then delve into greater detail concerning the HSP by highlighting program priorities and partnerships, by providing specific examples of past projects, and concluding with the larger vision of how the program is ultimately contributing to the greater goal of native prairie and biodiversity conservation.

NATIONAL STRATEGY FOR THE PROTECTION OF SPECIES AT RISK

Canada's National Strategy for the Protection of Species at Risk is a three-part strategy designed to cover species at risk recovery at all levels and within all jurisdictions. The first component is the *Accord for the Protection of Species at Risk*. Signed in 1996 by all 16 federal, provincial, and territorial wildlife ministers, the Accord recognizes a commitment to develop a national approach for the protection of species at risk through various means including complementary legislation, regulations, policies, and programs. Stewardship is specifically highlighted as an integral element within the Accord.

The second part of the Strategy is the *Species at Risk Act* (SARA) that passed into law in June of 2003 and which will be fully implemented on June 1, 2004, including those sections of the Act concerning the prohibitions. This is the federal government's commitment to complementary species at risk legislation by all jurisdictions and follows previously enacted provincial legislation. Again, stewardship is prominent throughout the Act and specifically highlighted as the primary means for protecting species at risk, particularly critical habitat.

The third element of the National Strategy is the Habitat Stewardship Program (HSP). Initiated in 2000, the overall goal of the program is to contribute to the recovery of Endangered, Threatened, and Special Concern species and to prevent other species from becoming a conservation concern by assisting stewards in implementing activities that protect and conserve species at risk and their habitats. The federal government approved $45 million over five years for the HSP, providing $5 million in the first year and $10 million thereafter. The Prairie and Northern Region of Environment Canada receives approximately $2.5 million annually. To date, the HSP has funded close to 90 projects throughout the Prairie Provinces, primarily in the Prairie Ecozone on private lands, provincial crown lands, Aboriginal lands, and in aquatic areas. The HSP cannot be used to fund projects on federal lands.

HSP PARTNERS AND PRIORITIES

Partnerships are the key to any stewardship program and the HSP is no exception. Partners to date have included private landowners, conservation organizations, industry, Aboriginal groups, universities as well as provincial governments and their agencies.

To ensure efficient use of limited resources, the HSP has developed a 'directed' program approach in which planning partners establish both national and regional priorities and then work in cooperation with implementation partners to develop specific projects which deliver on those priorities. The following priorities have been established for the program:

- projects which implement activities for species listed as Endangered or Threatened by the SARA or the Committee on the Status of Endangered Wildlife in Canada (COSEWIC),
- projects which deliver stewardship activities at a landscape level,
- projects which benefit multiple species,
- projects which implement activities listed in recovery strategies or action plans,
- integrated stewardship projects, and
- projects that have local and regional support from multiple partners.

With the SARA coming into full effect by June 1, 2004, two emerging priorities have also been identified for implementation where feasible. These include increased priority for projects that protect or secure important habitat for listed species at risk and for those projects that directly mitigate threats to species at risk and their residences in anticipation of the general prohibitions of the SARA.

In response to these priorities, the focus of the HSP to date has fallen primarily within the Prairie Ecozone. A multi-species landscape approach within the Prairie Ecozone is practical, as the majority of species at risk within Environment Canada's Prairie and Northern Region are located therein. Similarly, threats to species at risk are not point source, but rather broad scale, as are the threats to native prairie, and thus a native prairie landscape approach is warranted. The need to work primarily within the Prairie Ecozone becomes clearly evident if you overlay the range maps of COSEWIC-listed species at risk on a map of the Prairie Provinces. The areas with multiple species at risk correspond very closely with those areas that have the highest amount of remaining native prairie, such as the Frenchman River watershed or the Missouri Coteau in Saskatchewan, both HSP-priority areas in that province.

The large majority of the remaining native prairie in Manitoba, Saskatchewan, and Alberta is in private hands (e.g., approximately 85% in Saskatchewan). Given that habitat loss and degradation are the primary threats to species at risk on the prairies, a private landowner stewardship approach to species at risk recovery should be adopted. Private landowners clearly want to do the right thing, but often require assistance to implement stewardship activities that would otherwise be unaffordable. The HSP delivers both financial and technical assistance, and to date it has been very successful, primarily because of its win-win-win results in which species at risk benefit, landowners benefit, and native prairie is conserved.

HSP-FUNDED ACTIVITIES

A number of activities are eligible under the HSP to help achieve its overall goal of species at risk recovery and prevention. These include habitat securement and improvement; direct mitigation of threats to species at risk; program planning and development; outreach, education, extension, and technology transfer; and stewardship evaluation and monitoring. The next section of this paper will showcase three different HSP-supported activities from previously funded projects as examples of ways in which the program can support on-the-ground stewardship efforts for native prairie conservation.

Habitat Securement

The first of these activities is habitat securement, which is a significant component of the HSP and which is anticipated to play an increasingly important role as critical habitat designations and prohibitions against their destruction come into effect. This example involves the Prairie Ecozone Habitat Stewardship Project by the Manitoba Habitat Heritage Corporation (MHHC). When prioritizing landscapes and candidate sites for securement options, MHHC begins by acquiring numerous datasets and then evaluating those datasets against a number of criteria, such as the relative significance of the habitat to observed species at risk. (Other criteria used to evaluate candidate sites include threats to the habitat as well as the broader importance of the specific parcel to other landscape values such as connectivity.) GIS analysis is then used to determine the presence or proximity of COSEWIC or Manitoba endangered species observations in relation to the size and quality of a specific habitat parcel. The HSP has been instrumental in assisting in the acquisition of some of these key datasets used for prioritization.

The result of all this work is an effective and objective system for targeting and prioritizing potential species at risk habitat for protection. If a candidate site is chosen, the data in this decision support system are further used to develop the securement proposal for the property. This includes detailing the type of restrictions necessary to protect the significant features of the property while maintaining landuse activities that are consistent with the species at risk and habitat conservation goals. A very similar approach is also used in Saskatchewan and Alberta, most notably by the Nature Conservancy of Canada through their ecoregional planning exercises.

Habitat Improvement

Another significant HSP-funded activity is habitat improvement, which includes habitat restoration, enhancement, and land management planning. The Saskatchewan Prairie Habitat Stewardship Project by the Saskatchewan Watershed Authority provides an example of a project involving piping plover enhancement activities, which ultimately result in overall native prairie riparian and upland habitat improvements that benefit multiple species at risk.

The initial step in this project involves gathering key landscape information on habitat composition, land tenure and ownership, and level of habitat protection for piping plover basins identified as prime breeding locations by past piping plover surveys both within and outside the Missouri Coteau. This information is collected and used as a base reference for identifying unprotected areas within specific basins and targeting landowners and lessees for follow-up visits. During these one-on-one site visits, specific information is gathered through native prairie, riparian, and wildlife habitat assessments that identify threats and other negative as well as positive factors that might influence piping plover use and nesting success. The georeferenced information gathered during these visits is mapped onto air photos and used to develop basin-specific management plans that facilitate the establishment of enhancement projects.

The finished product is used by field staff to locate, prioritize, establish, and secure specific cooperative enhancement projects with landowners in a fashion which ensures that the highest priority sites within the landscape and within a basin are selected first for completion by the most appropriate agency. Annual updating of the site plans allows the recipient and the HSP to track progress over time.

Outreach and Education

The final HSP activity to be showcased involves outreach and education. The Saskatchewan Prairie Conservation Action Plan (PCAP) Stewardship Education project by the Saskatchewan Stock Growers Association is a highly successful youth and adult education program. The message presented to urban and rural students across southern Saskatchewan is “healthy native prairie and riparian areas are essential to all species”.

The youth education component has two parts. The first consists of the “Owls and Cows Tour”, an interactive educational program on native prairie and riparian stewardship and species at risk for grade three to six students. It combines the ever-popular “Cows, Fish, Cattle Dogs and Kids Game Show” on riparian health and conservation with the “Owls on Tour” program which uses a live burrowing owl to teach issues that affect this species and to highlight the importance of maintaining healthy native prairie. The second part involves the highly acclaimed “Eco-Extravaganza”, delivered in partnership with up to eight agricultural and conservation PCAP Partner groups. It offers daylong programming for kindergarten to grade six students. Teachers and students learn about native prairie and species at risk conservation and management through games, skits, and songs. Skits include the popular “Samson & Polonius: PI (Prairie Investigators)” by Grasslands National Park, a role-playing game in which Polonius the Prairie Dog and Samson the Sage Grouse help students search for clues to factors that affect species at risk and influence native prairie health. There is also the piping plover dress-up game in which students learn about piping plovers and their habitat and how to differentiate them from other species such as killdeers. Other games include “Biodiversity Bash” and burrowing owl skits and songs among others.

The success of these activities lies in the strong influence they have on future native prairie land managers (i.e., the students) as well as on the current managers (i.e., the parents) when students return home to discuss their day’s activities. The adult component of this project involves town-hall meetings that provide information to local landowners on PCAP partner stewardship programming available to them.

All of these various HSP-funded projects and related activities are each important components to species at risk conservation and recovery. However, the greater benefit becomes apparent when these projects are viewed at a larger scale across the entire Prairie Ecozone. Collectively, these activities are demonstrating to a larger audience the socio-economic and environmental value of native prairie conservation. Landowners and all Canadians are receiving and understanding the message of the importance of native prairie conservation.

CONCLUSION

The HSP acts as an important catalyst in fostering improved cooperation among species at risk partners and programs through the development of new, and strengthening of existing, partnerships. These partnerships support organizational and individual efforts in meeting the requirements of the National Strategy for the Protection of Species at Risk, including recovery programming and implementation of the new SARA. The result is the delivery of integrated species at risk programming at a larger landscape level across the entire Prairie Ecozone. The cooperation fostered through the HSP also results in strong linkages to prairie-wide programs and partnerships including the Agricultural Policy Framework and its development of Environmental Farm Plans and Beneficial Management Practices, some of which specifically address species at risk and native prairie conservation and provide the same messages to landowners. There are also important links to the North American Waterfowl Management Plan and the Prairie Habitat Joint Venture, the federal and provincial protected areas programs, the PCAP, the Nature Conservancy of Canada, and others. In conclusion, the HSP is an important part of the National Strategy for the Protection of Species at Risk. It enables prairie-wide species at risk stewardship programming that supports the priority stewardship components of the Accord and the SARA. Finally, the HSP, through its integrated programming, has been successful in demonstrating the socio-economic and environmental value of native prairie to a larger audience and is thus contributing to the broader goal of native prairie and biodiversity conservation, through which species at risk recovery and prevention are attained.

AGRICULTURAL INFLUENCES ON AMPHIBIAN POPULATION DEMOGRAPHICS IN PLAYA WETLANDS IN THE SOUTHERN HIGH PLAINS

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Abstract: Amphibian species are declining in many locations around the world, and these declines may serve as warnings of ecosystem imbalances. The Southern High Plains, a highly fragmented portion of the short-grass prairie, is home to several species of amphibians. These amphibians breed in playa wetlands, sites that serve as the primary water source for many wildlife species of the Southern High Plains. Playas surrounded by cropland often have reduced hydroperiods due to sedimentation. This can affect the species diversity and morphological development of amphibians, but information regarding amphibians that breed in playas is scarce. Because most playas are highly modified by agriculture, our main goal is to study the influence of land use (cropland and grassland) on the survival, population size, and population structure of the plains spadefoot *(Spea bombifrons)*, New Mexico spadefoot *(S. multiplicata)*, and the barred tiger salamander *(Ambystoma tigrinum mavortium)* in larval and terrestrial life stages. We selected 12 playas as study sites with 6 surrounded by cropland and 6 surrounded by native grass. We captured terrestrial forms of amphibians using the pitfall/drift fence technique and aquatic forms by seining and minnow trapping. During 2003, we marked amphibians by toe-clipping cohorts of metamorphs uniquely by date and location and by marking recaptures uniquely with elastomer fluorescent ink. Results from the first field season are currently under investigation.

NORTHERN PRAIRIE SKINK CONSERVATION: HABITAT AVAILABILITY AND ENVIRONMENTAL CHANGE IN SPRUCE WOODS PROVINCIAL PARK, MANITOBA

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Abstract: The northern prairie skink *(Eumeces septentrionalis septentrionalis)* is considered a vulnerable species in Manitoba, the only province where they occur in Canada. We characterized the habitat available to northern prairie skinks in Spruce Woods Provincial Park based on a number of biologically important habitat attributes, including the vegetation community, slope and aspect, and microclimate. We then tracked individual skinks to determine usage of available habitats, including microhabitats. Critical habitat attributes were determined using multivariate statistics. We found that, in addition to differing vegetation communities, the habitats available for use by northern prairie skinks within the Park vary widely in the types of microclimates provided. Our analysis suggests that skinks are restricted to areas consisting of native grasses and low-lying shrubs on well-drained slopes with high solar absorption. We then examine changes in habitat availability arising from landuse and management activities in the region. Based on current trends, the persistence of northern prairie skinks, as well as other rare and endemic species, in Spruce Woods Provincial Park is uncertain.

INTRODUCTION

Northern prairie skink *(Eumeces septentrionalis septentrionalis)* populations in Canada are remnants, disjunct from their continuous range to the south in Minnesota and North Dakota. The largest populations of northern prairie skinks are found in the Carberry Sandhills, while a much smaller population occurs in the Lauder Sandhills, 90 km to the southwest. These areas are characterized by loose sandy soils thought to be necessary for overwintering survival of northern prairie skinks in the area, as individuals must burrow below the frostline to survive the long and harsh Manitoba winters (Breckenridge 1943; Bredin 1989). During the active season, however, other habitat features may be important for activities such as feeding, mating, nesting, and dispersal. Ectotherms must be able to regulate body temperatures and maintain activity rates by choosing habitats that meet thermoregulatory needs or by modifying behaviour to move across thermally suitable habitats (Diaz 1997). Other ecological factors may also influence the choice of habitats and microhabitats by an animal, including predation pressure (Dealy et al. 1981; Seburn 1993; Diaz 1997; Downes and Shine 1998), food abundance (Breckenridge 1943; Diaz 1997; Pitt 2001), and social advantages (Downes and Shine 1998). Changing environmental conditions can affect these ecological factors and result in unsuitable habitat conditions for the persistence of northern prairie skink populations. For instance, conditions that alter prey abundance will force northern prairie skinks to either switch prey or move into new habitats, if possible.

Areas characterized by native mixed-grass prairie on south- and west-facing slopes with thermally suitable microclimates are hypothesized to be important for the presence of northern prairie skinks in Manitoba (Bredin 1993). However, the mixed-grass prairie landscape, especially within northern prairie skink habitat, is changing at an unprecedented pace. Less than 20% of the original native mixed-grass prairie now remains in Manitoba (Mixed Grass Prairie Stewardship Program 2001). This change is largely a result of aspen and other woody vegetation encroachment that has occurred in the absence of fire and grazing disturbances.

Long-term species viability may be threatened by the near complete loss of native mixed-grass prairie in the region. Despite the unique conservation challenges presented by this species, very little is known about the ecology and habitat requirements of northern prairie skinks. Studies to date have focused on general life history parameters and density estimates of northern prairie skink populations that occur within the continuous distribution of the species (Breckenridge 1943; Nelson 1963; Pitt 2001). With the exception of work by Bredin (1989), no formal studies have investigated Manitoba populations with respect to specific habitat requirements. Our study has important implications for the conservation of a species at the northern edge of its distribution and habitat range. It is difficult to plan effective conservation strategies for northern prairie skink populations in Manitoba because of their isolation and sensitivity to environmental disturbance; however, these populations are often “vital to the long-term survival and evolution of a species” (Seburn and Seburn 2000). The objective of our study was to determine how northern prairie skink abundance is associated with various habitat features in the region and speculate on how the changing landscape will affect the persistence of northern prairie skink populations in Spruce Woods Provincial Park.

METHODS

Study Area

Spruce Woods Provincial Park is located 60 km east of Brandon, Manitoba. The area is characterized by the concurrence of boreal forest, deciduous forest, and grassland biomes. Furthermore, the presence of open, active sand dunes and a gently undulating topography create a unique landscape in Manitoba. The soils are Stockton loamy sand and the area is well drained with the water table occurring close to the surface in some areas. We documented changes in the landscape of our study areas over time by examining a series of aerial photos beginning in 1948 and continuing through to 1994.

Field Methods and Analysis

Field sampling for this project took place from May to September of 2002 and 2003. Study sites were designated based on their accessibility and ability to adequately represent a range of habitat features. Each study site (n=6) was first stratified according to dominant vegetative cover (forest, shrub, grassland) and secondarily by aspect (north, east, south, west). Within each strata, untreated, spruce plywood boards (2 cm x 30 cm x 60 cm) were randomly laid out, marked, and mapped to sample for northern prairie skink presence. Each site was visited on a 10 to 14 day interval to check for the presence of northern prairie skinks. At the same time, these microclimates provided by each board (temperature above board, temperature below board, soil temperature, soil moisture) were measured and recorded, although this microclimate data will not be presented here. In addition to the presence of skinks, we recorded the abundance of potential prey items (grasshoppers, crickets, beetles, caterpillars, centipedes, spiders) as well as all other organisms (rodents, ants, green snakes) under the boards.

To characterize the vegetation community within each stratum, two 1 m x 1 m quadrats (vegetation under 1 m height) and two 5 m x 5 m quadrats (vegetation over 1 m height) were randomly sampled. Vegetation was categorized according to its functional form, as northern prairie skinks more likely respond to the physical characteristics of vegetation rather than the species. The functional form categories include coniferous tree, deciduous tree, tall shrubs (>1 m), low shrubs (<1 m), prostrate shrubs, tall forbs (>30 cm), low forbs (<30 cm), clonal grass/sedge, bunch grass/sedge, spreading grass/sedge, and lichen.

Other environmental variables including the depth of leaf litter, slope (in degrees), slope position, and aspect were collected in each stratum. Slope position was measured on a scale of 1 to 4, with 1 being the top of a slope and 4 being the foot of a slope. Heat load, an index of solar radiation based on slope, aspect, and latitude, was calculated following McCune and Keon (2002) to determine the relative amount of heat received by each stratum.

To examine the relationship between the vegetation communities and environmental variables of the strata, we used redundancy analysis (RDA, Legendre and Legendre 1998, pg 579) to constrain the functional forms by the depth of leaf litter, slope, slope position, aspect, and heat load of each stratum. The presence of northern prairie skinks within each stratum was then superimposed on the redundancy analysis triplot. The relationships among all potential prey items, predators, or competitors, including skinks found under the boards, were examined using correspondence analysis (Legendre and Legendre 1998, pg 451). For this analysis, we pooled the species abundance data within each stratum and then pooled strata across sites (pooled n=12) to improve data linearity.

RESULTS

Examination of the time-series aerial photos in Figure 1 demonstrated increasing cover of woody vegetation over open sand dunes and grasslands, predominately by shrubs such as *Juniperus* spp. This is particularly apparent in the lower left-hand corner of the photos where areas of open sand in 1948 are heavily colonized by 1980. Areas where trees were present early in the time series have become more densely packed and increased in patch size.

a)

b)

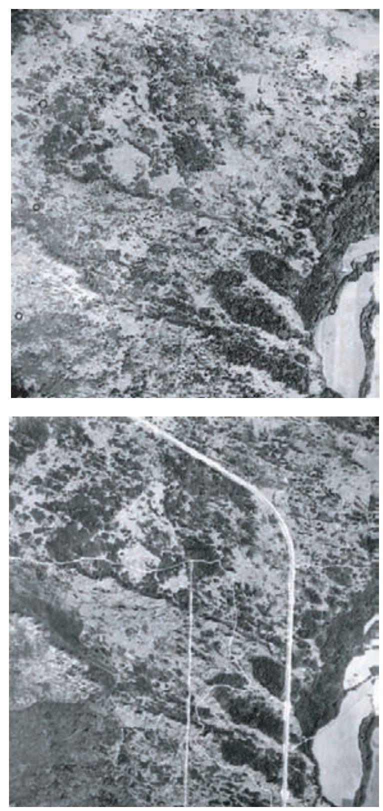

Figure 1. Aerial photos of a representative study area in a) 1948 and b) 1980. Note the increasing patch size of treed areas and increased colonization of open sand and grassland areas to woody vegetation.

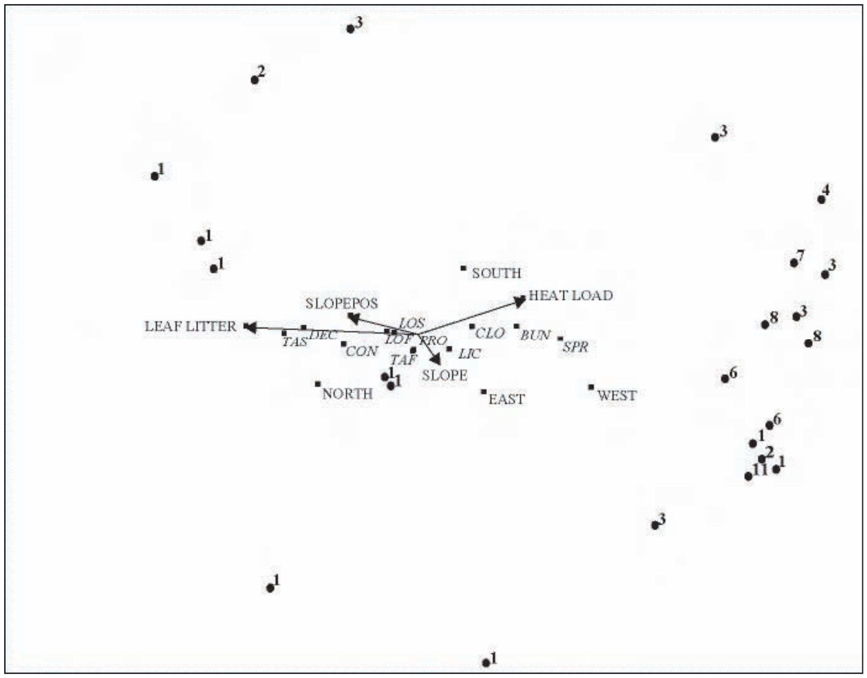

Figure 2. Redundancy analysis ordination triplot of functional forms of 2002 vegetation data constrained by environmental data. Canonical correlations are 0.747 for axis 1, 0.414 for axis 2. Redundancy is 31.4%. Functional forms are as follows: Spr=spreading grasses, Bun=bunch grass, Clo=clonal grasses, Lic=lichen, Taf=tall forbs, Pro=prostrate shrubs, Los=low shrubs, Lof=low forbs, Con=coniferous trees, Dec=deciduous trees, Tas=tall shrubs. Northern prairie skink presence from 2002 and 2003 is superimposed on the strata in which they were found.

RDA was able to capture 31.4% of the variation in our data (Figure 2). A total of 131 different vegetation species were categorized into 11 functional forms. It is apparent from Figure 2 that forest- and shrub-dominated areas are characterized by a higher leaf litter base, low heat loads, and are generally located at the foot of north-facing slopes, whereas grass strata have a higher heat load value and are located at the top of south- and west-facing slopes. The majority of northern prairie skinks were associated with grass-dominated, west-facing aspects of higher heat loads. A handful of northern prairie skinks were also found on shrub-dominated slopes with low heat loads and high leaf litter.

The correspondence analysis showed a strong trend along the first axis, accounting for 60.59% of the variation in the data (Figure 3). The presence of ants trended the most with Axis 1 and centipedes with Axis 2. Overall, ants and spiders are grouped (Group 1); grasshoppers, caterpillars, and centipedes form a separate group (Group 2); and a third group (Group 3) is formed by skinks, green snakes *(Opheodrys vernalis)*, and crickets. Organisms that did not group are beetles and rodents. Group 1 is associated with forested areas, regardless of slope and east-facing shrub strata. Group 2 is associated with west- and north-facing shrubby areas and north-facing grass-covered slopes. Group 3 is associated with south-, west-, and east-facing grass-dominated slopes.

DISCUSSION

Woody vegetation and forest patches are becoming more dominant as the characteristic vegetation across the landscape of Spruce Woods Provincial Park. Open sand is colonized by pioneer shrub species, such as *Juniperus* spp., and eventually the areas become forested. In general, northern prairie skinks inhabiting Spruce Woods Provincial Park were found in habitats dominated by native grass vegetation on south- and west-facing aspects, which have high values of heat absorbance and low leaf litter. However, we also found northern prairie skinks on north-facing aspects dominated by shrubs, low heat loads, and high leaf litter. These findings are a departure from what would be considered 'typical' northern prairie skink habitat in Manitoba. In Manitoba, northern prairie skinks have historically been associated with native, mixed-grass prairies on south- and west-facing aspects (Bredin 1989). It is possible that individuals were attracted to shrub-dominated areas by the coverboards and the microhabitats they provide; however, because the boards were placed at least two meters from a strata edge, the skinks likely did not travel such a distance across unfavourable habitat in search of a board. Therefore, it is more likely that individuals were not previously found in these habitats because of a lack of intensive sampling in these areas compared to grasslands.

For small ectotherms, the choice of habitat and

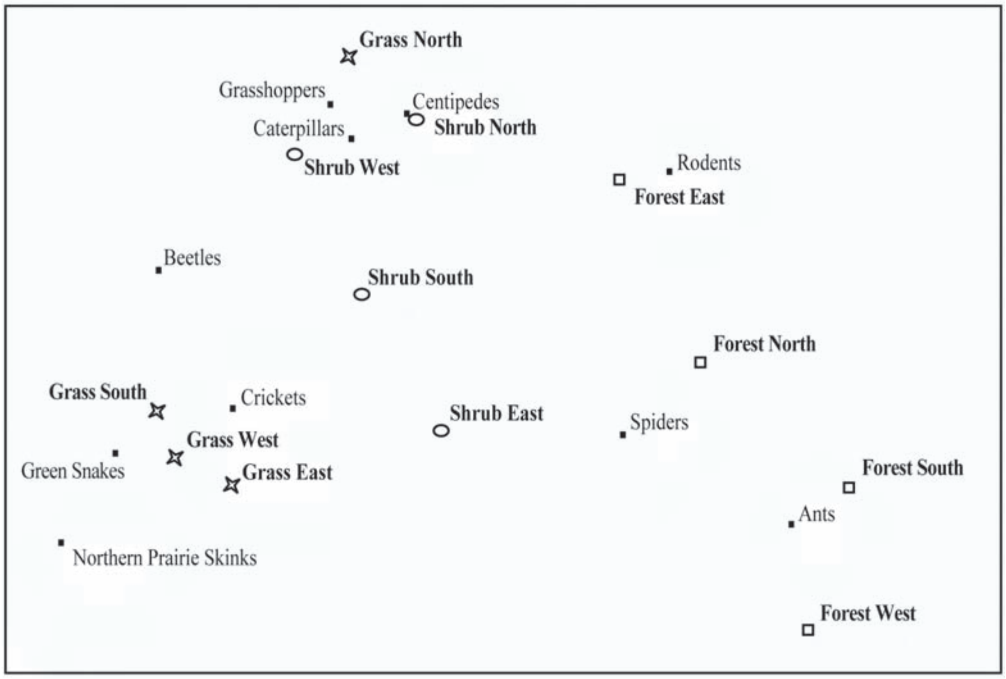

Figure 3. Correspondence analysis biplot of the relationships between organisms found under the boards in the sites, pooled by strata. Axis 1 accounts for the greatest amount of variation (60.59%).

movement within and between habitats is a reflection of the interplay between a number of conflicting factors, including predation pressure, food availability, social advantages and, most importantly, thermal needs (Huey 1982; Diaz 1997; Downes and Shine 1998; Pitt 2001). In Spruce Woods Provincial Park, these types of habitats are associated with south- and west-facing slopes, whereas north- and east-facing slopes are covered with trees such as trembling aspen, bur oak, and white spruce. Lizards thermoregulate between lower and upper threshold temperatures rather than around a single body temperature (Barber and Crawford 1977), and generally lizards tend to select body temperatures located near the upper critical temperature (Huey 1982). Skinks in northern climates, in particular, may rely heavily on solar radiation to increase body temperatures to the upper critical limit and subsequently maintain activity rates. Hecnar (1991) found that five-lined skinks *(Eumeces fasciatus)* primarily use open habitats because they provide more opportunities for basking. Diaz (1997) hypothesized that the population density of *Psammodromus algirus*, a temperate lizard, should be proportional to the thermal quality of a habitat if differences in availability of thermally suitable microhabitats were the primary determinant of overall habitat quality. In this study, it appears that the shrub stratum, particularly prostrate shrubs, and the grass stratum dominated by spreading and bunch grasses allow northern prairie skinks to maintain a high body temperature and therefore provide a higher quality habitat than, for instance, areas dominated by tree cover. The shrub and grass strata also provide circumstances under which skinks are able to modify their behaviour in times of thermal stress. Prostrate shrubs and spreading and bunch grasses provide shade at the bases of the plants under spreading branches and surface litter created from dead vegetation. Therefore, skinks can quite easily shuttle across thermal gradients in habitats of prostrate shrubs and grasses because of their growth forms and proximity to open areas. Additionally, because it is easier for an animal to compensate for high temperatures by moving into shade rather than compensating for low temperatures (Diaz 1997), we would not expect to find skinks in forested areas. Seburn (1993) suggests that basking under the cover of thin planks in sunny locations allow five-lined skinks to raise their body temperatures without the risk of predation. Fitch and Von Achen (1977) found *Scincella laterale* used the surface litter of dead grass for concealment. Therefore, in order to raise body temperatures under cover, the cover objects must receive and conduct a high amount of heat. The diffusion of heat in grass strata with high heat loads may be great enough that skinks are able to thermoregulate while also avoiding predators.

Although northern prairie skinks must be able to maintain high body temperatures throughout the active season, other ecological factors will also influence the choice of habitats. The main predators of northern prairie skinks in the area are the plains hognose snake *(Heterodon nasicus nasicus)*, a variety of hawks, striped ground squirrels *(Citellus [=Spermophilus] tridecemlineatus)*, raccoons *(Procyon lotor)*, and meadow voles *(Microtus minor [M. ochrogaster])* (Bredin 1989). Although northern prairie skinks may experience higher predation risk in the grasslands, especially from aerial predators, skink density remained (relatively) high. Diaz (1997) found that food availability and predation pressure might have a greater impact than thermal benefits on the overall quality of a habitat for *P. algirus*. Similarly, Downes and Shine (1998) found that although *Oedura lesueurii* preferred artificial retreat sites that mimicked the thermal properties of natural rock in full sun, the avoidance of predators was a higher priority than thermoregulation, which may account for some of the individuals found in shrub strata in our study. Crickets form a large proportion of northern prairie skink diets (Breckenridge 1943; Nelson 1963; Bredin 1989). Pitt (2001) found that the density of prairie skinks in Minnesota was significantly correlated with arthropod density and that the high arthropod density is the most likely factor explaining the high prairie skink density in old fields. Likewise, we found that northern prairie skinks in southwestern Manitoba were present in areas also occupied by high abundance of crickets, beetles, and, to a lesser extent, grasshoppers. Contrary to other studies, however, we found that northern prairie skinks and arachnids were not associated with similar habitats. In addition to thermal benefits, areas dominated by native mixed-grass prairie vegetation also provide an optimal prey base for skinks.

This study has important implications for the conservation of northern prairie skinks in Spruce Woods Provincial Park. The presence of northern prairie skinks was correlated with what would be considered typical habitat types, specifically native mixed-grass prairies with high heat absorbency. However, we also found skinks present in atypical habitats, including north-facing slopes and areas dominated by shrub vegetation with high amounts of leaf litter and low heat values. Northern prairie skinks appear to be responding to the microclimates provided by the physical structure of the vegetation and the prey base provided by grassland vegetation. Although the relative influence of factors that affect habitat selection cannot be discerned in this study, the grass and shrub vegetated areas appear to provide a greater combination of benefits than risks for northern prairie skinks. The widespread encroachment of woody vegetation in the Park over time is therefore reducing the amount of thermally suitable habitat and food available to northern prairie skinks. Eventually these aspen forests could eliminate northern prairie skink habitat and lead to population declines within the Park. It is our recommendation that management should focus on reducing forest encroachment and creating a mosaic of habitats that are likely to be most beneficial to northern prairie skink populations in Spruce Woods Provincial Park.

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AMPHIBIAN SURVEYS IN THE MILK RIVER BASIN

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Abstract: The Milk River Basin Species at Risk Conservation Strategy is directed at identifying key management areas for species at risk at the landscape level. Amphibian surveys were completed as part of the inventory phase of the project. There has been little interest in the plains spadefoot *(Spea bombifrons)* and great plains toad *(Bufo cognatus)*, likely because of their sporadic appearance on the landscape. Historically, only 10 great plains toad sites and 45 plains spadefoot sites had been recorded within the Milk River Basin. Thus we adapted amphibian call surveys to determine range and abundance of both species within the study area. In 2002, a total of 253 plains spadefoot sites were identified, extending their historical range 50 km to the west. There were 21 great plains toad sites identified; however, all observations of this species remained clustered in the southeastern corner of the province despite the increased number of sites found. Native prairie class, soil type, soil texture, and ephemeral pond characteristics were examined at sites where the two species were found. Plains spadefoot were found to select moderately coarse soils and Class 1 (>75%) native prairie vegetation. The great plains toad sample was too small for adequate analysis of the variables; however, they were generally found in ponds one meter deep with little aquatic vegetation and good water clarity. The data collected during these surveys serve as baseline data and should be repeated in three to five years to confirm recruitment for both species.

INTRODUCTION

Great plains toads *(Bufo cognatus)* are explosive spring breeders, and breeding activities are strongly associated with rainfall (Bragg and Smith 1943; Krupa 1994). Great plains toads primarily occur throughout the grasslands of central North America (Krupa 1990). In Alberta, great plains toads are found in the dry mixed grass of the southeastern corner of the province (James 1998). Wershler and Smith (1992) identified the following six general population areas in Alberta: Empress/Bindloss, South Saskatchewan River/Hilda, Medicine Hat, Lost River/Milk River, Lake Newell/Little Rolling Hills, and Hays/Purple Springs. James (1998) notes that additional populations have been recorded in and near the Canadian Forces Base Suffield. Typical breeding habitat for great plains toads in Alberta is shallow ponds with relatively fresh, clear water in sandy soil (Wershler and Smith 1992).

The plains spadefoot *(Spea bombifrons)* is a plump toad with short limbs and a pronounced spade-shaped tubercle on the inner surface of the hind feet (Seburn 1993). They also undergo explosive breeding in the spring following heavy precipitation events (Lauzon 1999). Lauzon (1999) noted single plains spadefoot could be heard calling from 1 km away and a large chorus could be heard from distances greater than 2 km. Plains spadefoot have been strongly correlated with sandy soils in Alberta (Lauzon 1999). Lauzon (1999) noted that plains spadefoot in Alberta were found in wetlands 15 to 40 cm deep. Areas identified as plains spadefoot breeding habitat are sloughs with little vegetation, marshy depressions, flooded cultivated fields, temporary wetlands in pastures, river backwaters, and ditches (Klassen 1998). Plains spadefoot also breed in the shallow water of vernal pools on uplands and along streams, semi-permanent ponds, oxbow lakes, and stream meander channels (Cottonwood Consultants 1986).

Limited data on the great plains toad and plains spadefoot within the Milk River Basin resulted in a need to conduct surveys on these two May Be At Risk species (Alberta Sustainable Resource Development 2001). Both species had rarely been found in the Milk River Basin, particularly in the three years prior to the project. Drought was believed to be the main factor behind their apparent absence. The objectives of this study were to determine the distribution and the habitat characteristics of the great plains toad and plains spadefoot throughout the Milk River Basin. This work was carried out as part of MULTISAR: The Milk River Basin Project.

METHODS

Survey Protocol

Sites previously identified as containing amphibians were identified using the Biodiversity/Species Observations Database, Alberta Natural Heritage Information Centre, and the Lethbridge Area Critical Wildlife Database. Aerial photographs of the basin were also examined in order to identify other potential sites for great plains toads and plains spadefoot. All surveys were conducted within the Milk River Basin, which runs from the historical town of Whiskey Gap east to the Saskatchewan border and north from the United States/Canada border to Cypress Hills (Taylor and Downey 2003). The majority of transects surveyed were within the eastern half of the basin.

Transects were established along roadways to cover as much of the basin as possible. Roadside surveys involved a five-minute call survey at least every 800 m along the variable length transects. The number of stops per transect varied based on the amount of potential habitat (i.e., ephemeral or permanent wetlands within 400 m of the road). The five-minute survey included a two-minute waiting period to offset effects of disturbance followed by the three-minute listening period. During this period, the observer recorded the air temperature, weather, moonlight, time, date, wind speed, species calling, relative abundance, and general direction of call.

The surveys were conducted from May 26 until June 26, 2002 from 30 minutes after sunset until 3:00 a.m. One survey was attempted prior to this start date; however, due to the lack of moisture, no amphibians were detected. If great plains toads and plains spadefoot were still active, a given survey was continued until 4:00 a.m. As suggested by Kendell (2002), surveys were conducted when wind speeds were lower than Level 3 on the Beaufort wind scale (gentle breeze, leaves and small twigs in constant motion), when there was light or no rain, and when temperatures were close to the average for the season (i.e., above 10°C).

Analysis

The native prairie classifications used in this study were consistent with the Native Prairie Vegetation Baseline Inventory developed by Alberta Environment (Prairie Conservation Forum 2000). Data from the native prairie vegetation database were analyzed in ArcView 3.2 and divided into 5 classes ranging from greater than 75% native prairie coverage (Class 1) to 0% native prairie coverage (Class 5). Native prairie data from each plains spadefoot site were analyzed using the utilization-availability method described by Neu et al. (1974) at the 95% confidence level. Only sites falling within the drainage boundaries were used in the analyses.

RESULTS

During the summer of 2002, the Milk River Basin was subject to precipitation levels that were approximately 80-100% higher than the 30-yr average for the area (Alberta Environment 2002). Between May 22 and June 10, 2002 approximately 236.1 mm of precipitation fell in the area, with the majority falling in one large event between June 8 and 10 (approximately 173.2 mm). Both great plains toads and plains spadefoot began calling shortly after these major precipitation events.

A total of 529 stops were surveyed across the basin. Great plains toads were present at 19 stops. General habitat conditions at the breeding sites were ephemeral ponds with clear water, approximately one metre deep with little aquatic vegetation. Toads were observed calling from clumps of terrestrial grasses and sedges emerging from the water. Plains spadefoot were found at 192 stops. General habitat conditions at the breeding sites were ephemeral ponds approximately 50 cm deep with little to no aquatic vegetation. Water clarity was variable, with plains spadefoot found in tea-colored, clay-colored, and clear water. Plains spadefoot were associated with habitat comprised of more than 75% native prairie (Class 1) and were rarely found in areas of Class 5 habitat, which contained no native prairie (χ^2 = 12.4, p=0.015).

DISCUSSION

General

Roadside surveys were an effective tool for assessing the distribution of the great plains toad and plains spadefoot in the Milk River Basin. They allowed for extensive coverage of the basin in a relatively short period of time. When weather conditions were agreeable, low numbers of great plains toads could be heard 800 m to 1.6 km away, and large choruses of plains spadefoot were usually heard 800 m away. Roadside call surveys may not be as effective in areas with greater densities of farmyards or oil and gas development due to the increased noise, which may reduce detection of calling amphibians. Another noteworthy aspect of the call surveys was the temporal delay between the emergence and subsequent calling of plains spadefoot and great plains toads. Plains spadefoot were heard calling after the first precipitation event, indicating the species may require smaller amounts of moisture to begin breeding activity than the great plains toads. The great plains toads were not detected until after the large June 8-10 precipitation event. This species may require significantly larger precipitation events to begin breeding activities.

Great Plains Toad

The number of great plains toad sites was increased over the number previously known, with additional sightings north of Wildhorse. Although new sites were found, the majority of the sites only had 1-5 toads calling. Great plains toads could be heard over the chorus of many plains spadefoot. The range of great plains toads in the Milk River Basin is still restricted to an area east of Lost River.

Plains Spadefoot

As a result of these surveys, the known distribution of plains spadefoot was extended 50 km west from Writing-on-Stone Provincial Park and east to the Saskatchewan border. Spadefoot presence was identified at previous gaps in their range, and historic sites were reconfirmed. The increase of plains spadefoot sites demonstrates the hardiness and opportunistic qualities of this species found in habitats ranging from ephemeral ponds in native prairie to ditches adjacent to cultivated fields. Even though plains spadefoot breeding ponds were widely dispersed, the only sites with complete development of tadpoles were the ephemeral ponds within high quality native prairie. Ditches and other poor quality sites (i.e., sites adjacent to cultivation) failed to retain enough water for complete metamorphosis to occur.

FUTURE MANAGEMENT AND RECOMMENDATIONS

To maintain these amphibian populations within the Milk River Basin, the following measures are recommended:

- continue monitoring of plains spadefoot and great plains toads sites, and
- create and distribute information in the form of pamphlets, posters, and tapes to residents in the Milk River Basin to create an awareness of amphibians and their habitat requirements.

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SWIFT FOXES ARE SWIFT ENOUGH: REINTRODUCTION TECHNIQUES, SUCCESSES, AND CHALLENGES OF CANADA'S MOST ENDANGERED CARNIVORE

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Abstract: Habitat loss, fragmentation, and degradation continue to impact imperilled swift fox populations. Since 1983, a reintroduction program has been underway to restore Canadian populations of swift foxes, which were extirpated in the 1930s. Over a span of 3.5 years, we compared the movement rates, survival, and reproductive success of 48 wild-born, resident swift foxes in Alberta and Saskatchewan to those of 29 translocated individuals from Wyoming. High survival rates and successful reproduction indicated that translocation can be an effective reintroduction tool for this species. Radio-telemetry showed that survival and reproductive success were highest for foxes with small dispersal distances, suggesting that animals should be acclimated to release sites. Survival rates were higher for translocated males than females and similar between age classes. Using juveniles for translocation may subsequently minimize impacts on source populations while female-biased releases could lead to equal sex ratios at the release site. While evaluating the effectiveness of such reintroduction techniques on a population level, we determined a significant increase in population number, distribution, and proportion of wild-born foxes in Canada and Montana over four years. The blend of integrated release technique evaluations, censusing approaches, and current GIS modelling illustrate the multiple layers that are crucial for species recovery on the prairies.

CONSERVATION OF NORTH AMERICAN PLAINS BISON: STATUS AND RECOMMENDATIONS

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Abstract: The plains bison *(Bos bison bison)* was the dominant keystone herbivore on much of the North American landscape, providing sustenance and materials for many of North America's original human residents and staple food for early explorers, fur traders, and European settlers. Political, economic, and environmental forces accompanying European colonization conspired to drive the species to near extinction by the close of the 19th century. Recovery efforts during the 20th century salvaged the species, and now there are over 500,000 bison scattered across North America in remnant and reintroduced herds. At least 95% of the existing bison population is under commercial production.

There is currently no unified conservation plan for bison in North America. The Bison Specialist Group of North America, operating under the auspices of the IUCN Species Survival Commission, required a status survey as the basis for developing a bison conservation strategy for North America. Through a process of iterative consultation with members of the Bison Specialist Group, dialogue with herd managers across North America, and compilation of relevant literature, I assessed the status of plains and wood bison herds managed by governments and conservation organizations. The survey addresses the taxonomic, numerical, geographic, demographic, habitat, genetic, disease, and legal status of bison.

Although the plains bison is no longer in imminent danger of extinction, there are threats to its persistence as a wild species, including habitat loss from agricultural development and other intensive land use, reduction in genetic diversity, hybridization, domestication through commercial bison production, disease, and inconsistent legislation and policies. Plains bison are not recognized on any international or national list for species at risk; however, my analysis suggests that wild plains bison are threatened numerically. Free-ranging, disease-free populations that are potentially influenced by predators, minimally handled, and within original plains bison range account for only 689 bison in three populations; none of these populations are considered viable by the current benchmark.

The focus of this paper is to summarize the status survey, with an emphasis on plains bison, and outline my recommendations for bison conservation actions. I also review current plains bison recovery initiatives and highlight how bison restoration can contribute to grassland conservation.

CONTEXT FOR BISON CONSERVATION

The bison *(Bos bison)* is the largest land mammal in North America and was once the dominant herbivore of the Great Plains, providing sustenance and materials for many of North America's original human residents and staple food for early explorers, fur traders, and European settlers. Prior to European settlement, there were likely over 30,000,000 bison on the continent. Political, economic, and environmental forces accompanying European colonization conspired to drive the species to near extinction by the close of the 19th century. Recovery efforts during the 20th century salvaged the species, and now in the 21st century, over 500,000 bison are scattered across North America in remnant and reintroduced herds with at least 95% of the bison population under commercial production. Although bison are no longer in imminent danger of extinction, there are threats to the persistence of bison as a wild species. The most evident pressures affecting bison include habitat loss from agricultural development and other intensive land use, reduction in genetic diversity, hybridization, domestication through commercial bison production, disease, and inconsistent legislation and policies. Diverse values underlie modern conservation of bison, including the intrinsic existence value of the species, the heritage and cultural value related to their historic importance to North American aboriginal people and European settlers, the value as a North American icon, and the value of the ecological functions bison provide within their natural habitat. Bison are often viewed as playing a keystone role in maintaining the grassland ecosystem, increasing biodiversity by creating a mosaic of vegetation and microclimates through differential grazing, urine deposition, trampling, tree rubbing, and wallowing.

The goal of bison conservation is to maintain the bison as a wild species in contrast to the domesticated state. Ideally, 'wild' bison would be non-domesticated, subject to evolutionary adaptation through natural selection, and normally reside in free-ranging, naturally regulated herds within original bison range. It is evident, however, that most herds are confined by fences or socio-political forces in habitats of varying sizes, sometimes outside of original range, and are subject to varying levels of management intervention by humans. Therefore, the realities of the developed landscape and existing human settlement limit opportunities for conserving bison under completely natural conditions.

PROJECT CONTEXT

This project was initiated by the Bison Specialist Group of North America (BSG), which is an assemblage of bison specialists that operate under the auspices of the Species Survival Commission (SSC), the largest of six commissions under the World Conservation Union (IUCN). The mission of the IUCN is to influence, encourage, and assist societies throughout the world to conserve the integrity and diversity of nature and to ensure that any use of natural resources is equitable and ecologically sustainable.

PURPOSE AND OBJECTIVES

There is currently no unified conservation plan for bison in North America. The purpose of this project was to assemble and synthesize information on North American bison conservation and management and to assist the BSG with setting priorities for bison conservation actions as part of an IUCN/SSC Conservation Status Survey and Action Plan document (Action Plan). The project had four objectives: (1) inventory the current status of North American bison conservation herds; (2) identify threats to bison conservation; (3) identify opportunities to improve bison conservation status; and (4) provide recommendations for development of a bison conservation Action Plan.

SCOPE

This status assessment includes bison herds managed by municipal, state, provincial, and federal governments, as well as several herds managed by private organizations with clear conservation objectives (e.g., The Nature Conservancy). Throughout this document, these target herds are referred to as 'conservation herds'. This status assessment does not include commercial bison herds or zoo populations. For the purposes of this survey, 'status' encompasses several factors with respect to conservation herds:

- Historical status: historical distribution and numbers; historical importance
- Taxonomic status: naming conventions and uncertainties
- Numerical status: number of herds; herd populations
- Geographic status: location; relation to original range
- Demographic status: sex ratio and age composition
- Habitat status: size and availability of habitat
- Ecological status: free-ranging or captive; level of human management
- Genetic status: genetic variability; degree of hybridization; genetic management
- Disease status: presence, prevalence, and impact of diseases
- Legal status and listings: classifications of vulnerability assigned by scientific listing organizations and under wildlife protection legislation; legal classification as livestock or wildlife

Through a process of iterative consultation with members of the BSG and other collaborators, dialogue with conservation herd managers across North America, and extensive compilation and review of relevant literature, this survey represents a current treatment of North American bison conservation status. The full assessment includes a review of the conservation status of plains bison *(Bos bison bison)* and wood bison *(Bos bison athabascae)*; this document summarizes the information only as it relates to plains bison.

BISON IN THE NORTH AMERICAN CONTEXT

Bison were rapidly reduced in abundance following European settlement. Commercial hunting by North American aboriginals and Euroamericans for meat and hides was the primary cause of the decline. Other contributing factors included subsistence hunting, indiscriminate slaughter for sport, and transection of the plains by railroads. Environmental factors such as regional drought, introduced bovine diseases, and competition from domestic livestock and domestic and wild horses may also have played a role. Additionally, the elimination of bison was viewed by Euroamericans as an efficient method to force the aboriginal population onto reserves and allow for continued western development. By the late 19th century, it was estimated that there were fewer than 1,000 bison in North America.

As the great herds of plains bison diminished there was some public outcry, but few laws were enacted to protect the bison. Early bison conservation efforts occurred through the establishment of refuges and the independent actions of private citizens, whose efforts to establish herds from the few remaining bison secured the foundation stock for most contemporary public and private plains bison herds. Their numbers increased considerably once plains bison were protected from hunting; by the early 1900s, the subspecies was considered safe from extinction. Initially sparked by reverence for the animal and nostalgia, motivations for bison recovery became increasingly driven by commercial value. By 1970, there were 30,000 plains bison in North America, with approximately half in conservation herds and half in private herds. Presently, 95% of the over 500,000 bison are under commercial production.

Various forms of bison have coexisted with human beings, providing sustenance and shaping human social and economic patterns. The bison is a North American icon immortalized as a symbol on currency and stamps, and institutionalized as a logo by school sports teams, government departments, and businesses. There are few animals that carry with them so much history, political significance, and cultural importance as bison.

TAXONOMY

An Historical Misnomer

The bison is not a buffalo. The term 'buffalo' has been used interchangeably with 'bison' since early explorers first discovered the North American species and has become entrenched as a colloquialism in North American culture and language. Although bison historians, ranchers, biologists, and managers are aware of the correct name, the term 'buffalo' persists as an accepted non-scientific convention for reasons of nostalgia and habit.

Genus: *Bos* vs. *Bison*

Since the genus *Bison* was assigned to the bison in 1827, taxonomists have debated whether bison are sufficiently distinct from cattle, guar, yak, and oxen to warrant a distinct genus. As molecular genetic and evolutionary evidence have emerged during the last two decades, scientists have used *Bos* with increasing frequency. Genetic analysis has revealed that the genus *Bos* is paraphyletic with respect to the genus *Bison*. *Bison* would need to be included in the *Bos* clade to correct this phylogenetic incongruity. Although there is an established history of public, policy, and scientific identification of this animal with the genus *Bison*, the original assignment of bison to its own genus appears to reflect morphological evidence rather than a phylogenetic scheme. In the absence of compelling scientific evidence beyond nostalgic, habitual, and morphological arguments to maintain the genus *Bison*, it appears that reverting bison to the genus *Bos* [Linnaeus 1758] will more accurately reflect evolutionary relationships and genetic similarities of bison and *Bos* species. This change would also provide continuity and stability to a species name that currently has two genera in common use.

Subspecies Debate

A controversial aspect of bison taxonomy is the legitimacy of the subspecies designations for plains bison *(Bos bison bison)* and wood bison *(Bos bison athabascae)*. Some taxonomists argue that differences in outward morphology and pelage characteristics alone do not adequately substantiate subspecies designation. Unlike the clinal variation among plains bison, a phenotypic discontinuity exists between plains bison and wood bison caused by differing habitat preferences and seasonal movements, and the natural barrier formed by the boreal forest. Hybridization between the subspecies in Wood Buffalo National Park after an introduction of plains bison during the 1920s complicates the subspecies designations; however, studies have determined that the hybridization did not result in a phenotypically homogeneous population. Evidence suggests that the morphological characteristics that distinguish plains and wood bison are genetically controlled and that wood bison are functioning as distinct genetic entities from plains bison.

While there appears to be sufficient grounds for formal recognition of the bison subspecies, the debate may continue. This, however, should not preclude conservation of the two forms as separate entities. Debating whether a name is warranted within a relatively arbitrary taxonomic system does not absolve us of the responsibility to recognize and maintain intraspecific diversity as the raw material for evolution.

POPULATION VIABILITY

Investigation into theoretical and empirical minimum viable populations (MVPs) for various species indicates that the MVP for bison may be between 100 and 1,000. The Canadian National Wood Bison Recovery Team inferred an MVP of 400 for bison. No other MVP estimates currently exist for bison.

NUMERICAL STATUS

Numerical status refers to the number of bison both within individual populations and in total in North America. There are currently over 500,000 bison in North America including both commercial and conservation populations. There are 50 plains bison conservation herds in North America within the scope of this survey. Of these herds, 32% have 50 or fewer bison, while 13 herds have populations greater than 400. Only 22% are currently increasing in size. The number of plains bison in conservation herds is estimated at 19,200, with 90% in the United States, 10% in Canada, and none in Mexico.

GEOGRAPHIC STATUS

Geographic status refers to the distribution of bison populations across North America and their locations with respect to the original range of each subspecies. Most plains bison conservation herds fall within original plains bison range. Eight herds residing in Arizona, California, northern British Columbia, and Alaska are distinctly outside plains bison range.

DEMOGRAPHIC STATUS

Demography refers to the factors that contribute to the growth or decline of a population, including natality, mortality, immigration, and emigration. Other than a brief overview of the male to female ratios for plains bison, this survey did not inventory specific demographic information. The adult sex ratio in some plains bison conservation herds is not managed; many other herds are managed but not necessarily for an even sex ratio. Thirty-four percent of plains bison conservation herds are maintained at 34-50% males, while 30% of herds fall between 10-33% males, and 18% are maintained at lower than 10% males. The lowest percentage of males maintained in a plains bison conservation herd is 6%. For captive herds, an even sex ratio may not be practical given the aggressive nature of older and rutting bulls. Managers may skew the male to female ratio by selectively culling bulls of all ages, leaving just enough males to facilitate reproduction in the herd. Some managers may increase the percentage of females to maximize calf production, a practice commonly employed by many commercial herd managers.

HABITAT STATUS

The bison is a land-intensive, nomadic species that once roamed over great distances on the North American landscape. Human population growth and development have led to the appropriation of extensive areas of land within original bison range for natural resource extraction, agriculture, ranching of both cattle and commercial bison, and urban and rural settlement. These competing land uses constrain the possibilities for preserving or restoring large tracts of habitat for bison recovery.

Current plains bison conservation herds are largely scattered and isolated across the original range of the subspecies, and occupy ranges of varying sizes. Thirty-eight percent of plains bison conservation herds reside on ranges smaller than 10 km^2 and 60% have ranges smaller than 100 km^2. There is no range expansion potential for 52% of plains bison conservation herds. Of those herds with expansion potential, only 11 are currently expanding by natural dispersal or through active expansion management plans. Plains bison herd managers cited several socio-political, ecological, logistical, and financial barriers to expansion.

ECOLOGICAL STATUS

Ecological status within this survey refers to the state of the relationship between a herd and the processes of natural regulation and selection. Captive herds account for 37 of 50 plains bison conservation herds. Captive herds are subject to various forms of management intervention. Population management in 95% of captive herds is achieved through culling followed by various methods of disposal. Thirteen of 50 plains bison conservation herds are free-ranging, accounting for approximately 8,337 bison. Two major free-ranging populations are chronically diseased. Two free-ranging herds reside on islands. All of the free-ranging herds reside on open range and are therefore not subject to forced rotation through pastures. Only one free-ranging herd is supplementally fed. Eleven herds are potentially subject to predation by bears, wolves, coyotes, and mountain lions. Only the two island populations are subject to regular whole herd round-ups. Hunting by humans is the primary mechanism for managing free-ranging herds; only two herds are not subject to hunting pressure.

Free-ranging, disease-free populations that are potentially influenced by predators and are within original plains bison range account for only 1,289 plains bison, or 6.7% of the total conservation population. Only three herds, or 689 bison, are not subject to regular handling; these herds have not attained the currently inferred MVP benchmark of 400.

The Pink Mountain herd of approximately 1,000 bison in northern BC and the Farewell Lake herd in Alaska of 400 bison are currently the only free-ranging herds of plains bison that meet or exceed the MVP, are brucellosis-free, are influenced by predators and other natural forces, and are not subject to management interventions by humans other than controlled hunting. Both of these herds, however, reside outside of original plains bison range, prompting the need to evaluate the importance of focusing conservation efforts only on bison within original range. Habitat constraints within original range may dictate that greater emphasis be placed on maintaining and establishing herds outside of their original range.

GENETIC DIVERSITY

Over the last two centuries, bison in North America have to varying degrees experienced the four interrelated mechanisms that can reduce genetic diversity: demographic bottlenecks, founder effects, genetic drift, and inbreeding. North American bison approached extinction in the late 1800s and experienced a severe demographic bottleneck, raising the concern that extant bison populations may have lower genetic diversity than pre-decline populations. Some authors speculate that prior to the bottleneck, the North American plains bison expressed surprising homogeneity despite its extensive range. Recent studies indicate that existing isolated populations are likely derived from one large gene pool; however, several bison herds are genetically distinguishable. This raises the issue of whether conservation herds should be managed as a large metapopulation, with translocation of bison among herds to maintain overall diversity, or managed as closed herds to preserve emerging localized diversity. A precautionary approach may be to diversify conservation efforts by transferring randomly selected animals among some herds to maximize intrapopulation genetic diversity while maintaining other herds as closed populations to preserve low frequency alleles.

Selection for diversity in one system, such as blood group proteins, or biased selection for maintaining specific rare genetic characteristics could lead to reduced diversity in other parts of the genome. Biased selection for maintaining rare alleles is especially questionable if it is not known what the rare allele does or if it is detrimental. Variation throughout the genome, rather than the maintenance of one specific rare allele, conveys evolutionary flexibility to a species. Therefore, it is crucial for a genetic management plan to consider all available measures of genetic diversity in the policies and procedures for breeding and culling decisions.

While the diversity for some herds has been assessed, the information has not been compiled, and there are many conservation herds for which no genetic information exists. An inventory of genetic diversity within conservation herds would assist managers with genetic management of bison and identifying localized diversity. Maintaining genetic diversity of North American bison also requires an understanding of herd population dynamics to assess the probability of persistence of that diversity. Normally, some individuals in a population fail to successfully contribute their genes to subsequent generations. The potential for disproportionate reproductive contributions emphasizes the importance of maintaining large herds, which accommodate mating by many males and reduce potential loss of genetic diversity.

HYBRIDIZATION

Hybridization, involving the interbreeding of individuals from genetically distinct populations, can compromise the genetic integrity of the individual populations and produce offspring that are devalued by the conservation and legal communities. The genetic legacy of introducing plains bison into a wood bison population and cross-breeding bison and cattle has made hybridization a controversial topic in bison conservation.

Plains Bison x Wood Bison

Evidence is mounting that plains bison and wood bison are geographically and genetically distinct populations (see Taxonomy); notwithstanding the ongoing debate over North American bison subspecies designations, hybridization between plains and wood bison should, therefore, be considered detrimental to maintaining the genetic integrity and distinctiveness of the two forms and the separation of their evolutionary paths.

Cattle x Bison

There have been many historical attempts to hybridize bison and cattle. Private ranchers involved with salvaging bison had aspirations to combine the hardiness and winter foraging ability of bison with the meat production traits of cattle. Historical cross-breeding attempts have created a legacy of genetic issues related to the introgression of cattle DNA into plains bison herds. Introgression refers to gene flow between populations caused by hybridization followed by backbreeding of the hybrid offspring to their respective parental populations. The introgressed DNA displaces sections of the original genome, thereby affecting the genetic integrity of a species and hampering the maintenance of genetic diversity. Many contemporary bison herds are founded on, and supplemented with, animals from herds with a history of hybridization.

Studies have revealed both mitochondrial DNA and nuclear DNA introgression in several plains bison conservation herds. Although only 14% of plains bison conservation herds currently demonstrate evidence of cattle DNA introgression, 68% of herds are untested. Plains bison herds with no evidence of hybrids comprise all five US national park herds, two of five US National Wildlife Refuge herds, the state-managed Henry Mountains herd in Utah, and the Elk Island National Park herd in Canada. These herds are important reservoirs of the plains bison genome, accounting for 7,984 bison or 42% of the plains bison conservation population. Currently, there is no means to determine if the presence of cattle genes in bison poses a threat to their fitness or productivity. Given that there are several substantial bison herds free of cattle DNA, it is possible to maintain these herds in reproductive isolation from herds containing hybrids until the prevalence and effects of cattle gene introgression are better understood.

DOMESTICATION

Approximately 95% of North American bison are under commercial production and, therefore, experiencing some degree of domestication. Domestication is an evolutionary process involving the genotypic adaptation of animals to the captive environment. Purposeful selection for traits favourable for human needs over several generations results in detectable differences in morphology, physiology, and behaviour between domestic species and their wild progenitors. The primary goal of many commercial bison ranchers is to increase profits by maximizing calf production, feed-to-meat conversion efficiency, and meat quality. This requires non-random selection for traits that serve this purpose, including conformation, docility, reduced agility, growth performance, and carcass composition. Selection for these traits reduces genetic variation and changes the character of the animal over time.

The goals of commercial bison production are generally not compatible with the conservation of the wild species. Further, commercial bison operations could pose a threat to conservation populations through a form of genetic pollution if genetically selected commercial animals are mixed into conservation herds or escape and join wild herds. The most prudent action is to identify and maintain existing conservation herds and avoid mixing commercially propagated stock into those herds. Bison producers and the bison industry could benefit in the long term by supporting efforts to restore and maintain conservation herds, particularly those subject to a full range of natural selection pressures. Conservation herds secure the bison genome for the future use of producers – an option not available for most other domestic animals.

GENETIC MANAGEMENT OF PLAINS BISON CONSERVATION HERDS

Genetic testing for some herds has typically been for a specific study and has not provided comprehensive genetic information. Approximately two-thirds of plains bison conservation herds have not been subject to any form of genetic testing. Consequently, management of the bison genome is impeded by the substantial lack of genetic inventory data for North American herds.

Most herd managers lack the information to create well-defined goals for genetic management plans, but they may employ some genetic management practices based on limited information. The most common management practice applied in conservation herds to maintain genetic diversity is augmentation (the addition of animals). Approximately half of plains bison conservation herds have received bison from various sources. The herds that do not receive new animals may not require additional genetic material or the herd managers may not want to risk introduction of animals that carry diseases, have hybrid ancestries, or have been influenced by domestication.

Many managers noted bull replacement as another method for maintaining genetic diversity and avoiding inbreeding in both open and closed herds. By culling previously dominant bulls, younger or recently introduced bulls have the opportunity to breed and contribute new genetic material. Several managers indicated that they select replacement bulls based on physical and behavioural traits, such as size, vigour, appearance, and aggressiveness. Therefore, even though these managers are not actively selecting which bull may mate, they make decisions that will influence the genome. Selective breeding for managing diversity is used in only one plains bison conservation herd. Only two herds are subject to purposeful selection for maintaining identified genetic characteristics.

Selective culling may alter the genetic composition of a herd. Only 12 plains bison conservation herds are not actively culled by the managing authorities. Of these, 11 are managed through human hunting, allowing hunters to exert some selection pressure. Thirty-eight herds are culled regularly, normally on an annual basis, using various criteria and practices. There is no standard culling method that would eliminate the risk of losing genetic diversity. Herd circumstances vary and many herds have not had a genetic assessment, making informed culling decisions difficult. Commercial producers often select for market traits by considering appearance, body conformation, and weight. Random culling or emulation of natural mortality patterns (e.g., mimicking natural predator choices) are preferable methods for conservation herds. Research is needed to develop appropriate culling practices and to evaluate how they impact the genetic composition of conservation herds.

DISEASE

The primary disease of concern for plains bison conservation is bovine brucellosis, which is a reportable disease in both the United States and Canada. Two of 50 plains bison conservation herds in North America have significant chronic disease issues: Yellowstone National Park (YNP) and the Jackson herd in Grand Teton National Park/National Elk Refuge (GTNP/NER). These herds, residing in the Greater Yellowstone Area (GYA), harbour brucellosis and account for 4,700 bison, or 24% of the North American plains bison conservation population.

Studies have determined that brucellosis is not a threat to the long-term survival of the YNP bison, but it affects herd management primarily because of the potential risk to the livestock industry. The purpose of the current management plan is to maintain a wild, free-ranging population of bison while protecting the economic viability of the livestock industry in Montana by addressing the risk of brucellosis transmission; it is not a brucellosis eradication plan. Although eradication of brucellosis from bison in the park is a future goal, such an effort is complicated by retransmission potential from GYA elk *(Cervus elaphus)* which also harbour the disease.

Similar to the YNP herd, the free-ranging nature of the Jackson herd allows for the possibility of transmitting brucellosis to domestic livestock in the area. There is currently no management plan in place for the Jackson bison herd. GTNP and the NER determined that a combined elk and bison management plan is needed to address the interconnected issues of the two species including winter feeding and disease management. Development of the plan is underway with completion expected in spring 2004.

LISTING AND LEGAL STATUS

Listing and legal status refers to classifications of vulnerability assigned to a species by scientific listing authorities and under wildlife protection legislation. Plains bison are currently not recognized at the subspecific level on any international or national list for species at risk. This survey, however, reveals trends demonstrating that plains bison warrant consideration for a listing. Only 3.6% of the total plains bison conservation population comprises free-ranging, disease-free populations that are potentially influenced by predators, not handled, and within original plains bison range; none of these populations has attained an MVP of 400. Therefore, there are few plains bison populations within original range that exist under natural conditions, and none are considered viable by the current benchmark. Conservation issues related to genetic diversity, hybridization, and domestication further support consideration of plains bison for listing.

There are potential complications that could accompany the process of listing plains bison. First, the presence of cattle DNA in plains bison herds may preclude listing under some legislation, such as the United *States Endangered Species Act*. Second, if all plains bison are considered, then the growing commercial population precludes any arguments for listing based on numerical status. Third, legislation supporting listings may prohibit commercial and captive propagation of a listed species; a situation that the current momentum of the bison industry would not allow. A distinction between wild and domesticated populations would be required under law to support protection of the wild form. Legal recognition of the wild form is impeded by the classification of bison as livestock by many state and provincial governments.

RECOVERY

Recovery of a species is achieved through population growth, augmentation, and reintroduction. Bison recovery should ideally involve the maintenance and establishment of free-ranging herds within their original range; captive herds subject to minimal human intervention may also support conservation goals. To maximize conservation value, these herds should occupy large geographic areas and be of sufficient size and demographic composition to maintain population viability. Management of several herds as metapopulations may be required to establish viable populations. The herds should also be subject to forces of natural selection, including predation, and effective genetic, disease, and range management, as well as be protected under law and free of the previous causes of extirpation.

The most fundamental limitation to bison recovery is lack of suitable habitat. The pressures of a developed landscape, a burgeoning commercial bison industry, and localized issues such as disease and absence of natural predators constrain the current possibilities for effective bison recovery. Identification and evaluation of potential recovery sites is needed for both plains and wood bison.

There are three potential Canadian plains bison recovery projects planned for Banff, Grasslands, and Waterton Lakes National Parks and one underway at the Nature Conservancy of Canada's Old-Man-On-His-Back Prairie Heritage and Conservation Area. Plans to reintroduce conservation bison populations in the United States are limited. Four suitable areas of public land in Montana have been identified for potential bison reintroductions; however, no further action has been taken by the Montana government. Some consideration has been given to bison reintroduction in parts of Wyoming and Utah as part of the Heart of the West Wildlands Network, developed primarily by the Wild Utah Project and the Biodiversity Conservation Alliance; however, no specific reintroduction plans have been developed. There are two landscape-level grassland restoration projects being planned that involve bison reintroduction, The Big Open and The Buffalo Commons' Million Acre Project.

The grasslands of the Great Plains comprise one of North America's most threatened ecosystems. Plains bison restoration has the potential to unite Great Plains residents, encourage a shift from cattle to bison grazing, and effectively support ecological and economic restoration of the grasslands. Although beyond the scope of this survey, there is also recovery potential through the process of repatriating bison to the lands of North American aboriginal people.

RECOMMENDATIONS FOR BISON CONSERVATION

The general recommendations relate to overriding issues of bison conservation in North America. The remaining recommendations are organized by status factor and are not prioritized.

General Recommendations

- Clarify the goals for North American bison conservation. This exercise should outline the characteristics of wild bison and address the relative roles of free-ranging and captive herds in supporting conservation goals. Develop a definition of free-ranging that moves beyond the construct of presence or absence of a fence. Determine the size of range and herd that would allow bison to effectively fulfill their ecological roles within a fenced area.
- Develop a communication strategy targeted at the general public and bison industry members to emphasize the wildlife conservation value of bison. This strategy should address differences between wild and domesticated bison.
- Develop a set of objective criteria to evaluate the priority of bison conservation projects that emerge from the Action Plan.
- Develop a process to evaluate the conservation value of bison herds. The goal of this evaluation process would be to identify bison herds, whether privately, publicly, or tribally owned, that should be included in conservation planning and their relative conservation value. This process could assist with prioritizing conservation actions.
- Identify herd-specific and ecological research needs to complement overarching conservation actions.

Taxonomy

- Maintain the use of 'buffalo' as a reference to North American bison whenever appropriate for historical or nostalgic reasons.
- Use the true common name 'bison' for all scientific and conservation purposes.
- Clarify the difference between buffalo and bison through interpretation and displays wherever bison-related education occurs.
- Discontinue using the genus *Bison*. Incorporate all species of bison into the genus *Bos* to best reflect the genetic and evolutionary relationships between bison and other bovids.
- Maintain the subspecies designations for both plains bison *(Bos bison bison)* and wood bison *(Bos bison athabascae)*.
- Conduct further DNA analyses to identify specific genetic differences between the subspecies.
- Evaluate the applicability of non-traditional taxonomic classifications such as the evolutionarily significant unit and the geminate evolutionary unit for elucidating a distinction between wood and plains bison.

Population Status and Management

- Monitor the numerical status of free-ranging herds to identify trends in population fluctuation.
- Establish population recovery goals for plains bison (e.g., how many free-ranging, disease-free, viable populations should there be?).
- Collect demographic data for conservation herds for which a population viability analysis is recommended.
- Evaluate strategies for managing several conservation herds as a metapopulation (i.e., a group of discrete populations treated as one herd).
- Identify areas of suitable habitat for both subspecies within their original ranges. Assess the potential of each area to allow for free-ranging herds and natural selection pressures. Identify areas of suitable habitat for plains bison outside of their original range.
- Evaluate the feasibility of replacing plains bison conservation herds within original wood bison range with wood bison herds. Consider the ramifications of herd replacement for plains bison conservation.

Genetics

- Inventory the genetic variation of all conservation herds. Evaluate strategies for preventing loss of genetic diversity in conservation herds.
- Identify herds best suited to provide stock for reintroductions.
- Conduct demographic studies to establish the genetically effective population size for all conservation herds.
- Test all conservation herds for the presence of mitochondrial and nuclear cattle DNA.
- Evaluate the conservation significance of cattle gene introgression into bison conservation herds and develop strategies for managing this issue.
- Investigate and minimize possibilities for hybridization between commercial and conservation bison and between wood and plains bison.
- Evaluate culling strategies used in conservation herds. Develop culling guidelines that align with genetic management goals.

Disease

- Identify existing disease management methods and protocols for captive and free-ranging wildlife. Inventory and evaluate the methods presently applied to bison conservation herds.
- Re-evaluate the conservation significance of brucellosis in the Greater Yellowstone Area.
- Support research on effective vaccines and vaccination methods for brucellosis in bison and elk.

Legal Status and Listings

- Conduct an IUCN Red List assessment for plains bison using the IUCN Red List Categories system.
- Evaluate the impact on wild bison recovery of classifying bison as domestic livestock under provincial and state legislation.
- Evaluate the legal barriers to protecting conservation herds that have hybridization histories (between subspecies and between bison and cattle).

Recovery

- Identify and prioritize potential locations for reintroducing plains bison.
- Refer to the IUCN/SSC Guidelines for Reintroductions when evaluating potential reintroduction projects.
- Consider specific reintroduction principles identified through previous experience with bison to avoid reintroduction failures. Develop a set of bison reintroduction guidelines to assist with future recovery projects.
- Consider the historical and cultural context for recovery efforts to assess the validity and appropriateness of a given action. This might include referring to historical documents and archaeological evidence to understand the conditions prior to the need for conservation efforts, including ecological factors, levels and season of bison presence, and interactions with North American aboriginal populations.
- Consider existing protocols for reducing disease risk associated with translocations and reintroductions.
- Ensure that bison stock used for reintroductions originates from sources of known genetic composition (i.e., no cattle DNA, genetically diverse, and non-domesticated).
- Assess the potential for human-bison conflicts and develop a risk mitigation plan for each reintroduction proposal. Consult with managers of existing herds on the frequency of human-bison conflicts and methods to minimize conflicts.
- Identify and evaluate strategies for cooperation with private landowners and North American aboriginal communities to facilitate bison recovery.

This document is based on information presented in a Master's degree dissertation entitled Conservation of North American Bison: Status and Recommendations by Delaney Burton (nee Boyd). Please refer to the full document for further information, figures and tables, a complete list of conservation recommendations, referencing, and brief profiles of the identified plains and wood bison conservation herds in North America.

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MODELING SAGE-GROUSE HABITAT IN ALBERTA: A LANDSCAPE APPROACH

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Abstract: Greater sage-grouse exist at the northern fringe of their range on the mixed-grass prairie of southeastern Alberta and southwestern Saskatchewan. Within the currently occupied habitat, the endangered Canadian greater sage-grouse population has declined by 66 to 92% over the last 30 years. Only 8 of 35 known mating grounds (leks) in this area are currently utilized. This paper presents resource selection function models at several spatial scales, developing probability maps to predict the occurrence of potentially unknown lek sites. We also present models identifying how changes in habitat and increases in human access may affect the viability of leks. Poor nest success and chick survival have been shown to limit population growth, and we present models identifying key nesting and brood rearing areas and how habitat could be improved to enhance productivity. Models presented include covariates drawn from recently created air photo-interpreted sagebrush maps, litter and forb biomass models generated from Landsat TM imagery, range ecosite classification maps, and a digital elevation model. Road developments and density of energy developments (well sites and pipelines) permit the assessment of the impact of human use features on lek activity. These models help identify habitat management needs for sage-grouse in Alberta and will form the bases of future management initiatives.

DOES AN ECOSYSTEM CHANGE CORRELATE WITH CHANGES IN A PRAIRIE RAPTOR COMMUNITY NEAR HANNA, ALBERTA?

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Abstract: Breeding densities in a raptor community in the prairie/parkland transition of southeastern Alberta have been monitored for 20 of the past 29 years. Ferruginous *(Buteo regalis)* and Swainson's hawks *(B. swainsoni)* have increased for a period but recently declined. Burrowing owls *(Athene cunicularia)* have declined and are locally extirpated. Red-tailed hawks *(B. jamaicensis)* have gradually but steadily increased.

Changes in the landscape and ecosystem that may correlate with these population changes include the following: expansion of parkland into open prairie habitat, changes in predator-prey interactions, changes in competition, changes in precipitation and range condition, an earlier arrival of spring, and an increase in vehicular traffic. No major changes in land use occurred during this time, apart from an expansion in a strip mining operation and associated coal-fired power generation. Logically, all these changes could be implicated in the observed raptor community change. The potential influences that may operate on migratory raptors outside of the study area are only partly known.

INTRODUCTION

Raptors, including burrowing owls, have been monitored for banding and population studies on a well-defined and completely searched study area near Hanna, Alberta. This work was initiated by Richard Fyfe and colleagues (e.g., Schmutz and Fyfe 1987; Schmutz et al. 1991). My own population monitoring began in 1975 and, except for some missing years, continues today. This 20-year dataset spanning 29 years is one of the longest known for these species (but see also Schmutz et al. 2001).

The purpose of this paper is to highlight population trend data for hawks and burrowing owls. Related changes that have occurred on the study area are briefly outlined, and some potential causal links are suggested. Evidence for these links is not presented in detail, but pertinent articles are suggested where possible.

STUDY AREA

Richard Fyfe and colleagues originally selected the study area because of the considerable densities of raptors nesting therein. This high nesting density may have been related to the area bridging two ecological communities, representing an ecotone between open mixed grass and aspen parkland ecoregions. Plants in the gently undulating landscape experience a severe moisture deficit, resulting from the ecological 'rain shadow' cast by the Rocky Mountains to the west. From 1979-89, the total annual precipitation was 27.2 cm, and the mean temperature was 5ºC (Strong and Leggat 1992).

Trees used by the hawks for nesting, including trembling aspen *(Populus tremuloides)* and willow (*Salix* spp.), have expanded southward since the control of prairie fires (Houston and Bechard 1983). Swainson's hawks are now nesting in trembling aspen that did not exist in the mid-1970s. The hawks also use introduced varieties planted for shade and windbreaks (e.g., *P. petrowskyana, Acer negundo, Caragana arborescens).*

METHODS

Starting in 1975, the boundaries of the study area were well defined using existing roads and fencelines. The size of the study area changed depending on the time available for surveys each year (Table 1). A smaller study area always coincided with the southern portion of the larger area, except in 1975 when the overlap was only 72%. Density calculations were adjusted accordingly (see Figure 1).

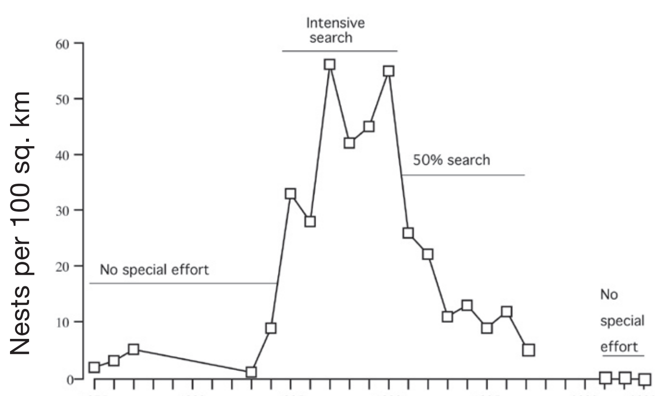

Figure 1. Numbers of nesting pairs of ferruginous, red-tailed and Swainson's hawks on a 326-km^2 portion of the study area near Hanna, Alberta.

Table 1. The timing of various raptor research activities in Alberta, including the size of the study area monitored at Hanna each year.

Year	75	76	77	78	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	01	02	03
Hanna area km²	335	480	480	100		326	480	480	480	480	480	480	480	480	480	480	480	480			326	326	326
Hawk Surveys	X	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X			X	X	X
Burrowing Owl Surveys									X	X	X	X	X	X	X	X	X	X	X	X			
Southeast AB Survey					X				X						X								

Nests were located by inspecting all trees and shrubs using a motorcycle for transportation. Searches were conducted in early to mid June and lasted for 10 to 15 days, with a small northern portion of the study area searched in early July. Unattended nests containing new nesting material were closely examined by climbing trees. For inclusion as a valid reproductive attempt, the nest base had to be complete, the cup lined, and the lining flattened as by a hawk's body during laying or incubation. Often new material had been added to nests, and they were sometimes even completed but not flattened. The presence of down feathers in the nest material was not a reliable indicator of laying or incubation. Nests in which young had died during the second half of the nestling period generally showed a trampled nest rim, droppings, and a nest cup filled with prey remains, pellets, and sprigs of herbaceous plants. Nests in which young hatched but died soon thereafter showed the original deep cup. Often tiny egg fragments from pipping eggs remained lightly buried in the base of the nest cup. Eggs abandoned before hatching were opened and the approximate stage of the arrested development recorded. In this way, a total breeding population count was achievable in this sparsely treed landscape. Pairs that did not proceed to at least laying were excluded.

Burrowing owls are difficult to monitor in the vast expanse of grassland habitat on the study area because their nests are difficult to find. No special effort was made to find owls in the early years of this study, but pairs were encountered as part of the hawk monitoring. In the mid 1980s, an intensive search was began by Dan and Gwen Wood, which included monitoring known nesting areas, opportunistically identifying owls in new nesting areas, and particularly asking landowners. In the 1990s, this effort was continued but concentrated within 100 km of the Hanna study area and with approximately a 50% effort in comparison to the intensive search period. Burrows were counted as nests if two owls resided at a burrow during what was judged as the incubation period.

RESULTS AND DISCUSSION

Hawk Breeding Densities

Changes in the population of breeding hawks are shown in Figure 1. For ferruginous hawks, four distinct periods can be identified: populations appeared stable in the mid 1970s to early 1980s, increased in 1986-90, returned to former levels, and finally declined. Swainson's hawks showed a similar pattern except the population rise started slightly earlier and was shorter. These trends likely reflect changes in ground squirrel abundance within the study area and, more broadly, within the region as discussed in Schmutz and Hungle (1989) and Schmutz et al. (2001). The influence of ground squirrel abundance on Swainson's hawk populations may have been slightly modified by vole availability (Schmutz et al. 2001).

Burrowing Owl Abundance

The number of burrowing owl nests recorded and the approximate effort devoted to finding these nests are shown in Figure 2. While the increase in number of owls simply reflects an increased searching effort, the decline is real. This local decline is corroborated by owl surveys using call-playback on repeated survey routes (Shyry et al. 2001). A repeat survey in 2003 yielded only one nest (G. Wagner, pers. comm.), and thus this local population can be considered essentially extirpated.

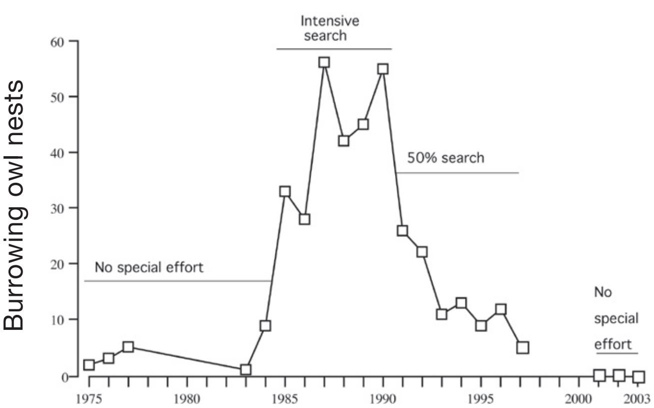

Figure 2. Number of pairs of burrowing owls in relation to searching effort near Hanna, Alberta.

Collisions with Vehicles

Owl deaths increased with number of vehicles on the roads and with speed of travel on the Great Plains (Houston and Schmutz 1997). There was an unspoken agreement among residents at Hanna during the early years of this study that one would refrain from traveling where possible on rainy days to protect gravel road surfaces. Many roads have been improved over the period of study, allowing faster travel at any time. With an increase in traffic in the area arising from the construction of the power generating station and increased oil and gas development, there was an apparent increase in road-related mortality. One operator of road grading equipment reported three burrowing owl and four Swainson's hawk deaths on a road maintenance route in 1988.

Aspen Parkland Expansion

Red-tailed hawks showed a gradual but nearly steady increase throughout the study period, and this is coincident with a habitat change. The red-tailed hawks' increase is not merely an increase in numbers, but also reflects a gradual expansion southward. In the 1970s, red-tailed hawks nested at low numbers in the northern part of the study area, and they were also more common northward into the core of the parkland (Schmutz et al. 1980). Throughout this study, red-tailed hawks gradually moved further south as did aspen trees. It was not until 2001 that red-tailed hawks occupied the very southern part of the study area. This range expansion likely reflects habitat that increasingly resembles parkland rather than the open mixed-grass communities of the past (see also Houston and Bechard 1983).

Predation in the Burrowing Owl's Annual Cycle

Clayton (1997) documented raptor predation on owls as a potentially significant factor in the long-term decline of owls. His telemetry data indicated that 55% of juvenile owls had died by the start of migration. This impending migration no doubt takes yet another toll on migration-naïve owls. In the grasslands at Hanna, predation was the largest mortality factor for owls; on the highly cultivated Regina Plain, vehicles and presumed starvation killed owls. Clayton and Schmutz (1999) attempted to place these factors in a larger ecosystem context. Accepting that the systemic changes affecting owls at Hanna and on the Regina plains prevail throughout the owl's annual cycle, the prognosis for this species is poor. Clayton and Schmutz (1999) suggest that the plight of the owl on the Great Plains serves as an example of what is yet to come for other species that inhabit and rely on the open plain, likely the region's most endangered habitat. In the case of owls, a species-level conservation approach is likely not a match for the system-level changes that apparently drive population declines.

Ferruginous and Swainson's Hawk Trends

Ferruginous and Swainson's hawks experienced substantial declines in breeding density at Hanna in the late 1990s and beyond. Breeding densities of Swainson's hawks recovered in 2003, apparently a good vole year, but the majority of nests failed. Thus, the population did not fully return to a 1970's level of productivity (Figure 1). Prey data from nests of Swainson's hawks suggest that ground squirrels had become either fewer in number or less vulnerable to predation by Swainson's hawks. A ground squirrel decline is corroborated by burrow count data from study plots monitored in the 1970s and again in 2001-03. In 1975, 66 apparently used burrows were counted on a transect 1 m wide and 3.6 km long extending over 6 study plots on the Bullpound community pasture. In 2001, 11 burrows were counted on a transect 2 m wide and 6.0 km long, extending over the same 6 study plots (J.K. Schmutz, unpubl. data). Based on casual observations of ground squirrels throughout the study area, a widespread decline had occurred, with only isolated pockets matching former squirrel abundances.

In addition to the Hanna study area, 20 artificial nests were attached to electricity transmission towers in 1987 and monitored for 12 years starting in 1988. The structures were distributed over 30 km in a line extending from the Hanna area boundary southward. On this extended study area, ferruginous hawks did not show the decline (J.K. Schmutz, unpubl. data) evident on the Hanna area (Figure 1). The number of pairs ranged from 4-12 nests per year, with a total of 105 occupied nests. This suggests that the decline observed at Hanna may reflect local conditions as much or more than a regional trend. The two areas also differed in soil landscapes, with most of the Hanna area being on the slightly more productive dark brown solonetzic soils and the artificial nests located on brown solonetzic soils. In the latter, grasses tended to be shorter and the plant community less vigorous which may favour Richardson's ground squirrels.

On the Bullpound community pasture, grazing pressure had been reduced during the study period to account for a drought and other changes in grazing intensity. As a result, range condition improved (Lorne Cole, pers. comm.). Interestingly, ground squirrel density apparently declined coincident with an increase in range condition. This could conceivably call into question an often-implied assumption that improving the health of the plant community, and thus range productivity and sustainability, also enhances biodiversity.

In addition to ground squirrel and range condition changes, interspecific competition may have affected changes in hawk density on the Hanna area. Competition for space was evident in these species (Schmutz et al. 1980), and the increase in red-tailed hawks could have affected ferruginous hawks adversely.

Climate Change

Several scenarios have been postulated for mechanisms whereby climate change can negatively impact birds (e.g., Thomas et al. 2004). Hanna data from 1975-2001 plotted against an El Niño/Southern Oscillation index suggest that climate change is affecting the breeding phenology of ferruginous and Swainson's hawks. Ferruginous hawks have advanced their hatching dates over this period, while Swainson's hawks have delayed theirs. These changes are consistent with other research on climate change indicating mistimed reproduction. The impact of this change and its potential mechanism through food chain effects needs yet to be corroborated (Schmutz and Maingon 2002).

SYNTHESIS

The results presented above are trends for species at specific localities, with some reference to ecological (parkland expansion) and human processes (grazing, traffic). Since three raptor species are apparently experiencing long-term declines, and only one species is stable, conservation efforts may have failed those 83% of Canadians who suggested that "maintaining abundant wildlife is very or fairly important" (Filion et al. 1993). Is this maintenance goal possible? Is it desirable and at what cost?

Within the context of an ecosystem change from open grassland to parkland, the decline among ferruginous hawks may be expected as this reflects a habitat change trend operating for 100 years (Schmutz et al. 1984; Houston and Schmutz 1999). Red-tailed hawks are increasing and thus all is not lost; in fact, depending on one's goal, much may be well. Conversely, burrowing owls are declining and evidence suggests that the declines were influenced by Swainson's hawks and possibly by other raptors. Ferruginous and Swainson's hawks may have occurred on the Hanna study area in the 1970s and 1980s at abnormally high densities (e.g. Schmutz et al. 2001), encouraged by high grazing pressure favouring Richardson's ground squirrels.

In view of these considerations, a species approach to conservation is fraught with difficulty. Attempts have been made to manage or protect both buteos and owls on the Hanna study area, through monitoring (Shyry et al. 2001; this study), nest management (Schmutz et al. 1984), and raising awareness locally and globally (this study and many others). These actions have been successful but a decline among ferruginous hawks, Swainson's hawks, and burrowing owls could not be avoided because ecosystem-level changes in factors such as habitat conditions and predation were taking place. A focus on landscape-level characteristics may be more productive than a species-based approach. In some landscapes, Swainson's hawks may be favoured over burrowing owls and vice versa. By protecting landscape diversity, the species endemic to these landscapes may naturally follow.

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THE IMPORTANCE OF PRAIRIE GRASSLANDS AS POST-BREEDING HABITAT FOR PRAIRIE FALCONS FROM IDAHO

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Abstract: From 1999 through 2003, we tracked movements of adult female prairie falcons *(Falco mexicanus)* using satellite telemetry. We instrumented falcons from April-May on their nesting grounds in the Snake River Birds of Prey National Conservation Area (NCA) in southwest Idaho. The NCA has been recognized as the home to one of the world's largest assemblages of nesting raptors, particularly prairie falcons. All of the instrumented prairie falcons left the Snake River Canyon from late June through mid-July. Most individuals headed northeast across the continental divide en route to summering areas in Montana, Alberta, Saskatchewan, and the Dakotas. The Northern Great Plains, particularly southwest Saskatchewan, southeast Alberta, and eastern Montana, appears to be an important post-breeding area for falcons that nest in the Snake River Plain. Prairie falcons stayed at their northern summer areas from one to four months before heading south to the southern Great Plains or back to Idaho. Almost all areas that prairie falcons used in the Northern Great Plains are privately owned. The Bureau of Land Management is the principal manager of non-private lands used by prairie falcons during the post-breeding season in Montana. Conservation of the Snake River's prairie falcons must be an international venture that requires cooperation of agencies from both the U.S. and Canada. In addition, successful management of prairie falcon habitat on a range-wide scale must involve private landowners as well as state, provincial, and federal agencies. Programs to preserve and maintain grassland habitats on private lands throughout western North America maybe crucial in safeguarding prairie falcon habitat in years to come.

DOES THE DENSITY OF RICHARDSON GROUND SQUIRRELS PREDICT FERRUGINOUS HAWK DENSITY?

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Abstract: Five-year trend block surveys were initiated in 1982 for ferruginous hawks *(Buteo regalis)*, a Threatened species in Alberta. An apparent decrease in the ferruginous hawk population prompted an assessment of factors that may be influencing their decrease such as prey abundance. Richardson's ground squirrels *(Spermophilus richardsonii)* are a key component to the prairie ecosystem and are a vital prey species for ferruginous hawks; however, limited ground squirrel surveys have been conducted within the grasslands of Alberta. In 2003, a survey protocol for Richardson's ground squirrels was developed with the goal to determine a survey method that could determine trends in Richardson's ground squirrel populations. We evaluated two survey methods for Richardson's ground squirrels, one using adult alarm call playback and one using a visual scan without call playback. The results from the survey showed that there was a significant difference in the number of ground squirrels seen using the adult alarm call playback versus no call playback. We also examined the relationship of Richardson's ground squirrel densities to ferruginous hawk, Swainson's hawk *(Buteo swainsoni)*, and red-tailed hawk *(Buteo jamaicensis)* densities.

INTRODUCTION

Richardson's ground squirrels *(Spermophilus richardsonii)* are distributed throughout the grasslands and are a key component to the prairie ecosystem. Smith (1993) and Michener (1996; 2002) identify Richardson's ground squirrels as a vital prey source for ferruginous hawk *(Buteo regalis),* Swainson's hawk *(Buteo swainsoni)*, prairie falcon *(Falco mexicanus)*, prairie rattlesnake *(Crotalus viridis)*, American badger *(Taxidea taxus*), and long-tailed weasel *(Mustela frenata)*. Prey species population fluctuations can have dramatic effects on predator populations (Brand et al. 1976). Schmutz and Hungle (1989) found a strong correlation between ferruginous hawks and the number of ground squirrels based on cans of poison purchased by landowners.

Several methods have been used to survey ground squirrel populations. These range from intrusive approaches such as mark-release-recapture to less intrusive surveys such as burrow entrance counts and visual observations. The use of alarm calls to help increase observability of individuals has also been used with notable increases in the numbers observed (Lishak 1977; Leung 1991; Hare and Atkins 2001). Visual observations of adult ground squirrels were chosen for this study as the most cost effective and efficient way of surveying for Richardson's ground squirrels across the grassland region of Alberta.

Ground squirrel habitat was examined to determine its effect on the number of ground squirrels observed on a ferruginous hawk inventory block. Additional factors that may influence ferruginous hawk use of blocks, such as active farmyards and available nest sites, were also examined. Competition from other hawks such as red-tailed hawks *(Buteo jamaicensis)* and Swainson's hawks were also examined as a factor restricting ferruginous hawks from nesting in areas with abundant ground squirrels.

The purposes of this study were to (a) evaluate two survey methods for determining trends in Richardson's ground squirrel populations and (b) determine the relationship between Richardson's ground squirrels and ferruginous hawk populations. Although not within the original study scope, relationships between ferruginous hawks and other hawks within the Grassland Natural Region of Alberta were also determined.

METHOD

Survey Conditions

The emergence of young ground squirrels may vary from two to three weeks between years depending on the severity of the winter and geographic location (Michener and Schmutz 2002). Adult surveys were therefore conducted during the first three weeks of April 2003 to ensure that all adult ground squirrels had emerged from hibernation and were potentially visible above ground. This allowed the maximum adult density to be assessed each year and alleviated the biases that could result from the emergence of juveniles later in the season. Morning surveys started 75 min after sunrise and ended by 12:00. Afternoon surveys were conducted from 16:00 until 75 min prior to sunset. These survey periods corresponded to when ground squirrels are most actively feeding. Due to reduced levels of activity, surveys did not occur during extremely high temperatures (>30°C), when winds exceeded 30 km/hr, or when there was inclement weather such as snow or rain (NatureServe Explorer 2001; G. Michener pers. comm.).

Point Site Visual Surveys

Point site surveys were conducted every 800 m along a 12.8 km (8 mile), predetermined road-side transect. One 12.8 km transect was conducted yearly in each of 30 existing ferruginous hawk blocks. The ferruginous hawk blocks of 6.4 km by 6.4 km (4 miles by 4 miles) are located throughout the grassland region of Alberta. Twenty-eight of the 30 blocks were also selected as candidates for yearly ferruginous hawk monitoring (Taylor 2003).

At each point site survey stop, an observer used binoculars to count each ground squirrel within 200m starting at a recognisable point and rotating around 360° (four 90° quadrants; NE, NW, SE, SW) during a 2-min period. In cases where quadrants could not be surveyed for the full 200 m due to obstructions such as topography, observers continued along the transect (up to 400 m from the original site) until they could see 200 m in each direction. Any changes in the locations of the stops were noted. The dominant habitat for each quadrant and the habitat in which ground squirrels were seen were also recorded.

Call Playback Survey

On completion of the first count at a given stop, the observer played a recording of the alarm call of an adult Richardson's ground squirrel for 30 sec while facing each quadrant and counting the number of ground squirrels observed. Results of both counts were recorded to determine whether playback of alarm calls increased observability.

Analysis of Data

The Wilcoxon non-parametric test was performed to determine whether there was a significant difference between the two survey methods (Zar 1984; Fowler et al. 1998). A Chi-square test was conducted on Richardson's ground squirrel habitat characteristics at each site to determine use versus availability (Neu et al. 1974). An analysis was conducted comparing the number of hawk nests to the Richardson's ground squirrel density as well as the number of hawk nests compared to the number of farmyards, nest sites, and competition from other hawks on the block. Regression analyses were completed using SPSS and Microsoft Excel.

RESULTS

Call Playback versus Observation

Large differences in Richardson's ground squirrel numbers occurred between the 25 of the 28 blocks which could be surveyed. Observations of Richardson's ground squirrel adults along transects ranged from 1 to 73. Differences also occurred among wildlife management areas, with Medicine Hat having the lowest number of Richardson's ground squirrels on their ferruginous hawk blocks (7.8/km^2) and the Foothills having the highest (24.8/km^2). Significantly more ground squirrels were observed using call playback (31.8±20.86) as opposed to no call playback (16.00±12.22; T=0; p<0.001).

Habitat Selection

Habitat information was collected on 1,700 sites. The analysis showed that habitat was not used in proportion to availability (χ^2=126.09; p<0.005): native pasture was selected more often then available, while cultivation was selected less often then available (Table 1).

Correlation of Richardson's Ground Squirrels and Hawk Densities

Regression analysis on ferruginous hawk nests and Richardson's ground squirrel densities found no significant relationship (t=1.50; p=0.148). Upon removal of two blocks with anomalies, a significant positive relationship (t=2.46; p=0.023) was observed. One plot contained a large density of ground squirrels and several nest sites, but no hawks of any species were observed. The other site contained a ferruginous hawk nest site 75 m off the block. Detailed surveys will be carried out in 2004 to explain these anomalies. There was no relationship between Swainson's (t=0.935; p=0.361) or red-tailed

Table 1. Habitat selection by Richardson's ground squirrels in the Grassland Natural Region of Alberta in 2003.

Habitat	# of sites	Observed # of quarter sections with squirrels	Expected # of quarter sections with squirrels	Bonferoni 95% confidence intervals	Category
Cultivation	808	55	145.91	.111 - .246	Less
Native pasture	696	219	125.68	.634 - .793	Greater
Tame pasture	141	24	25.46	.031 - .125	No Diff
Other	55	9	9.93	-.003 - .059	No Diff
Total	*1,700*	*307*			

hawk (t=0.346; p=0.732) densities when compared to Richardson's ground squirrel densities.

The number of potential nesting sites on the ferruginous hawk blocks and their effect on nesting hawks showed that potential nest sites positively affected the number of red-tailed (t=3.075; p=0.005) and Swainson's hawk nests (t=3.339; p=0.003), while there was no effect on the number of ferruginous hawk nests (t=-0.828; p=0.415). Similar results were found for active farmyards, which positively affected the number of red-tailed (t= 3.033; p=0.005) and Swainson's hawk nests (t=2.805; p=0.009) but had no significant effect on the number of ferruginous hawk nests (t=-1.419, p=0.168). The number of other hawk nests had no significant effect on the number of ferruginous hawk nests in the blocks (t=-1.440; p=0.162).

DISCUSSION

Richardson's Ground Squirrel Survey Method

Call playback is an effective means of surveying for grounds squirrels across vast areas. Lishak (1977) counted 44-47% more thirteen-lined ground squirrel using call playbacks versus no call playbacks. Call playback of a Richardson's ground squirrel alarm call allows an observer to count actual individuals rather then relying on evidence of the species occupying the area. Direct observations reduce discrepancies arising from whether burrows are being used or not, what species produced the burrows, and how many ground squirrels can use one burrow complex. Results from the 2003 surveys show that alarm calls significantly aided the observer in seeing ground squirrels, and this survey method will be continued for future trend surveys.

Habitat Analysis

Habitat analysis indicated a greater use by Richardson's ground squirrels of grasslands compared to cultivated lands. Smith (1993) states the preferred habitat of Richardson's ground squirrels is extensive short and mixed grasslands. Similar results by Schmutz (1989) suggest Richardson's ground squirrels occupy cropland at lower densities.

Relationships

Our analysis of the 2003 data showed that other hawks, farmyards, and nest structures do not influence the number of ferruginous hawks found on the blocks. For both red-tailed and Swainson's hawks, however, there was a significant increase in use when large numbers of farmyards and nest sites were available within the block. The absence of a relationship between nest sites and ferruginous hawks is probably related to the species' ground-nesting abilities (Schmutz 1989) and lower reliance on trees compared to the other two hawks. The only factor that appeared to influence ferruginous hawks, and which had little effect on the other two species, was the density of ground squirrels.

The results of this project support the hypothesis of a strong predator-prey relationship between Richardson's ground squirrel and ferruginous hawk in Alberta. Our analyses found that Richardson's ground squirrel densities significantly impacted the number of ferruginous hawk nests found on survey blocks. Until further trend surveys on ground squirrels are conducted, we are not sure whether 2003 represented low, moderate, or high conditions in the ground squirrel population cycle. Limited historical information indicates a possible high in the ground squirrel population around the late 1980s and early 1990s based on cans of poison used by farmers (Schmutz and Hungle 1989). This "high period" for ground squirrel populations corresponds with two of Alberta's provincial ferruginous hawk surveys in 1987 and 1992 that calculated a provincial population of over 1,700 breeding pairs (Schmutz 1987; 1993). The next provincial survey was not conducted until 2000, and this survey estimated the Alberta population at 731 breeding pairs (Stepnisky et al. 2001). This decrease may be in response to decreased ground squirrel populations on blocks. Houston and Schmutz (1995) identified the start of a Swainson's hawk population decline in the Hanna, Alberta area during the early 1990s due to an apparent decline in Richardson's ground squirrels. This decline in prey densities was documented to have spread from the east (Kindersley, Saskatchewan) to the west (Hanna, Alberta) over three years (Houston and Schmutz 1995).

MANAGEMENT IMPLICATIONS

The preservation of native grassland will aid in supplying ferruginous hawks with a sufficient prey base as well as providing habitat for a variety of other species. Management and stewardship programs, which promote native grassland and the prevention of tilling, are key in protecting the grassland habitat. Management for ferruginous hawks should take into consideration the prey base instead of the provision of trees for nest sites as no relationship was observed between nest sites and ferruginous hawks. The provision of trees is important when managing for other species such as red-tailed and Swainson's hawks that have significant relationships with nest site abundance.

ACKNOWLEDGEMENTS

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DO BURROWING OWL POPULATIONS DEPEND ON PREY IRRUPTIONS?

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Abstract: From a synthesis of the literature, we found that North American owl species that feed primarily on irruptive prey (e.g., voles, lemmings) have larger average clutch sizes and a larger range of clutch sizes than species that feed primarily on non-irruptive prey species. Burrowing owls lay the largest average clutch sizes of any North American owl species; they also have the largest range of clutch sizes, suggesting they are adapted to irruptive prey species. Furthermore, we found correlations between prey abundance and burrowing owl fledging rate, post-fledging survival rate, and ultimately population growth rate. In 12 years of monitoring burrowing owl populations in Saskatchewan, the population increased in only 3 years; all 3 years were associated with an abundance of voles. If burrowing owl populations depend on regular peaks in prey abundance, the impacts of current agriculture practices may negatively affect these endangered owls by reducing the magnitude or frequency with which their prey species (e.g., voles, grasshoppers) are reaching peak populations.

HYBRIDIZATION BETWEEN NATIVE WESTSLOPE CUTTHROAT TROUT *(ONCORHYNCHUS CLARKII LEWISI)* AND INTRODUCED RAINBOW TROUT *(O. MYKISS)* IN THE EASTERN SLOPES OF THE ROCKY MOUNTAINS IN ALBERTA

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Abstract: The abundance and distribution of native westslope cutthroat trout *(Oncorhynchus clarkii lewisi)* have declined dramatically throughout the subspecies' historical range in North America including southwestern Alberta. In Alberta, most of the remaining populations of cutthroat trout within the Bow River drainage are small, isolated, and occupy less than five percent of their native range. The severe declines in cutthroat trout populations are most certainly due to anthropogenic influences, specifically overexploitation of the fisheries and introduction of non-native species. Introduced species of salmonids, primarily rainbow *(Oncorhynchus mykiss)*, brook *(Salvelinus fontinalis)*, and brown trout *(Salmo trutta)*, presently occupy most of the native range of westslope cutthroat trout where the cutthroats are now absent. The non-native salmonid species have noticeably influenced cutthroat trout communities through hybridization, competition, and predation. In this study, we compared the habitat and genetic characteristics of 61 stream populations of westslope cutthroat trout in the eastern slopes of the Rocky Mountains in Alberta.

INTRODUCTION

The westslope cutthroat trout (*Oncorhynchus clarkii lewisi* Girard) is the only subspecies of cutthroat trout endemic to Canada. It is found in lakes and streams of the Bow, Kootenay-Columbia, and Waterton river systems in British Columbia and Alberta (Benhke 1992). Recent evidence from numerous studies in western North America indicates that cutthroat trout distribution has declined dramatically throughout the subspecies' historical range (Benhke 1992; Mayhood 1999). Indigenous populations are most likely rare and isolated in headwater habitats. Moreover, many of these habitats have been affected by over-harvesting, land and water use practices, and invasion by non-native species (Krueger and May 1991; Carmichael et al. 1993).

Most inland populations of cutthroat trout have evolved in isolation from other trout. As a result, native cutthroat populations have not developed isolating mechanisms that would allow them to coexist with other salmonid species. Introduced non-native species have markedly influenced cutthroat trout communities through hybridization (Carl and Stelfox 1989), competition, predation, and the introduction of parasites and diseases. Hybridization between native cutthroat trout and rainbow trout *(Oncorhynchus mykiss)* results in the production of viable hybrids and loss of genetic integrity within native populations (Leary et al. 1984; Deeds et al. 1999; Rubidge et al. 2001). Introduced exotic species such as brown trout *(Salmo trutta)* and brook trout *(Salvelinus fontinalis)* successfully compete with native cutthroat trout for habitat and food resources (Young 1995).

The genetic status, biology, and ecology of most populations of cutthroat trout in Alberta are presently unknown. Although a few genetic studies have been conducted, they have concentrated on assessing the genetic identity of stocks suspected to be pure. Similarly, hybridized and introduced cutthroat trout populations, although widespread among existing populations, have rarely been assessed. This research represents one of the most detailed genetic assessments of the westslope cutthroat trout hybridization on the eastern slopes of the Rocky Mountains in Alberta. The information presented in this study can contribute to the conservation of native westslope cutthroat trout by identifying priority areas for conservation (i.e., areas with no apparent hybridization) and by increasing our understanding about the potential outcomes of hybridization (i.e., creation of hybrid swarms).

METHODS

Study area

The study was conducted along the eastern slopes of the Rocky Mountains in Alberta, Canada. We sampled the headwater reaches of 14 different watersheds within the Milk, South Saskatchewan, and North Saskatchewan river systems (Figure 1). Within the Milk River system, we sampled one reach, Lee Creek. Within the South Saskatchewan River system, we sampled the Bow, Castle, Crowsnest, Elbow, Ghost, Highwood, Kananaskis, Livingstone, Oldman, Sheep, Spray, and Waterton watersheds. Within the North Saskatchewan River system, the sampling occurred in the Ram River watershed.

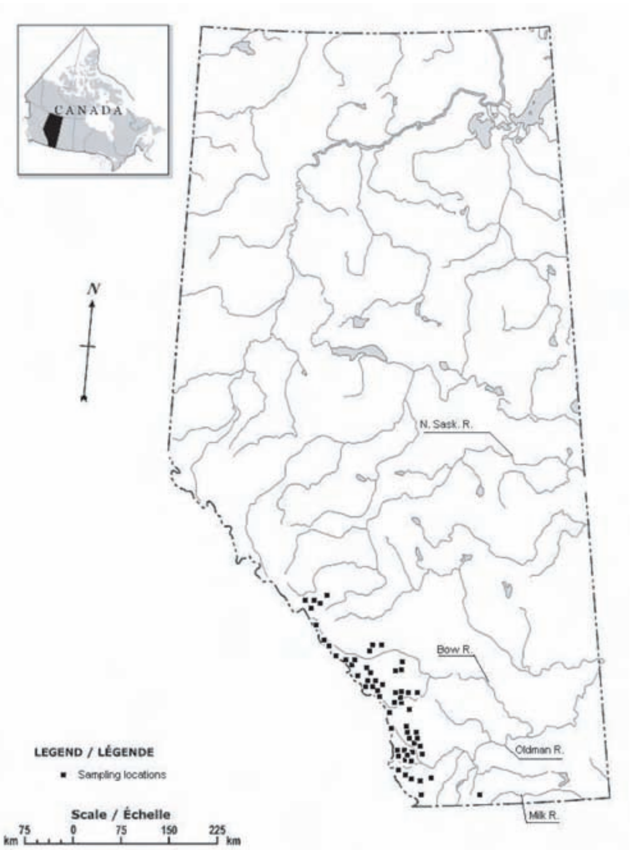

Figure 1. Distribution of sampling locations within 14 watersheds on the eastern slopes of the Rocky Mountains in Alberta.

Sample collection

Cutthroat trout samples were collected at sixty-one locations from the South Saskatchewan and North Saskatchewan River systems (Figure 1). All sampling occurred during low summer flow conditions. Tissue samples (adipose and/or pectoral fins) were collected from 2000 to 2003 by electrofishing and angling within the stream reaches, which ranged in length from 250 m to 1km, by the primary investigator (M. Janowicz) and by fisheries biologists from the Fish and Wildlife Division of Alberta Sustainable Resource Development. Samples were then preserved in 95% ethanol and stored at 4ºC. Reference samples of westslope cutthroat trout (WCT) populations were obtained from Job, Marvel, and Picklejar Lakes 2 and 4. Samples of Yellowstone cutthroat trout (YCT) from Taylor Lake were provided by Dr. C. Strobeck's repository at the University of Alberta and from the Clark's Fork Trout Hatchery, Wyoming. Samples of three strains of rainbow trout (RT) currently used in stocking programs in Alberta were obtained from the Allison Brood Trout Station (Coleman, AB) and the Raven Brood Trout Station (Caroline, AB).

Laboratory methods

DNA was isolated from all samples (5 to 25 mg of adipose/pectoral tissue) using GenEluteTM Mammalian Genomic DNA Kit (SIGMA). DNA was stored at 4ºC until PCR amplification and then frozen in -28ºC for permanent storage of the isolated DNA. Six microsatellite loci were used in this study (Table 1). Primer sequences were obtained from L. Bernachez (University of Laval). The PCR-amplified fragments of cutthroat trout DNA were analyzed on a 377 automated DNA sequencer.

Table 1. Primer sequences and primer concentrations (mM) used in PCR amplifications.

Locus (µM)	Primer Sequence F: Forward; R: Reverse	Label	Source Species
Omy77 (0.30)	F: 5' –CGT TCT CTA CTG AGT CAT' R: 5'-GTC TTT AAG GCT TCA CTG CA	FAM	*Oncorhynchus mykiss*
Oneu11 (0.10)	F: 5'-GTT TGG ATG ACT CAG ATG GGA CT R: 5' TCT ATC TTT CCT GTC AAC TTC CA	TET	*Oncorhynchus nerka*
Ots4 (0.04)	F: 5' GGA GGA CAC ATT TCA GCA G R: 5'-GAC CCA GAG GAC AGC ACA A	TET	*Oncorhynchus tshawytscha*
Sfo8 (0.30)	F: 5' –CAA CGA GCA CAG AAC AGG R: 5' CTT CCC CTG GAG AGG AAA	TET	*Salvelinus fontinalis*
Ssa85 (0.15)	F: 5' –ACC CGC TCC TCA CTT AAT C R: 5' AGG TGG GTC CTC CAA GCT AC	HEX	*Salmo salar*
Ots107 (0.10)	F: 5' –ACA GAC CAG ACC TCA ACA R: 5' ATA GAG ACC TGA ATC GGT A	HEX	*Oncorhynchus mykiss*

Data analysis

To identify individuals with possible mixed ancestry (hybridization), we ran two-species and three-species assignment tests (STRUCTURE assignment test; Pritchard at al. 2000, program available at http://pritch.bsd.uchicago.edu/) without and with prior information about sampled populations, respectively. We set the number of populations to be assigned to two and three and provided the two or three learning populations (WCT-1, RT-2, YCT-3). Individuals were considered pure WCT if the probability of being assigned to WCT was greater than 0.9. All individuals with the probability greater than 0.9 of being assigned to rainbow or Yellowstone cutthroat trout were allocated as rainbow or Yellowstone trout, respectively. The hybrid assignment was then given if the probability of being from pure rainbow trout or pure Yellowstone cutthroat trout was greater than 0.1 but less than 0.9. To compare the presence of hybrids across all watersheds sampled, we assessed the degree of hybridization in each sampled creek using following equation: H = (# of Hybrids/N) * 100, where N = number of all individuals in a sampled creek. To assess the extent of introgression, the means were calculated for each watershed.

RESULTS

A total of 644 westslope cutthroat (70%), 96 rainbow (10.5%), 5 Yellowstone cutthroat trout (0.5%), and 169 hybrids (18.5 %) were identified by DNA extraction and PCR amplification from 915 fish (excluding WCT, RT, and YCT references; Figure 2).

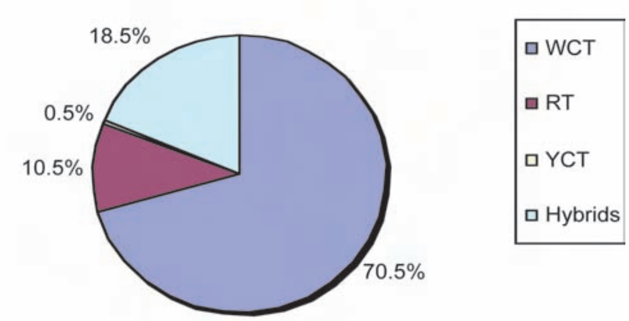

Figure 2. Percentage of pure westslope cutthroat (WCT), rainbow (RT), Yellowstone cutthroat trout (YCT), and hybrids out of 915 fish sampled.

Overall, 61 populations were sampled, and 26 of these were identified as pure westslope cutthroat trout. One creek, Muskeg Creek was composed of only 1 westslope cutthroat and 13 rainbow trout and was determined to be a non-hybridized population (0%). Thirty-five populations were identified to be hybridized (Figure 3). Of these, twelve populations were identified as having pure rainbow trout and WCT x RT hybrids. Twenty populations were identified as having WCT x YCT hybrids. Other hybridized populations included pure WCT, pure RT, and WCT x RT hybrids.

Four of sixty-one sampled creeks exhibited at least an 80% degree of hybridization (Kiska, Suicide, Nice, and Moraine; Figure 3). Ten populations exhibited 50% or

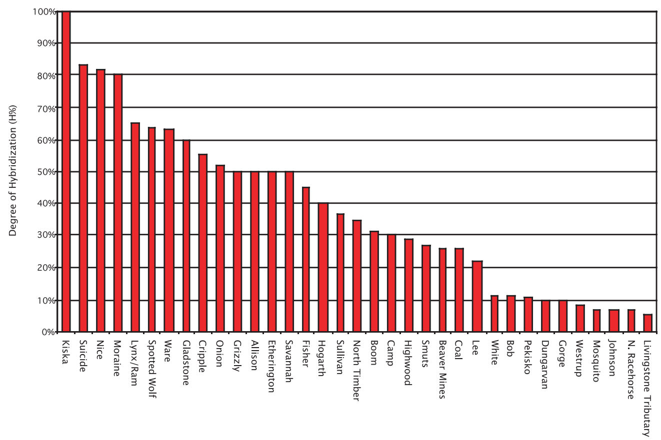

Figure 3. Degree of hybridization (%H = number of hybrids out of the total number of all individuals sampled in a creek x 100%) in 35 hybridized populations.

more individuals being hybridized within sampled creeks, specifically Lynx/tributary to Ram River (68%), Spotted Wolf (64%), Ware (63%), Gladstone (60%), Cripple (55%), and Onion (52%) with Grizzly, Allison, Etherington, and Savannah each exhibiting 50% hybridization. In seven populations, the degree of hybridization was found to be ten or less percent (Figure 3). Only one hybrid individual was found in each of the Johnson, Livingstone tributary, North Racehorse, and Westrup populations. These populations should be further evaluated for the presence or absence of hybrids within these creeks. Nine of the hybridized populations, including Beaver Mines (26%), Pekisko (10.5%), Bob (11%), North Timber (35%), Coal (26%), and Lee (22%), contained mainly rainbow trout.

The frequency of hybridized creeks within a given watershed was generally high (Figure 4), ranging from 100% in the Ram and Sheep River watersheds to 22% in the Kananaskis River drainage. Four hybridized creeks in the Castle River watershed indicated 80% frequency of hybridized creeks. The Highwood, Bow, and Livingstone River watersheds were found to be 56 to 67%

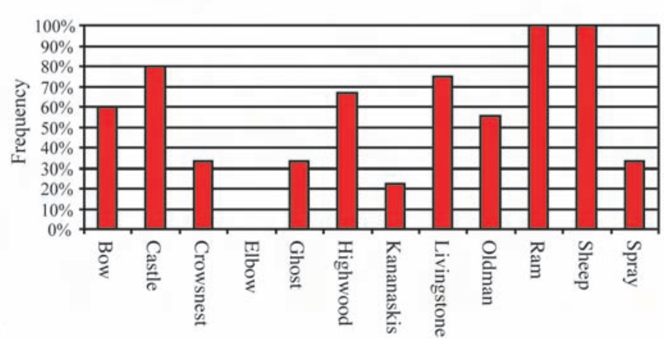

Figure 4. Frequency of hybridized creeks (number of creeks with detected hybridization/number of creeks sampled) in each watershed.

hybridized. Only one watershed, the Elbow, was free from hybridization.

DISCUSSION

The current study suggests that hybridization and introgression with introduced rainbow trout, and in some instances with Yellowstone cutthroat trout, is widespread within the eastern slopes of the Rocky Mountains in Alberta. Westslope cutthroat and rainbow trout have been found to hybridize readily in areas of contact, and gene flow between these species has been broadly documented (Allendorf and Leary 1988; Rubidge et al. 2001; Taylor et al. 2003). Moreover, hybrids are viable and there has been no evidence of reduced fertility in hybrids between these subspecies (Forbs and Allendorf 1991). Introgression and the formation of hybrid swarms have consequently been found in cutthroat and rainbow trout hybrids in as few as five generations (Hitt et al. 2003).

Our results show that hybridized populations of westslope cutthroat trout are much more common than previously thought. Thirty-five of 61 sampled creeks (57%) showed the evidence of hybridization. Hybrids were found in 13 of the 14 watersheds sampled in 3 river basins (Milk, South, and North Saskatchewan) and ranged from 25% to 100% of sampled creeks being hybridized. Only one watershed, Elbow River, was found to be non-hybridized. This strongly suggests that hybridization between westslope cutthroat and introduced salmonids is widespread across an extensive geographical area in Alberta. The degreee of hybridization is, however, variable among the watersheds. For example, in the Ram River watershed, about 63.5% of cutthroat trout examined were classified as hybrids whereas only 2% were hybrids in the Ghost River watershed. Taylor et al. (2001) observed similar variability in the rate of hybridization between Dolly Varden and bull trout across watersheds in southwestern British Columbia. They suggested that the variations in hybridization rates might be attributable to the variability in habitat or life history characteristics of the char populations. For instance, habitat choice and size-dependent differences in spawning behaviour have been observed to play an important role for both of these species. Furthermore, differences in viability, fertility, and sex ratio in the progeny of reciprocal F1 matings could be responsible for differential hybridization and introgression. Sexual differentiation is particularly most susceptible to disruption in hybrids (Forbes and Allendorf 1991). An alternate hypothesis may be that postmating processes are major determinants of the extent of hybridization and gene flow and that the distinct watersheds sampled vary in the degree to which they select against hybrids (Taylor et al. 2001).

Many of the pure westslope cutthroat populations throughout their range are limited to upper mainstem reaches or headwater tributaries (Brown and Mackay 1995; Mayhood 1999; Rubidge et al. 2001). Twenty-six of 61 sampled creeks (43%) were identified as having pure westslope cutthroat trout, and the majority of these were also located at higher elevations and further upstream from the main rivers than the streams with hybrids. The distribution of identified westslope cutthroat populations supports elevation refugia (Paul and Post 2001), where the native species, including westslope cutthroat, are resilient to invasions by non-native species. At higher elevations where water temperatures are colder, cutthroats are superior competitors to non-native fishes (Griffith 1988; Fausch 1989; Paul and Post 2001). On the contrary, Hitt et al. (2003) and Rubidge (2003) found that the environment does not play a significant role in limiting the spread of hybridization, but rather the non-hybridized populations avoided hybridization because of isolation from stocking sites and other hybridized populations. Unless there are impassable barriers preventing the dispersal of introduced rainbow trout or their hybrids, the streams with pure westslope cutthroat may be at risk of hybridization.

This study gave a good indication of the genetic status of remaining pure westslope cutthroat populations and the extent of hybridization in Alberta. Further genetic sampling throughout the range of westslope cutthroat should be conducted to advance our knowledge about Alberta's westslope cutthroat trout populations. Because this study was designed to investigate westslope cutthroat and rainbow trout hybridization, the mixed WCT and YCT genotypes presented a considerate challenge in identifying hybrids of these species. Further genetic markers in addition to diagnostic loci used in this study should be developed to clearly distinguish between native cutthroat, Yellowstone cutthroat, and rainbow trout genotypes.

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MULTI-SPECIES APPROACH TO CONSERVATION OF NATIVE FISH

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Abstract: Approaches to the conservation of fish species are different in some respects to those employed for terrestrial animals. For terrestrial animals in southern Alberta, conservation efforts usually target landowners and stewards on private landscapes. For fish species, however, a number of government agencies, sometimes on both sides of the international boundary, must cooperate to maintain or recover species. The limiting factor for conservation is often sufficient water at certain times of the year, and treaties and political agreements may furthermore limit options.

I will focus on three fish species: western silvery minnow *(Hybognathus argyritis)*, stonecat *(Noturus flavus)*, and St. Mary sculpin (*Cottus* sp.). These species occur in the Milk River, which is the southernmost river basin in the province and the only basin that is part of the Mississippi River drainage. The only Alberta populations of two of these species are found in the Milk River.

The biology of many fish species at risk is poorly understood. However, that does not preclude producing recovery or maintenance strategies and action plans. I would argue, for example, that knowledge of food items consumed by western silvery minnow is not critical prior to producing a recovery/maintenance strategy. My presentation will provide an overview of fish distribution, limiting factors, and the proposed approach for Milk River fish.

INTRODUCTION

Approaches to the conservation of fish species are different in some respects to those employed for terrestrial animals. For terrestrial animals in southern Alberta, conservation efforts usually target landowners and stewards on private landscapes. For fish species inhabiting lotic waters, however, the habitat ownership is different as flowing waters are considered to be the property of the Crown. Most irrigation reservoirs in southern Alberta are owned by irrigation districts and will not be discussed in this paper.

LANDSCAPE

The Milk River was named by Lewis and Clark in 1805 when they reached the Missouri-Milk River confluence because the water colour resembled milk-laced tea. Its headwaters are in a plateau on the Blackfeet Reservation in Montana, and a low divide separates it from the St. Mary watershed. The North Milk River flows for 73 km before entering Alberta, and then it flows another 90 km before joining the mainstem Milk River. The Milk River flows for about 230 km before re-entering Montana at the eastern border crossing and continuing about 85 km downstream to the uppermost dam (Fresno). Currently there are no dams in the Canadian portion of the Milk and North Milk rivers. Between the eastern International Boundary crossing and the Missouri River in Montana, the Milk River has seven dams for either water storage or diversion purposes. These dams lack fish passage facilities.

IRRIGATION/DIVERSION

The Milk River Valley was one of the last areas to be settled in Montana. While other parts of Montana had irrigation as early as the 1840s, water diversions in the Milk River Valley did not begin until the 1880s. The early delivery systems functioned well during high flows, but the inconsistent nature of Milk River flows resulted in efforts to ensure a stable supply of water. In the early 1900s, plans were initiated for the Milk River Project, which was to divert water from the St. Mary River in Montana to the North Milk River in Montana. Funding for the project construction was conditional upon the governments of the United States and Canada agreeing to the transportation of water through Canadian territory. After several years of negotiation, both nations signed the Boundary Waters Treaty in 1909 and established the International Joint Commission to resolve differences of opinion.

The Boundary Waters Treaty stated, among other things, that the United States was entitled to a prior appropriation of 14.2 cubic metres per second (m^3/s), or 500 cubic feet per second (cfs), of the Milk River waters. Canada was entitled to a prior appropriation of the same amount from the waters of the St. Mary River. The Treaty also affirmed that the channel of the Milk River in Canada could be used by the U.S. for the conveyance of waters diverted from the St. Mary River. The 1921 Order of the International Joint Commission clarified portions of the Treaty and stated when Milk River flows from April 1 to October 31 (irrigation season) were below 18.9 m^3/s (666 cfs) as determined at the eastern border crossing, the U.S. was entitled to 75% of natural flow and Canada was entitled to 25% of natural flow. When flows exceeded 18.9 m^3/s, the excess shall be divided equally between the two countries. A reverse arrangement was agreed upon for the St. Mary River, where Canada was entitled to 75% of natural flows, etc.

Construction on the portions of the St. Mary Project, which included a canal to divert water from the St. Mary River to the North Milk River in the U.S., began as early as 1907. Diversion of waters into the Milk River began in 1917 (McLean and Beckstead 1980). The St. Mary Canal is 47 km long and originates about 1 km below Lower St. Mary Lake. It joins the North Milk River about 10 km upstream of the western border crossing, and was designed to have a maximum carrying capacity of about 24 m^3/s (Stash 2001). The major storage reservoir in the St. Mary drainage is Lake Sherburne, which is used to provide water to the St. Mary River upstream of the St. Mary Diversion dam (Mogen and Kaeding 2002).

FISH

There are a total of 19 fish species reported as occurring in the Milk River in Alberta: 5 are considered sportfish species and 14 are non-sportfish species. The 2000 General Status of Alberta Wild Species (Alberta Sustainable Resource Development 2001) ranked two species as May Be At Risk and two species as Undetermined (Table 1).

Table 1. Alberta status of four fish species occurring in the Alberta portion of the Milk River.

Common Name	Scientific Name	2000 Alberta Status
western silvery minnow	*Hybognathus argyritis*	May Be At risk
St. Mary sculpin	*Cottus* sp.	May Be At risk
stonecat	*Noturus flavus*	Undetermined
brassy minnow	*Hybognathus hankinsoni*	Undetermined

In 2001, the Committee on the Status of Endangered Wildlife in Canada listed western silvery minnow as Threatened in Canada. In 2003, Alberta's Minister of Sustainable Resource Development indicated a government intention to list western silvery minnow as Threatened in Alberta. The taxonomic status of the "St. Mary" sculpin is unclear. It has been variously identified as mottled sculpin *(Cottus bairdi)* or shorthead sculpin *(Cottus confusus)*. Thus the Alberta Endangered Species Conservation Committee is currently reviewing this fish's status. If the St. Mary sculpin receives a designation of Threatened, then the stonecat will also likely receive a status of Threatened.

FISH DISTRIBUTION

The distribution of western silvery minnow in Canada is limited to the Milk River. Its Alberta range is from the eastern border crossing to Writing-on-Stone Provincial Park. While the species inhabits the mainstem Milk River, the minnow has not been collected from any of the tributaries. However, use of the lowermost reaches of tributaries is likely in confluence areas. Western silvery minnow also occurs in the Milk and Missouri rivers in Montana, but it does poorly in reservoir environments.

The range of St. Mary sculpin includes the upper St. Mary River (above the St. Mary Reservoir) and the upper Milk and North Milk rivers. This sculpin ranges within the Milk River downstream to the Writing-on-Stone Provincial Park vicinity. Spoonhead sculpin *(Cottus ricei)* occurs in the St. Mary River below the St. Mary Reservoir. Sculpins are benthic species and, as such, do not exhibit significant upstream movements.

In Alberta, stonecat only occurs in the Milk and North Milk rivers. The known range of stonecat extends from about 60 km upstream of the eastern border crossing to the Mackie Creek confluence with the North Milk River. Since stonecats have been collected in the Montana portion of the Milk River upstream of the Fresno Reservoir (Stash 2001), the species likely also occupies habitats in the lower 60 km of the Milk River in Alberta.

LIMITING FACTORS

Water supply is the major limiting factor for fish species in the Milk River. During the irrigation season, which usually begins in March and ends in October, stream flows average about 12 m^3/s at Milk River and about 14 m^3/s at the eastern border crossing. Maximum instantaneous discharge can peak around 280 m^3/s. Therefore, low flows during the irrigation season are not a concern. Water Survey of Canada data for the Milk River at Milk River station (11AA005) indicates the minimum flows typically occur in January, and the minimum daily discharge in winter rarely exceeds 1.0 m^3/s. Data for this station also indicated that minimum daily flows of zero were recorded in some years.

Southern Alberta experienced drought conditions from 1999 to June 2002. Fisheries studies conducted on the Milk River in October 2001 indicated that the lower 60 km of the Milk River was reduced to a series of isolated pools (RL&L 2002). For example, in a 6.2 km section in the vicinity of the Pinhorn Ranch, there were 32 isolated pools. March 2002 surveys of some isolated pools indicated water depth below the ice ranged from 0 to 0.34 m (RL&L 2002). Approximately 5% of the water (based on surface area) available in July 2001 was available in March 2002.

APPROACH TO MAINTENANCE AND RECOVERY PLANNING

In July 2003, the Minister of Alberta Sustainable Resource Development (ASRD) indicated support for the Endangered Species Conservation Committee recommendation of a

Threatened status for western silvery minnow. Alberta's Wildlife Act stipulates that for species designated as Threatened, ASRD should prepare a recovery plan and the management actions required to recover or maintain a species over a five-year period. Maintenance and recovery plans provide a basis for cooperation among government, industry, conservation groups, landowners, and other stakeholders to ensure populations are restored or maintained for Alberta's future. ASRD's timetable for producing the plan is two years.

Alberta Sustainable Resource Development and the Department of Fisheries and Oceans will be the lead agencies responsible for the development of the recovery plan for the western silvery minnow. Because strategies employed for the maintenance and recovery of western silvery minnow will likely benefit St. Mary sculpin and stonecat, the recovery team will explore options for all three species.

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NATIVE FISH CONSERVATION: SOME THOUGHTS ON A PROCESS

Lorne Fitch

Cows and Fish Program

INTRODUCTION

Riparian areas are the transition zones between aquatic ecosystems and the adjacent upland terrestrial ecosystems. This is a landscape strongly influenced by water, small in spatial extent, but ecologically diverse. "Healthy" riparian areas support unique plant communities that establish watershed function, provide diverse habitats for fish and wildlife, and provide a highly productive forage supply for livestock. Despite their small size, riparian areas are the most valuable, productive, and vulnerable areas for the agriculture sector.

The use and abuse of riparian landscapes by livestock grazing has been a focal point of nearly three decades of debate in the United States. This debate has resulted in remedial programs among federal and state agencies, including fencing to exclude cattle from riparian areas and extending to the removal of livestock altogether from public rangelands. Initiatives to reduce or remove livestock often relate to the overuse and degradation of riparian areas. The American situation provides an example of a riparian grazing issue characterized by deeply entrenched conflict among interest groups and legislated solutions.

In the 1970s, the impact of decades of unmanaged livestock use on several high profile trout streams in west-central Alberta became apparent through biological surveys. Those baseline surveys provided the catalyst to galvanize restoration actions designed to improve the habitat conditions for trout. Without the knowledge and tools to manage the grazing of riparian systems, initial efforts for recovery involved fencing programs to permanently exclude livestock from variable portions of riparian areas. Exclusion fencing can provide rapid recovery and help to demonstrate a site's biological potential; this was the case for the initial riparian management program in west-central Alberta. As the program to use exclusion fencing as the riparian management tool expanded, however, some issues related to this narrow focus became apparent. Initial fencing costs are high and the associated maintenance of fences in close proximity to flood-prone areas often exceeds the original cost. Streambank fencing was also° seen to cause a loss of abundant forage and limit livestock watering opportunities. The acceptance of exclusion fencing as a solution and adoption by landowners became problematic in other areas of the province, and perceptions evolved that riparian areas and cattle are incompatible, contrary to disturbance process theory in ecosystem dynamics. Yet, streams, adjoining riparian zones, and watersheds function as inseparable units. Thus, exclusion fencing does not allow the opportunity to find the solution to a riparian grazing problem in the adjacent uplands and to manage on a landscape basis.

COWS AND FISH

The Alberta Cows and Fish initiative began as a recognition that the impasse over riparian areas and their management would be resolved with a range of solutions including, but not exclusively, streambank fencing. In 1992, six groups and agencies sat around a rancher's kitchen table and established what would become the Cows and Fish program. This partnership between the Alberta Cattle Commission, Trout Unlimited Canada, the Canadian Cattlemen's Association, Alberta Environmental Protection, Alberta Agriculture, Food and Rural Development, Fisheries and Oceans Canada, and later Prairie Farm Rehabilitation Administration created a synergy of experience, perspective, background, and resources that broadened the approach to riparian issues.

The Cows and Fish initiative was not intended to develop as a program that superseded or replaced land/resource management activities undertaken by agencies or groups; rather staff, resources, and mandates will always remain the purview of government agencies, either at national, provincial, or municipal levels. However, it can be argued that the effectiveness of agencies involved in management, conservation, or stewardship activities could be increased substantially by overcoming a number of factors including lack of resources, priority, interest, and motivation. All factors are intertwined but the driver of relative ineffectiveness may be approach. The approach of agencies (and agency staff) to resource management issues is typically regulatory, prescriptive, or incentive-based. Phrased differently, "this is what you must do" versus "this is best and you should do it this way" versus "here is some money, please co-operate". These delivery mechanisms tend to be centralist or top-down in nature; a consequence of this approach is that products tend to be viewed with suspicion and distrust by those who are the intended recipients of the advice, direction, and resources.

Engagement of Participants

The Cows and Fish program began (and continues) as a different way to engage with people, especially livestock producers, to move beyond suspicion, denial, and conflict to trust, acceptance, and co-operation. Engagement begins with ecological awareness and a non-threatening, non-confrontational extension effort to help people understand some of the ecological processes that shape the landscape on which they live on and make a living. Part of that critical, initial message is that choices and alternatives exist to current management practices. As the antithesis of the centralist or top-down approach, Cows and Fish encourages the formation of local or community teams, composed of technical experts, producers, and other local interests, to engage with each other to "drive" the process.

A working arrangement of local individuals and technical staff begin to deliver ecological awareness on a broader basis in the community or watershed area. Acceptance is enhanced because people perceive the initiative is internal as opposed to being externally driven and motivated. Message deliverers go where the community invites them and as an invitee are given more prominence. This working relationship helps assemble diverse experience, talents, perspectives, and resources in a multi-disciplinary fashion.

Ecological awareness, specifically begin sensitising individuals at a community level to recognize elements of their environment, must lead to ecological literacy. Literacy is the ability to see and respond to choice, opportunity, or option in land management decision. Changes to land management are driven by informed decisions that are, in part, based on a greater appreciation of ecological function and process. Individuals that make ecologically appropriate land management decisions can minimize risk, avoid liability, and maintain future options. The Cows and Fish program assists in the assemblage of technical advise and tools for management changes to provide options and alternatives to current practices. Information sources include those innovative, progressive, or practical solutions already being used by a limited and select group of landowners.

Demonstration Sites and Riparian Health Assessments

It is difficult to sell concepts or ideas without tangible products or examples. Thus, key tools for Cows and Fish include demonstration sites and riparian health assessments. Demonstration sites provide examples of changes in grazing management that allow producers to assess whether these management changes make sense for their own operations. Sites selected for demonstration purposes also represent research opportunities to test and measure a riparian response to a particular grazing management option. Since many livestock producers are reluctant to experiment at their own expense and risk, the development of demonstration sites using capital from elsewhere provides some of the first steps towards acceptance of other management ideas.

Riparian health assessment is a useful tool to allow people to critically observe, measure, and assess the status of ecological function on their own property or within their communities. The term "riparian health " is used to mean the ability of a riparian area to perform certain key ecological functions, including sediment trapping, bank building, water storage, aquifer recharge, water filtration, flow energy dissipation, maintenance of biodiversity, and primary production. If these functions are impaired, so too will be the ability to sustain agricultural operations. Health assessment is not just an ecological measuring stick; it becomes a communication device to allow people with differing backgrounds and experience to "see" a riparian area and its status through the same set of eyes. Arguments about riparian condition are minimized and productive discussions about how to restore damaged areas can begin. The current status of watersheds within a community can become a catalyst for action based on health assessments and forms a benchmark useful to chart progress both on individual properties and within watersheds.

Four Step Process To Community Stewardship

The Alberta Cows and Fish program assists in community-based conservation through a process of engagement that creates opportunity to move from conflict to cooperation. Stewardship opportunities are created through a four-stage process or pathway. It begins with ecological awareness, a fundamental building block often skipped in other initiatives. The second step is assisting in the development of teams and partnerships. A network of resource professionals, landowners, and others who value riparian landscapes form to solve issues and problems in a multidisciplinary fashion. Step three is the assemblage of technical advice and tools for management changes to provide options and alternatives to current practices. Much of the information is gathered from the solutions already being used by some progressive landowners. The task is one of locating those individuals, understanding the management action taken, and translating that action into an alternative for others to assess for possible application to their operation. Part of this step includes the development and use of ecological measuring sticks to assess riparian function or health. Those measuring sticks allow an objective review of watershed condition, link ecological status to management, help galvanize community action, and provide a monitoring framework for landowners and others. Other tools help communities link biodiversity, economics, and water quality to management actions and alternatives.

The last step (although the process steps are often constantly repeated) is critical: responsibility for action is transferred to the community best able to make the changes and benefit from them. Riparian and watershed actions need to be community-based, locally-driven, and largely voluntary. To help a community to arrive at this point requires knowledge building, motivation, acknowledgement of problems, and empowerment. The reasons for positive action may result from enhanced awareness, motivated self-interest, concern about legislation, marketing opportunity, or altruism. The net effect will be a return to a landscape that maintains critical ecological function and provides a greater measure of support for agricultural operations. Cows and Fish builds a cumulative body of knowledge regarding how riparian systems function and link us, how watersheds work, the vital signs of landscape health, the essentials of how people need to work together, how solutions need to benefit us all, and the kinds of information that will enable us to restore or maintain natural systems and build ecologically resilient communities and economies.

CONCLUSION

Concerns about riparian areas in Alberta began over fisheries issues. The more the microscope focussed on this seemingly insignificant landscape, the greater our understanding has become about the disproportionate importance of riparian areas. Issues of biodiversity, economics, and water quality now crowd the media; all relate to landscape use, especially use of riparian areas. Long-lasting solutions will have to engender a thoughtful application of initiatives that are accepted and effective at a community level. Inevitably, this is where we will succeed or fail, based on approach.

PRAIRIE TIGER BEETLES: THE MOST PROTECTABLE OF ALL INSECTS

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Abstract: Tiger beetles are of concern in insect conservation efforts, but their importance in this field is far out of proportion to their relatively low taxonomic diversity. Some of the features reputedly responsible for this phenomenon include their colourful appearance, relatively large body size, and popularity with traditional collectors. Their propensities for subspecific endemism in habitats that form ecological islands, along with a growing trend in tiger beetle protection, make them defensible, manageable units in conservation biology. The Canadian grasslands provide a number of good candidates for conservation efforts, many of which involve uniquely Canadian taxa.

STRATEGIES FOR SURVIVAL: PERSISTENCE OF THE MOTH-YUCCA MUTUALISM AT THE NORTHERN EDGE OF RANGE

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Abstract: The threatened soapweed *(Yucca glauca)* and its endangered pollinator, the yucca moth *(Tegeticula yuccasella)*, exist in two small populations at the northern periphery of their ranges in southeastern Alberta. These two species engage in a mutualistic relationship and cannot survive without each other over the long term: moth larvae only feed on yucca seeds, and yuccas can only produce seed if flowers are pollinated by yucca moths. Such a relationship is presumed risky at range edges because neither moth emergence, nor flowering can be ensured in any particular flowering/emergence season. Elements of moth and plant population dynamics and behaviour were studied in Alberta and northern Montana to determine how both species and their interaction persist in the face of unpredictability and low partner densities. Results indicate that despite northern yucca moths occurring in lower densities than in other locations, they have less egg mortality. Furthermore, yucca fruit produce similar numbers of larvae relative to more southern sites. Preliminary investigations suggest that moths may have evolved a unique behavioural strategy that reduces ovule damage via oviposition and subsequently enhances their survival at the periphery of their ranges. Despite high variability and low population densities, the mutualism between yuccas and yucca moths remains strong at the northern periphery of their ranges, and peripheral populations are not necessarily in decline.

SEEING PRAIRIES THROUGH BUG EYES: BIODIVERSITY REVEALS HOT SPOTS AND COOL PLACES

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Abstract: The Canadian plains fauna consists of more than 226 species of grassland-endemic leafhoppers and related insects ("short-horned" bugs or Homoptera-Auchenorrhyncha). Sampling at more than 350 native prairie sites confirms two biotic provinces: (1) fire-maintained prairie, characterized by 39 endemic species, and (2) drought-maintained steppe, characterized by 34 generally distributed species. Each of these biotic provinces has two distinctive faunal subdivisions. Canadian steppe has the greatest biodiversity in the driest sites, with a smaller fauna on moist regions around the periphery of the grassland and fewer, widely distributed insects between these areas. The fauna of true tall grass prairie (comparable to that of the eastern Dakotas and southern Minnesota) occurs south and west of Lake Manitoba, while the interlake district and Red River valley have a fauna characteristic of oak savanna in Wisconsin. The Qu'Appelle coulee has a mixed fauna connecting all four biotic regions, with a "hot spot" (maximum biodiversity) where it meets the canyon of the South Saskatchewan. Steep slopes, such as those of coulees, maximized diverse habitats, but even slight slopes and ditches along railway grades increase floral and faunal diversity. Land between abandoned railway grades and roads (if not frequently burned) could be utilized as wildlife corridors to connect refugia, thus increasing the effective extent of native grasslands.

INTRODUCTION

The Canadian plains are best known as the semi-arid mixed-grass prairie of which more than 33,000 km^2 still exists in Saskatchewan (Samson et al. 1998). More arid grasslands also lie across extensive areas of Alberta. Most of the existing unplowed plains grasslands are west of 104°W (Coupland 1973). By contrast, less than 0.05% of the original eastern tall grass prairies of North America remain (Samson et al. 1998), and these have been reduced to tiny fragments in Manitoba (Joyce 1989). Where the prairies meet aspen parkland, prairie boundaries become almost wholly conjectural due to expansion of aspen groves over the last century with the suppression of wildfires. Attempts to define ecoregions by unique or endemic biota (Ricketts et al. 1999) lack sufficient data from Canada, with the result that our Great Plains ecosystems are defined almost entirely by substrate type (Wiken 1986).

What is needed to define the ecoregion is some measure of endemism that is little influenced by drought and fire, can survive in a highly fragmented landscape and yet have enough biodiversity to reveal patterns of wide-ranging significance. Insects are abundant enough to be well represented in samples, highly diverse on grasslands, and well studied to reveal actual species ranges, microclimate influences, and host associations. These criteria are fulfilled best by leafhoppers (family Cicadellidae). Collecting these insects also yields many other insects allied to leafhoppers, including cicadas (Cicadidae), spittlebugs (Cercopidae), treehoppers (Membracidae), and planthoppers (Fulgoroidea), and these are also included in this study. These insects (Homoptera-Auchenorrhyncha) are collectively known as "short-horned bugs" because they have unusually tiny antennae. They are by far the most species-rich group of organisms endemic to northern grasslands (Ricketts et al. 1999). Many species of leafhoppers appear to spread very slowly (Hamilton 1999) and cannot invade grassland patches separated by only a few kilometres, yet they can survive on tiny sites even in urban environments. They are, therefore, ideal for characterizing pre-settlement grasslands based on remnant habitats.

Leafhoppers and their relatives are so abundant and diverse on the Canadian plains that four to five grassland-endemic species per site must be considered a minimal representation from a single sampling. Since short-horned bugs often occur in either early or late summer (June or August), but seldom in both months, sampling is most efficient in July when portions of both early- and late-season species are present. Nevertheless, sampling twice during the year should nearly double the known fauna at any one site, and continuous sampling with pan traps is more efficient yet.

More than 350 sampling sites on the Canadian plains (Figure 1) have yielded 226 species that are endemic to Canadian grasslands (Hamilton, in press). These sites provide abundant evidence of native ecological areas on the Canadian plains, and at a local level, reveal unexpected biodiversity "hot spots" and areas of particular significance to conservation efforts and popular interest that might be termed "cool places".

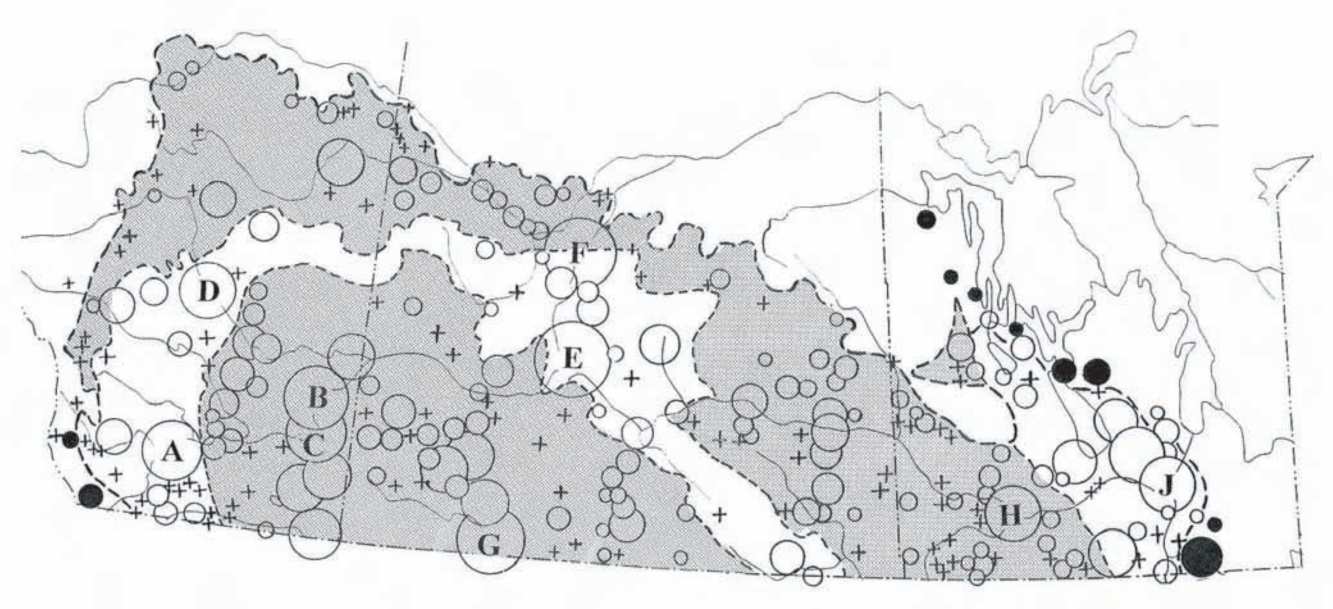

Figure 1. Sites where short-horned bugs have been found on the Canadian plains. Circles are proportionate to the number of grassland-endemic bug species within 10 km of each site, while crosses indicate fewer than four species present. The sites (open circles) are superimposed on aspen parkland (shaded, upper) and mixed grassland ecoregions (shaded, lower); filled circles represent grassland faunas outside Prairie Ecozone boundary. Areas with maximum biodiversity are lettered: A, Lethbridge; B, CFB Suffield; C, Medicine Hat; D, Drumheller; E, Elbow; F, Saskatoon; G, Grasslands National Park; H, Spruce Woods; and J, Winnipeg.

HOT SPOTS

At present, there is an average of 11 grassland-endemic bug species per site in Canada, which is considered a good representation of species from a single sampling in native grasslands (Hamilton 1995). Sampling twice or more nearly doubles the number of endemic species captured. Thus, a well-collected site with moderate floral diversity should yield at least 20 grassland-endemic bug species or about 10% of the entire Canadian plains fauna. A site with high floral diversity, or encompassing a variety of habitats, should have twice this fauna. Grasslands around Drumheller and Onefour, Alberta have at least 40 grassland-endemic species each, while those around Medicine Hat and Lethbridge, Alberta and Winnipeg, Manitoba have yielded 47 or 48 species each. A site with more than 60 species may be considered a biodiversity "hot spot". The best-managed sites on the Canadian plains are CFB Suffield with 66 species and Grasslands National Park with 70 species. Saskatoon had 78 species 40 years ago, but whether this fauna survives urbanization of the district remains unknown. By far, the richest and least disturbed site is Elbow, Saskatchewan with 86 species. Extensive grasslands existed between the Gardiner and Qu'Appelle dams and east as far as Highway 627 (Coupland 1973). This area is surely deserving of urgent consideration for conservation action.

Overall, short-horned bug faunas are readily divisible into those of fire-maintained prairie and drought-maintained steppe (Hamilton, in press). Canadian steppe has the greatest biodiversity in the driest sites, with a smaller fauna on moist regions around the periphery of the grassland and fewer, more widely distributed insects between these areas. The Qu'Appelle coulee has a mixed fauna connecting east and west, with its maximum biodiversity where it meets the canyon of the South Saskatchewan.

COOL PLACES

Steep slopes such as those of coulees maximize diverse habitats. Arid bluffs on the South Saskatchewan-Qu'Appelle-Assiniboine valley system still maintain a native flora and fauna, contain some of the easternmost and westernmost records resulting from faunal exchanges, and are visually appealing. Native vegetation may be found from Highway 47 west of Crooked Lake to Highway 637 east of Round Lake, Saskatchewan; another equivalent area eastwards exists at the Spy Hill Natural Area (Coupland 1973). These areas ought to be high priority for conservation.

Even slight slopes and ditches can increase floral and faunal diversity. A roadside cutting through rolling fields five kilometres west of Stockholm, Saskatchewan has an impressive array of prairie grasses, mostly little bluestem *(Schizachyrium)*, but also big bluestem *(Andropogon)*, needle grass *(Stipa)*, wheatgrass *(Agropyron)*, alkali grass *(Distichlis)*, and even some prairie dropseed *(Sporobolus)*. This site has the largest bug fauna in Saskatchewan typical of tall grass prairie.

The greatest insect diversity from a small site is from Grosse Isle, Manitoba. This narrow site lies mainly between the railway and the road yet has 35 grassland-endemic species. Another small site with unexpected insect diversity is an even narrower roadside and ditch five kilometres west of Morden, Manitoba with 25 grassland-endemic bugs. Thus, it appears that even very narrow strips of land such as those between abandoned railway grades and roads could connect refugia by wildlife corridors and, if burned only infrequently, support a diverse fauna, thus increasing the effective extent of native grasslands.

Most of the managed prairies in Manitoba are on very rocky or sandy soil because these were considered marginal for farmland. The most extensive grasslands with well-represented insect biotas are around Spruce Woods Forest Reserve and CFB Shilo near the Assiniboine River. These sites are on the delta of Glacial Lake Agassiz and represent the eastern terminus of the South Saskatchewan-Qu'Appelle-Assiniboine coulee flora and fauna.

Tall grass prairie in Manitoba is best represented across two square miles of land along Highway 411 in Lake Francis Wildlife Management Area at the southeastern end of Lake Manitoba. The insect fauna of this interlake grassland is even richer than tall grass sites between Tolstoi and Gardenton in southern Manitoba. The insect fauna of both these areas, however, indicates that they were originally oak savanna, comparable to such sites in Wisconsin. True tall grass prairie, comparable to that of the Dakotas, is now limited to very small sites west of Lake Manitoba. Perhaps the most extensive remaining site along a main thoroughfare is on Highway 10 west of Dauphin. The site runs from "Crocus Hill", a World Wildlife Fund-designated site 16 km north of Ashville, 6 km south to rural municipality-owned land on the east side of Brokenpipe Lake where there is a picturesque abandoned homestead. The intervening land is under private ownership but appears not to have been plowed.

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TRENDS IN ABUNDANCE AND DISTRIBUTION OF RARE ORTHOPTERA OF THE CANADIAN PRAIRIES

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Abstract: Dry conditions on western Canadian grasslands since 1999 have strongly influenced the distribution and abundance of Orthoptera. Insects in this order are known for great shifts in population abundance. Changes in range and species composition are also apparent if sampling and collection programs span decades, rather than months or years. Rarity during a short interval is insufficient cause to support conservation or even concern. Some species, especially spur-throated and band-winged grasshoppers, increase during the dry years. However, some species, such as the large-headed grasshopper, increase under moist conditions usually because of food plant associations. Species such as Bruner's spur-throated grasshopper, normally not a pest grasshopper but often confused with the lesser migratory grasshopper, have gone from rare status to widespread with record population explosions within the past five years. The present outbreak of the clear-winged grasshopper in east-central Alberta was preceded by years in which this grasshopper was difficult to find. Some previously rare species, such as the greenish-white sage grasshopper have been rare in Canada for decades and remain so (confirmed by annual collections). Other sage-associated species of short-horned grasshoppers and some previously rare katydids have increased between 10 and 100 fold. Several species have been photographed for the first time in history. A summary of these changes will be presented.

BACKGROUND

Grasshoppers and their allies (Orthoptera) are important components of grassland ecosystems, mainly because of their active roles in food webs, but also because of the periodic devastation to agricultural and native plants that has accompanied increases in the abundance of certain Orthopteran species, primarily the Acrididae. Because of their feeding rates and preferences, varying from generalist to obligate dependencies, Orthoptera distribution and abundance are often linked to vegetation type. Orthopteran diversity reflects not only the plant community and condition, but it also serves as an indicator of ecosystem health and long-term trends. The general sensitivity of Orthopteran abundance to environmental and biophysical variables means that their community composition and population dynamics reflect trends in weather, climate, and soil (Johnson and Worobec 1988; Johnson 1989). While grasshoppers are capable of making small individual behavioural adjustments to microclimate (Lactin and Johnson 1998), their populations are generally strongly influenced by weather over one generation.

Orthoptera of the Canadian Prairies include numerous short-horned grasshoppers, a smaller number of long-horned grasshoppers (katydids, bush crickets, and tree crickets), some relatively rare pygmy grasshoppers, several true crickets, and camel crickets. Some families and subfamilies of North American Orthoptera do not occur in Canada, such as the silent slant-faced grasshoppers (Acridinae) and lubber grasshoppers (Romaleidae).

Some Orthoptera are restricted to particular habitats, contributing to their US designation as species at risk, though they are not yet listed in Canada. For example, the Zayante band-winged grasshopper *(Trimerotropis infantilis)* was listed as Endangered in the US (1997). This species is found only in the Zayante sand hills of the Santa Cruz Mountains (Rentz and Weissman 1984), where sand mining and urban development threaten the species. We have few endemic species in Canada, but many are rare or largely restricted to local features, such as the greenish-white grasshopper *(Hypochlora alba)* in the Big Muddy Badlands or the montane grasshoppers in the Cypress Hills. The band-winged grasshoppers *(Trimerotropis campestrisl* and *T. agrestis)* are rare in most settings, but common in the Great Sand Hills of Saskatchewan. The alkaline pallid-winged grasshopper *(Trimerotropis pallidipennis salina)* is rare everywhere except on salt flats, which may seem to produce them in sudden clouds of salty, papery wings.

Species richness of the Orthoptera on Canadian grasslands varies widely according to habitat and vegetation diversity. Crops and pastures typically have 10 to 15 species of Orthoptera compared to much greater species richness in undisturbed semi-native grassland such as Suffield National Wildlife Area, which has typically 25 to 40 species at a single location. Landscape and vegetation diversity (such as dunes) adds some rare or specialized Orthoptera species to the lists. Two three-day weekends of day and night collecting in the Great Sand Hills of Saskatchewan during August and September 2003 yielded voucher specimens of a surprising 58 species of Orthoptera (Johnson and Olson, unpubl. data). Climate change may eventually result in range extensions into the Canadian Prairies by species of Orthoptera found in the US. For example, the differential grasshopper *(Melanoplus differentialis)* can be expected to breed and survive in Canada under warming scenarios.

Anyone who lived during the 1930s, the early 1960s, the mid-1980s, or even the last few years knows that pest grasshoppers seem to thrive during periods of low precipitation. All grasshoppers need sufficient heat to complete development, grow, feed, and reproduce, but heat may be in short supply in the north in some years. Grasshoppers do not all react in the same way each year and among regions, largely because of differences among the species of grasshoppers found on the Prairies. In some cases, the effect of weather on grasshoppers is mainly a result of the effect of moisture and heat on insect diseases. Some fungal grasshopper diseases germinate and grow better under cool and moist conditions, while others thrive in warm and moist conditions. Dry weather may thus release grasshoppers from the population limitations of disease, while the return of rain following a long dry spell can make Orthopteran populations crash. This was the case in 1962 and 1977 when the fungus *Entomophaga grylli* caused widespread death among grasshopper infestations. Pathotypes of this disease may affect only a few species of grasshopper and drive some (such as the normally common clear-winged grasshopper, *Camnula pellucida)* to local and regional extinction. Grasshoppers are also attacked by hyphomycete fungi that kill a broader range of species (though these are safe for avian predators and may be developed as control agents; Johnson et al. 2002).

The effects of weather on grasshoppers are also mediated by the effects of weather on the preferred food plant or on the nutritional quality of the plant. For example, the large-headed grasshopper *(Phoetaliotes nebrascensis)* was extremely rare, usually occurring at a rate much lower than 1 per 1,000 grasshoppers, on pastures and rangeland in southern Alberta until the rainy weather of 1992 and 1993. The timing and quantity of rain resulted in exceptional growth of native grasses such as needle-and-thread grass and western wheatgrass. The large-headed grasshopper increased in density up to 100 fold in only 2 years, while some other species declined. The late timing of hatching in the large-headed grasshopper allowed it to avoid the rains. In this case, a previously rare species remained unhatched during the cool, rainy spring, emerged to find an abundance of preferred food plant, and increased dramatically, becoming one of the main grasshoppers found in pastures and grazing reserves in subsequent years.

As part of long-term plans to model community change, I have kept personal and research notes on relative abundance of all species of Orthoptera on the prairies (mainly Alberta) for over 20 years. The summaries presented below briefly describe changes in rare and interesting species during that period. Common species are not discussed here. The key messages are that (1) weather and vegetation strongly influence relative abundance, but not always in the same simple ways, and (2) judging rarity based on only a few years of data would be invalid or unsound at best.

NOTES ON RARE SPECIES

Family Acrididae, subfamily Melanoplinae (spur-throated grasshoppers)

- *Aeoloplides turnbulli* (Thomas), Turnbull's grasshopper (Russian thistle grasshopper in the US)

This stubby, army-green grasshopper feeds on Chenopodiaceae, including winterfat (*Ceratoides lanata*), Kochia (*Kochia scoparia*), and Russian thistle (*Salsola kali*). It was very rare in Alberta and Saskatchewan until about 2000, after which there may have been weather-related increases in its food plants.

- *Hypochlora alba* (G.M. Dodge), greenish-white grasshopper (cudweed grasshopper in the US)

This grasshopper occurs mainly in the dry mixed-grass zone on the Saskatchewan-US border, where it feeds on prairie sage *(Artemisia ludoviciana)*. In Alberta, the species occurs as less than one in one million individuals. I have only a half dozen specimens, which means it is very rare.

- *Melanoplus alpinus* Scudder, alpine grasshopper

This easily recognizable species (large and distinctive staghorn male cerci) was widely collected across Alberta and Saskatchewan during cooler, moister times in the mid-1900s. Now confined to small zones of fescue in the foothills of the Rocky Mountains, the species is found in very low numbers. I have also collected it in the Cypress Hills, where it is rare. *M. alpinus* may be confused with the much smaller *M. infantilis* when using keys.

- *Melanoplus angustipennis* (G.M. Dodge), narrow-winged grasshopper
- *Melanoplus bowditchi canus* Hebard, sagebrush grasshopper

These two species are very rare in Alberta, and in Saskatchewan they occur only in limited sandy patches with pasture sage *(Artemisia frigida)*, where the sage can be quite dense. They are normally found in very low densities, if found at all. However, I have seen small patches with several mating pairs per sagebush but no other conspecifics for hundreds of kilometers. These species are common in the Great Sand Hills of Saskatchewan, while beating the vegetation in the Oldman River valley near Lethbridge for hours might yield only a few. The effort is well-rewarded as the sagebrush grasshopper mimics the colour and physics of a dry sage leaf flicking off a plant and then remaining still.

- *Melanoplus bruneri* Scudder, Bruner's spur-throated grasshopper

This species was rare until 1984-1988, when it increased in montane, fescue, and boreal ecoregions, and again in 1999-2003, when populations greatly increased in BC grasslands, along the eastern slopes of the Rocky Mountains, and near the Swan Hills of Alberta. An outbreak near Edmonton shows bright red on the forecast map this year, but needs to be differentiated from the more damaging pest species in other regions. This species feeds readily on alfalfa, canola, and other broad-leafed plants. It has the unusual trait of also feeding on pine needles, possibly sharing the strong detoxification system of the two-striped grasshopper (*M. bivittatus*; Majak et al. 1998; Johnson et al. 2001).

- *Melanoplus dawsoni* (Scudder), Dawson's grasshopper

Dawson's grasshopper is often the most common grasshopper in fescue grassland, recognized by its short, stubby wings and yellow underside. There is a rare long-winged form that could not be found between 1991 and 1999, and I found only four between 2000 and 2003 (out of a few thousands seen closely enough to identify).

- *Melanoplus femurrubrum* (DeGeer), red-legged grasshopper

This species is common in eastern Canada and in the US where it is a pest of corn and other crops. Virtually absent from the dry portions of the Canadian prairies between about 1980 and 1992, the red-legged grasshopper slowly increased in numbers during subsequent years with adequate precipitation. The species was common until the current drought (2000-2004), when it concentrated in spots of lusher vegetation, such as around Pakowki Lake, river valleys, roadside brome grass, irrigated fields, hedgerows, and windbreaks.

- *Melanoplus gladstoni* Scudder, Gladston's grasshopper

Gladston's grasshopper is a short, broad melanopline grasshopper flecked with gray and white. It is relatively common during years with adequate rainfall but becomes rare during drought. It emerges late in the summer and could avoid rainy springs that might limit other species.

- *Melanoplus montanus* (Thomas), montane grasshopper

Like the alpine grasshopper *(M. alpinus)* and the boreal grasshopper *(M. borealis)*, the montane grasshopper was previously found across the Prairies, indicating a cooler, moister climate than we have experienced during the last two decades. This species is currently restricted to higher elevations (where it is doing very well, based on my observations in cooperation with Parks Canada at Yoho, Banff, Jasper, and Waterton Lakes National Parks).

- *Schistocerca emarginata* (Scudder), spotted bird grasshopper

This grasshopper was reported from the prairies in the 1930s and 1940s, but is almost completely absent now.

Family Acrididae, subfamily Gomphocerinae (slant-faced grasshoppers)

- *Bruneria brunnea* (Thomas), Bruner's slant-faced grasshopper

This handsome spur-throated grasshopper (see Johnson 2003) was rare to the point of local extinction in the 1980s and early 1990s, recovering in numbers only after 1997. It became relatively common (> 0.1%) in 2002-2003.

- *Eritettix simplex tricarinatus* (Thomas), velvet-striped grasshopper

This grasshopper went from a common species in the early 1980s to nearly absent for a decade. It then returned to the most common species on south-facing slopes of the Oldman River and South Saskatchewan River valleys during early spring of 2001-2003. Similar to eight other early species, the velvet-striped grasshopper is rare after July.

- *Opeia obscura* (Thomas), obscure grasshopper
- *Phlibostroma quadrimaculatum* (Thomas), four-spotted grasshopper
- *Pseudopomala brachyptera* (Scudder), bunch-grass grasshopper

These three species all increased from rarity to commonness within a ten-year span. The reasons are not clear, but vegetation effects may explain some of the differences. For example, the obscure grasshopper typically occurs on *Stipa-Bouteloua* pastures, yet it will rarely move into other habitats even metres away. These species are all slowly extending their ranges northward. The bunch-grass grasshopper was previously known from the most southern regions of Alberta and Saskatchewan (Vickery and Kevan 1986), but over the last 20 years, the species has been found in roadsides and pastures hundreds of kilometres north despite its inability to fly. This movement may be related to the network of roadside ditches planted with brome grass, which may have acted as corridors.

Family Acrididae, subfamily Oedipodinae (band-winged grasshoppers)

- *Arphia conspersa* Scudder, speckled range-land grasshopper
- *Chortophaga viridifasciata* (Degeer), northern green-striped grasshopper

These two early-season species were rare until around 1998. They are currently very common on the Prairies in March and April. An examination of weather records indicates that their populations did not increase only in years with dry spring weather, but they have generally increased over the past five years, regardless of whether conditions were wet or dry.

- *Cratypedes neglectus* (Thomas), pronotal range grasshopper

This heavy and rugged-looking species has always been rare in upper elevations, and rarer still on the grassland, yet it is easier to find in Saskatchewan than in Alberta for unknown reasons.

- *Derotmema haydenii* (Thomas), Hayden's grasshopper

This small and finely-structured grasshopper occurs in a red-winged and a yellow-winged form. Both forms were rare before 1990 and nearly extinct between 1990 and 1997. The species reappeared in both forms on the Milk River

Ridge, at Drumheller, and in native range in southwestern Saskatchewan concurrently in 2001 and is now easy to find in these locations. I have no explanation, other than that Hayden's grasshopper might be very susceptible to the diseases that kill other band-winged grasshoppers, such as *Entomophaga grylli* pathotype 1.

- *Encoptolophus costalis* (Scudder), western clouded grasshopper or dusky grasshopper

This band-winged grasshopper was one of the most common grasshoppers in southern Saskatchewan and Alberta in the 1970s but disappeared around 1984 when conditions were dry and hot. It has been rare during every dry period since and more common during years with significant rain. In 2002, very high densities of this grasshopper followed a single year with heavy June rains in the southern swath that received the rain.

- *Hadrotettix trifasciatus* (Say), three-banded range grasshopper

This large and colourful banded-winged grasshopper has always been uncommon on the Canadian Prairies and remains so (which is unfortunate, given its beauty and interesting mating behaviour).

- *Stethophyma lineatum* (Scudder), striped sedge grasshopper

The sedge grasshoppers are restricted to bogs in more northern zones, for example near Rocky Mountain House, Fort Assiniboine, and the boreal transition zone of Saskatchewan (Prince Albert).

Family Tetrigidae (pygmy grasshoppers)

- *Tetrix ornata* (Say), ornate grouse-grasshopper
- *Tetrix subulata* (Linnaeus), granulated grouse grasshopper

The grouse grasshoppers are rare, but they seem especially rare because they are small, do not fly, are restricted to moist zones, and have unusual life cycles. In March 1975, I collected and identified, with Bob Randell's assistance, *Tetrix subulata* from the surface of snow in Saskatoon.

Family Tettigoniidae (long-horned grasshoppers, bush crickets, and katydids)

Subfamily Conocephalinae (meadow katydids)

- *Conocephalus fasciatus* (De Geer 1773), slender meadow katydid
- *Conocephalus saltans* (Scudder 1871), prairie meadow katydid
- *Orchelimum gladiator* Bruner 1891, gladiator meadow katydid

These small katydids are normally found in dense, moist vegetation and have been rare or restricted until recently. Their numbers have increased in roadside smooth brome, and I have recorded several northern range extensions in the last seven years.

Subfamily Phaneropterinae (false katydids)

- *Scudderia pistillata* Brunner 1878, broad-winged bush katydid

On the Canadian Prairies, this large, attractive, leaf-like katydid was found in small numbers in the early part of the century, almost unknown during the last 20 or 30 years, and then suddenly rare again 2001-2003. I found a dozen in 2003 compared to only one during 1985-1995. Individuals hide in vegetation and are hard to locate, except by following their quiet and scratchy sparrow-like call. (I suspect that the grasshopper sparrow and its grasshopper-like call were so named after either a katydid or a slant-faced grasshopper.) When disturbed, the broad-winged bush katydid may suddenly fly up like an ungainly flapping leaf.

Subfamily Tettigoniinae (shield-backed katydids)

This subfamily is well-known for the Mormon cricket *(Anabrus simplex)*, a formerly uncommon species that became very common during 1985-1986 and 2001-2003. *Steiroxys trilineata* (Thomas 1870) has no common name (I might suggest the fescue bush cricket), but it is currently the most interesting rare Orthopteran on the prairies, in my opinion. The population was thought to be limited to very old records in southwestern Alberta and a few US states. In 2003, I found individuals in both sides of the Cypress Hills, extending the eastern range to Saskatchewan. In 2000-2003, I found the species along the foothills as far north as Calgary, extending the northern range. I compared my specimens to museum specimens (including at the Canadian National Collection in Ottawa) and found that some of my specimens might be a new species, based in part on the unusual square notch in the female subgenital plate. I sent a photograph of the living specimen to Tettigoniidae authority Thomas Walker, who noted that before this photo was available the only known image was a hand drawing from the 1940s. This illustrates that progress can still be made studying biodiversity in our area.

Family Gryllidae (crickets)

Subfamily Nemobiinae ground crickets

- *Allonemobius fasciatus* (De Geer 1773), striped ground cricket

This small, rusty-coloured cricket is hard to find and restricted to moist spots. I have seen this species only a few times.

- *Allonemobius griseus* (E. Walker 1904), gray ground cricket

Although this species should be collected in pitfall traps as far north as Edmonton, it is rarely found.

Subfamily Oecanthinae (tree crickets)

- *Oecanthus quadripunctatus* Beutenmuller 1894, four-spotted tree cricket

The four-spotted tree cricket was relatively rare for a decade, but its piercing call in summer evenings (and often during the day) makes it hard to miss now. Look, and listen, after dark on bushes in well-vegetated areas such as riparian zones. Four-spotted tree crickets can be photographed with a flash. I was surprised to catch one black-horned tree cricket (*Oecanthus nigricornis* F. Walker 1869) in 2003. Normally, this species is found in eastern Canada and the US.

Family Gryllacrididae (camel crickets)

A number of *Ceuthophilus* species are found on the prairies, but they often inhabit special container environments, such as basements, old tires, and animal burrows. I found a male-female pair sitting at the bottom of a deep hole in a grave at the Etzikom cemetery (as I was reaching for a black widow spider). I am seeking information on camel cricket specimens; you can contribute information at www.uleth.ca/~dan.johnson. I will pay shipping and postage!

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RECOVERY AND STEWARDSHIP OF WESTERN BLUE FLAG – A COMMUNITY-BASED APPROACH FOR MANAGING A THREATENED SPECIES

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Abstract: The western blue flag *(Iris missouriensis)* is an attractive flowering plant with a Canadian range limited to a small portion of the foothills of southwestern Alberta. It is a COSEWIC Threatened species and has been approved for legislation as Threatened under Alberta's *Wildlife Act*. Following the *Accord for the Protection of Species at Risk in Canada*, Alberta Fish and Wildlife is responsible for preparing the national recovery plan as the total Canadian population of western blue flag is in this province. The Western Blue Flag Maintenance and Recovery Program is a cooperative, voluntary conservation initiative addressing the needs of this Threatened species in the context of a landscape and the people living on that landscape. This presentation describes the history leading up to formation of the Canada Western Blue Flag Maintenance/Recovery Team and the composition of the team and its basic principles. The recovery plan content, major recommendations, plan implementation, stewardship, and ongoing monitoring are also outlined. Details on the stewardship activities and monitoring plan are emphasized.

BACKGROUND

Alberta contains the only known populations of western blue flag *(Iris missouriensis)* in Canada. The species is restricted to a small area (300 km^2) in southwestern Alberta near Carway and was reported in 2003 at two additional sites, one in Calgary and one in Fort Macleod. Western blue flag is a long-lived perennial that is a member of the Iris family. The plant is 30-60 cm tall, with pale blue-green sword-like leaves that are 10-40 cm long, 5-10 mm wide, and are folded lengthwise. In Alberta, flowers generally appear between mid-June and mid-July, usually on leafless stems (Alberta Environmental Protection 1998). Western blue flag prefers sites where abundant spring and early summer moisture is present, but which dry out later in the season. It is normally found on level or slightly sloping ground with abundant subsurface moisture and commonly grows at the edges of wet meadows or seepage springs. This species can also appear near willow thickets in moist depressions. Light to moderate grazing may be beneficial to maintaining western blue flag (Ernst 2002).

Due to its restricted range and low number of occurrences, western blue flag has been listed as Threatened by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) since 1990. In 2000, COSEWIC reviewed the status of western blue flag in Canada and upheld its classification; in 2001, Alberta's Minister of Sustainable Resource Development approved western blue flag to be legislated as a Threatened species under Alberta's *Wildlife Act*. These actions stimulated the initiation of the recovery process for western blue flag.

WESTERN BLUE FLAG MAINTENANCE AND RECOVERY TEAM

A committee comprised of landowners, resource managers, and various stakeholders, known as the Western Blue Flag Maintenance/Recovery Team was assembled in September 2001 to prepare a Provincial Recovery Plan for western blue flag. The team is comprised of five Cardston area ranchers, five representative stakeholders (Alberta Beef Producers [formerly the Alberta Cattle Commission], Alberta Conservation Association, Alberta Native Plant Council, Lethbridge Naturalists' Society, and Society for Range Management), and two government departments (Alberta Fish and Wildlife Division and Alberta Parks and Protected Areas). Their goal was to develop a plan that would encourage range/habitat management to ensure the long-term maintenance of the naturally occurring populations of western blue flag in Canada through the cooperation and voluntary participation of landowners.

WESTERN BLUE FLAG MAINTENANCE AND RECOVERY PLAN

Recovery Plan Approval

The *Maintenance and Recovery Plan for Western Blue Flag in Canada* was provided to the Alberta Endangered Species Conservation Committee (ESCC) in February 2002. On March 26, 2002 the ESCC recommended to the Minister of Sustainable Resource Development that the recovery plan be approved, and on April 18, 2002 Hon. Mike Cardinal approved the plan submitted by the

Maintenance/Recovery Team as the Alberta Recovery Plan for western blue flag.

In late spring 2002, Alberta Fish and Wildlife requested Environment Canada to accept the Provincial Recovery Plan as the National Recovery Plan for western blue flag. This designation was delayed due to the process surrounding approval of the federal *Species at Risk Act* (SARA). SARA requires a national recovery plan for all Threatened species by June 2007. The Provincial Recovery Plan for western blue flag was subsequently resubmitted to Environment Canada in July 2003 and is currently under review for approval as the National Recovery Plan for the species. Amendments to the plan may require the Western Blue Flag Maintenance/Recovery Team to reconvene.

Recovery Plan Overview

The maintenance and recovery plan for western blue flag is comprised of two sections. The maintenance/recovery strategy outlines the principles, goals, and objectives of the plan and describes the current status, limiting factors, and general recommendations for management of western blue flag. The action plan identifies the specific activities to be initiated for the management and maintenance of western blue flag and provides a schedule of when they are to be done and by whom. The recovery plan has a designated five-year life, after which time it will be reviewed by the Maintenance/Recovery Team.

To ensure the long-term maintenance of the naturally occurring population of western blue flag in Canada, several specific objectives were identified (Canada Western Blue Flag Maintenance/Recovery Team 2002):

- To identify and initiate appropriate management activities for western blue flag,
- To implement an ongoing inventory and monitoring program for western blue flag,
- To identify approximate minimum and maximum population objectives as ± 20% of current stem numbers for each naturally occurring western blue flag site,
- To recommend effective criteria for regulations that protect western blue flag and respect private landowners rights,
- To provide information to the Alberta Endangered Species Conservation Committee for an update of species management status,
- To develop, communicate, and encourage general principles for grazing management of western blue flag,
- To identify and act upon any government policy changes that may be necessary for the long-term sustainability of western blue flag,
- To develop a range/habitat management plan for each landowner with western blue flag sites and encourage implementation of specific recommendations to maintain western blue flag,
- To assist landowners through provision of various improvements that enable them to manage their land in a manner which sustains western blue flag, and
- To provide education on management of this species and other species at risk.

WESTERN BLUE FLAG INVENTORY AND MONITORING

Inventories in 2000 and 2001 identified 11 known naturally occurring western blue flag sites in Alberta with a population estimate of 14,757 stems. In 2002, four additional landowners agreed to participate in the Western Blue Flag Conservation Program. An inventory of the new sites was completed and the landowners agreed to subsequent monitoring. The stem count following the 2002 inventory was 59,200 at 13 sites located in a 300-km^2 area south of Cardston (Ernst 2002). Western blue flag was also reported in 2003 at two additional sites, one in Calgary and one in Fort Macleod. This discovery is significant since both sites are located outside the species' previously known range. The Canadian portion of the western blue flag population is currently estimated as approximately 73,000 stems at 19 sites.

A monitoring protocol for western blue flag was initiated in 2002 and repeated in 2003 (see Ernst 2003). Monitoring plots were established on each site to facilitate tracking the abundance and distribution of western blue flag populations and to monitor the vigour of the plant over time. Monitoring plot data in 2003 showed an overall increase in total stems and flowering/fruiting stems from 2002, although some sites showed marginal decreases. Site trends must be monitored over several years, with environmental conditions taken into consideration, before they can be fully understood.

STEWARDSHIP ACTIVITIES

Range Management Plans and Ranch Improvements

A total of eight landowners that have western blue flag on their land have taken advantage of the Western Blue Flag Conservation Program. The program contracts the services of an independent range consultant to complete a range inventory of all property held by the participant and to consult with the landowner on ways to improve ranch management. The consultant then produces a range management plan, which also includes recommendations for ranch improvements to benefit western blue flag and prairie conservation. Range management plans were completed for all eight participating landowners; however, the implementation of management recommendations has not yet occurred for the two newest participants. Four additional landowners were contacted, though none of them have chosen to participate in the program to date.

Through discussions between the Alberta Conservation Association and participating landowners, partner funding for several improvements has been arranged through the Western Blue Flag Conservation Program. Five ranchers have taken advantage of this aspect of the program through the development or improvement of watering facilities, fence improvements and installations, and the use of tame pasture seed for pasture renovation.

PROGRAM EVALUATION

Rangeland Conservation Service Ltd. prepared a report titled *Program Evaluation and Monitoring Plan for the Western Blue Flag Conservation Program* during the spring of 2003. The report reviewed the inventory and monitoring protocol for western blue flag and introduced a monitoring process to evaluate the success of range management plans and subsequent improvements in achieving the desired objectives of conservation of the species and native prairie in general.

A landowner questionnaire was developed for the participants in the Western Blue Flag Conservation Program. The questionnaire was designed to gather information on previous and current land uses, grazing systems, and stocking rates to provide an evaluation of the newly implemented management recommendations and their overall effectiveness pertaining to the objectives of maintaining western blue flag and improving range condition. During the winter of 2003-2004, several landowner meetings were held to review the individual results of the questionnaire. Although ranch improvements and management recommendations had only been implemented for one full season, landowners expressed positive feedback as a result of their involvement with the program. Improved range condition and slight increases in the number of western blue flag plants were noted, and generally all landowners felt they had benefited significantly simply from their increased knowledge gained as a result of the independent range consultants' work.

FUTURE MANAGEMENT AND RECOMMENDATIONS

- Alberta Fish and Wildlife Division will continue to encourage Environment Canada to endorse the *Maintenance and Recovery Plan for Western Blue Flag (Iris missouriensis) in Canada* as the National Recovery Plan for the species. The maintenance/recovery team will be involved in drafting any amendments.
- Alberta regulations for western blue flag have been developed in draft format and will be conveyed through the process for ministerial approval.
- The Scientific Subcommittee of the Alberta Endangered Species Conservation Committee has been provided with the latest inventory information for western blue flag and has been asked to review the species status.
- Inventory and monitoring activities identified in the recovery plan will continue in 2004.
- Range management plans will be offered to new western blue flag landowners on a first-come priority basis as funds allow. Partnering with landowners on ranch improvements that improve management of western blue flag and prairie conservation will also occur as funds allow.
- The program monitoring outlined in the *Program Evaluation and Monitoring Plan for the Western Blue Flag Conservation Program* report will be implemented to provide tracking of management changes and the effects of those changes on western blue flag. This will provide a system to evaluate effectiveness of the cooperative voluntary involvement of landowners as opposed to the use of mechanisms such as legal agreements.

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ENHANCING POLLINATION OF THE ENDANGERED WESTERN PRAIRIE FRINGED ORCHID, *PLATANTHERA PRAECLARA* (SHEVIAK AND BOWLES), ON THE MANITOBA TALL GRASS PRAIRIE PRESERVE IN SOUTHEASTERN MANITOBA.

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Abstract: The floral structure of the western prairie fringed orchid (*Platanthera praeclara* Sheviak and Bowles) limits pollinators to Sphingidae (hawkmoths) that possess a long proboscis. Under natural conditions, rates of seed capsule development are extremely low. Ultraviolet lights are used to lure pollinators from surrounding areas to increase their feeding activity among the orchids.

BACKGROUND

In the United States, there are several small populations of the western prairie fringed orchid *(Platanthera praeclara)* in North Dakota, South Dakota, Minnesota, Nebraska, and Iowa (Sheviak and Bowles 1986; Bray and Wilson 1992; US Fish and Wildlife Service 1996). The only known location in Canada is found within remnant tall grass prairie in southeastern Manitoba (Borkowsky 1996). The species was officially documented in Manitoba in 1987 (Catling and Brownell 1987): previously collected specimens were identified as the prairie white fringed orchid (Johnson 1985). A distinction was made between the eastern and western orchids when Sheviak and Bowles (1986) demonstrated that in addition to geographical displacement, the plants also possess different pollination mechanisms and floral characters. These differences are distinctive and suggest that hybridization is unlikely.

The discovery of this perennial orchid and remnant pieces of tall grass prairie habitat led to the formation of the Manitoba Tall Grass Prairie Preserve. The Preserve has been established through the cooperation of a number of partners including the Manitoba Naturalists' Society, Nature Conservancy of Canada, World Wildlife Fund, as well as the provincial and federal governments. The entire orchid population exists within 115 km^2, including agricultural lands such as pastures and cultivated cropland. Since 1993, the Preserve and surrounding area have been surveyed for flowering western prairie fringed orchids. These annual surveys have lead to the discovery of 60 quarter sections of land with flowering orchids, of which 26 quarter sections are a part of the Preserve and protect approximately 90% of the population (Borkowsky, in prep.).

To date, most research on the life history of the western prairie fringed orchid has occurred in the most southern parts of its range in the United States (Pleasants and Moe 1993; Sieg and King 1995; Hof et al. 1999). However, limited evidence indicates that the populations of western prairie fringed orchids in Manitoba and the United States frequently have very poor seed set, and often less than 5% of plants produce viable seed capsules (Sheviak and Bowles 1986; Westwood 1999). This phenomenon of low seed set may be an impediment to maintaining healthy populations in the few remaining areas where the orchid is found. Higher levels of seed production would ensure adequate reproduction over the long term and help maintain core orchid populations.

The floral characteristics indicate a Lepidopteran pollinator method (Faegri and van der Pijl 1971, in Bowles 1983). While the small opening to the nectar spur restricts the position of the moth or butterfly, it increases the likelihood that one or both pollinarium will contact the eyes while feeding on the nectar (Sheviak and Bowles 1986). The length of the nectar spur and position of the pollinaria further reduces the list of potential pollinators to those belonging to the Sphingidae or hawkmoth family. Members of this family possess long tongues that enable them to reach the nectar within the long spur. Few, if any, observations of pollination by the swift-flying hawkmoths have been made in the field (Bowles 1983; Sheviak and Bowles 1986; Pleasant and Moe 1993). At the Preserve, two species of hawkmoths were collected with one to several orchid pollinaria during the flowering periods between 1997 and 1999. These species were identified as *Hyles gallii* (Rottenburg), commonly called the gallium sphinx, and *Sphinx drupiferarum* J.E. Smith, known as the wild cherry sphinx (Westwood and Borkowsky 2004).

The populations of both hawkmoths known to pollinate the western prairie fringed orchid in southern Manitoba could be considered rare to uncommon at the best of times. This study examined a possible method to entice these nectar-seeking moths into fields with western prairie fringed orchids, with the assumption that increased feeding activity will lead to increased pollination and ultimately increased seed capsule production.

METHODS

A series of ultraviolet attractant traps were randomly placed within orchid groupings in four separate tall grass prairie fields within the boundaries of the Preserve, and an additional four control groups were placed in fields sufficiently far away from the treatment fields. These ultraviolet attractant traps were fitted with baffles to prevent moth capture and were operated on alternate nights to allow moths attracted to the traps to fly over the orchids and not be continually attracted to the traps. The traps were placed in the center of the plots with a 60 m radius (11.3 ha). At the onset of flowering period, all flowering orchid stems were uniquely identified and their specific locations recorded. The orchids were revisited each week to document flower condition and presence or absence of the pollinaria for each flower within the inflorescence. In early August, all plants were relocated and checked for the development of seed capsules. Pollination success was identified by the presence of a seed capsule, and this was compared between the plots with ultraviolet attractant traps and the control groups.

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NATIVE GRASSLANDS OF THE PEACE RIVER PARKLAND: WHY ARE THEY VALUABLE?

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Abstract: Native grasslands in the Peace Country are valuable from a biological, historical, social, spiritual, and economic viewpoint. Biologically, they support a rich diversity of plants, animals, and insects and are home to disjunct populations of plants and butterflies that are habitat-limited. Since the 1900s, the most extensive land alteration of any parkland region of Alberta has occurred in the Peace Parkland. Less than 1% of the original native grassland uplands remains, and this native grassland is threatened by landuse activities, shrub encroachment, and exotic plant invasion. We must take advantage of current opportunities to study, understand, and conserve the biodiversity of these grasslands before their uniqueness is lost forever.

BACKGROUND

Many people perceive northern Alberta as entirely forested. Although this is true for most of the area, a significant portion of the Peace River region is parkland and thus, in its natural state, is characterized by large, open grasslands with pockets of trees. The Alberta Conservation Association (ACA), with funding from several partners, conducted an inventory of upland native grasslands in the Peace River region of Alberta between 2001 and 2003. The Peace River Parkland is found in the white zone (settled land), and the entire white zone of northwestern Alberta was our study area. Potential sites were located through air-photo interpretation and verified for accuracy through field inspections. We focused on upland native grasslands as these areas had limited previous work and have also been the most impacted and fragmented with less than 0.5% of the original 435,000-1,100,000 hectares of grassland remaining. Although our work was focused on the white zone, 10% of the sites were in the green (forested) or pink (Indian reservation) zones or were of unknown ownership. The land ownership of the sites identified as potential native grassland sites was split between private (41%), crown (54%), mixed (1%), and unknown (4%). Nearly half (46%) of the crown area was under some kind of grazing disposition. Of the 880 potential sites, we were able to verify 50% of these, by either field inspections (82%) or through conversations with landowners (18%).

Perimeter and transect plots were recorded with a GPS for later mapping. Data on plant species diversity and composition, range health, and butterfly occurrence were collected at native sites using established protocols (Robertson and Adams 1990; Adams et al. 2000). During 2003, moth species were also recorded. Plant specimens were collected at locations that would expand the known distribution of the species in Alberta; these data will be used in the upcoming revision of *Flora of Alberta* (Moss 1983). We measured relative abundance of plant species on most sites, with the addition of a more rigorous, transect-based vegetation inventory on 102 sites. A small number of sites were large and covered the majority of the area, but most of the remnants were less than one hectare in size.

VALUE OF NATIVE GRASSLANDS IN THE PEACE

Native grasslands in the Peace River region are valuable from a biological, historical, social, spiritual, and economic viewpoint. Native grasslands are a great place to recreate and popular activities include hiking, photography, bird watching, wildlife watching, picnicking, and wildflower viewing. Grasslands are a place to stop, contemplate, and appreciate their beauty. They are inspiration for poetry, songs, literature, and art. Native grasslands have intrinsic value, containing a diversity of living things. The grasslands were deemed suitable for agriculture because of the soil that supported them. Settlers in the early 1900s concentrated on developing the grasslands, as they were free of trees and easier to cultivate in fulfilment of the homesteading development requirements (Leonard 2000). This development has left the Peace River Parkland as the most fragmented of Alberta's Parkland Natural Regions (Alberta Environmental Protection 1997). Many place names in the region still bear testament to the grasslands or prairie with names like Grande Prairie, High Prairie, Big Prairie, Salt Prairie, Paddle Prairie, John D'Or Prairie, Buffalo Head Prairie, Wilson Prairie, Savage Prairie, Clear Prairie, Little Prairie, Prairie Echo, and Prairie Point. Currently, grasslands provide pasture for livestock, particularly on the south-facing slopes of the Peace River and other drainages. The genetics from the plant material found in the grasslands can also be used to develop native plants for use in reclamation and urban gardening.

Perhaps of greatest interest to this audience is the biological value provided by the native grasslands. The location of remaining grasslands varies, with native grasslands found on river slopes, tops of slopes, upland areas that were too difficult to plow, sandy areas, moist meadows, and areas associated with water. These areas are biologically diverse and are made up of different proportions of plants and animals that live and depend on each other. Three disjunct butterfly populations found in the Peace Parkland (plains skipper, Uhler's arctic, and Alberta arctic) depend on native grasses as a larval food source (Hervieux 2002). In addition, the larval stage of the Pike's Old World swallowtail, a subspecies found only in the Peace region, feeds exclusively upon dragonwort *(Artemisia dracunculus)* growing on the dry, eroding river slopes. Researchers from Alberta Community Development are studying this relationship between the butterfly larvae and plant. There is some question regarding the taxonomy of the Peace River butterfly populations, and butterflies were collected for researchers at the University of Alberta who will be conducting future genetic work. As there is very little information about many moths species, especially in northern Alberta, a number of moth collections were also made during 2003 for University of Alberta researchers. They anticipate more discoveries of moth species that are reliant on native grasslands for survival.

Other animals that make use of native grasslands include snakes that use undisturbed areas for their hibernacula and for foraging. Bison in the Hay-Zama wetland complex graze the grassy meadows. Prairie falcons have been found along the cliffs of the Peace River, and sharp-tailed grouse use grasslands along with associated shrub communities for their mating and dancing sites. The western meadowlark, which is usually found in the southern prairies, is also found in native grasslands of the Peace River region.

Native grasslands in the Peace are home for a number of rare or disjunct plant species. Rare species found during the study included leather grape fern *(Botrychium multifidum)* and Carolina wild geranium *(Geranium carolinianum)*. One of the more notable disjunct plants is the brittle prickly-pear *(Opuntia fragilis)*, as its northernmost recorded location is slightly north of the town of Peace River. Researchers from the University of Alberta, Public Lands and Forests Division, and University of Keele, United Kingdom, are studying the relationships between burning, grazing, and the cactus.

Native grasslands in the Peace River region are described by Moss (1952) as combinations of sedge (*Carex* spp.), wheat grass (*Agropyron* spp.), and needle grass (*Stipa* spp.) communities. Other botanists like Wallis (1982) and Wilkinson (1981) have described these grassland communities in various ways (see Vujnovic and Bentz 2001). This study also observed great variation in the species composition and subsequent plant community classification. Some of the variations include communities dominated by three-flowered avens *(Geum triflorum)*, harebell *(Campanula rotundifolia)*, and northern bedstraw *(Galium boreale)*, to those dominated by grasses like marsh reed grass *(Calamagrostis canadensis)*, intermediate oat grass *(Danthonia intermedia)*, sweet grass *(Hierochloe odorata)*, and western porcupine grass *(Stipa curtiseta)*.

THREATS

Although most upland remnants are in places that are too difficult to cultivate, they still face threats from development (especially roads and housing projects), agronomic plant (especially awnless brome, *Bromus inermis*) and weed invasion, overgrazing, and shrub encroachment.

NEXT STEPS

ACA is working with Alberta Public Lands and Forests Division who are interested in some of the relationships between soils and grasslands found by Wilkinson and Johnson (1983). Public Lands is also setting up long-term monitoring sites to understand grazing effects and management and developing a field guide to plant community classification. ACA is working with other conservation organizations to help landowners conserve, manage, and maintain the integrity of their native remnants.

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RARE ANNUAL PLANTS - PROBLEMS WITH SURVEYS AND ASSESSMENTS

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Abstract: Rare annual plants may have widely fluctuating populations, may or may not have abundant seed banks, are often adapted to disturbances, and may rely on metapopulations for their long-term persistence. These characteristics influence the way we design rare plant surveys, assess their status and threats, and design recovery plans or mitigation. Surveys and assessments should include historical locations, locations with few individuals, and all suitable habitat in close proximity to known populations. Information on seed bank size and viability and dispersal distances is needed to assess the status and potential threats to rare annual plants.

CHARACTERISTICS OF RARE ANNUAL SPECIES

Rare plants typically have few occurrences and may have small populations. These small populations are more susceptible to stochastic events (Primack 2002), often have low pollination rates (Dieringer 1999; Wolf 2001), decreased seed viability or seed production (Watson et al. 1994; Fischer and Matthies 1998; Wolf 2001; Brys et al. 2004), and low genetic variation (Ellstrand and Elam, 1993; Watson et al. 1994; Hackney and McGraw 2001; Primack 2002). The importance of small isolated populations on the long-term persistence of a species depends on how the species reproduces, whether it needs insects to assist in pollination, and the characteristics of the gene pool (Holderegger and Schneller 1994; Schemske et al. 1994; Heschel and Paige 1995; Sipes and Tepedino 1995; Husband and Barrett 1996). Generally, this information is unavailable for plant species at risk in Alberta, many of which are peripheral to core populations. Species-specific information may be found about populations in other jurisdictions, but there is no guarantee that the information will be applicable to peripheral populations as the genetics may be distinctly different (Lesica and Allendorf 1995), nor can one confidently extrapolate from more common species in the same genus (Kunin and Shmida 1997).

Rare annual plants add a layer of complexity to the equation. Annual plants only grow for one year, and the seed stage represents a large portion of the life cycle. Plant numbers often fluctuate widely from year to year depending on the seed production in previous years, germination of seedlings, and environmental conditions (e.g., timing and amount of rainfall) (Primack and Miao 1992; Fischer and Matthies 1998; Harrison et al. 1999; Primack 2002). Annual plants are often adapted to disturbances, such as fire, landslides, grazing, or flooding, and are often out-competed in later successional stages (Watson et al. 1994; Harrison et al. 1999; Hayes and Holl 2003). For example, in Alberta we have found woollyheads *(Psilocarphus elatior)*, smooth boisduvalia *(Boisduvalia glabella)*, and chaffweed *(Anagallis mimina)* only when spring or summer precipitation is sufficient to create ponds in ephemeral prairie wetlands. The wetland area must also be grazed sufficiently such that taller perennial species are kept short and mineral soils are exposed.

Seed Bank

Of the seed produced each year by annual plants, some portion is non-viable, some is lost to seed predators, some form seedlings, and some is stored in the seed bank. Seed bank and germination ecology are especially important to annual plants, but information on them is extremely difficult and time-consuming to gather (Elzinga et al. 1998; McCue and Holstford 1998).

Most annuals have small seeds, and small seeds tend to remain viable longer than large seeds (Guo et al. 1999). However, the seed may or may not persist in the seed bank (Watson et al. 1994), and the seed may be abundant or rare, depending on the species (Guo et al. 1999). The presence of abundant seed in the seed bank influences the genetics and hence the fitness of a population. Seeds germinating from the seed bank are "composed of progeny produced in many generations and represent migration from the past" (McCue and Holtsford 1998). The seed bank may have a broader genetic diversity than the current population of plants and, therefore, may compensate for the harmful consequences of genetic drift or inbreeding that is characteristic of small populations (Ellstrand and Elam 1993; McCue and Holtsford 1998).

Fluctuating Populations

Many annual plant populations vary widely in size from year to year depending on environmental conditions, such as moisture or disturbance. The degree of fluctuation is recognized as an important criterion in assessing the status of animal and plant species at risk (IUCN criteria B and C). For annual plants, fluctuation in plant numbers from year to year can be a substantial risk factor if there is no dormant seed bank, as very small populations at the low point of the fluctuation have a high risk of losing valuable genes or losing entire populations. If, however, only a portion of the seed within the seed bank germinates in a given year then the fluctuating population may not be a serious risk factor. In some cases, what appears to be a local extinction may be simply prolonged seed dormancy (Lesica and Steele 1994; McCue and Holtsford 1998). This ability to persist as dormant seeds is an "escape in time" from environmental harshness (Harrison et al. 1999), as opposed to an "escape in space" employed by mobile animals. Seed dormancy is an effective survival mechanism, but makes the task of assessing the status of an annual species more difficult for botanists.

Metapopulations

Plant populations can move, albeit very slowly. Populations that are found in isolated patches rely on the movement of pollen or seeds within metapopulations to maintain their genetic diversity. (A metapopulation is a shifting mosaic of populations linked by some degree of migration (Primack 2002)). Even common plant species suffer reduced seed set and smaller populations when isolated (Soons and Heil 2002; Lienert and Fischer 2003), and species with small populations, short life cycles, or high habitat specificity are particularly susceptible (Fischer and Stöcklin 1997). Some species, however, seem to have adapted to small populations and limited gene flow (Holderegger and Schneller 1994). Metapopulations may be structured around one central core population that provides pollen or seed for numerous smaller populations. If the core population is eliminated, then the surrounding populations will also go extinct (Primack 2002). In addition, vacant but suitable microsites might be necessary for long-term persistence of a metapopulation in a balance between local extinctions and recolonizations (Hanksi et al. 1996; Primack 2002).

Long distance dispersal of seeds, however, is often rare and highly episodic, depending on a combination of unusual occurrences (Wolf 2001). Local populations, especially those in clusters, are more likely to produce seeds and are more likely to recolonize a vacant habitat (Wolf 2001). Populations of annual plants farther than 100 m (Primack and Miao 1992) or 300 m (Harrison et al. 1999) from each other have higher rates of extinction and fewer recolonization events than close populations. Primack and Miao (1992) conducted seeding studies and concluded that "animals walking and digging through the soil, plus the action of wind and water flow, apparently do not move seeds any significant distance once they have landed on the soil surface." While pollination may occur over large areas, seed dispersal appears restricted to small areas in most years.

Metapopulation theory is confounded by two additional factors when dealing with annual plants. First, when species have persistent seed banks, or are capable of long-term vegetative reproduction, the local extinction and recolonization rates are obscured, and the dispersal rates may be difficult to discern in space versus time (Wolf 2001). Second, if nearby populations fluctuate independently, then there is more potential for rescue and recolonization than if populations within dispersal range of one another behave synchronously (Harrison et al. 1999). Asynchronous populations take advantage of "escape in time" where populations produce seed in different years under different conditions. This means that a severe large-scale event such as a flood, fire, or hailstorm would only eliminate the seed production from one population rather than the entire metapopulation.

SURVEY TECHNIQUES

Survey techniques must be adapted to the characteristics of rare annual plants. Because a large portion of the life cycle is passed in the seed stage, the number of individuals visible above ground may fluctuate widely and are not easy to identify. Surveys should always include a thorough search of historical records and a survey of historical locations. The timing of the surveys should be flexible to reflect the moisture conditions and the disturbance regimes required by the species in question. Potential habitat should be examined in several years, under different climatic conditions, since "the absence of individuals above ground in any given year does not necessarily mean that the population is truly extinct" (Harrison et al. 1999). All potential habitat in close proximity to the survey area should be surveyed, for often the existence of at least a portion of the metapopulation will ensure the long-term survival of the species or subpopulation.

As annual plants are often associated with disturbances, such areas should be carefully surveyed, even though we intuitively associate rare plants with undisturbed habitats. In southern Alberta, we have found American pellitory *(Parietaria pensylvanica)* under shrubs where cattle gather for shade and subsequently churn the soil. We have also found smooth boisduvalia and chaffweed under irrigation pivots in cultivated fields, and sand verbena is found in open, shifting sand dunes.

ASSESSMENT

The assessment of threats or status of rare annual plants is difficult. Most research on conservation biology has been done for animals, and there has been little work done on the role of metapopulations and seed banks for rare annual plants (Ellstrand and Elam 1993; McCue and Holtsford 1998). Little work has been done on rare plants in Alberta, so we do not know if a given species has a persistent seed bank, how long the seeds lie dormant, or how far the seeds are dispersed, much less the reasons for rarity. Several points should be considered when assessing the threat or status of a rare annual plant species:

- the absence of plants at a historical location does not imply extinction: a seed bank may be present
- the presence of one individual may indicate that there is a viable seed bank
- the presence of many individuals, however, does not mean that there is a viable seed bank

- a habitat that appears suitable but has no rare plants this year may have a population in a different year (due to migration or seed bank germination)
- adjacent populations may be critical to the survival of a population (and vice versa)
- past disturbances do not preclude rare plants
- future disturbances, such as a pipeline, fire, or grazing, may increase the population (or may decrease it)
- long-term changes in disturbance regimes or climatic conditions may affect the viability of populations.

The Alberta Endangered Species Conservation Committee and the Committee on the Status of Endangered Wildlife in Canada use the criteria established by the International Union for the Conservation of Nature (IUCN 2001) to assess the status of plants and animals at risk. One of the criteria (B - extent of occurrence) considers extreme fluctuations in the extent of occurrence, area of occupancy, number of locations or subpopulations, or number of mature individuals. The number of mature individuals is defined as the number of individuals known, estimated, or inferred to be capable of reproduction. When estimating this quantity, the following points should be borne in mind: where the population is characterized by natural fluctuations, the minimum number should be used…. For plants with seed banks, use the juvenile period + either the half-life of seeds in the seed bank or the median time to germination. Seed bank half-lives commonly range between <1 and 10 years (IUCN 2001).

Primack (2002) suggests that the effective population size for annual plants should be somewhere between the lowest and the highest number of breeding individuals, and he proposed using the harmonic mean of several years data, $N_e = t/(1/N_1 + 1/N_2 + ... + 1/Nt)$. McCue and Holtsford (1998) point out that even a small number of seeds in the seed bank can have a significant impact on the effective population. They suggest that the N_e should include an estimate of viable seeds/population area. This, however, assumes that you know the size of the seed bank and how long the seeds persist.

Without data on the seed bank, we run the risk of under-estimating the effective population (by ignoring a viable seed bank) or under-estimating the impacts of population loss (by assuming that a fluctuating population will have a seed bank and is therefore safe).

RECOVERY PLANS AND MITIGATION

The mitigation of impacts to rare plants should always concentrate on protecting existing populations rather than using experimental techniques to establish new populations (Bush 2001). Successful introductions likely depend "on the fortuitous combination of a particular genotype in a suitable microsite in a particular year" (Primack and Miao 1992). If experimental introductions are attempted, they should involve seeding numerous potential microsites in several years (Primack and Miao 1992). The mitigation of human impacts to rare annual plant populations should therefore do the following:

- protect historical populations, even if plants are absent;
- conserve habitat that has a high potential value, even if plants are absent;
- confine impacts to dormant periods, prior to germination, or after seed set;
- conserve the seed bank;
- maintain the natural disturbance regime;
- maintain the environmental conditions (the shape of the wetland, slope, etc.);
- collect and redistribute seed to numerous potential sites in several years; and
- monitor the results.

MONITORING

Monitoring is essential to any mitigation project that involves disturbing rare communities and rare plant species. Monitoring is the only way to assess if the mitigation was successful or not, and to make informed choices about future mitigation strategies. Successful mitigation techniques can therefore be used with greater confidence and unsuccessful ones re-evaluated or avoided.

Many of the techniques recommended for rare plant mitigation are experimental, and little is known about the biology and reproductive capacity of individual species (Allen 1994; Falk et al. 1996; Primack 2002). To account for the natural fluctuations in populations, monitoring should be conducted regularly and for several years, as absence might be the result of prolonged dormancy instead of extinction.

When monitoring for recovery plans, data should be collected from years when the plants are absent as well as from years when they are present, to fully describe their response to environmental fluctuations. When monitoring to determine if mitigation was successful (assuming the budget is very limited), it may be appropriate to survey in selected years (e.g., 3 years in 5, or 5 in 12) to take advantage of years with good growing conditions (provided you understand what conditions are needed for germination). In either case, the results should be published so that we can increase our understanding of rare plant biology and mitigation.

CONCLUSIONS

Rare annual plants have a suite of unique characteristics that affect our ability to assess their status and to develop recovery and mitigation plans. Rare annual plant species may naturally experience large fluctuations in plant numbers and may have dormant seed banks that are difficult to assess in terms of size and viability. In addition, they may rely heavily on the presence of nearby populations and disturbance for their long-term persistence. These characteristics must be included into the design of field surveys, into assessments of the status and threats to the population, and when designing mitigation and monitoring programs.

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EFFECTS OF WATER MANAGEMENT PRACTICES AND PRECIPITATION EVENTS ON SAGEBRUSH HABITAT IN SOUTHEASTERN ALBERTA

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Abstract: Overflow and sedimentation caused by episodic flood events are important for the maintenance of silver sagebrush *(Artemisia cana)* and sage grouse *(Centrocercus urophasianus)* habitat. Water diversions such as dugouts, dams, and irrigation, which can reduce overflow to sagebrush habitat, were investigated in a 48.5-township area in southeastern Alberta. Aerial photography was used to identify and describe all drainage impediments during four time periods: 1951-52, 1962, 1984-85, and 2001. A geographic information system was used to determine the catchment area and stream length affected by impediments during the four time periods. Soils and landscapes were characterized at three active and five inactive sage grouse lek locations, and the degree of overflow and creek down-cutting were assessed. Precipitation data from 1928 to 2002 were analyzed from the Onefour Range Research Station. Air-photo interpretation indicated the number of drainage impediments increased four-fold, from 535 in 1951 to 1901 in 2001, and the number of impediments located on streams increased by a factor of more than three. Catchment area above all impediments increased from 24% of the study area in 1951 to 81% in 2001. Episodic precipitation events, defined as more than 60 mm over a five-day period or more than 25 mm in one day, occurred on average every 2.2 years between 1935 and 2002, with the exception of the 1978 to 1995 time period when only one event occurred (in 1986). Sage grouse habitat may have been adversely affected by the decrease in the frequency of precipitation events and by the dramatic increase in drainage impediments since 1951. Field evidence verified the importance of overflow for the maintenance of silver sagebrush habitat. The restriction of new impediments in the area of active leks is required to maintain valuable sagebrush habitat. Some incised streams could be bermed at strategic locations to redirect flow to areas where overflow could promote sagebrush re-establishment.

INTRODUCTION

Sage grouse *(Centrocercus urophasianus)* in southeastern Alberta are at the northern periphery of their range. Sage grouse numbers in southeastern Alberta declined significantly between 1969 and 1994 and remained low between 1994 and the present. Drought conditions reduce vegetation available for both nesting cover and food. Sage grouse numbers in Montana decreased during drought conditions in the 1980s and early 1990s, but their numbers rebounded with the return of wetter conditions since 1997 (Alberta Environment 2000).

LandWise Inc. (2001) conducted an investigation to characterize soils and landscapes associated with silver sagebrush *(Artemisia cana)* and sage grouse in southeastern Alberta. They concluded that overflow and sedimentation caused by episodic flood events are important for the maintenance or increase of silver sagebrush and for the maintenance of sage grouse habitat. LandWise Inc. was contracted by the Alberta Conservation Association and Alberta Sustainable Resource Development in 2002 to conduct a follow-up investigation in the study area of Townships 1 to 7, Ranges 1 to 7. The goals of this study were as follows: (1) to characterize and quantify water management practices during four time periods (1951-52, 1962, 1984-85 and 2001); (2) to characterize creek incision in 2002; and (3) to relate changes in (1) and (2) to possible decreases in episodic run-off events and overflow frequency by characterizing the soil, landscape, overflow, and silver sagebrush vigour surrounding three active and five inactive leks. Historic precipitation data recorded at Onefour, Alberta were assessed for potential changes in episodic precipitation events.

METHODS

Factors that may be linked to decreasing runoff volume in the study area were investigated, including potential reductions in precipitation and potential increases in man-made drainage impediments.

Precipitation Data

Daily precipitation data recorded at Onefour from May 1928 to December 2002 and at Foremost from 1961 to 2001 were obtained from Agriculture and Agri-Food Canada. The total precipitation over five-year intervals was summed to smooth variations in annual precipitation. A linear regression analysis between time and total five-year precipitation was conducted to assess changes in annual precipitation. The data were plotted and assessed to characterize high-intensity precipitation events that might cause runoff.

Aerial Photography

Aerial photography flown in 2001 (1:15,000 scale) was used to identify the location, type, and other characteristics of all drainage impediments in the study area. The identified impediments were listed as registered or non-registered by comparing them to two previously existing datasets of licensed impediments:

1. Alberta Environment dataset of licensed water consumption, complete to July 27, 2001, and
2. Public Lands dataset, complete to December 21, 2001.

Three earlier sets of aerial photography (1951-52, 1962, 1984-85) were then used to determine whether each impediment existed during the earlier evaluation periods. Information recorded for each dataset included the following: type of impediment, easting, northing, legal location, approximate elevation, registration status, drainage basin description, stream order, estimated height of dams and berms, and assumed effect on silver sagebrush habitat.

Field Investigation at Three Active and Five Inactive Leks

Three active and five inactive sage grouse leks were investigated in mid to late June of 2002, following a major overflow event that occurred on June 8 to 10 in which 108 mm of precipitation fell over five days at Onefour. The storm event allowed observation of maximum flood height in the creek drainages (based on debris and water marks) and portrayed the influence of overflow on silver sagebrush habitats. Soils, landscapes, overflow, creek-down-cutting and silver sagebrush vigour were described at all eight leks.

Determination of Catchment Area and Stream Length for Each Overflow Impediment

A geographic information system (GIS) was used to delineate the boundaries of all watersheds in the study area, to calculate the drainage area of each watershed, and to determine the catchment area and stream length affected by drainage impediments during the four separate time periods (GISmo Solutions Ltd. 2002).

RESULTS

Long-term Precipitation at Onefour

Annual Precipitation: Total annual precipitation at Onefour from 1929 to 2002 averaged 332.4 mm, with a median value of 313.5 mm. Linear regression analysis suggested that total five-year precipitation increased significantly between the 1931-1935 and the 1981-1985 time periods, with an r^2 value of 0.65. Total five-year precipitation at Onefour was less than 1,450 mm before 1950 and greater than 1,600 mm from 1951-1955 to 1996-2000. Precipitation at Foremost increased significantly between the 1961-1965 period (1,527 mm) and the 1996-2000 time period (2,256 mm), with an r^2 value of 0.76.

Monthly Precipitation: On average over the recorded time period, 60% of the precipitation at Onefour occurred in the summer months of May to September and nearly 20% occurred in June. Total monthly precipitation varied widely over the years, but no significant trends with time occurred. However, five-year total June rainfall decreased sharply from 423 mm in 1961-1965 to 137 mm in 1981-1985 (Figure 1). The decrease in total June rainfall may have compromised silver sagebrush, as late spring conditions are critical to most range species. In addition, precipitation in December, January, and February generally decreased between highs in the 1960s and the present. Drifting snow in winter tends to accumulate in low areas and drainage channels, and this snow is a major source of runoff during spring thaws. Therefore, the decrease in winter precipitation between the 1960s and 2000 may also have reduced the intensity of runoff events.

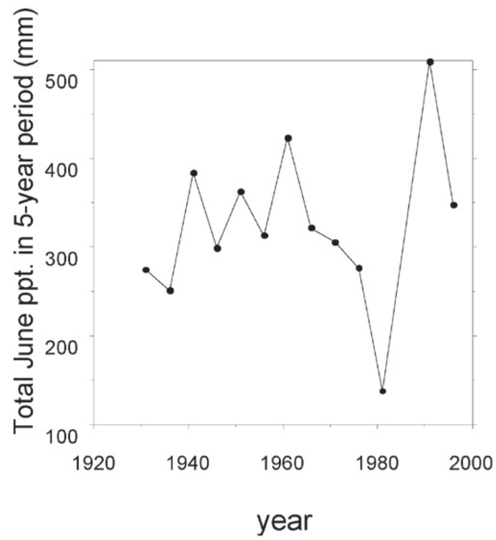

Figure 1. June precipitation at Onefour as totaled over five-year intervals.

Event-related Precipitation: The amount of rainfall generally required to cause runoff in the study area has not been quantified and will vary with antecedent moisture conditions and storm intensity. Runoff and resulting water erosion on cultivated land, and to a lesser extent on native range, have been observed on several occasions. Episodic high-intensity precipitation events, defined for this investigation as greater than 25 mm per day or greater than 60 mm over a five-day period, occurred on average once every 2.2 years between 1935 and 2002, with the exception of the 1978 to 1995 time period when only one event occurred in 1986. The low number of high-intensity precipitation events between 1978 and 1995 may have compromised silver sagebrush health.

Impediments

Increase in Impediments and Impeded Drainage: The number of drainage impediments in the study area increased four-fold between 1951-52 and 2001 (Table 1), while the number of impediments located on streams increased three-fold. Seventy-one percent of impediments were located on streams in 2001 (Table 1), and dams and dam-dugout combinations, which have larger storage capacities than other types of impediments, accounted for 53% of all impediments.

The area of impeded catchments (the drainage basin area above and draining to each impediment) increased from one quarter of the study area in 1951 to over three-quarters of the study area in 2001 (Table 2). The total stream length upstream of impediments increased by 267% between 1952 and 2001, from 2,937 to 7,852 km. The average catchment area affected by each impediment has remained close to 200 ha in all four time periods (Table 2).

Table 1. Impediment numbers along drainages between 1951-52 and 2001.

Parameter	1951-52	1961-62	1984	2001
Total number of impediments	535	912	1,451	1,901
Impediments as a % of impediments in 2001	28%	48%	77%	100%
% of impediments classified as dams, dugouts, or dam-dugout combinations	80%	84%	88%	90%
Number of impediments located on streams	415	684	1,028	1,338

Table 2. Area (ha) of impeded catchments in the study area between 1951-52 and 2001.

Statistic	1951-52	1961-62	1984	2001
Total area affected by impeded drainage*	110,378	182,352	256,000	365,513
% of study area	24.4%	40.3%	56.5%	80.7%
Average size of catchment affected by individual impediments	206	200	176	193
Standard deviation	411	422	387	591

*The entire study area is 452,752 ha.

Effect of Impediments on Overflow Volumes: LandWise Inc. (2001) concluded that overflow and sedimentation caused by episodic flood events are important for the maintenance or increase of silver sagebrush and for the maintenance of sage grouse habitat. To assess the potential impact of impediments on overflow volumes, 3 rainfall values were selected for illustrative purposes: 40, 70, and 100 mm. Rainfall events of greater than 70 and 100 mm during a 5 -day period occurred 11 and 3 times, respectively, during the 75-year monitoring period at Onefour. The calculations are based on the total storage capacity of 3.44 x 107 m^3 within the 664 registered impediments in the study area (Kevin McFadzen, Alberta Environment, pers. comm.); however, only 53% of impediments present in 2001 were registered. The calculations suggest that impediments would capture about 25% of runoff from 100-mm events and up to 63% in 40-mm events if 30% of the rainfall is available for runoff (Table 3).

The Importance of Overflow for Silver Sagebrush Health
The health of silver sagebrush surrounding one of the three active leks was promoted by the diversion of water from an incised creek channel across an alluvial fan. At other locations, creek incisement has reduced overflow. Silver sagebrush habitat was generally sparse or in poor health surrounding the five inactive leks. Two of the leks were not located adjacent to streams, and overflow at a third lek was reduced by stream down-cutting. The remaining two leks were located adjacent to streams with numerous impediments, but they still received overflow.

During the air photo assessment, several hectares of silver sagebrush cover were noted downslope of a never-repaired, 40-year-old breach in a water-delivery canal near Lodge Creek. Silver sagebrush habitat in the overflow path was still healthy in 2002, evidently due to 40 years of overflow from the canal, since this location would not normally be suited to sagebrush.

CONCLUSIONS

The example of silver sagebrush being maintained in a healthy condition by overflow from a canal in an otherwise unlikely location supports the hypothesis that periodic overflow is important for the maintenance of silver sagebrush habitat and suggests that silver sagebrush can be enhanced by artificial measures. The field assessment of three active and five inactive leks provided further evidence of the importance of overflow for the health of sagebrush habitat.

The dramatic increase in the number of dams, dugouts, and other drainage impediments in the study area and the increase in the overall drainage area affected by impediments have probably caused a decrease in periodic overflow necessary for the maintenance of silver sagebrush habitat. The existing impediments are estimated to capture about 36% of runoff from a 70-mm precipitation event (a one-in-seven year event) if 30% is available for runoff. Stream incisement (down-cutting) has also played a role in decreased overflow at some locations.

Episodic high-intensity precipitation events occurred on average once every 2.2 years, with the exception of the 1978 to 1995 time period (i.e., single event in 1986). Reduced overflow related to the low amount of event-related precipitation between 1978 and 1995 may have adversely affected sage grouse habitat.

Spring runoff and moisture conditions in late spring are critical to most range species. The decrease in total June rainfall between 1960 and 1980 and the decrease in

Table 3. Estimates of the amount of overflow contained by impediments in the study area, assuming events ranged from 40 to 100 mm.

Total storage capacity of impediments in the study area (m^3)	Percentage of runoff captured by impediments					
	40 mm event		70 mm event		100 mm event	
3.44×10^7	100% runoff	30% runoff	100% runoff	30% runoff	100% runoff	30% runoff
	19%	63%	11%	36%	7.6%	25%

winter precipitation between the 1960s and 2000 may have reduced the intensity of runoff events and thus the health of silver sagebrush habitat.

RECOMMENDATIONS

Recommendations arising from the current investigation are as follows:

- No further impediments should be allowed in the area of active leks or in the area of inactive leks that have potential for silver sagebrush rejuvenation. Given the small number of remaining active leks and the sensitivity of sagebrush habitat to any reductions in overflow, Alberta Fish and Wildlife Division and Alberta Public Lands should continue to work in cooperation with landowners or leaseholders to emphasize the importance of silver sagebrush habitats and to provide alternative water sources. Some incised streams could be bermed at strategic locations to redirect flow to areas where overflow could promote silver sagebrush re-establishment.
- An ecological assessment of silver sagebrush habitat should be conducted, focusing on the current study area and the Dry Mixed Grass and Mixed Grass Natural Subregions. The assessment should include a determination of whether silver sagebrush is recruiting as a result of the relatively large number of high-intensity precipitation events that occurred between 1995 and 2002. In addition to the characterization of silver sagebrush health, specific questions to be addressed should include the following: (1) Why is the vigour and health compromised at various locations? (2) What effect do drainage impediments have on vigour and health at various sagebrush locations? (3) Are late spring precipitation events critical to sagebrush habitats? (4) How can sagebrush plant communities be revitalized? (5) Can antelope damage sagebrush under certain winter-spring conditions?
- The storage capacity of impediments should be characterized in more detail, particularly for large dams and reservoirs. This would allow for a more accurate determination of the percentage of runoff captured by impediments.

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A METHOD FOR DEVELOPING AN ECOSYSTEM-BASED INSTREAM FLOW NEEDS DETERMINATION FOR RIVERS IN THE SOUTH SASKATCHEWAN RIVER BASIN, ALBERTA, CANADA

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Abstract: Alberta Sustainable Resource Development and Alberta Environment developed a methodology for integrating multiple riverine components to provide a single Instream Flow Needs (IFN) determination. The IFN determination was based on the objective of full protection of the aquatic ecosystem and used natural flow paradigm concepts as guiding principles. Site-specific evaluations of water quality, fish habitat, riparian vegetation, and channel maintenance flows were used to represent the aquatic ecosystem. Water quality modeling was used to evaluate flows sufficient to meet temperature, dissolved oxygen, and nutrient limits for the aquatic ecosystem. Fish habitat was evaluated using 1-D PHABSIM modeling, conducting habitat time-series analyses, and defining acceptable habitat reduction thresholds from the natural condition. The riparian vegetation analysis was based on the flows necessary for the recruitment, growth, and survival of riparian poplar trees. Channel maintenance flows were evaluated to ensure the IFN retained the magnitude, frequency, and duration of flows necessary to maintain the channel structure. The final IFN provides a variable flow recommendation that incorporates the natural intra- and inter-annual flow variability on a weekly time-step.

INTRODUCTION

The Province of Alberta is currently developing a water management plan to maximize the benefits of water use in the South Saskatchewan River Basin (SSRB) in a sustainable and environmentally responsible way. Led by a government steering committee, the SSRB water management planning process involves consultation with four Basin Advisory Committees and the general public. A key goal of the water planning process is to develop a strategy for the protection of the aquatic environment. To achieve this goal, the Steering Committee appointed a technical team to develop instream flow needs (IFN) determinations for all mainstem reaches in the SSRB.

The Technical Team was comprised of staff from Alberta Environment and Alberta Sustainable Resource Development. The Technical Team accessed expertise from within and outside the Government of Alberta to develop the IFN determinations. This paper describes the riverine components that were addressed and the integration of the components to develop an instream flow needs determination.

STUDY AREA

The study area (Figure 1) included reaches on the Red Deer River downstream of the Dickson Dam to the Alberta-Saskatchewan border, the Bow River downstream of the Western Irrigation District weir, the Oldman River downstream of the Oldman River Dam, the St. Mary River downstream of the St. Mary River Dam, the Belly River downstream of the Belly River diversion weir, the Waterton River downstream of the Waterton Reservoir, and the entire extent of the South Saskatchewan River to the Alberta-Saskatchewan border.

BACKGROUND AND APPROACH

The approach developed by the Technical Team was based on the premise that an IFN determination should reflect the seasonal pattern and the general nature of the magnitude, frequency, timing, and duration of the natural flow hydrograph. Accordingly, both intra-annual (within a year) and inter-annual (between years) characteristics of the flow variability should be maintained. This concept is commonly referred to as the natural flow paradigm (Poff et al. 1997). Furthermore, the Steering Committee directed that the IFN recommendations should be based on the latest scientific understanding

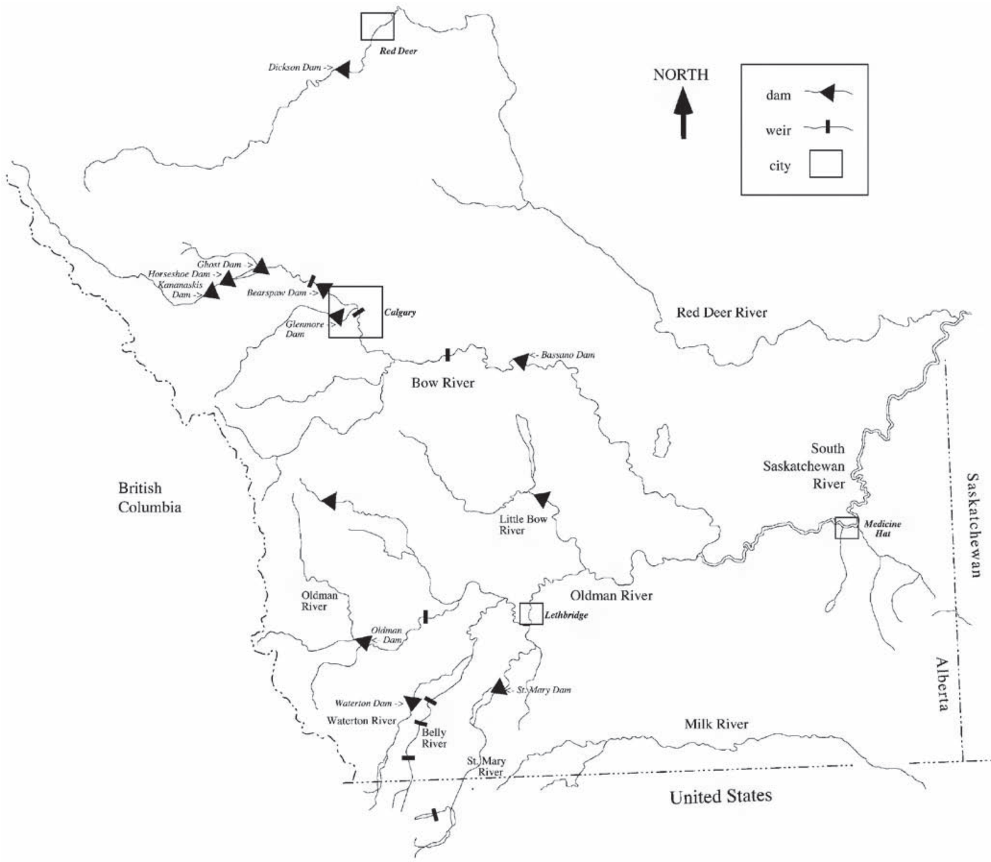

Figure 1. Map showing the mainstem reaches in the South Saskatchewan River Basin.

of riverine ecosystems. Therefore, a holistic approach was required, as opposed to a single species or single riverine parameter approach, to preserve the processes and functions of the river ecosystem.

The Technical Team chose to use the natural flow regime as a benchmark condition in making instream flow needs descriptions based on the following objectives and principles:

1. The primary objective of determining instream flow needs is to describe flow requirements for achieving a high level of protection of the riverine ecosystem, to the extent that such protection can be achieved by instream flows alone.
2. Providing instream flows that create habitat conditions similar to naturally occurring habitat conditions should also provide ecosystem protection, in the context of IFN analysis.
3. An IFN determination must provide for protection of aquatic habitats in the short term and protection of the processes that maintain aquatic habitats in the long term.
4. Habitat enhancement is considered distinct from a purely environmental protection objective. Therefore, instream flow needs for protection do not address habitat enhancement; however, implementing a protective IFN may result in an improvement of habitat compared with existing conditions.

The Technical Team subsequently chose four ecosystem components to represent the full extent of the aquatic ecosystem: water quality, fish habitat, riparian vegetation, and channel maintenance. IFN flow values were generated for 27 reaches, on a weekly time-step, in a duration curve format. A weekly time-step was deemed appropriate from the perspective of biological, hydrological, and water planning modeling. The water quality IFN was based primarily on flows required to protect against high instream temperatures and, in some instances, high ammonia levels. The water quality IFN was also chosen to ensure that minimum dissolved oxygen concentrations are maintained for the protection of fish species. The fish habitat IFN was based on flows required to protect physical fish habitat. The riparian IFN was based on flows required to provide adequate recruitment opportunities for riparian poplar forests and to promote tree growth between recruitment events. The channel structure IFN was based on flows required to maintain channel structure processes. These flows ranged from low flows necessary to flush fines from streambed substrates to higher flows that shape and form the channel within the river valley.

No new data were gathered for this study; however, some new modeling was carried out using existing information. Previous modeling results were re-examined and improved where possible. Although not every aspect of every component of the aquatic ecosystem was addressed in this evaluation, the information used is believed to be comprehensive by current standards. Methods for quantifying instream flow needs have evolved considerably since the original instream flow studies were carried out in the South Saskatchewan River Basin in the 1980s and early 1990s. Most of the original studies were based on the quantification of instream flows from the relatively narrow perspective of identifying flows for only a few select sport fish species and for water quality. Now, as many riverine components as possible are generally included when making comprehensive IFN determinations.

Channel Maintenance

Channel maintenance flows cover the range of flows commonly referred to as flushing flows, bed mobilization flows, channel structure flows, or channel forming flows. Although the importance of these flows to the aquatic ecosystem is well understood, methods to describe such flows in the context of developing IFN determinations are only just emerging. As with most IFN methods, detailed data and predictive models are required. The Technical Team reviewed several well-documented sediment transport models that can be used to determine channel maintenance flows, but the Team found that most of these methods were data-intensive and could not be used in this study as new data were not collected.

Channel maintenance flow recommendations were thus developed using an incipient motion method based on the Shields entrainment function. This method incorporates sediment grain size and channel slope in the estimation of flushing and bed mobilization flows. The Shields Equation predicts a flow magnitude needed to initiate transport of the channel bed material and, as a long-term consequence, to sustain the natural configuration of the channel. The equation does not stipulate the timing or duration of the needed flow, and thus IFN values could not be generated in a duration curve format for channel maintenance, as was done for riparian vegetation, fish habitat, and water quality. Instead, a comparative analysis was done following integration of the other three components to ensure the IFN determinations from those components were adequate to provide the necessary flows for channel maintenance.

The channel maintenance flow recommendations are, at best, preliminary. Before any decisions are contemplated regarding implementation of these flows, more work is necessary to understand possible changes in sediment regime. Changes to the current high flow regime could have unexpected effects on the present channel structure.

Riparian Vegetation

The instream flow recommendations for riparian poplars were designed to provide the full range of flows required to help preserve and restore riparian forest ecosystems in the South Saskatchewan River Basin. The calculated instream flows are expected to sustain the health of existing trees in a condition comparable to that expected under natural conditions and to maintain the frequency of seedling recruitment events that sustain the long-term viability of the riparian forest. The determination of poplar instream flow needs addressed the flow patterns that meet the varied moisture requirements of the poplars during the growing season. The natural degree of streamflow variability was incorporated in the design of flow regimes for sustaining riparian cottonwoods and the fluvial processes upon which they depend. Riparian poplar IFNs were based on the exceedence curves of naturalized flows and were defined by a composite of three weekly time-step exceedence-based curves and bankfull discharge.

The first limit defined by the Poplar Rule Curve (PRC) set the minimum streamflow required for long-term cottonwood survival and maintenance as the 90% exceedence flow. Lower flows will occur naturally, but cottonwoods should be able to tolerate acute-level events, provided their frequency and magnitude are not increased beyond natural flows. Thus, our IFN determination did not alter natural flows that were less than the 90% exceedence flow. Natural flows that were greater than the 90% exceedence flow were not reduced below the 90% exceedence flow level. Moderate to high PRC flows were defined by the greater of either 65% of naturalized flow or the flow that corresponds to a 50% increase in the return interval (RI). These two values bridged the minimum flow requirements for cottonwood survival and the higher flows needed for seedling establishment. The maximum flow required to meet IFN for cottonwoods was set at 125% of bankfull discharge. This included flows critical for continuing the sediment transport processes necessary to create essential nursery sites for poplar seedling establishment.

The determination of poplar instream needs can be simplified into four rules:

1. There were no reductions to flows with natural exceedences of 90% or greater;
2. Flows above the 90% exceedence flow were not reduced below the 90% exceedence level;
3. A reduction of up to 35% of the natural flow was acceptable provided the resulting RI shift was not greater than 50%; and
4. The highest flows were reduced to 125% of bankfull.

A complete IFN recommendation for riparian poplars was comprised of a series of natural weekly exceedence curves adjusted according to the decision criteria described above for the poplar growing season.

Comparisons between calculated PRC flows and actual flow regimes along the selected test reaches in the South Saskatchewan River Basin supported the validity of the PRC for sustaining riparian cottonwood populations. A detailed validation of the PRC was completed through the assessment of each of the four decision criteria that form the basis of the final PRC. Comparisons with test reaches could not adequately evaluate the reduction of peak flows that exceed 125% bankfull as no flow regimes along the test reaches have been modified in this way. Trends observed along the test reaches showed only minor revisions could be made to any of the PRC criteria without initiating measurable changes in riparian vegetation communities.

Fish Habitat

The fish habitat IFN component determination was based on site-specific data and habitat modeling using the PHABSIM (Physical HABitat SIMulation) group of models (Milhous et al. 1989; Bovee et al. 1998). Existing hydraulic data were re-calibrated using recent technology to update the hydraulic simulations. A workshop was held with experts from within and outside the government to assess existing data and produce a set of basin-wide Habitat Suitability Criteria (HSC) curves. The fish habitat IFN determination process consisted of five basics steps:

1. Develop a series of constant-percent flow reductions from the natural flow in 5% increments;
2. Calculate the Ecosystem Base Flow (EBF);
3. Identify the flow range to conduct habitat time-series analyses using site-specific Weighted Usable Area (WUA) curves as the assessment criteria;
4. Conduct habitat time-series analyses for the natural flow and each constant-percent flow reduction with the added constraint of the EBF; and
5. Review the habitat evaluation metrics to identify the fish habitat IFN.

The first step in the process was to prepare the flow files for use in the time-series analyses. Flow files were created with a constant 5% reduction from natural (i.e., 5%, 10%, 15% of natural, etc.). An Ecosystem Base Flow value was then established. This threshold was chosen to reduce the impact on habitat during naturally low-flow periods. The EBF was defined for each reach and was calculated on a weekly time-step (i.e., there is a different EBF value for each week). For certain times of the year and for some reaches where site-specific data were not available, the Tessmann Method was adapted to a weekly time-step and used to set the Ecosystem Base Flow. The third step was to determine a range of flows on which to carry out the fish habitat time-series analyses. An upper limit (or threshold for flow) was set, beyond which the use of the fish habitat data becomes questionable. During the spring freshet, for example, ecosystem tools such as data on riparian vegetation and channel structure processes are more suitable than WUA curves for fish. Within the year, weeks with median flows beyond the evaluation range of a WUA curve were removed from the analysis. Standard habitat time-series analyses were then evaluated for habitat during the open-water season, defined as the period from the beginning of April to the end of October. The fifth and final step for the fish-habitat component was to review the results using three evaluation metrics: change in total average habitat (chronic), maximum weekly loss in average habitat (intermediate chronic), and maximum instantaneous habitat loss (acute). For these metrics, three specific habitat loss thresholds were defined:

- 10% loss from natural in average habitat;
- 15% maximum weekly loss from natural in average habitat; and
- 25% maximum instantaneous habitat loss from natural.

The greatest flow reduction from natural that did not exceed any one of the three thresholds was chosen as the flow recommendation. The reduction in flow from natural throughout the 27 reaches varied from 15% to 55%.

Water Quality

Water quality variables include nutrients, major ions, metals, pesticides, and bacteria. In most cases, these variables are best managed by source control, rather than by dilution and bio-assimilation. Water quality instream flows needs focused on water temperature and concentration of dissolved oxygen and ammonia because these variables are amenable to management by flow regulation. These factors are also critical water quality variables for fisheries protection in southern Alberta rivers. High water temperatures have a negative effect on fish metabolism and can cause fish mortality. The acute temperature for most sport fish in Alberta is between 22 and 29°C. The seven-day chronic value is between 18 and 24°C. Instream flows were determined to prevent the occurrence of acute or chronic high temperature incidents from exceeding their natural frequency. Oxygen becomes less soluble as water temperature increases, causing a reduction in dissolved oxygen (DO) levels. The Alberta guideline for dissolved oxygen for the protection of fish is 5 mg/L for acute occurrences. A seven-day average DO concentration of 6.5 mg/L is set for protection against chronic deficits. Instream flows that would prevent the occurrence of acute or chronic DO deficits from exceeding their natural frequency were determined.

Additionally, waste assimilation flows and scouring flows are important elements of water-quality-based instream needs. Instream flows that dilute waste discharges and allow for biological breakdown of organic wastes are required to protect the aquatic environment. These waste assimilation flows were calculated to ensure that dissolved oxygen and ammonia levels remain within provincial guidelines for the protection of aquatic life. River flows for waste assimilation are a consumptive use of our waterways since such use limits the volume of water that can be applied to other purposes. The needs for these flows are greatest downstream of municipal wastewater treatment plant outfalls. Scouring flows are the high flows that typically occur in late spring and early summer due to snowmelt. The scouring or flushing flows dislodge organic-laden sediments that accumulate on and within the riverbed and carry them downstream. This action reduces existing aquatic vegetation and impedes the establishment of new plants. Removing the accumulating sediments and aquatic vegetation limits the oxygen demand that would otherwise occur in the river. High oxygen demand lowers dissolved oxygen levels and can contribute to fish kills. Scouring flows were not specified within the water quality component of the integrated IFN, but the scouring flows determined within other components, such as the riparian and channel maintenance IFN, fulfilled this need.

The water quality IFN determination was presented as a series of weekly exceedence curves for the critical summer and winter low flow periods in most reaches in the project study area. Where possible, IFN values were determined for all four seasons.

Making One Ecosystem IFN Determination Using Four Riverine Components

IFN practitioners generally accept the need to consider all elements of the aquatic ecosystem in defining instream flow needs (Annear et al. 2002). However, there is no broadly accepted method for combining the different ecosystem components to develop an integrated flow recommendation. For this study, the Technical Team developed a method to integrate the four ecosystem-component IFNs into a flow duration curve format using a weekly time-step.

For the most part, water quality IFN determinations were provided as a single value for each reach for each week of the year. The fish habitat IFN determination was a variable flow curve applied seasonally for each week in the open-water season, excluding the spring freshet. Fish habitat data were not available for the winter weeks; therefore, values were derived using the Tessmann Method. The riparian IFN determination was also a variable flow curve and was applied only during the growing season in the spring and summer. The channel maintenance IFN determination was not readily incorporated into a weekly duration format. Instead, a check was conducted to ensure the IFN determination at the higher discharges was adequate to provide the necessary flows to maintain channel configuration and processes.

The integrated IFN was determined by comparing the IFN value for each of three components on a week-by-week basis for every data point in the period of record. Usually, but not always, there was some overlap among the components. When this occurred, the component with the highest flow requirement became the primary determinant of the integrated or ecosystem IFN. Situations arose where all three IFN components were not represented. In these cases, the component with the highest flow requirement was still used to define the integrated IFN. If IFNs were only available for one component, the integrated IFN was based solely on that component for that reach in that week.

Both the fish habitat and riparian IFN determinations identified a base flow below which no reduction in flow was recommended. In situations when the natural flow was below the base flow determination, the final integrated ecosystem IFN was usually the same as the natural flow. The exception to this rule occurs when augmented flows were required to meet the water quality IFN determination based on the current loadings in the system: it is considered unrealistic to factor out current loadings from various sources. For this study, all IFN determinations were made on a reach-by-reach basis. Future work will ensure the IFN determinations increase incrementally from upstream to downstream, a necessary refinement step normally completed during the running of the water balance model.

SUMMARY

The instream flow needs determinations reported here are an improvement compared with earlier IFN analyses for a number of reasons. The ecosystem IFN was comprised of four riverine components, specifically water quality, fish habitat, riparian vegetation, and channel maintenance. These components addressed a broad range of natural flows in terms of magnitude, frequency, and duration. Similarly, there have been improvements to the determination of IFN requirements for each of the individual IFN components. The inter-annual and intra-annual flow variability of the IFN better incorporated the pattern of natural flow variations in a consistent manner for every week. Finally, the current IFN has a comprehensive EBF, defined for every week.

Even though the instream flow needs determinations in this report are an improvement, uncertainty remains, as is the case with any instream flow needs study. In the absence of data, assumptions must be made. The Technical Team made every attempt to reduce the uncertainty, and in those instances where arbitrary decisions were made, the decisions were documented and made through consensus of the Technical Team.

The instream flow determinations made for the South Saskatchewan River Basin are designed to fully protect the aquatic ecosystem. The instream flow needs determinations are based on the natural-flow paradigm and are best described as a “percent-of-flow” determination. A percent-of-flow (the natural flow) determination, coupled with a low-flow cutoff (Ecosystem Base Flow), maintains the intra- and inter-annual flow dynamics of all flow ranges and events, thereby preserving the essential services and functions of a flowing aquatic ecosystem. Variations of the percent-of-flow determination approach have been recommended for other rivers in North America (Muth et al. 2000; Flannery et al. 2002; Hardy and Addley 2002) and in Australia (Brizga 2001). The approach is clearly gaining popularity.

Our understanding of how rivers function and the key role of the natural flow regime has increased tremendously. Notwithstanding these advances, natural resource managers are still hindered by knowledge gaps and limits on our abilities to predict changes as a result of flow manipulation. This uncertainty is due mainly to the complexity of flowing aquatic ecosystems and the simplistic models that are used to describe these complex ecosystems. Therefore, regardless of future flow management decisions in the South Saskatchewan River Basin, an adaptive environmental assessment and management program should be established to validate the predictions of the models used in this study and the impact of the water management plan that is ultimately selected. Well-designed experiments and monitoring offer the best approach to learning and understanding the intricate complexities of aquatic ecosystems in the long term (Walters 1997).

For a detailed description of the instream flow needs method used in the South Saskatchewan River Basin, a copy of the report can be found at: www3.gov.ab.ca/env/water/regions/ssrb/IFN_reports.asp

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WATERSHED AND AQUIFER PLANNING MODEL IN SASKATCHEWAN

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Abstract: The sound management of watersheds and aquifers begins with planning mechanisms that lead to effective water management. Planning in the water management field can take many forms, ranging from a holistic approach whereby all aspects relating to water and the related ecological resources are evaluated and all issues are considered, to planning directed towards a specific issue or activity. With this range of perspectives, a Saskatchewan Watershed Authority planning model has been developed to achieve a broad range of applications and to achieve consensus, collaboration, and stakeholder involvement throughout the process. This paper describes the committees and steps involved in the process of developing a watershed plan using this model.

FOREWORD

Saskatchewan's Watershed & Aquifer planning model was developed by the Watershed & Aquifer Planning Unit, Stewardship Division, Saskatchewan Watershed Authority. This planning model and the information contained in this paper are also contained in the brochure *Protecting Our Water* published by the Saskatchewan Watershed Authority.

INTRODUCTION

In Saskatchewan, as in other areas of Canada and North America, an adequate supply of quality water is coveted. Some of the perceived threats to water quality and quantity in Saskatchewan include loss of riparian habitat, wetland loss, soil erosion, poor rangeland management, introduction of ammonia from urban water treatment systems, urban storm water collection and release to water courses, and impacts by oil and gas exploration and production. The provincial government formed the Saskatchewan Watershed Authority in the fall of 2001 to manage and protect source water quantity and quality in Saskatchewan. An important element of Saskatchewan's long-term *Safe Drinking Water Strategy*, the Saskatchewan Watershed Authority incorporated staff from Sask Water, Saskatchewan Wetland Conservation Corporation, and Saskatchewan Environment.

The sound management of watersheds and aquifers, units that envelop entire water systems, begins with planning mechanisms that lead to effective water management. Planning in the water management field can take many forms, ranging from a holistic approach whereby all aspects relating to water and the related ecological resources are evaluated and all issues are considered to planning that is directed towards a specific issue or activity. The Saskatchewan Watershed Authority has developed a planning model that is able to achieve a broad range of applications and include diverse perspectives. Regardless of the scope, the model is designed to achieve consensus, collaboration, and stakeholder involvement throughout the process.

The Saskatchewan Watershed Authority planning model is structured to serve many different purposes of varying degree or magnitude. At one end of the scale, the watershed and aquifer planning model can be comprehensive in scope addressing all of the issues in a watershed and usually requiring substantial time and resources to complete. In contrast, watershed planning can also focus on a single activity and its impact on one component of the ecosystem, for example the impact of a proposed water control structure on fish habitat, populations, and migration. The planning model can be applied effectively in each case, but the magnitude of the effort and the resources to support the process will vary significantly.

The product of this planning process will be a watershed or aquifer plan documenting the state of the water resources from a quantity and quality perspective, the health of the ecosystem as it impacts the water resources, and an overview of the basin water demand with an emphasis on source water. Furthermore, the plan will provide written strategies to address these threats and include efforts to rank or prioritize the threats to drinking water quality.

A PLANNING MODEL FOR SOUND WATERSHED AND AQUIFER MANAGEMENT

The management and protection of the water resources for the benefit of Saskatchewan residents is best served when stakeholders collaborate through frank rapport and mutual respect, and then commit to actions that support a common goal. Stakeholders in watershed management include residents, producers, land managers, industry representatives, conservation representatives, and health and natural resource managers. Through the representation of these interests by municipal, First Nations, provincial and federal governments, and other interest groups, substantial efforts can be undertaken to identify threats to source waters and provide a plan to address these threats. The Authority's planning through consultation in a watershed setting is designed to bring people to a shared common understanding, resulting in tangible benefits for residents.

Sound watershed management is proactive, accommodating diverse points of view, needs, and expectations, and is conducted at round-table discussions in various community settings. Planners from the Authority help to identify key water management and ecosystem issues, lead discussions, provide information, and ultimately guide the members of the planning committee in efforts to achieve consensus and collaboration around sound water management and safe and secure water supplies.

STEPS IN THE PLANNING PROCESS

An effective watershed and aquifer planning process incorporates a number of key elements. The following section provides a discussion of these components beginning with the establishment of three committee structures: the Watershed Advisory Committee to provide local input, guide the process, and share in the implementation of outcomes; the Technical Committee to collect and analyze information required; and the Planning Team to coordinate the activities with ultimate responsibility to develop the plan.

Watershed Advisory Committee

The Watershed Advisory Committee has responsibilities to incorporate into the process all interests of the watershed residents. The committee is expected to provide significant input towards the development of the plan, become informed about the relationship between activities and the environment, and share in initiatives to manage the water resources and improve and protect source water. Rural and urban municipalities, First Nations, Irrigation Districts, and Conservation Area Authorities are legislatively established entities and will provide representation on the committee. Participation of other interest groups such as stewardship associations, producer groups, and other locally based organizations will also be considered for the committee to ensure there is a balanced representation of interests within the plan. The members represent their constituents, specifically producers, community residents, recreation interests, and other residents of the watershed who have a stake in the protection and management of the water resources.

A framework to address general and specific aspects of the Watershed Advisory Committee will be developed. It will include information to address terms of reference, establish rules of committee operation, set objectives, promote sound decision-making, and ensure timely delivery of findings. Establishing the terms of reference helps clarify the purpose and scope of the committee and identify and obtain agreement on the structure, influence, and specific committee responsibilities. The Watershed Advisory Committee meets regularly to understand and discuss issues, consider options, and make decisions. Thus, in large watersheds, more than one planning committee may be needed to accommodate travel logistics and group dynamics, and representatives from sub-watersheds would contribute to the development of a plan encompassing the entire watershed.

Technical Committee

A key component of the development of a watershed or aquifer plan is the assembly and analysis of information. A Technical Committee of agency representatives specializing in natural resource management will be tasked with this responsibility. Chaired by the Planning Team, the Authority members on the Technical Committee could include surface and ground water specialists, regional operations staff, water monitoring and projects and partnership representatives, and communication specialists. Typical representation on the committee from external agencies would include Saskatchewan Environment, Saskatchewan Agriculture, Food and Rural Revitalization, Saskatchewan Health, Government Relations and Aboriginal Affairs, Agriculture and Agri-Food Canada (PFRA), Environment Canada, Fisheries and Oceans Canada, and Ducks Unlimited.

Initial activities of the Technical Committee will involve gathering the necessary information to facilitate Watershed Advisory Committee discussions among the partner agencies and stakeholder representatives. As issues arise within the planning process and data collection and analysis become necessary, once again the onus shifts to the Technical Committee to provide assistance. Typically an issue can be addressed through a range of options; the Technical Committee will have the responsibility to identify and assess these options.

Planning Team

The Planning Team will usually consist of two staff from the Watershed and Aquifer Planning branch of the Saskatchewan Watershed Authority whose role is to coordinate activities and manage the planning process. The key responsibilities of the Planning Team include overseeing the establishment and guidance of the Technical and Watershed Advisory Committees, development of committee terms of reference, compilation of background information, management of the public consultation process, documentation of the findings of the Technical Committee and outcomes of stakeholder deliberations, and development of the final watershed plan.

Emphasis is placed on the important role of the Planning Team with respect to the stakeholder representatives and the public at large. The team facilitates meetings, becomes involved in the analyses of the strengths, threats, and opportunities of the watershed, and guides solution-driven consensus and collaboration. They must maintain public rapport while intuitively balancing interests and getting the job done. The team guides participants in round-table discussions to synthesize issues and set priorities. Simply put, planners encourage group validation and commitment to sound water management and source water protection.

The Planning Process

Upon establishment of the teams, the first step in the planning process is a thorough discussion of the issues. Local knowledge and discussion are central to this step, supplemented by technical input. Through a Watershed Advisory Committee agreement, the objectives of the planning process are established. This is a critical step since the eventual outcomes of the planning process are a direct response to these initial objectives. Information is then gathered, analysis is undertaken, and strategies to address the objectives are developed and evaluated. Finally, conclusions and recommendations are assembled. Although much of this work is directly linked to the activities of the Technical Committee and the Planning Team, this work is transparent requiring considerable involvement and support from the Watershed Advisory Committee representatives.

The last phase in planning is the implementation of the findings. This step is likely the most important element from a public perspective, given the considerable effort and collaboration invested in the process. All committee and team participants expect a tangible outcome from this work.

To ensure the public has an ongoing awareness and input to the planning process, various communication activities will be scheduled during the planning process. Open houses, informal community meetings, interaction with local media to enhance awareness, educational initiatives, field days, and pilot projects to research solutions are all tools available to increase public awareness.

THE WATERSHED/AQUIFER PLAN

Each watershed plan will contain background information, an environmental scan of the watershed, an analysis of issues and perceived threats, a commitment to action, timelines and responsibilities, and a measure of results and evaluation of effort. These components are discussed below.

Background Information

The background information in a plan includes a description of the Saskatchewan Watershed Authority and its mandate, mechanisms, and structure with an emphasis on watershed planning and a commitment to the implementation of outcomes. Where applicable, information about water management, ecosystem health, sound wetland and riparian management, and wildlife biodiversity is included as an introduction to the watershed.

Environmental Scan

The environmental scan contains relevant data to assist stakeholders in understanding the watershed and making decisions. Among the information to be detailed in the scan is population and demographics; economic activities and land use; aboriginal knowledge; climate, physical, and topographic characteristics including soils; surface and ground water availability; water allocations; trends in water use; and wastewater disposal and treatment. The environmental scan will also focus on the ecology of the watershed with an emphasis on ecological diversity, indicators of riparian health, native prairie sites, and ecologically sensitive areas. Real or perceived threats to the ecology will also be presented.

Issues

Issues that focus on water management, including associated ecological components, typically dominate the initial committee discussions within the planning process. The range of issues that are regularly brought forward include concerns about water management, the quality and quantity of the water resources in contrast to the demands that are placed on the resource, flooding and drought, climate change, the protection of riparian and wetland areas, and the maintenance of biodiversity. Validating these concerns, with the advice of the Technical Committee, and prioritizing these issues are important outcomes of these discussions.

Objectives

Examples of planning objectives that result from discussions of the Watershed Advisory Committee range from activities to provide the watershed residents with an improved understanding of the quality and quantity of the water resources and related ecological components to a determination of the impact of development on these resources to an assessment of a specific issue of particular interest or concern to the stakeholders. Narrower objectives, such as an improved operating plan for a reservoir, addressing unauthorized drainage, or taking steps to improve source water protection, could also be pursued in a watershed or aquifer plan.

Analysis

The type of information gathered and the degree of analysis conducted by the Technical Committee is contingent upon the issues under consideration. In many cases, the analysis takes the form of evaluating a range of scenarios. For example, in drought-prone areas the options could range from developing water storage to improving the efficiency of existing water use to reallocating water rights to better meet societal needs. In any event, the result of the analysis provides the basis for activities to address watershed issues and concerns.

Recommendations and Key Actions

The concluding section of the watershed or aquifer plan summarizes the outcomes of the committee discussions and technical analysis. Responses to the planning objectives are presented usually through a series of recommendations, and a general discussion of the perspectives of the watershed residents is provided. As noted earlier, actions to address the recommendations are critical to the acceptance and ultimate success of the plan. Care should be exercised to ensure activities are realistic and can be completed within an acceptable and well-defined time frame. The lead responsibility for the actions should also be clearly identified. Key actions are a function of the objectives and recommendations for a particular watershed or aquifer, but can include commitments to enhanced water quality monitoring, revisions to reservoir operating plans to address instream flow needs, the application of livestock grazing management alternatives to achieve sound riparian management, and the implementation of programming to protect wetlands. The completion of the watershed plan, with the support of the Watershed Advisory and Technical Committees, paves the way for delivery, program support, regular follow-up and updates, and the sharing of new information, programs, and strategies that continue to support the management and protection of Saskatchewan's water resources.

Plan Development Considerations

The development of a watershed or aquifer plan is subject to a number of controls external to the planning process. The willingness of the planning committee members to become and remain involved in the process, their support of the process through information sharing, and their ability to achieve agreement on fundamental issues may present challenges to planning timelines. Similar challenges are linked to the geographic size of the watersheds as the physical characteristics of each watershed vary, leading to issue diversity. The availability of internal and external technical support, and linkages to ongoing funding opportunities, will also influence timelines. Leadership by the Planning Team to achieve results in a timely fashion is crucial to successful plan development.

CLOSING

Watershed and aquifer planning is a key activity of the Saskatchewan Watershed Authority. With a focus on the protection of water supplies, from both a quantity and quality perspective, the planning process is designed to identify threats and initiate opportunities to address these threats. Significant effort will be made to involve the key stakeholders in all aspects of the planning process.

The participation of technical specialists from both the Authority and other natural resource management agencies is an important element in the success of the planning process. Many provincial, federal, and non-government agencies have a stake in healthy ecosystems and have resources available to help achieve this objective. Similarly, other agencies have management responsibilities for other components of the ecosystem and linkages among the processes are critical.

The role of the Watershed Advisory Committees in the planning process is particularly noteworthy. Participation in the identification of threats to source water is only the first step. Solutions to the problems will be based on collaboration; all watershed residents, with the support of government, have responsibilities to take measures to protect source waters. The Saskatchewan Watershed Authority is committed to working with stakeholders to assist with this responsibility.

FARM PLANNING ON SUB WATERSHED BASIS

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Abstract: Unprecedented opportunity for habitat conservation is occurring in Alberta through the simultaneous implementation of the provincial water strategy, the Agriculture Policy Framework, and provincial and federal species at risk initiatives. To incorporate goals for the retention of natural lands and the restoration of wetlands and degraded uplands into basin planning in Alberta, a model watershed approach is being proposed. Watershed Stewardship Groups provide a significant opportunity to extend stewardship programs and to implement best management practices offered through the Agriculture Policy Framework. The conservation community can be a catalyst in facilitating these efforts through collectively building awareness among our constituents and providing leadership to provincial government agencies in demonstrating the complementary links between integrated watershed management planning and environmental farm planning. By providing a model of success in one watershed stewardship group, this template can be extended throughout Alberta's watersheds.

GRAZING FOR BIODIVERSITY BENEFITS – THE CANADIAN FORCES BASE SUFFIELD EXAMPLE

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Abstract: Historically, the prairies were a mosaic of patches in various stages of recovery from roving grazers or from fire. Recovery rates for patches varied with environmental conditions and soil type. Most of the variation in post-settlement times has been removed from the prairie grassland system, specifically, native grass on good soils has been converted to crops; fire has been suppressed; and grazing now occurs almost annually by cattle which differ from bison in their grazing behaviour and impacts. Grassland birds are declining as a result of this habitat loss and suppressed variation.

Field sizes in the Prairie Farm Rehabilitation Administration pasture at Canadian Forces Base Suffield are large with few water sources. Stocking rates are maintained within those suggested for the type of range sites, and wildfires burn a portion of the area each year. Monitoring indicates that the sites are in good to excellent range condition. We documented a gradient of grazing use that creates variety in vegetation structure and results in an extremely diverse grassland bird community within the pasture. Our monitoring from 1994 to the present shows the dynamic nature of that community in response to changing climatic conditions. We suspect the reason that grassland birds do so well in ranching country is not just the presence of grass, but also the tendency to use appropriate stocking rates and to have large fields that minimize fencing and manpower expenses associated with moving animals between fields.

INTRODUCTION

Historically, the quantity and type of cover existing on the prairies was a function of four factors. Soil quality and climate determined the amount of grass growth and the ability to support shrubs or trees while fire and grazing, both of which were temporally and spatially irregular, determined vegetation removal in any given year. The result was a mosaic of patches in various stages of recovery from roving grazers or from fire. Recovery rates for patches varied with environmental conditions and soil type. Individual members of the grassland bird community in the Great Plains had diverse habitat preferences: some species liked short grass, some liked intermediate heights, and some liked the tallest cover available in the plains. Some species preferred homogeneous cover, while others liked a mixture of heights and thicknesses. Some avoided shrub, some tolerated it, and some required it.

In post-settlement times, the majority of grassland has been broken, and most of the variation has been removed from the prairie grassland system. Native grass on most good soils has been converted to crops. The remaining grass is thus on less productive soil so variation in potential for growth has been curtailed. Fire has been suppressed, eliminating post-fire patch types and allowing shrubs and trees to invade grassland in moister areas. Grazing is now almost always annual and performed by cattle, which differ from bison in their grazing behaviour and impacts. Grassland birds are declining as a result of this habitat loss and suppressed variation. Although those species that tolerate conditions created by modern agriculture have experienced fewer declines, species that need patch types uncommon under modern conditions are subsequently uncommon.

Current grazing management practices tend to favour rotation systems over season-long grazing, because rotation has the potential to increase the number of animals that can be raised. Rotation systems also require some additional inputs to add cross fencing, water systems, and labour to move cattle. One potential benefit of rotation systems is improved wildlife diversity; however, all known studies to date on bird diversity and grazing systems show little or no difference in bird communities. In this paper, we use our findings from a bio-inventory, supplemented with findings from a long-term monitoring project, to illustrate that season-long grazing creates a gradient of grazing conditions and supports a diverse bird community. We use our study area as the focus of discussion to challenge the wisdom of seeking one solution for all situations.

METHODS

Our study took place within the Prairie Farm Rehabilitation Administration (PFRA) community pasture at Canadian Forces Base (CFB) Suffield near Medicine Hat, Alberta in the Dry Mixed Grass Ecoregion. Field sizes therein are large (1,200 to 5,000 ha), and water sources are few. Each field is grazed from June through September, typically by cattle from producers living south of the military base. Stocking rates are within those suggested for the type of range sites. Monitoring indicates sites are in good to excellent range condition, and wildfires burn a portion of the area each year.

Bird surveys were conducted within much of the PFRA pasture in 1994 and 1995 as part of the multi-disciplinary inventory of the larger proposed CFB Suffield National Wildlife Area (NWA). Portions of the "Falcon" unit were not sampled. Bird sample sites (n=741) were located every 500 m along northing lines, and the data were collected using 5-min long, 100-m radius point counts conducted between 0500 and 0900 hours on each June day where winds were less than 20 km/hr and rain and fog were absent. Time of day, time of year, and observer bias were controlled by sampling order and observer assignment. Bird surveys have been conducted annually since 2000 on the sample sites south of Trumpeter / Interface roads in the PFRA pasture. This includes sites surveyed in 1994 or 1995 plus additional sites inside the pasture but outside the NWA.

Cattle fecal pile counts ("doo-doo index") were conducted in every second bird plot in April 1994, 1995, 1999, 2001, and 2002. The number of new (i.e., deposited during the past grazing season) and old fecal piles was recorded in a 2-m wide transect across the plot.

Structural measures of vegetation were collected in 1994 and 1995 on a subset (n=211) of the bird sample sites. The technique involved counting the number of contacts with a small diameter (5 mm) vertical rod by grass, shrubs, semi-shrubs, forbs, and standing dead vegetation. Litter depth (mm) was also measured.

The total number of bird species detected was tabulated and percent occurrence of each species on the northing lines south of Interface or Trumpeter calculated for each survey year. Values of the "doo-doo index" and of structural vegetation measures in 1994 and 1995 were contoured for the entire proposed NWA to create a map showing variability in their values. From 2000 through 2003, the Department of National Defense produced maps of the area showing the Brightness Component of Tasseled Cap transformed Landsat 7 satellite imagery.

RESULTS AND DISCUSSION

In 1994 and 1995, the bio-inventory of the proposed NWA documented a full suite of grassland birds occupying the area. In particular, heterogeneous and moderate cover species (Table 1), uncommon in prairie Canada under modern conditions (see BBS data in Table 1), were common and often the dominant species in the Suffield bird community. The only grassland birds not present were those for which Suffield would be considered outside their breeding range. We concluded that this bird diversity was possible because the large fields had variation in soils, topography, vegetation community, distance to the few water sources, and time since last fire. These factors, combined with the tendency of the cows to drift southward within fields (in the direction of their home location), created a gradient of use which was very evident in the "doo-doo index" map. The soil, topography, and grazing use created wide variation in grass cover and litter as illustrated in our maps of the structural vegetation. Because of the large variety in habitat conditions, all possible bird species could be accommodated. As the years of the initial inventory (1994 and 1995) were years of above-average moisture, the bird community composition might shift under drier conditions. Our long-term monitoring program initiated in 2000 does indeed show that percent occurrence of moderate cover specialists declined during the increasingly dry period (2000-2002) and showed some recovery in 2003 (Table 1). Conversely, species preferring short cover increased in the dry period and began to show declines in 2003. The Brightness maps from this period show cover decreased from 2000 to 2002 and began to improve in 2003. The maps also show that, in spite of dry conditions, there was still variation in the amount of cover across the pasture. This dynamic within the community is natural and represents variation that would have naturally occurred in pre-settlement prairies. Most importantly, even during the drought, this PFRA system was able to sustain all the bird species.

Range sites in the PFRA pasture were in good to excellent condition. A North Dakota study found that sites in good to excellent range condition were better able to maintain existing bird species through a drought period. A joint Canadian Wildlife Service and Saskatchewan Watershed Authority study that found many bird species did best where range condition was good to excellent and that both rotation and season-long sites could be in those condition classes. Our surveys through ranching country in southwest Saskatchewan and southeast Alberta also show very high occurrence of many moderate cover grassland birds, and many producers in these regions use large fields and season-long systems. Thus, we conclude that season-long grazing, provided it is managed to maintain healthy plant communities, is consistent with bird conservation. In the drier parts of the prairies, season-long grazing may also be consistent with good economics for the producer. If traditional season-long grazing is already producing good plant health, then the extra inputs of fencing, water systems, and labor for rotational grazing may not be worthwhile.

SUMMARY

We have documented a gradient of grazing use and thus variety in vegetation structure associated with season-long grazing in large fields. The grassland bird community within the pasture is extremely diverse. Our monitoring from 1994 to the present shows the dynamic nature of the grassland bird community in response to changing climatic conditions. We suspect the reason that grassland birds do so well in ranching country is not just the presence of grass, but also the producer's tendency to use appropriate stocking rates and to have large fields to minimize fencing

and manpower expenses associated with moving animals between fields. We suggest that a variety of grazing systems can produce good plant and bird community health and contend that the system used should be the one most economic for the location, holding size, and manpower constraints. If the extra economic inputs (including labor) needed for a rotation system exceed the value of the extra output in plant health/beef production, then switching from a season-long to a rotation system does not make either economic or ecological sense.

Table 1. Percent occurrence of birds from various grassland guilds in the prairies as a whole and in the CFB Suffield National Wildlife Area community pasture.

Species (habitat group)	BBS [1]	1994	1995	2000	2001	2002	2003
sample size	>5000/yr	107	129	152	259	260	250
short cover							
McCown's Longspur	1.4	0	0.7	2.6	29.3	43.5	14.8
Horned Lark	44.3	79.2	68.0	63.2	82.2	91.2	82.8
Chestnut-collared Longspur	6.5	39.6	41.4	75.0	72.6	78.1	74.0
shrub or exotic							
Vesper Sparrow	32.6	40.6	31.3	28.3	27.0	31.5	24.0
Lark Bunting	0.2	10.4	0	27.0	12.0	7.3	26.0
Savannah Sparrow	32.7	5.7	8.6	48.7	34.0	12.3	32.0
heterogeneous							
Willet	5.5	7.5	5.5	10.5	10.4	11.5	2.8
Marbled Godwit	6.2	18.9	10.2	16.4	19.3	22.7	13.2
Long-billed Curlew	2.4	17.0	13.3	17.1	19.7	21.2	15.6
moderate cover							
Baird's Sparrow	3.5	38.7	38.3	36.2	1.2	1.1	28
Grasshopper Sparrow	0.7	67.0	84.4	60.5	31.3	10.0	43.6
Upland Sandpiper	1.9	19.8	23.4	7.2	13.1	8.5	11.2
Sprague's Pipit	3.8	53.8	85.2	71.1	23.6	8.8	29.2
generalist							
Western Meadowlark	53.0	100	100	99.3	92.7	98.5	95.2

[1] The Breeding Bird Survey (BBS) reflects habitats and bird populations across the prairie region. For those species needing grassland, the maximum percent occurrence would be 25-30% since that is the amount of grassland remaining on the prairies. Species able to use some artificial habitats such as crops and ditches (e.g., horned lark, vesper and savannah sparrows, and western meadowlark) may occur at a higher percentage of sites. The majority of grassland birds occur on far less that 25% of sites, and this reflects a lack of grassland in suitable condition for their needs. No "specialist" is liable to find all grassland suitable. For example, one would conclude that only 10-15% of the remaining grass in the prairies as a whole is suitable for Baird's sparrow since it is found at 3.5% of prairie sites on average. One expects values at Suffield to be higher since the area is entirely grass. Again using Baird's sparrow, we see that at Suffield in most years the proportion of sites supporting the species is much higher than the long-term prairie average.

NEW RANGE HEALTH ASSESSMENT TOOLS FOR GRASSLAND MANAGEMENT

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Abstract: In 2003, Alberta Sustainable Resource Development formally introduced a new system of rangeland health assessment for the province. The concept of range health builds on the traditional range condition approach that measures the alteration of plant species composition due to grazing or other disturbances relative to the climax plant community (i.e., the potential vegetation for the site). While the old system has served range managers well, it has a number of serious limitations: the old system can prove complex to apply, does not adequately address invaded and forested rangelands, assumes all declines in plant succession are reversible, and is only one measure of health. The new system continues to look at ecological status, but also addresses plant communities that have been modified to non-native species. An important new feature is a series of questions that focus on important processes and functions performed by healthy range plant communities, such as net primary production, maintenance of soil/site stability, capture and beneficial release of water, nutrient and energy cycling, and functional diversity of plant species. A range health assessment requires an understanding of the plant communities and soils under assessment. Range plant community guides provide the standards that are used to evaluate the five questions included in the health assessment, namely ecological status, plant community structure, moisture retention and nutrient cycling, site stability, and noxious weeds. This presentation briefly illustrates the health assessment protocol, its application to native grasslands, and the suite of tools developed by Alberta Sustainable Resource Development to implement the new system.

INTRODUCTION

Over the past four years, range managers in Alberta have been developing a new system of range health assessment for use by land management agencies, ranchers, wildlife managers, and a wide spectrum of rangeland users. Alberta's first range condition guide was published in 1966. The range condition approach measured the alteration of plant species composition due to grazing or other disturbances relative to the climax plant community (i.e., the potential vegetation for the site). The "Stocking Guide" was a very popular and widely used tool. For a given set of soil and climate conditions, range site could be established and range condition applied to estimate an initial stocking rate, an important feature for establishing sustainable grazing levels.

Though the approach worked well in semi-arid grasslands, there were shortcomings. The range condition concept assumed that all declines in range condition were reversible. Experience shows that this may not be the case. Stable states in plant succession that are relatively resistant to change, even with decades of rest, may be established. This is particularly true in those plant communities invaded by non-native species. Also, the concept of a single climax community does not address the dynamic character of native plant communities where a number of successional outcomes are possible. American debates also identified the need to consider the management requirements of soil when management practices lead to accelerated erosion. New and robust range health tools were needed to include indicators like site stability. Overall, resource managers needed a more ecologically based approach with which to address many new issues that the old approach did not address, such as biodiversity maintenance and watershed protection.

In 1999, a provincial working group in Alberta initiated a new system for rating native range and tame pasture health for the province. Provincial specialists and ranchers had followed the debate on approaches to range condition assessment over the previous decade (e.g., Busby et al. 1994; Task Group on Unity in Concept and Terminology 1995). After considerable procrastination, a number of factors triggered our decision to move forward. First, our newfound experience with riparian health assessment illustrated the value of using multiple indicators to focus on practical measures of ecosystem functions: landowners found the riparian health assessment approach both transparent and useful. Second, Alberta was in the midst of reviewing grazing lease policy, and we needed a consistent method to evaluate rangeland stewardship. Previously, we had multiple approaches depending on agency and region of the province. Finally, the Natural Resource Conservation Service in the US published the new *Range and Pasture Handbook* (Butler et al. 1997). This document provided some new consensus on where the science was going and useful templates for defining our ecological site descriptions, the standards used in range health assessment. Our group experimented with a prototype and then refined the method through field testing and interaction with a host of clients and stakeholders. The results of this process were published in 2003 as a field workbook and three abridged field worksheets (Adams et al. 2003), all available on our website at www3.gov.ab.ca/srd/land/publiclands/rangehealth.html.

ELEMENTS OF THE SYSTEM

We use the term "range health" to mean the ability of rangeland to perform certain functions. These functions include net primary production, maintenance of soil/site stability, capture and beneficial release of water, nutrient and energy cycling, and plant species functional diversity. The term "health" conveys the impression that things are working well just like the human body. Healthy rangelands provide a wide range of ecological functions (Table 1) and sustain a long list of values and benefits (Table 2).

Table 1. Functions and their importance in healthy rangelands (taken from Adams et al. 2003).

Rangeland Functions	Importance of the Function
Net Primary Production	• Efficient utilization of available energy and water resources in the production of maximum biomass • Forage production for livestock and wildlife • Consumable products for all life forms (e.g., insects, decomposers, etc.)
Site Stability	• Maintenance of the potential productivity of rangelands • Protection of soils that have taken centuries to develop • Stable long-term biomass production
Capture and Beneficial Release of Water	• Storage, retention, and slow release of water • More available moisture for plant growth and other organisms • Less runoff and potential for soil erosion • More stable ecosystem during drought
Nutrient Cycling	• Conservation and recycling of nutrients available for plant growth • Reduced fertilizer requirements
Plant Species Diversity	• Maintenance of a high diversity of grasses, forbs, shrubs, and trees • High-quality forage plants for livestock and wildlife • Maintenance of biodiversity, the complex web of life

The new methodology builds upon the traditional range condition approach and continues to consider ecological status of a plant community, but adds four more indicators of rangeland natural processes and functions. With background knowledge about the local soils and vegetation, range health is rated for an ecological site type by scoring five questions that address selected indicators of range health:

1. Integrity and Ecological Status – Is the plant community native or modified to non-native species, and what is the successional status of the plant community?
2. Plant Community Structure – Are the expected plant layers present, or are any layers missing or significantly reduced?
3. Hydrologic Function and Nutrient Cycling – Are the expected amounts of organic residue present to safeguard hydrologic processes and nutrient cycling?
4. Site Stability – Is the site subject to accelerated erosion?
5. Noxious Weeds – Are noxious weeds present on the site?

The five indicators are weighted according to their relative importance to rangeland health. When a site is rated, the combined score of all five indicators is expressed as percent health score so that the site can be ranked as healthy, healthy with problems, or unhealthy. The field workbook is designed for application on native grassland, native forest, tame pastures as well as modified rangelands where range plant communities have become invaded by non-native species such as smooth brome and timothy.

Table 2. Values and benefits of healthy rangeland (taken from Adams et al. 2003)

Rangeland Users	Values and Benefits of Healthy Range
Livestock Producers	• Lower feed costs • Renewable and reliable source of forage production • Stability of forage production during drought • Greater flexibility and efficiency for alternate grazing seasons (e.g., autumn or winter where applicable) • Lower maintenance costs such as weed control • Reduced (i.e., eliminate) requirements for the input of inorganic fertilizers and other soil amendments and additives • Reduced concern for noxious weeds
Resource Managers	• Quality wildlife habitat • Fisheries habitat • Grazing opportunities • Minimal soil erosion • Timber production • Increased total net benefits
Public	• Esthetic landscape values • Watershed protection • Water quality • Large soil carbon sinks • Biodiversity • Opportunities for passive and consumptive recreation, such as tourism and hunting
Socio-economics and Governance	• Increased cooperation and increased total benefits to society with fewer conflicts to resolve, less regulation, and less enforcement. This means lower costs!

APPLICATION OF THE NEW SYSTEM

We envision three applications for the assessment method: as an awareness tool that helps tune the rancher's eye to better recognize any key impacts to range health, for rapid assessment purposes with appropriate study and field training, or as a component of a detailed range vegetation inventory carried out by field practitioners. The response to date from agency staff, the consulting community, and the environmental community has been positive, and many have adopted the new system. Most importantly, ranchers have found it to be very accessible, visual, and applied. While species composition may take many years to influence, indicators like structure, organic residue, and soil exposure are more readily observed, providing managers early warning as to trend in health status. The question on evaluating residue proved popular at field days and workshops for monitoring drought impacts and recovery given the recent severe drought conditions. Wildlife managers have considered using the tool as a coarse-filter approach to recognize habitat quality for species like the greater sage-grouse.

One limiting factor in applying the method is the need for information on ecological sites, successional pathways, and plant communities that are the product of various natural and man-made disturbance regimes. In Alberta, range plant community classification guides have been developed for each natural subregion of the province. These guides are based on data from over 200 rangeland reference areas in the province combined with vegetation inventory data. A considerable monitoring infrastructure is required to make the system work.

Our hope is that the new range health assessment system provides a common language for resource managers, ranchers, and the public when discussing rangeland problems and issues. If we can reach an early consensus, more time can be invested in developing solutions.

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THE COTEAU LEGACY: A PRAIRIE LANDSCAPE CONSERVATION PLAN

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The Prairie Pothole Region (PPR) forms the core of what was formerly the largest expanse of grassland and pothole complexes in North America. Covering 300,000 square miles, the PPR extends 1,500 miles from the Peace Lowlands of Alberta to the Tall Grass Prairie of Iowa. The recession of glaciers from the last ice age left a landscape of rolling grassland interspersed with millions of depressions that are known today as prairie potholes. For thousands of years, this complex of wetlands and grasslands sustained breeding populations of waterfowl unmatched anywhere else in North America. Over the short span of the past 125 years, however, the landscape has changed dramatically. Over 70% of the wetlands in the PPR have been drained or severely degraded; yet the destruction continues. In many places, upland habitats have been under greater siege than wetlands. The amount of cropland in prairie Canada has increased significantly in the last 25 years, and as a result, some species of waterfowl, such as northern pintails, have been particularly hard hit. Since shallow wetlands and fragile grasslands are their preferred breeding habitats, pintail populations have declined 53% during the last 20 years.

Given this degree of habitat loss and degradation, Ducks Unlimited Canada's (DUC) vision for the PPR is to "achieve a mosaic of natural, restored, and managed landscapes capable of perpetually sustaining populations of waterfowl and other wildlife". The challenge for DUC is to rapidly expand our efforts to conserve critical landscapes like the Missouri Coteau. The Missouri Coteau, or "hills of the prairie", is a 25,700 square mile (16,500,000 acre) band of recessional moraine, 10 to 50 miles wide, which stretches from southern Saskatchewan to South Dakota. The dominant land use and primary threat to habitat in the Missouri Coteau is annual cropping with approximately 60% of the lands under cultivation. Annual cropping has radically transformed vast expanses of native prairie that historically characterized this region, replacing it with drained wetlands and cultivated uplands.

DUC has worked hard at conserving habitat within the Missouri Coteau since 1940. Traditional strategies have made important gains, but the future depends on using new approaches to preserve and develop habitat in the face of a dominant agricultural industry. To meet the challenge of continued habitat loss and degradation and to restore lost value, *The Coteau Legacy: A Prairie Landscape Conservation Plan* will strive to meet the following three goals in the next 20 years:

1. Protect two million acres of existing prairie grassland and associated upland habitats and a half million acres of wetlands from further loss or degradation. Because prairie grassland land tenure is divided into two main categories, protection strategies will be directed into different approaches for Crown and privately owned lands.
   - Efforts toward Crown lands will be directed toward maintaining lands in the name of the Crown and not sold without protection of natural features.
   - Protection of privately held grasslands will be accomplished by having landowners recognize the value of native prairie grasslands and wetlands and take action to conserve them and by developing public policy that ensures protection of grasslands. Some activities include rangeland stewardship programs, conservation easements, and a property tax credit program.
2. Restore degraded prairie that has already been or will be affected by harmful rangeland management. This accounts for an estimated 60% of the rangeland in the next 20 years, including wetland fringes. Restoring degraded prairie will be accomplished by educating rangeland managers, both Crown and private, on the impacts of their current land management practices, demonstrating alternative, improved management practices, and assisting in the implementation of these improved systems on the land they control. Some activities include grazing clubs, demonstration sites, Crown and private grazing systems, and extension events.
3. Compensate for historical and ongoing loss of prairie habitats within strategic geographical portions of the Coteau. This 20-year goal affects 40% of the currently cultivated acreage of the Coteau. Although native prairie habitat can never be replaced, there are alternative agricultural practices that can compensate for this loss relative to nesting waterfowl and other wildlife. Reducing disturbance by agricultural equipment during the nesting period, although not the ideal solution can significantly improve nesting success of waterfowl. Activities directed at compensating for loss include land acquisition with grassland restoration, conversion of annual cropland to forages, and utilization of winter cereals.

The funding requirements to achieve the three principle goals identified in our long-term vision will require an ambitious commitment of funding and overall resources. We believe that by implementing the strategic conservation initiatives we have proposed, the stated goals can be attained. These ambitious goals will require a 20-year funding commitment in excess of $100 million. This funding challenge speaks to the importance of capturing new partnerships and funding opportunities. The success of maintaining and improving the ecological integrity within the Coteau can be achieved only through the development of an integrated habitat management action plan with all partners that share a common purpose. We will actively pursue and maintain partnerships with an array of conservation agencies such as Saskatchewan Environment, Saskatchewan Watershed Authority, the Prairie Farm Rehabilitation Association (PFRA), Saskatchewan Agriculture, Food and Rural Revitalization (SAFRR), and the Nature Conservancy of Canada, as well as the thousands of private land managers who steward land in the Coteau.

As a result of the first two years of conservation program delivery under the 20-year Coteau Legacy Plan, DUC has managed to accomplish the significant impacts on the landscape as detailed in Table 1.

Table 1. Accomplishments of the *Coteau Legacy Plan* between April 2002 and January 2004

Conservation Initiatives/Programs	Direct Programs (Secured Acres)[1]	Extension Programs (Influenced Acres)[2]	Program Totals (Acres)
Protection of Existing Habitats	1,823	91,767	93,590
Donated Easements	-	-	-
Conservation Easements	317	-	317
Land Purchase–Natural Land	-	-	-
Lease / Land Use Exchange	506	-	506
Tax Credit Program	-	91,767	91,767
Improved Ecological Function	63,884	403,000	466,884
Grazing Clubs	-	200,000[3]	200,000
Tours, Workshops	-	81,000	81,000
One-on-One Extension Contacts	-	122,000	122,000
Stock Watering Demonstr. Sites	-	-	-
Deferred Grazing	8,500	-	8,500
SAFRR Pastures	17,519	-	17,519
PFRA Pastures	31,545	-	31,545
Provincial Grazing Co-ops	6,320	-	6,320
Compensation for Lost Habitats	16,646	10,900	27,546
Conservation Forages	12,746	-	12,746
Winter Cereals Core Growers	1,200	3,100	4,300
Winter Cereals 1000X	2,700	-	2,700
Winter Cereals Information Inquiry	-	7,800	7,800
Land Purchase–Upland Restoration	-	-	-
Conservation Program Totals	82,353	505,667	588,020

[1] Direct programs are those programs whereby DUC directly impacts actions of producers, improves, or protects habitat.
[2] Extension programs are those programs whereby DUC extends technical advice that is mutually beneficial to both producers and wildlife habitat.
[3] Acres are based on the entire holdings of producers involved in extension events. This represents the maximum potential impact on the landscape of extension events for the period.

ADAPTIVE MANAGEMENT STRATEGIES FOR THE FOOTHILLS FESCUE GRASSLANDS: DEALING WITH HUMAN DISTURBANCES

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Abstract: Rough fescue, Alberta's provincial grass, also known as the queen of the grasses, has historically been the dominant grassland species in the black soils of Alberta. Foothills rough fescue *(Festuca campestris)* dominated the rich, black soils of the Foothills Fescue, Foothills Parkland, Montane, and Subalpine Natural Subregions. Unfortunately, rough fescue grasslands are threatened by invasive agronomic species including Kentucky bluegrass *(Poa pratensis)*, timothy *(Phleum pratense)*, and smooth brome *(Bromus inermis)*. These species radically alter the character of the native rough fescue plant community. Rich, moist, bottomland soils are the most prone to invasion and are often completely modified to non-native agronomic species.

There is a growing awareness that we lack the tools and knowledge to restore rough fescue grasslands after they are disturbed by landuse activities such as road construction, oil and gas, mineral exploration, and country residential developments. An adequate supply of native rough fescue seed is often cited as the principle limiting factor in the restoration of these grasslands following disturbance, but a growing number of people ranging from producers to the scientific community are realizing that the issue is much more complex.

In order to prevent landuse disturbance from threatening the integrity of rough fescue grassland communities on black soils, a two-pronged adaptive management strategy will be required. The first prong is to increase our knowledge of the agronomy of these native communities and the dynamics of their competitive relationships with these aggressive agronomics. A strong understanding of these relationships is the only route to understanding and achieving successful restoration of rough fescue plant communities. Second, a conservative and precautionary approach must be taken during industrial development in the black soils of the foothills until the required technology for rough fescue restoration is available. This approach will involve significant preplanning of operations that look at short- and long-term facility development plans, use of existing and further development of improved minimum disturbance techniques specifically designed for the black soil zone, and avoidance of native plant communities by placing development on previously disturbed areas.

INTRODUCTION

Historically, the rich, black soils in the Foothills Fescue, Foothills Parkland, Montane, and southern Subalpine Natural Subregions of Alberta have been dominated by foothills rough fescue *(Festuca campestris)* plant communities (Looman 1969; Strong 1992). Recently named Alberta's provincial grass, foothills rough fescue is a competitive, deep-rooted, tall-growing bunch grass that is well adapted to climatic conditions and historic herbivory patterns along the eastern slopes of Alberta (Tannas 1998). Foothills rough fescue is extremely competitive and can grow almost to the exclusion of other plants in the absence of disturbance on mesic rich black soils (Moss and Campbell 1947; Looman 1969; Willoughby 1992). These grasslands are one of the most productive range types in the Northern Great Plains, and rough fescue is the most productive forage species therein (Bradley et al. 2002). Rough fescue is also quite resistant to weathering, providing high forage availability and forage quality throughout the year. These characteristics make rough fescue communities extremely valuable for dormant season grazing by wildlife and livestock.

Although these grassland communities have undergone significant conversion to agriculture through cultivation (Bradley et al. 2002), they have not fallen victim to the plow to the same extent as grasslands in other natural subregions. A harsh climate with an extremely short growing season makes many of these areas unsuitable for traditional grain farming despite the extremely productive soils (Strong 1992). Public ownership of large tracts of land in these subregions has also been a factor in the conservation of these communities (Bradley et al. 2002).

INVASION OF AGRONOMICS INTO FOOTHILLS FESCUE GRASSLANDS FOLLOWING DISTURBANCE

In its historic natural setting, foothills rough fescue is an extremely competitive species, but management changes, disturbance, and the introduction of invasive agronomic species since European settlement have changed the environment in which foothills rough fescue is found. Accordingly, the foothills rough fescue grasslands now face threats that could eventually result in the extirpation of this grassland species and its associated communities from the landscape.

Although the loss of native rough fescue communities to agriculture through cultivation has not been as significant as in other natural subregions, disturbances such as oil, gas, and mineral exploration, road development, poorly-managed grazing, and an extremely high demand for country residential development have put significant pressure on the native foothills rough fescue grassland communities. These pressures have resulted in the invasion of the foothills fescue plant communities on black soils by invasive agronomics such as Kentucky bluegrass *(Poa pratensis)*, timothy *(Phleum pratense)*, and smooth brome *(Bromus inermis)*. This, in turn, has had a radical effect on the native plant community and has resulted in the conversion of many of the richest bottomland soils to a modified community dominated by non-native agronomic species (Willoughby and Alexander 2000; Adams et al. 2002; Adams et al. 2003; Willoughby and Alexander 2003; Willoughby et al. 2003).

These agronomic species exhibit several qualities that have made them valuable in agriculture, in particular competitiveness, early-season growth, rapid maturity, prolific seed production, drought tolerance (particularly later in the growing season), and adaptation to the climate exhibited by these natural subregions. The invasion of these species into the black soil zone has also been assisted by the societal belief in the 1940s and 1950s that these agronomic species were superior to the native species and thus their colonization should be promoted. Currently, their prolific seed production and widespread distribution maintain a significant seed bank throughout the black soil zone. When disturbance occurs, these aggressive agronomics are quick to colonize the site.

The effect of these invasive agronomics is not limited to disturbed areas. The disturbance creates a foothold from which the invasion process begins (Bradley et al. 2002; Bradley 2003), sometimes referred to as a “shadow” effect. Bradley et al. (2002) found that non-native species had invaded from a disturbance an average corridor width of 50-70 m by 22 years after the disturbance. Tyser and Worely (1992) found that alien species on ungrazed rough fescue grasslands in Glacier National Park had invaded up to 100 m from both paved and unimproved dirt roads, and further invasion was anticipated over time.

Some may question why we should attempt to preserve the integrity of the foothills fescue grassland. Research has shown that intact native fescue communities provide ecological and managerial values unmatched by modified or invaded communities (Adams et al. 2003). These values include forage productivity, forage quality and availability (particularly during the dormant season), production stability, managerial efficiency and flexibility, site stability and soil maintenance, moisture retention and watershed function, plant community structure, wildlife habitat values, and biodiversity maintenance.

RESTORATION OF ROUGH FESCUE GRASSLANDS FOLLOWING DISTURBANCE

There is a growing awareness that we lack the tools and knowledge to restore rough fescue grasslands after they are disturbed by landuse activities like road construction, oil and gas, mineral exploration, and country residential developments (Bradley et al. 2003). The rapid invasion by non-native species and displacement of native species on North American grasslands is well documented in the scientific literature. Grasslands dominated by bunch grasses such as rough fescue are particulary susceptible. Soil disturbance, water enrichment, and increased fertility from mineralized organic fractions provide a competitive advantage to the invasive agronomics that are already in the soil seed bank.

An adequate supply of native rough fescue seed is often cited as the principle limiting factor in the restoration of these grasslands following disturbance. However, a growing number of people ranging from producers to the scientific community are realizing that the issue is much more complex. Our understanding of the agronomy of rough fescue and its associated communities, particularly stand establishment and competitive relationships that exist between native species and introduced aggressive agronomics, is poor and limits our ability to manage these areas after surface disturbances.

The black soil zone is expected to experience unprecedented oil and gas and mineral exploration, as well as road and country residential development into the next decade. In order to prevent landuse disturbance from threatening the integrity of rough fescue grassland communities on black soils, adaptive management strategies will be required. The successful conservation and management of rough fescue grasslands requires a two-prong approach. We must first increase our knowledge into the agronomy of native rough fescue communities and the dynamics of their competitive relationships with aggressive agronomic species. A strong comprehension of these relationships is the only route to understanding and achieving successful restoration of rough fescue plant communities. These relationships are extremely complex and significant research is required.

The seond adaptive management strategy is to take a conservative and precautionary approach to further development on the black soils zones while the technology required to restore rough fescue plant communities is put into place. A product similar to the *Best Management Practices for Pipeline Construction In Native Prairie Environments* (Neville 2003), which provides direction and sets standards based on the best known management practices, is required to set minimum disturbance protocols for industrial development. This approach will involve significant preplanning of any development activity that occurs. Preplanning must include short- and long-term facility development plans that coordinate all resource users on the landscape. Developments should be carried out using minimum disturbance techniques, and new minimum disturbance techniques specifically designed for the black soil zones will have to be developed. Most importantly, development activities should practice avoidance of native plant communities where possible by placing activity on areas already disturbed or invaded by invasive agronomics. Due to the susceptibility of these grasslands following disturbance and the interest expressed by the energy industry, there is a level of urgency in developing and implementing these products and methods before significant fragmentation or loss of grassland integrity occurs.

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CUMULATIVE EFFECTS OF LANDUSES IN THE PRAIRIE ECOSYSTEMS OF ALBERTA

Brad Stelfox
FOREM Technologies

Abstract: This presentation will focus on the past, current, and future scale and rate of landscape transformation in Alberta's Grassland Natural Region. Using Alberta Landscape Cumulative Effects Simulator (ALCES) and based on the interdisciplinary work of the Grassland Natural Region Cumulative Effects Team, this presentation tracks historical landuse practices in southern Alberta and projects a future landscape based on industry and government estimates of development for the agriculture, energy, transportation, and human population sectors. The anthropogenic footprint in the Grassland Natural Region is not stationary, but growing for many landuse variables. The future ability of the landscape to provide appropriate levels of biological and physical services, production of petrochemical and agricultural resources, aesthetic appeal, and homes and infrastructure for people will largely be determined by how well society recognizes the cumulative effects of our landuse practices, by whether society has the vision and fortitude to develop a landscape plan that seeks balance to the competing demands on this landscape, and by the commitment through which this landscape plan is implemented. An important component to seeking a balance between landuse practice and ecological integrity lies in a better understanding by managers of how all land uses conduct their practices and in devising a more integrated approach to laying out landuse footprints. Significant savings to capital budgets and reduced ecological risk await those managers prepared to "think outside the box" and contribute to landscape planning across "meaningful" space and time.

A FRAMEWORK FOR TRANSBOUNDARY CUMULATIVE EFFECTS ANALYSIS IN THE CROWN OF THE CONTINENT

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Abstract: Cumulative Effects Assessment (CEA) has most often been applied with respect to a particular project under review. Typically, the project proponent is responsible for undertaking a CEA as required by legislation. This position supports the polluter-pay principle whereby the organization proposing to introduce an environmental hazard must demonstrate that the development will not cause irreparable damage. An emerging view recognizes that CEA should also function as a regional planning tool whereby government, industry, and community members work together to assess the impacts of specific projects and regional impacts of a development on the landscape. This position supports the view that once completed on a regional level, a CEA would provide the context within which site-specific assessments are performed. This approach is more conducive to landscape-level planning exercises whereby proposed developments would be assessed in relation to an overall landscape plan.

A self-initiated, regional standing body of government land managers has emerged in the Crown of the Continent region of Alberta, British Columbia, and Montana with an expressed intent to engage in a cumulative effects assessment for regional planning. The Crown Managers Partnership has selected modeling software (ALCES) and agreed to share data in the regional interest. The Miistakis Institute for the Rockies is the organization chosen to guide the development of a CEA framework and operate the model. This provides an unprecedented opportunity for research into effective regional CEA. This paper reports on the drivers and barriers to regional cumulative effects approaches to transboundary planning and management. In addition, a model framework for engaging in such a process is presented.

INTRODUCTION

The most significant environmental issues facing the prairies today (e.g., climate change, loss of biodiversity, declining quality and quantity of freshwater, etc.) exist not because of effects arising from any individual action, but because of the complex additive and synergistic effects in time and space of multiple human actions. As Shoemaker (1994, p. 95) summarizes, "The reality is not single stressors creating significant impacts, but multiple causality, interacting processes and populations of both past and present human activities affecting a number of valued resources in a geographic area." The proliferation of cumulative effects has been attributed to the incremental and disjointed nature of decision-making (tyranny of small decisions) that characterizes many contemporary institutional structures and regulatory approval processes (Kahn 1966; Odum 1982; Creasey 1998; Kennett 1999). Sustainable development, adaptive ecosystem-based management, and the emergence of other holistic planning, policy, and management paradigms echo the need for novel approaches to strategically address cumulative effects in order to achieve the goals of ecological integrity, economic sustainability, and social equity (Cocklin et al. 1992; Court et al. 1994; Slocombe 1994; Stinchcombe and Gibson 2001; Noble 2002; Piper 2002; Prato 2003).

The accumulation of past, current, and future impacts, resulting in additive or synergistic influences on the environment, are referred to as cumulative environmental effects (CEQ 1997; Hegmann et al. 1999). Cumulative effects may be the result of a single activity occurring repeatedly, such as industrial discharge into an aquatic system, or the result of multiple activities from related or unrelated sources, such as reductions in river flow as a result of irrigation, municipal, and industrial water withdrawals (Cocklin et al. 1992; Hegmann et al. 1999; Bonnell and Storey 2000). Cumulative effects result from activities that persist over time and transmit over space, leading to direct and indirect environmental effects (Barrow 1997; CEQ 1997; MacDonald 2000). Cumulative effects can arise from a variety of situations and activities ranging from large impact generating projects that produce significant environmental change to numerous, small, individually insignificant projects that in combination have a compounding and degrading effect on the environment (Kennett 1999; Piper 2002). Frameworks for understanding cumulative environmental effects generally consider the sources, pathways, and effects of environmental change (Sonntag et al. 1987; Contant and Wiggins 1991; Cocklin et al. 1992).

The two general kinds of cumulative effects assessment have been project-based and strategic (Noble 2000; Davey et al. 2002). In practice, this distinction should be considered more a spectrum of approaches rather than two completely different ideas, but we shall employ the project and strategic labels to discuss the differences and similarities. Project-based cumulative effects assessments are generally conducted under statutory environmental assessment processes as triggered by the terms of provincial, state, or federal legislation (Bonnell and Storey 2000). Project-based assessments have tended to be proponent-driven and focused on the incremental impacts of proposed projects within a limited area (Lee and Gosselink 1988; Kennett 1999). Strategic environmental assessments emerged partly as a response to the failure of project-based assessments. Stinchcombe and Gibson (2001, p. 346) explain that such strategic assessments are "…a response to the tendency of project-level assessments to be reactionary (examining already selected and often already designed undertakings), narrow (failing to address cumulative impacts), and poorly integrated into broader political and economic processes".

In general, strategic environmental assessment is focused on higher-level assessment of policies, programmes, plans, and their alternatives (Noble 2000; Partidário and Clarke 2000). While still evolving, the past decade has witnessed significant advances in the theory and methods of considering cumulative environmental effects at the project review level (Griffiths et al. 1998; Ross 1998; Baxter et al. 2001; Damman 2002). However, the development of strategic methods and approaches for assessing regional cumulative environmental effects earlier in the planning process, and in a more proactive manner, has been significantly more modest (Kennett 1999; McLaughlin 2001).

OBJECTIVES AND STUDY AREA

This paper reports on a demonstration research project to create and assess a regional framework for proactive examination of cumulative environmental effects within the Crown of the Continent Ecosystem (Crown). The transboundary Crown of the Continent region is bounded on the south by the Bob Marshall Wilderness complex in Montana and extends north to the Highwood River in Alberta. The Elk and Flathead Valleys in British Columbia and Montana demarcate the western boundary, and the region extends eastward to the foothills of Alberta. The entire area is comprised of approximately 42,000 km^2. The Crown of the Continent is accepted as a functionally defensible ecological unit at the scale of a greater ecosystem (see for example, Darrow et al. 1990; Long 2002; Stanford and Ellis 2002; Pedynowski 2003) and provides a critical ecological interface with the prairies.

Internationally recognized for its ecological and geological uniqueness, the region constitutes one of the most ecologically diverse areas on the continent (Long 2002). The ecological significance of the region is perhaps best indicated by the occurrence of eight large carnivore species and their associated prey, the only area remaining in the lower forty-eight States where such a fully intact assemblage exists. The valleys of the Crown serve as important wildlife movement corridors, connecting metapopulations of various species throughout the Rocky Mountain cordillera. Many small mammals, birds, reptiles, amphibians, fish, and a wide diversity of plants punctuate the ecological importance of the Crown (Flathead Transboundary Network 1999; Long 2002).

In particular, the following report focuses on the experience of a group of public land managers in the transboundary environs of Alberta, British Columbia, and Montana. The managers are participants in an informal, inter-agency, international working group known as the Crown Managers Partnership (CMP). The initiative described here is an ambitious attempt to consider the cumulative environmental effects of land use within the region. The overall goal of the cumulative effects assessment project is to develop an educational and analytical tool that will assist land managers in developing a strategic framework to consider the effects of future land uses across jurisdictions. Such an approach would also allow land managers to assess the environmental impacts of specific projects against a developed cumulative effects baseline.

The specific objectives of the project are as follows:

- to identify drivers and barriers to develop a multi-jurisdictional, international framework for regional cumulative effects assessment.
- to develop a process to facilitate ongoing, collaborative data collection and harmonization for modeling regional cumulative effects.
- to assess the value of both the process and the model and make recommendations regarding the ongoing development of the framework and its implementation.

The size and complexity of the task requires long-term commitment to the process. The findings reported herein should therefore be considered a work in progress.

SUMMARY OF FINDINGS AND PRESENTATION OF FRAMEWORK

Drivers and Barriers

A web-based survey was administered to members of the CMP to determine the level of knowledge and interest regarding cumulative effects assessment and to identify the most significant drivers and barriers to pursuing a complex regional cumulative effects assessment process. Survey respondents were supportive of pursuing a regional cumulative environmental effects assessment program and recognized the value of such an initiative to their individual mandates. Participants indicated that the most important characteristics of effective collaborative initiatives were (1) clearly defined and shared goals and objectives, (2) shared commitment for long-term involvement, (3) adequate commitment of resources, (4) common issues and pressing need for response, (5) frequent and effective communication, and (6) mutual respect and trust among participants. Conversely, participants identified the most important barriers to effective collaboration initiatives in resource management as (1) lack of resources, (2) lack of shared agency mandates and philosophies, (3) lack of agency support, (4) lack of continuity of participating members, and (5) inter-agency barriers and “turf” issues.

General Approach and Model Selection

The approach and framework for assessing cumulative environmental effects in the Crown of the Continent has been an incremental process with continuous adjustments made through consultation with the CMP membership. The fundamental components of the framework are project management (including shared issues identification), data collection, base case modeling, scenario modeling, and the development of communication products for decision support. The process is iterative and adaptive with the goal of continuous improvement. Although the process is still primarily in the data-gathering phase, the framework seems to be effective for the needs of the partners.

The cumulative effects analysis framework being developed by the CMP includes the use of a computer model known as ALCES® (A Landscape Cumulative Effects Simulator). ALCES® is a stock and flow (systems dynamics) model constructed in a STELLA® modeling environment. The model operates by establishing relationships (pathways and rates of flow) between entities or stocks of interest (e.g., landuse and land cover types) and then simulates the changes in the entities over time. The model basically functions as a sophisticated accounting system. ALCES® enables resource managers, industry, society, and the scientific community to explore and quantify the cumulative, dynamic effects of human landuse practices and existing natural disturbance regimes. ALCES® contributes to a strategic cumulative framework as an exploratory tool to identify emerging regional issues and opportunities and to examine the potential implications of trends and policy choices under a range of future scenarios. This model is driven through a collaborative visioning process that ultimately contributes to planning regional sustainability.

ALCES® was selected as the model of choice for the CMP due to its proven applicability for regional cumulative effects analysis in nearby areas, its validation and verification by independent experts (Hudson 2002; Van Laake 2002), and the familiarity of several CMP participants with the function of the model. Hudson’s (2002, p. iv) independent review of ALCES® as a strategic (comprehensive, long-term, large spatial scale) landuse planning tool concludes:

> ALCES fills a vacant niche among natural resource management models in providing a comprehensive framework to study cumulative effects among a wide variety of land uses ranging from human settlement, protected areas, recreation, agriculture, forestry and energy. It is an exploratory tool for strategic analysis and complements more detailed and focused models used for tactical analysis and operational planning.

Likewise, the authors of a comprehensive review of cumulative effects models for the Cumulative Effects Management Association state:

> The A Landscape Cumulative Effects Simulator (ALCES) developed in Alberta by Forem Consulting Ltd. is the most comprehensive model reviewed. This aspatial landscape simulator integrates all four model classes (habitat availability, population, land use, and natural disturbance). Unlike other integrated models, it also considers all land use activities likely to occur in the Wood Buffalo region. It includes both aquatic and terrestrial indicators and is able to incorporate stochasticity. Its greatest strength is its ability to rapidly incorporate user-defined changes so that the effect of various development scenarios and management options on future habitat availability and populations can be visualized (Salmo Consulting et al. 2001, cited in Hudson 2002, p.14).

The CMP is confident that the selected model will provide valuable utility to the overall regional landscape assessment process.

The framework developed for the regional cumulative effects analysis in the Crown of the Continent consists of three parts (Figure 1): data collection, base case modeling, and scenario modeling. The framework is designed to produce results that can then be incorporated into decision-making by individual agencies.

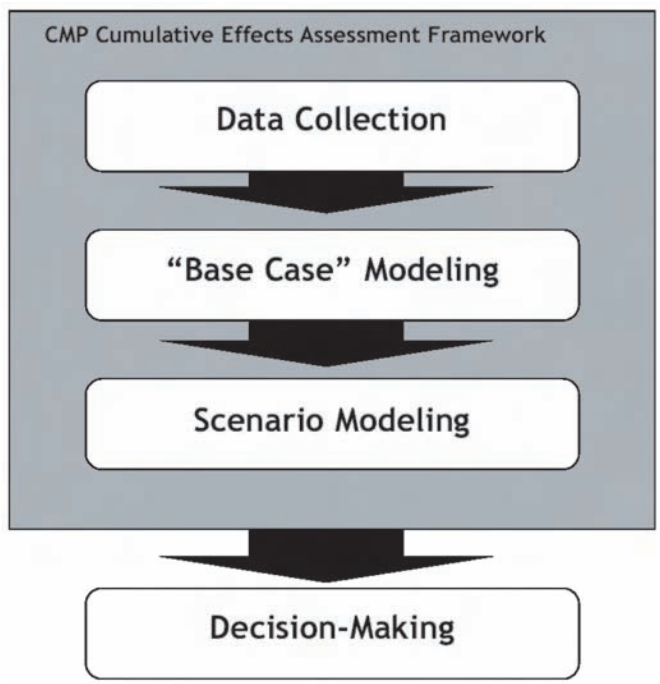

Figure 1. Fundamental steps in the Crown of the Continent regional cumulative effects analysis framework.

Data Collection

Working under the direction of the Project Team, the Data Collection Team coordinates the data collection for the modeling phase (Figure 2). The collection of the spatial, metric, and trend data that constitute the input to the

ALCES® model represents the greatest proportion of the time and effort in the project thus far. The strategic, cross-sectoral nature of regional cumulative effects assessment necessitates the inclusion of knowledgeable participants beyond the Data Collection Team: the small group of people on the Data Collection Team simply does not have expertise in the full range of land uses and ecological disciplines represented on the landscape. Furthermore, to facilitate eventual acceptance of the modeling results, data that each land use or sector considers most appropriate must be used. For each land use, at least one Sector Representative is recruited. These individuals are responsible for providing the bridge between their sector and the regional cumulative effects project. They are called upon to identify the location and accessibility of relevant data for their sector. As well, Sector Representatives are interpreters, explaining the specific needs of their sector to the Project Team and explaining the assumptions underlying the modeling process back to individuals within their sector.

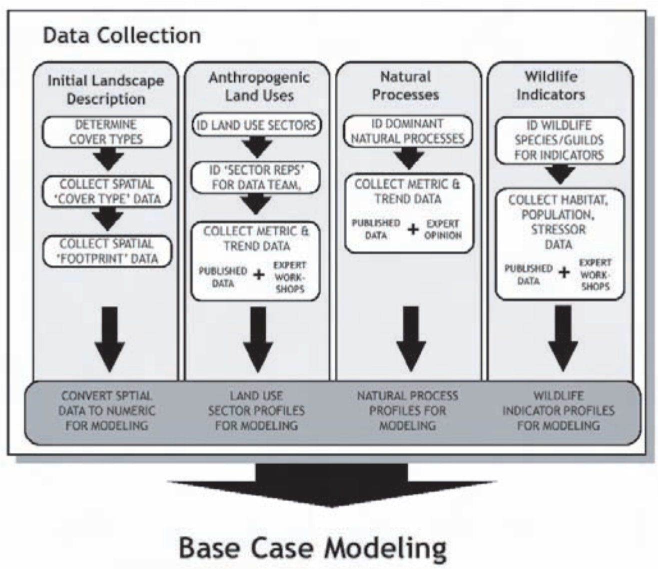

Figure 2. Data collection process for Crown of the Continent regional cumulative effects analysis framework.

The first step in assessing the cumulative effects of various land uses on a landscape is to establish a baseline landscape description. The 'initial landscape' description for the focal area includes the various cover types (vegetation, waterways, rock and ice, etc.) overlain by the various landuse types (transportation infrastructure, residential development, well pads, etc.). This description relies heavily on the collection of spatial datasets. For the entire region, spatial datasets of base features (roads, towns, industrial plants, etc.), vegetation, and other cover types are collected from agency and industry sources. However, datasets collected from multiple jurisdictions (e.g., Alberta, British Columbia, and Montana) are often not harmonious. The different jurisdictions have varying resolutions, degrees of completeness, and vegetation and base feature classification schemes. Accordingly, the collected data must then be standardized and converted to a form usable by the ALCES® model.

In consultation with area foresters and other relevant ecologists, the vegetative and non-vegetative cover types representative of the focal area are selected and condensed to approximately 25 categories. The collected cover data layers are then translated into these common categories based on standardized and well-documented protocols for re-classifying vegetation types, prioritizing overlapping datasets, etc. Perhaps the largest and most challenging data collection task is acquiring data related to the full spectrum of land uses active within the focus area. In the case of the Crown of the Continent region, the human activity on the landscape has been classified and data collection will be focused on the following landuse types: forestry; energy and mining; agriculture and livestock; transportation; humans and their settlements; protected areas; general industry and electrical; and tourism, recreation, hunting, and trapping. Similar to the cover type data, the relevant spatial landuse data are converted and reclassified.

The data required for the modeling come in three types: spatial, metric, and trend. Considering the stock and flow character of the model, spatial data collected from GIS databases can describe the initial 'stocks' – what we have now. However, metric data (non-spatial, non-trend parameters describing land use) and trend data (projections of future trends) describe and characterize the 'flows' – the factors that influence the changes in those stocks. For example, the ALCES® model requires information regarding how much land is in a particular crop type (spatial data), but it also requires data on such factors as the average herbicide application rates for that crop type (metric data) and whether the landbase in that crop type is projected to grow or shrink in the future (trend data).

Metric and trend data are the most difficult types to assemble. Values vary tremendously across the study area, are not uniformly collected nor standardized, and (in the case of trend data) are typically conjectural. In many cases, the data simply do not exist in a published format. Thus, the metric and trend data are gathered through a combination of published data and a series of expert workshops for each land use. This requires gathering experts in each field who can represent the various geographic and jurisdictional areas and working through a consensus-based process of determining, vetting, and substantiating all numbers. In essence, these are the parameters that the model utilizes to project future landscapes. For each landuse sector, data collection employs a four-stage process:

1. As much data as possible are collected from published sources and known experts prior to convening workshops;
2. A First Expert Workshop is convened to present modeling assumptions, increase general understanding

and comfort with framework, and identify data gaps and further data contacts;

3. Based on the results of the first workshop, follow-up data collection is pursued through identified individuals and sources; and
4. A Second Expert Workshop is convened to validate and reach agreement on sector data inputs.

Following the data workshops, the ALCES® model is updated with the consensus-derived metric and trend data. Where lack of agreement or a high degree of uncertainty characterize metric or trend data, the model has the capacity to represent a range of values.

Additional data types such as data on natural processes and wildlife are also collected and incorporated into the cumulative effects modeling process. Data related to natural processes are collected in much the same way as for the land uses; that is, published data and reports are consulted first, then expert opinion (via consultation or consensus-based workshop) is used to fill any data gaps. Data related to meteorological and hydrological influences such as precipitation, reservoirs, water demand, inflow, run-off, sedimentation, and pollutants are collected and included in the modeling as are fire return rates, fire suppression rates, burn characteristics, residential fire losses, insect mortality, and crop loss rates. When simulations are run, meteorology, fire, and insect regimes can be applied stochastically or deterministically and can include defined climate change scenarios. Finally, a selected suite of wildlife species are chosen to act as indicators of ecological health in the region. The process for collecting the data is very similar to that used with the landuse types: a combination of published data and expert opinion are used to derive metrics related to the chosen species.

Base Case and Scenario Modeling

The role of modeling is to generate plausible representations of future landuse dynamics and implications based on the inputs and assumptions provided to the model and then allow the user to explore mitigative scenarios. The main outputs of the model are a series of user-defined graphs showing various parameters and relationships over the simulation time period and spatially stratified descriptions of potential future landscapes. The model addresses cumulative effects through the interactions between modeled components in the stock and flow architecture. Some of the tools that the ALCES® model provides in support of this task are the following:

- simulation of future landscape composition or future anthropogenic edge;
- simulated impacts of various landuse patterns on biological, economic, or other indicators;
- user-defined monitoring panel of thresholds and targets for indicators, landscape, and footprint types;
- ability to turn on or off specific landuse or disturbance regimes during simulations;
- ‘backcasting’ to pre-settlement landscape composition which enables approximations of the range of natural variation;
- iterative scenario generation, comparing mitigative strategies to a base case;
- choice of habitat suitability, resource selection, or species richness functions for wildlife response simulations;
- stochastic or deterministic application of disturbance regimes during simulations; and
- comparative graph output.

Once the data have been collected, validated, and entered into the model, the model is tested and a baseline established against which potential scenarios can be measured (Figure 3). A Modeling Team is assembled whose responsibility is coordinating the ALCES® model runs based on input from the CMP. The Modeling Team is comprised of individuals from the CMP who have the ability to bridge the operational or tactical and strategic levels of resource management in the region. Each member receives advanced training in the ALCES® model. During testing, the Modeling Team conducts multiple runs and assesses the outputs for any apparent inconsistencies resulting from the model. Those inconsistencies are then addressed before the ‘base case’ is determined. The base case run provides output based only on the initial trends and metrics gathered for the model. Results of future modeling, incorporating proposed mitigations and alternate scenarios, will be compared to this base case. As new research and work provides improved data, the base case can be modified on an on-going basis.

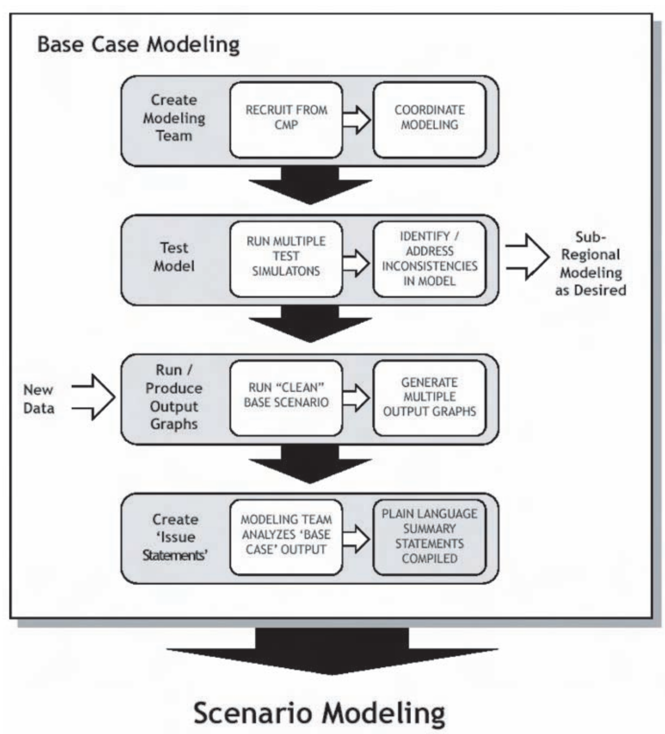

Figure 3. Base case modeling for Crown of the Continent regional cumulative effects analysis framework.

As mentioned above, the primary outputs of the model are a series of line graphs describing changes in the landscape and landuse parameters and the future landscape composition. However, this information does not immediately illustrate for middle- to upper-level managers the regional, strategic-level issues that may need to be addressed through policy and management action. To facilitate this, the Modeling Team converts the model output into plain language 'issue statements'. These summary statements make no judgments about the changes in management action that may be required; they simply identify areas where the model has indicated conflicts may occur in the future. Where possible, the Modeling Team will also identify the primary aggravating activities underlying the issue.

These issue statements then form the basis for an iterative scenario modeling process (Figure 4). The Modeling Team communicates the issue statements developed from the base case to the CMP through mechanisms such as the annual Crown Managers Forum. The CMP collectively identifies which of the issue statements represent issues of the highest priority and thus should be modeled. Working with the Modeling Team, a subcommittee of the CMP identifies mitigative strategies that may address the issues, as well as thresholds for certain parameters that must not be exceeded in the model simulations. From this, guidelines regarding alternate management scenarios are developed and passed on to the Modeling Team. The Modeling Team develops the instructions from the CMP into workable scenarios that can be modeled. As required, individual mitigations or multi-faceted management scenarios are then modeled in ALCES® and compared to the base case. The results of the scenario investigations, and an assessment of their potential for success, are reported back to the CMP. As well, any new issues that may have arisen are summarized into new issue statements and presented to the CMP. This iterative process continues, with new scenarios being created, tested, and analyzed in an ongoing fashion. Information from the scenario exercises are extracted as needed and incorporated by individual agencies into policy and management activity as they see fit.

The power of this modeling approach lies in the ability to examine cumulative effects of multiple sectors and land-uses at a regional scale. Furthermore, scenario modeling allows CMP managers to engage in virtual adaptive management. Rather than enacting resource management initiatives on the ground, monitoring their effect, and then adapting management regimes as necessary, this process allows managers to test management adaptations in a 'virtual' environment. Individual agencies or subregions of the Crown region can choose to run simulations on limited geographic areas. However, the spatial data will need to have been collected in such a way that the sub-region data can be 'clipped' to the desired boundaries. More importantly, trend and metric data values, which have been determined for the entire region, will have to be revisited to ensure they are still valid for the subregion.

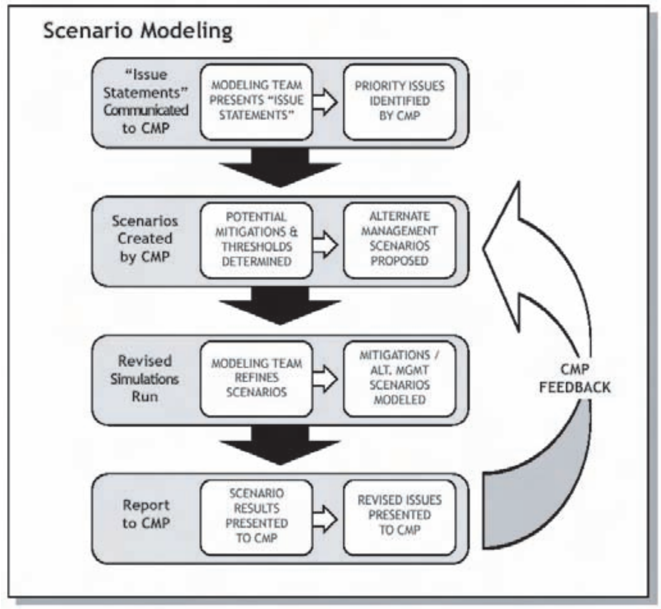

Figure 4. Scenario modeling for Crown of the Continent regional cumulative effects analysis framework.

REFLECTIONS ON THE PROCESS

The commitment on the part of the participating agencies to a strategic, regional cumulative environmental effects analysis evolved over a period of time and did not begin with a concrete goal or specific objectives. The CMP started as a meeting to discuss needs and possibilities for collaborative research and management, with the partnership eventually choosing to take on the cumulative effects project. Because the regional cumulative environmental effects analysis was conceived as a strategic tool for land management agencies in the Crown of the Continent, developing buy-in from those agencies is critical if the modeling outputs are to be employed for meaningful decision-support. As well, gathering data would be next to impossible without the participation of the agencies. This necessitates accommodating multiple agency circumstances, developing a shared understanding of the goals, having buy-in for the process in general, and acquiring the appropriate political support at the appropriate time.

Maintaining multiple agency involvement in a complex, multi-year project has been difficult, despite the high support expressed repeatedly by those agencies for a regional cumulative effects project. Agencies are operating under difficult conditions in terms of sparse budgets, shifting priorities, changing governments, and limited human resources. Accordingly, many participants have been hard-pressed to provide funding, time, and personnel – all of which have had a detrimental effect on the ability to maintain engagement.

Participants in the CMP are middle- to high-level managers; however, support at higher, more political levels continues to be unenthusiastic or absent, largely because of changing priorities and multiple demands on agency resources, but also due to political concerns regarding pursuing activities outside specific mandates and jurisdictional boundaries. This has ultimately led to a significant delay in advancing the project to the modeling phase. The CMP Steering Committee clearly recognizes the need for higher-level support and is discussing the potential for a tour of meetings with senior managers, and perhaps politicians, to generate support for the project.

CONCLUSION

The regional cumulative environmental effects analysis for the Crown of the Continent is a complex and long-term initiative. The framework and modeling being developed for the process appear adequate, but will require continuous improvement over time. In order to ensure the sustainability of the project, it is recommended that (1) the CMP continues to explore the potential mechanisms and appropriate timing for attaining higher-level recognition and support for the partnership and the cumulative effects project; (2) the goals and objectives of the project be revisited with CMP members through a series of small group meetings; (3) CMP members secure long-term financial and human resource commitments to the project through communicating the benefits of leveraging; (4) improved and more frequent communication tools be developed for internal use; (5) the activities and benefits of the CMP be communicated to the general public and relevant interest groups; (6) the CMP make a commitment to monitoring, feedback, and continuous improvement of the cumulative effects project; and (7) participating agencies look for opportunities to explicitly incorporate the data, tools, and model outputs from the cumulative effects project into existing agency programs in order to demonstrate the benefits of participation.

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MANAGING THE CUMULATIVE EFFECTS OF RURAL SUBDIVISION IN ALBERTA: THE FAILURE OF MUNICIPAL PLANNING

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Abstract: Regional planning is necessary to address the cumulative environmental problems caused by human settlement. One problem is the gradual loss, alteration, and fragmentation of wildlife habitat by the proliferation of rural residential subdivisions. Subdivision approval, a municipal responsibility, has two aspects that typify the cumulative effects problem: independent, sectoral decision making with minimal regard for the consequences to others and incremental change that is inconsequential in size but, when compounded over time and space, fundamentally alters a landscape.

Regional planning is defined as hierarchical, integrated, and inclusive planning and action in areas of substantial but varying size for the purpose of protecting ecological integrity. The responses of Cypress and Cardston Counties to subdivision pressure are used to illustrate the state of regional planning in the settled areas of Alberta. These examples show a lack of institutional support for systematic, multi-sectoral regional planning; as a consequence, occurrences are adhoc and occur by chance. Furthermore, the requirements for intermunicipal integration are inadequate or ignored. Finally, municipal contributions to environmental protection are compromised by vague direction and competing demands.

To deal with the cumulative effects problem, Alberta must move beyond an adhoc approach to regional planning and recognize the critical importance of municipal participation in environmental protection. Thus, regional planning requires the following: (i) increased support from the provincial government through legislation, policy, and provision of sufficient technical and financial resources; (ii) an acceptance that a basic design principle of a regional plan is the primary reliance on groups living within the region for plan development and execution subject to larger societal norms; (iii) the flexibility in organizational form that sees both collaborative, impermanent, cross-sectoral organizations that address strategic issues of importance and permanent, regional organizations that encourage cross-sectoral planning; and (iv) an expectation of, and support for, municipal participation in regional planning and environmental protection.

INTRODUCTION

The early 20th century flood of settlers into the prairies and parkland of Alberta fundamentally changed the character of the landscape. Land was tilled, woodlands removed, rivers dammed, and cities built. Settlement patterns and land use have resulted in the loss of over half of the original native prairie grassland (PCF 2002), while the parkland region of central Alberta has been virtually eliminated (AAFRD 2003).

Alberta's population continues to grow today: in the most recent census period (1996-2001), the province experienced the country's highest population growth rate (10.3%) (Statistics Canada 2002). An important component of settlement is subdivision development, a process that involves a number of seemingly insignificant activities that when compounded over time and space fundamentally alter the landscape. This process of environmental change is referred to as a "cumulative effect". Cumulative effects (CE) are subtle in nature and, as a consequence, difficult to address.

CUMULATIVE EFFECTS

The United States Council on Environmental Quality (CEQ 1978, Part 1 1508.7) defines a cumulative effect as "the incremental impact of [an] action [on the environment] when added to other past, present, and reasonably foreseeable future actions…." Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.

Cumulative effects have both spatial and temporal characteristics. Spatially, an assessment of the environmental impact of an individual action must consider all other activity in an area, including past and foreseeable future development. The incremental nature of subdivision development and hence its classification as a CE problem is illustrated by a series of time slices that map the numerical increase and spacial expansion of buildings in southwestern Alberta (Figure 1). These buildings and their accompanying infrastructure of roads, pipelines, and powerlines alter habitat and create linear disturbances that are key threats to ecological integrity and biotic populations (Forman 1995; PCF 2001). Henderson and O'Hearn (1992, p. 20), in a review of the effects of subdivision on wildlife, concluded that in

Montana the “most perilous change for wild ungulates is the conversion of relatively large agriculture holdings to relatively small residential tracts.”

ATTRIBUTES OF REGIONAL PLANNING

The regulatory requirements to address CEs are limited to federal and provincial Environmental Impact Assessments (EIAs). In both cases, the assessment process is designed to address individual projects of substantial size and identify those that present serious structural problems as they pertain to CE management (Kennett 1998). Problems include a failure to address incrementally insignificant activities and the limited management options to deal with a documented effect.

As an alternative to EIAs, Kennett (1999) and others suggest that CEs should be addressed on a regional basis and through proactive planning. For example, the *Cumulative Effects Assessment Practioners Guide* (Hegmann et al. 1999, sec. 2.2.2) states, “regional ‘nibbling’ effects usually cannot be adequately dealt with on a project-by-project review basis.... To properly address this type of cumulative effect, regional plans are required....”

Regions are important because their broad spatial scale allows cumulative changes to be discerned, they capture ecosystem types found outside protected areas, and they encompass habitat required by wide-ranging species. Regional planning is defined in this paper as hierarchical, integrated, and inclusive planning and action in areas of substantial but varying size for the purpose of protecting ecological integrity (Barss 2003). Successful regional planning requires institutional support for these attributes.

Hierarchy

Recognizing that ecosystems are organized on varying spatial scales, conservation writers agree that institutional structures should attempt to match these hierarchical levels (Grumbine 1994; Christensen et al. 1996). Such institutions might take the form of physical organizations, cascading landuse plans, or a tiered succession of guiding policies. The introduction of hierarchical institutions can result in political tension as existing local institutions and the newly formed region struggle over power sharing (Hooper et al. 1999; Wight 1999; Hodge and Robinson 2001).

Integration

Characteristic of many regions is the jurisdictional fragmentation of management responsibility for actions that impact the environment. In Alberta, responsibility

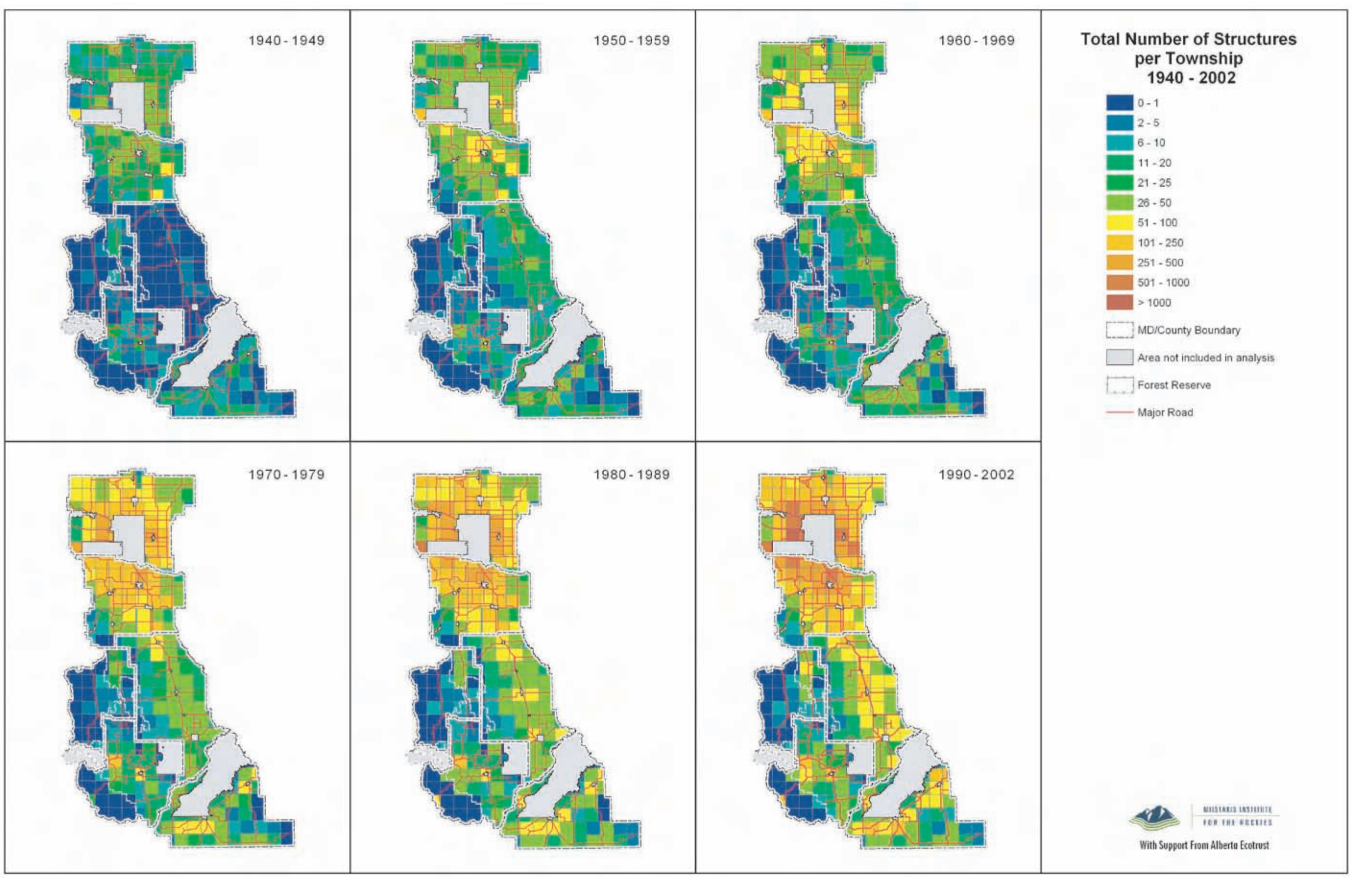

Figure 1. Incremental change in southwestern Alberta over time. The spatial and numerical expansion of building structures illustrates the incremental nature of subdivision development (modified from Duke et al. 2003).

for subdivision approval and design in the Parkland and Grassland Natural Regions is split among 44 rural municipalities based on territory (Figure 2). Regions are also fractured along sectoral lines with natural resources managed by provincial agencies according to resource type. A consequence of jurisdictional fragmentation is independent sectoral decision making with minimal regard for the consequences to others (Dykeman 1986; Meine 1995), a condition that exacerbates the environmental impacts of incremental change.

An integrated approach to decision making is proposed as a response to the compartmentalized sectoral decision making and its ensuing problems (landuse conflict, over-allocation of resources, and deterioration of ecological health). Integrated resource management literature advocates bridging sectoral boundaries through cooperation, coordination, and collaboration (Lang 1986; Margerum 1997).

Action

Planning requires action: planning "that changes nothing of substance is scarcely worth talking about" (Friedman 1987, p. 44). Achieving action requires a mandate to plan (Kirlin 1996; Dovers 2001); the capacity to act, which is a function of the appropriate tools and resources (technical and financial); and a venue where decisions can be made.

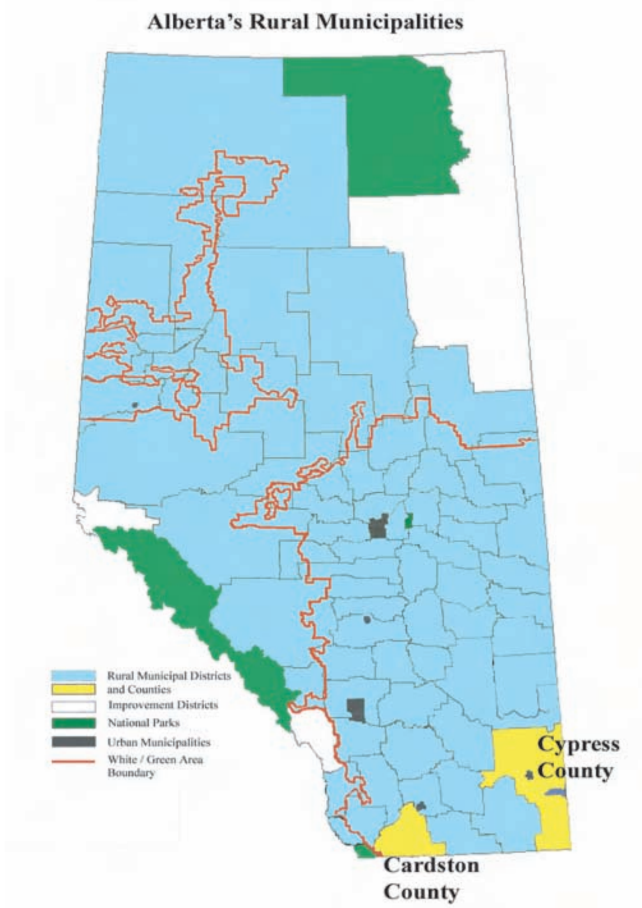

Figure 2. Alberta's municipalities.

MUNICIPALITIES AND SUBDIVISION

Given that regional planning is a necessary tool to control the cumulative change associated with rural subdivision, the following question arises: does Alberta provide the institutional framework that supports regional planning? Alberta's support for regional planning will be analyzed here using the criteria of hierarchy, integration, and action. The analysis will be illustrated by the response to rural subdivision applications adjacent to Cypress Hills InterProvincial Park (CHIP) and Waterton Lakes National Park (WLNP).

In Alberta, the *Municipal Government Act* (MGA) assigns responsibility for subdivision approval and overall landuse planning to municipal governments. Landuse plans and their accompanying mechanisms are primarily set up to deal with development and change to private land. Importantly, landuse planning is not designed as a tool to regulate static situations, control individual practice, or for conservation purposes; rather, such planning concerns itself with guiding the rate, direction, and form of human settlement. Therefore under the MGA, counties are responsible for determining whether subdivision applications are compatible with municipal plans.

A Tale of Two Counties

The southern Alberta counties of Cypress and Cardston (Figure 2) faced a similar situation, a request to change the landuse designation adjacent to a protected area from agriculture to one that allows country residential development. But the counties responded in quite different ways. In the Cypress case, the county council narrowly rejected the proposal (5 to 4 vote) and placed a two-year moratorium on development within a 3.2 km fringe of the CHIP boundaries. The council then formed a committee composed of municipal representatives, provincial agencies, and the public to oversee the creation of the *Cypress Hills Fringe Area Structure Plan* (Cypress County 2003). The primary goal of the plan is to "provide an opportunity for development in the Cypress Hills…in a manner that respects the…ecological landscape of the plan area" (Cypress County 2003, p. 22). The plan, covering an area 1060 km^2 in size, relies on extensive background data to identify and map ecologically sensitive land. It also contains mechanisms to protect that land by identifying appropriate areas for development and stipulating requirements for environmental review and mitigation.

In the Cardston case, the council agreed to a landuse change that allows 23 homes to be built along the Waterton River. The county did not respond to a request by the Municipal District of Pincher Creek to participate in a joint municipal planning effort that would guide future development around WLNP and would be funded by Parks Canada (DeMarco 2001). In this case, the *Rocking*

Horse Ranch Area Structure Plan (Garner & Garner 2001) was limited to the specific development (0.4 km^2 in size) and addressed environmental issues in a cursory fashion that relied on a dated regional study. Subsequent to this application, Cardston County approved a second subdivision five kilometres east of WLNP.

Hierarchical Institutions

Alberta municipalities are not required to engage in hierarchical, regional landuse planning. According to Laux (2002, sec. 2-2), the most substantive change to the new (1995) *Municipal Government Act* "was the elimination of regional planning and the abolition of the Alberta Planning Board." Although the MGA allows for intermunicipal planning, the essence of the Act and other provincial policies is to treat municipalities as independent sectors who are allowed to make unilateral landuse decisions with minimal provincial input (Barss 2003). For example, in response to inquiries regarding Cardston County's approval decision, the Minister of Community Development writes, "We must also recognize the rights of individual property owners and the rights of municipal authorities to manage development within their jurisdictions" (C. Bradley, Southern Alberta Environmental Group, pers. comm.). The consequences of independence are illustrated in the preceding two examples: one municipality chose to address the regional and environmental consequences of development, while the other approved an incremental change.

Despite the creation of a regional plan by Cypress County, their process highlights three areas of systemic failure. First, the decision to create and approve the *Cypress Hills Fringe Area Structure Plan* rests entirely with the municipal authority. Second, a great deal of luck was involved in its creation. For instance, if the council's vote of 5 to 4 against approval was reversed, development at Cypress would parallel that at Cardston. In Alberta, we rely on individuals and receptive governments to trigger regional planning. Third, the plan was created in reaction to a development proposal – there are no systematic ways of identifying areas of regional importance and assessing the risk to them *a priori.*

There is one final noteworthy point in the Cardston example: although the provincial government considers the approval of the subdivision a matter of local jurisdiction, the environmental consequences are regional, if not international, in nature. Allowing local authorities to make regional decisions counters a planning norm that those who are affected by a decision should be involved in the decision-making process (Barss 2003).

Integrated Municipal Planning

Despite the lack of statutory support for regional planning, the province recognizes that integrated municipal/provincial and municipal/municipal planning is important. The province has created a series of Land Use Policies (LUPs) that are intended to guide municipal planning and action. The polices open with the following statement:

> It is therefore important that municipal and provincial planning efforts utilize consistent approaches to pursue a high-level of cooperation and coordination.

Policy 3.1 is an example of a policy designed to encourage integration, specifically,

> Municipalities are encouraged to expand intermunicipal planning efforts…especially where valued natural features are of interest…and where the possible effect of development transcends municipal boundaries.

The LUPs have failed in the Cardston case in two ways. First, there is no intermunicipal plan that guides development in this high profile area, and there appears to be no municipal interest on the part of Cardston County in developing one. Second, there is not a high level of cooperation and coordination between the County of Cardston and other provincial agencies. This statement rests on the assumption that "high-level cooperation" means proactive planning that identifies areas of critical importance and considers ways to direct development prior to specific proposals. In the Cardston example, provincial involvement is the reactive application of regulations after land has been designated for country residential development.

The reason that municipalities are able to ignore the LUPs is found in the words of the policies themselves:

> The Province is entrusting to each municipality…to interpret and apply the Land Use Policies…. (LUP, Policy 1.2)
>
> The policies are presented in a general manner which allows municipal interpretation and application in a locally meaningful and appropriate fashion. (LUP, Policy 1.2)
>
> Municipalities are encouraged to… [43 of 45 policies are non-mandatory].

Municipal Action

Although the institutional framework that encourages regional planning in Alberta is weak, an unanswered question remains: could a municipality constrain or direct subdivision independently or as part of a larger regional plan that is concerned with environmental protection? The answer is a qualified yes. The *Cypress Hills Fringe Area Structure Plan* demonstrates that the MGA provides municipalities with the flexibility to direct subdivision to less ecologically sensitive areas and allows them to apply conditions to subdivision approval such as an environmental review. However, the answer is qualified based on a neutral mandate, tool limitations, and constrained resources.

Neutral Mandate - The mandate to protect the environment under the MGA is limited to the general purpose statement which directs municipalities to make plans "that maintain and improve the quality of the physical environment within which patterns of human settlement are situated" (MGA, sec. 617). The only direct reference is a stipulation that a

Municipal Development Plan may address environmental matters within the municipality (MGA, sec. 632). The LUPs have a number of policies that show provincial interest in the environment; however, there is no method to gauge that level of interest. This is because the LUPs contain numerous other policies (45 in total) with no indication of priority. A single policy may place a mandatory requirement on a municipality to consider cumulative development. Policy 2.3 reads,

> When considering a planning application, municipalities are expected to have regard to both site specific and immediate implications and to long term cumulative benefits and impacts.

The significance of the word "expected" is unknown. However, it is unlikely that it could be used to challenge a council's action as the LUPs state that they "are not intended to be the basis of legal challenges" (LUP, p. 3). In summary, given the plethora of LUP policies, their non-mandatory nature, and limited direction in the MGA, the individual municipality must determine what part environmental protection plays in its decision making.

Tool Limitations - The loss of agriculture land to subdivision has been of concern to rural municipalities for a number of years. An analysis of 36 rural Municipal Development Plans reveals that the protection of agricultural land was a common goal (Resource Planning Group 2002). Despite this goal, landuse planning appears to have had limited success in preventing subdivision (e.g., Figure 1). The reasons for this planning failure may include the mistaken assumption that subdivision increases net municipal revenue, a reluctance to override the private property rights of the individual in favour of the public good, and the simple inability of council members to say "no" to one's neighbour.

Constrained Resources - Finally, municipalities have numerous other responsibilities that place demands on what they perceive as limited financial resources (Barss 2003). Without a source of outside funding, many municipalities likely will not assume the costs associated with regional planning (data collection, staff, public consultation, etc.)

In summary, the MGA is neutral towards environmental protection (including the consequences of subdivision development), neither compelling nor prohibiting municipal action. This neutrality is preserved by the LUPs, which essentially provides no guidance at all by providing a multitude of non-mandatory directions. Furthermore, the environment must compete with multiple municipal obligations and for constrained financial resources. The resulting outcome in most municipal jurisdictions is the relegation of environmental protection to a second tier of consideration.

DISCUSSION AND CONCLUSION

The Premier of Alberta has formally committed to protecting the environment and maintaining species diversity (Government of Alberta 1999). If this commitment is to be achieved in the prairie region, three objectives must guide its action.

1. There needs to be recognition that human settlement plays a fundamental role in landscape change and, therefore, so do the municipal institutions that regulate it.
2. There must be an expectation that municipalities will look beyond their borders and participate in regional planning.
3. The current method of regional planning in environmentally significant areas, which is adhoc and relies on chance, should be replaced by a more systematic, institutional approach.

These objectives require the provincial government to assume an active role in promoting, supporting, sustaining, and requiring regional planning and environmental protection at the municipal level. Institutional changes that would achieve these objectives must account for the social and political context of the grassland region, a context which sees municipalities resisting any action that would decrease their existing power and yet unlikely to take extensive action to address regional issues (with a few notable exceptions). Nevertheless, the current situation is weighted too heavily towards allowing independent municipal decision making in areas of regional concern.

To help mitigate the resistance to change, regional planning should primarily be the responsibility of local organizations that make up the region, subject to wider public norms and direction. The implication for the prairie and parkland area is that municipalities should be the primary participants in the design, operation, and outcome of any regional governance system. However, initiating regional planning should not be the sole responsibility of municipal government. Where there is a specific issue of strategic environmental importance, the province must act as a catalyst to ensure the formation of a regional partnership and plan. The form of governance for this region should include municipalities as primary players; however, participation would be cross-sectoral in nature. There would be no assumed institutional permanence beyond the resolution of the specific planning issue. Detailed form, operations, and solutions would be unique to each strategic region. Where a permanent need for regional governance in the White Area is recognized, municipalities should be responsible for institutional design and operation. The provincial role should be that of an enabler. A permanent organization could address cross-jurisdictional issues; encourage intermunicipal planning; provide a venue for information exchange, communication, and education; and, by pooling resources, increase the research capacities of individual municipalities. The province, either as a catalyst or enabler, should include legislation and policy support for regional planning and access to resources that aid formation (e.g., planning templates, facilitation, mediation, data, technical expertise, and sustained financing).

This paper has not discussed potential governing models that might be used to develop a regional plan. Historically, regional planning was a government responsibility. Traditional regional governments derived their authority from the senior governing level, operated in a top-down fashion, and participation was largely confined to political and administrative representatives. This model is in decline across North America (Sancton 1994; Wallis 1994), replaced with a model of civic governance that involves permanent or temporary cross-sectoral alliances including groups outside of formal government. These governance organizations address issues of common strategic interest, operate in a collaborative fashion, and are often bottom-up in formation (Wallis 1994; Barss 2003). Participants have the benefits of increased influence, a broader range of expertise, increased legitimacy, financial leverage, and overall effectiveness. Promoting this latter model, which emphasizes collaborative participation of equals, may lessen the reluctance of municipalities to participate in regional planning.

Regardless of the support for the concept of regional planning, a number of specific improvements to the current institutional framework will enhance environmental protection. For example, municipalities must have a clear mandate to address the environment. The MGA should contain a purpose statement indicating that municipalities are expected to contribute to the protection of the air, water, land, and species diversity. Second, statutory plans such as the Municipal Development Plans should be required to address environmental matters within the municipality. This requirement necessitates that a municipality identify and document its environmentally sensitive areas. Additionally, the latitude given to municipalities to interpret and apply the LUPs should be reduced where environmental issues cross municipal boundaries. Finally, the development of a funding policy is necessary to support municipalities and cross-sectoral organizations that engage in environmental management. Equity demands that all Albertans should, through the provincial government, compensate a municipality that voluntary accepts the responsibility (or is legally required) to address environmental matters of regional, provincial, or national significance. Likewise, regional planning by multi-sectoral organizations will fail if these groups have insufficient technical and financial resources. It is unrealistic and unconscionable to expect cross-sectoral voluntary organizations to contribute to the provincial mandate of environmental protection without sustained funding. Sustained funding does not necessarily mean full funding; in some cases, a requirement to access matching funds may be appropriate. However, the government must be there each year to “prime the pump”.

Finally, the reasons for the failure of landuse planning as a tool to control subdivision requires further study. Tentative remedies include (i) the promotion and support of tools designed for land conservation that do not involve municipal decision makers (e.g., conservation easements, transferable development rights); (ii) the fettering of complete municipal independence regarding subdivision approval, with the form of such restrictions ranging from outright prohibition to moratoriums of limited duration; and (iii) the subjection of local councillors and their landuse decisions to wider public and peer accountability through participation in regional organizations. By moving decision making to a higher level of authority, these latter two options would help clarify those decisions that adversely affect a particular individual, but are important for the public good. Municipalities may be most effective in protecting the environment by influencing the design and form of a subdivision in a way that maximizes compatibility with the current landscape. Using the landuse bylaw, municipalities can require environmental assessments, dictate the size of riparian areas, select environmental reserves, and preserve wildlife corridors (Barton 2002; Barss 2003). However, a clear mandate and direction to do so are lacking.

Although the institutional support for regional planning is weak, the concept is not foreign to Alberta. Historically, the province has been a leader in regional planning and, with institutional support, can be again in the future. Models exist that address the need for wider civic participation in planning and help to reduce the political tension which accompanies regional governance. Debate by planners, resource managers, and other interested parties is required to move regional planning into a wider public discourse. Without discussion, uncertainty surrounds the degree of political will at the provincial level to support regional planning – support that is essential if the environmental consequences of cumulative development are to be addressed.

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TIERED ECOLOGICAL THRESHOLDS AS A CUMULATIVE IMPACT MANAGEMENT TOOL

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Abstract: Cumulative impacts arise when numerous, small independent decisions contribute to landscape-level effects. A suite of coordinated regional, sub-regional, and local or project-specific tools must be adopted to effectively manage cumulative impacts. While cumulative impact assessment tools are reasonably well developed for regional management and large projects, practical tools for small project decisions are lacking. Cumulative impact indicators and associated tiered ecological thresholds were developed for northeast British Columbia to provide a method to simultaneously track and manage impacts at multiple scales. The primary strength of tiered ecological thresholds is the formal link between thresholds and impact management. This provides a framework to gather data on actual responses and modify management actions as appropriate. A secondary benefit is that tiered thresholds directly recognize the uncertainty around our understanding of complex environmental relationships. Finally, tiered ecological thresholds allow social and cultural values to be explicitly recognized, thereby providing the flexibility necessary for different land management zones and environmental settings.

RATIONALIZING CANADIAN FEDERALISM WITH THE GOAL OF BIODIVERSITY CONSERVATION

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Abstract: Should a Canadian province be able to unilaterally sacrifice a species or ecosystem for the sake of local economic gain? Looking at this question another way: what are the federal interests in biodiversity conservation, and what degree of intrusion in provincial affairs and provincial proprietary rights to natural resources is warranted by Ottawa's pursuit of those federal interests? These questions raise difficult political, policy, and legal issues that were hotly debated in Parliament's recent adoption of the 2002 *Species at Risk Act* and are likely to resurface as the act is implemented and in numerous natural resource management contexts.

This presentation explores these issues with special focus on the local, national, and international dimensions of biodiversity and on how Canada's constitution divides legal authority between Ottawa and the provinces with respect to biodiversity conservation. The presentation addresses Ottawa's constitutional authority to conserve biodiversity in the context of not only endangered species, but also species and ecosystems that are not yet close to extinction. While recognizing a strong federal interest and legal authority to conserve biodiversity, this presentation urges a restrained federal role aimed at spurring provincial or local ecosystem or landscape planning processes.

THE POTENTIAL FOR TRANSFER OF DEVELOPMENT CREDIT PROGRAMS TO ASSIST HABITAT PROTECTION IN THE PRAIRIES

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Abstract: Transfer of Development Credit (TDC) programs allow landowners to sell development potential of certain land parcels in the form of credits that buyers subsequently use to achieve greater density on other specified parcels. "Development potential" means the difference between existing land use and potential land use as allowed by and set out in applicable local landuse bylaws and municipal plans. The objectives of TDC programs typically are to prevent habitat fragmentation, to preserve preferences for low density development, and to preserve landscape features such as agriculture and open space, heritage areas, wildlife habitat, or important ecological features. TDC programs meet objectives by shifting permissable densities from areas where development is less desirable to areas where it is more desirable. Such programs can enhance equity for landowners restricted by zoning or other land-related regulations and encourage private stewardship by providing the potential for economic return to landowners who choose not to develop land. The programs support public stewardship of municipalities with policies to preserve environmentally sensitve landscapes by offering an alternative to simply imposing restrictive zoning. TDC programs have been used in the United States for decades; Canadian municipalities have only recently considered this economic tool to help them carry out landscape or habitat protection policies.

CANADA'S SPECIES AT RISK ACT

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Abstract: The *Species at Risk Act* is Canada's newest piece of federal environmental legislation. It is perhaps the most consulted-upon piece of legislation that Canada has ever passed, with numerous bills developed and altered over a ten-year period. The purpose of this paper is to provide a brief overview of the Act, specifically how, where, and when it applies to private land and private landowners. This paper will also explain the federal government's stewardship approach in regards to the *Species at Risk Act* and demonstrate some of the available opportunities to work with us and our partners to protect species at risk and their habitats.

INTRODUCTION

There has been considerable press and heightened awareness of the more rapid extinction of organisms in recent times, with extinction rates higher than we have seen in the past few millennia. This fact is highlighted by a species found in the prairie and northern region of Canada, the whooping crane. The whooping crane population was precariously low around the 1940s with only 14 individuals surviving and was truly on the verge of extinction. The wild population of whooping cranes has now built up, albeit very slowly, to the point where it is much less threatened but still a highly endangered species with a total of 184 birds. This past spring, there was a record number of 61 nests in and around Wood Buffalo National Park. A number of other prairie species are also threatened with either extirpation or extinction such as the swift fox, sage grouse, burrowing owl, and piping plover. The passenger pigeon has, of course, completely disappeared from our environment.

SPECIES AT RISK ACT

The federal government's approach to species at risk in Canada has three basic components: (1) collaborative work among federal departments, provincial governments, and territorial governments under an Accord which was signed committing governments to work cooperatively; (2) the federal *Species at Risk Act* (SARA) itself which helps set a standard or bar for national species protection; and (3) stewardship programming and incentives to work with landowners to help species and their habitats.

There are three basic purposes written into the SARA. First, the Act aims to prevent wildlife species from becoming extinct and totally disappearing from the country or planet. The second purpose is to help recover those species that are currently endangered or threatened to reduce the likelihood of them disappearing. The final purpose is to manage species that are of special concern.

The Act is not administered by one agency or one department. Environment Canada, of which the Canadian Wildlife Service is a part, administers the Act overall and looks after the listed terrestrial species; the Department of Fisheries and Oceans Canada has responsibility for aquatic species; and Parks Canada Agency has responsibility for species that are wholly or primarily found in National Parks or National Historic Sites.

LISTING OF SPECIES AT RISK

SARA formalizes the pre-existing Committee on the Status of Endangered Wildlife in Canada (COSEWIC). The Act gives this group the mandate to consider biological, scientific, and community and aboriginal traditional knowledge when recommending what species should be listed as Threatened, Endangered, or Special Concern. COSEWIC makes recommendations to government, and the federal government makes the final decision about a species' inclusion on the list based on these recommendations.

There are a number of SARA categories under which a species can be listed. "Extirpated" means that although the species still exists in the world, it has been lost from Canada. "Endangered" is defined as facing immediate extirpation from Canada or extinction from the planet. A third category is "Threatened", which means that species may become endangered if no action is taken. Lastly, "Special Concern" species are those that may become threatened or endangered. The Act applies very differently and has greater application to Threatened, Endangered, and Extirpated species than it does to Special Concern species.

PROHIBITIONS UNDER SARA

As of June 2004, SARA makes it illegal to kill, harm, harass, capture, or take species that are listed as Extirpated, Endangered, or Threatened. You also cannot possess, buy, sell, or trade these species, although there are some allowances for permits and exceptions. SARA also makes it illegal to damage or destroy their residences; the Act defines a residence as a den or nest or similar kind of area.

The application of the prohibitions in June 2004 is to all species (e.g., birds, mammals, plants, etc.) which are Extirpated, Endangered, or Threatened anywhere on federal land (i.e., lands that are federally owned or operated by any federal agency or department). These prohibitions will also apply in June to all aquatic species (i.e., fish, etc., found in rivers, streams, lakes) wherever they occur whether it is on federal, provincial, or private land. Similarly, the prohibitions apply to migratory birds listed under the *Migratory Bird Convention Act* (MBCA; which covers most but not all birds) wherever they occur. Aquatic species and migratory birds listed under SARA are provided this comprehensive and immediate protection because of pre-existing federal responsibility for these species under the *Fisheries and Oceans Act* and the *Migratory Bird Convention Act*.

For other species listed under SARA and found on private land or provincial land (i.e., not aquatic species or MBCA species), there is a conditional application of these prohibitions. For example, SARA states that the prohibitions may apply if provincial legislation does not effectively protect a mammal or a plant on private land. This is part of the cooperative arrangement amongst the different levels of government whereby the provinces are first given the opportunity to protect these species with their own legislation. If a province does not protect a given species or if their legislation is not up to the standard set by SARA, then after discussions between the federal government and the provincial government, SARA enables federal prohibitions to be applied to private or provincial land as a "safety net". This provides a background check, in case a province or a territory does not have its legislation in place over the next period of time to protect the plants, mammals, non-MBCA birds, etc. on provincial or private land. To have this safety net apply, the federal government must pass an Order.

CRITICAL HABITAT

SARA also serves to protect critical habitat, defined as the habitat that is required or necessary for the survival or the recovery of the species. Critical habitat does not automatically exist however; biological experts, in consultation with others, must describe critical habitat for a particular species within a recovery strategy or action plan. SARA makes it an offence to destroy the critical habitat of any Endangered or Threatened species (or extirpated species, if reintroduction is feasible). This prohibition will apply on federal lands within 180 days after critical habitat is described and published in a finalized recovery strategy or action plan for that species. The prohibition will also apply immediately to aquatic species anywhere after critical habitat is described. But, similar to the basic prohibition on taking or killing species, a conditional application on private or provincial land for all non-aquatic species occurs through the safety net approach described above. First, we attempt to protect critical habitat through a stewardship agreement, conservation agreement, or provincial law. If the critical habitat cannot be protected through any of those measures, the prohibitions against destroying critical habitat can be applied to provincial and private lands as a last resort. The emphasis is on the stewardship approach and working cooperatively with landowners, and an Order is required for application to any non-aquatic species on provincial or private lands.

RECOVERY OF LISTED SPECIES

SARA requires the development of a recovery strategy and action plan(s) by experts on the listed species and its habitat requirements. There are timelines within the Act whereby a recovery strategy must be written. The Act also states that during the development of these recovery strategies or action plans those who are directly affected must be consulted. Hence, these recovery plans and action strategies are not devised in an isolated backroom, but rather they are developed cooperatively with federal and provincial governments, important stakeholders, and those that are directly affected by a recovery strategy. Critical habitat as well as a number of other specific items are described within these documents.

STEWARDSHIP FOR SPECIES AT RISK

Stewardship is an important element of our approach to species at risk and involves landowners or land managers who are interested and want to work cooperatively towards the protection of critical habitat or species at risk. The federal government has developed a Habitat Stewardship Program (HSP) that became operational three years ago, before the Act was officially proclaimed, demonstrating the federal government's commitment to the stewardship approach. Across the prairies, about $2,000,000 per year is provided by the federal government to third parties such as non-federal conservation agencies that are also interested in protecting species at risk and their habitats. In the past few years, this money has gone to a variety of agencies such as The Nature Convervancy of Canada, The Alberta Conservation Association, The Manitoba Habitat Heritage Corporation, The Saskatchewan Watershed Authority, and The Alberta Fish and Game Association through Operation Grassland Community. These agencies have then combined HSP funds with their own funds to work with private landowners.

The HSP program and its associated emphasis on stewardship have supported projects such as the following: (1) Operation Grassland Community which is operated under the auspices of the Alberta Fish and Game Association. Program representatives work with landowners who have native prairie, and often burrowing owls, to assist in the development of tools such as grazing management strategies that would help both their operation and the species at risk; and (2) Alberta

Conservation Association and Alberta Sustainable Resource Development work in the Milk River area on the western blue flag, a listed plant. These organizations work with landowners to install improvements on their land such as fencing, offsite watering facilities, or rotational grazing systems – practices that will benefit the species at risk, and quite often the landowner as well, in terms of his grazing operation.

The question of compensation often arises, and although this option is feasible under SARA, stewardship is the desired approach. The federal government really wants to work with landowners in the stewardship or voluntary approach, generally working through third parties, to protect species and protect their habitat. If a stewardship approach fails and a voluntary conservation agreement cannot be obtained, and if provincial government protection is lacking and a "safety net" Order has been passed prohibiting the destruction of critical habitat on private land, then SARA allows landowners to apply for compensation in such a last resort instance. This compensation is directed towards cases where people have sustained some extraordinary negative impact because of the prohibition against destroying critical habitat.

COMMUNICATION

The *Species at Risk Act* is a new act, and it comes into full force in June 2004. Hence, we recognize we need to get out and let people know about this Act, what it means, and what it says. This presentation is part of that process. We have also produced a number of materials such as a regional fact sheet that summarizes the Act, a 20-page national guide that is more comprehensive, and a guide to the Threatened and Endangered species on the prairies to which the law applies. These latter guides have good range maps, so a quick glance can determine whether there is any possibility one or two of these rare species might occur on a given piece of land. An excellent source of information on SARA is the public registry on the internet which is found at www.sararegistry.gc.ca. SARA was purposely designed to be very open and transparent and requires that there be a public registry with the listing of species, all the recommendations from COSEWIC, and every recovery strategy or action plan. The registry provides a wealth of information and often the opportunity for public comment on the recovery strategies and other documents.

LANDSCAPE CONSERVATION ON THE PRAIRIES: THE PINTAIL EXPERIENCE

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Abstract: The prairie grasslands of North America are one of the most impacted ecosystems in the world. Thus, the fact that grassland birds have exhibited population declines more than any other avian guild on the continent is perhaps not surprising. Isolated, local-scale efforts to solve conservation problems are often rendered ineffective by ecological forces that operate at broad spatial scales. Therefore, landscape-level planning must utilize broad-scale spatial relationships and predicative principles to make conservation headway. We will examine our work with northern pintails *(Anas acuta)* as an example of landscape conservation on the prairies.

Since 1980, population estimates of northern pintail have remained below the 1955-2000 average of 4.3 million birds and well below the population goal of 5.6 million birds set by the North American Waterfowl Management Plan. Agricultural expansion on their primary breeding grounds has been implicated in their decline and lack of recovery. Recent analyses suggest that agricultural intensification may be largely responsible for the population decline on the Canadian prairies. Due to the nomadic nature of pintails and their ability to nest in sparse cover, a conservation program intended to have population impacts must be spatially extensive and multi-faceted. To effectively implement our program, we developed biologically based decision support tools and conducted research on the potential benefits of different land uses. Ducks Unlimited Canada used these tools to develop the Pintail Initiative, with the goal of improving pintail productivity in key landscapes. We discuss the technical, programmatic, and financial challenges of implementing landscape-level conservation.

INTRODUCTION

Traditionally, conservationists employed one broad approach to program design: direct protection of relatively small patches of high quality habitat. However, isolated, local-scale efforts to solve conservation problems are often rendered ineffective by ecological forces that operate at broad spatial scales (Gutzwiller 2002). To make conservation headway, landscape-level planning using broad-scale spatial relationships and predictive ecological principles must be used. The specific approaches employed in landscape conservation are varied, but several authors recently have advocated key steps in the process (Salafsky et al. 2002; Redford et al. 2003). These steps include the following: (1) identification of the conservation target, including a biological understanding of the conservation target, its life history traits, and an assessment of the key factors limiting the target; (2) determination of where conservation action(s) is to be directed through the setting of geographic priorities; (3) clear articulation of conservation objectives (e.g., acreage goals) in a meaningful and measurable metric. Ideally, any habitat goals will be set through a model linking landscape characteristics to the biology of the conservation target; (4) determination of appropriate tools to use in the conservation action; (5) development of an implementation strategy to facilitate on-the-ground delivery of the conservation tools; and (6) the use of adaptive management to evaluate the effectiveness of the conservation program and to help guide subsequent iterations of the plan. As a real world example of this process, this paper will discuss Ducks Unlimited Canada's (DUC's) approach to conservation planning for the northern pintail *(Anas acuta)* in prairie Canada.

IDENTIFICATION AND ASSESSMENT OF CONSERVATION TARGET

Conservation Target

Since 1980, population estimates of northern pintail have remained below the 1955-2003 average of 4.2 million birds and below the population goal of 5.6 million birds set by the North American Waterfowl Management Plan (NAWMP). Following extended drought during the 1980s and early 1990s, favorable precipitation patterns returned to the critical waterfowl nesting areas of the Northern Great Plains of the US and Canada in 1993-1997 (USFWS 2003), the area known as the Prairie Pothole Region (PPR) (Bellrose 1980). Even though May ponds attained record high levels in 1996 and 1997, the pintail breeding population exhibited only a modest 30%

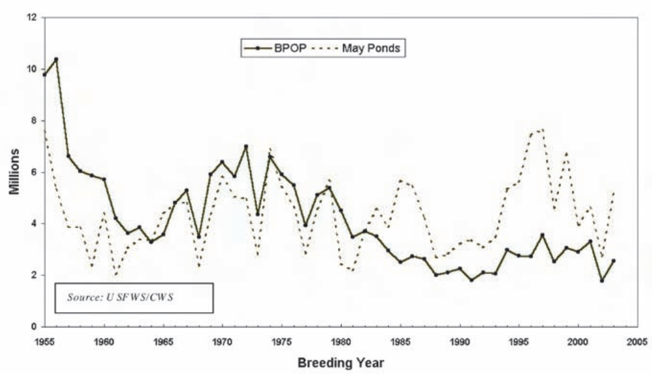

Figure 1. Northern pintail breeding pair populations (BPOP) and May pond counts from 1955 to 2003.

increase (Figure 1), remaining 19% below the long-term average and 36% below the NAWMP goal (USFWS 2003). In contrast, all other PPR-nesting dabbling ducks (tribe Anatini) rebounded in the 1990s to levels that exceeded objectives set by NAWMP.

Life History Traits

Life history traits were explored to assess if, and how, these traits might be linked with the pintail decline and failure to recover. Pintails tend to lay clutches 1 to 2 eggs smaller than those of other dabbling ducks (7.0–7.6 eggs in Alaska and 6.0–8.3 in the PPR; see references in Austin and Miller 1995). Pintails nest relatively early in the season when cold weather and high predation rates (possibly related to limited alternative prey and sparse nest cover) combine to cause most nests to fail. In the PPR, pintails tend to nest farther from water and show a stronger predilection to nest in sparse cover, particularly grain stubble, than do other species (see references in Miller and Duncan 1999). Recent analyses also suggest that pintails tend to settle in landscapes that are gently rolling and highly cultivated (J. Devries and K. Guyn, unpubl. data). Use of sparse cover and dispersed nesting may make nests vulnerable to loss, especially by cultivation. Pintails will renest upon destruction of their clutch, but not as persistently as mallards *(Anas platyrhynchos)*. While mallards can nest up to six times (Rotella et al. 1993), pintails have been recorded to only nest up to three times in a season (Guyn and Clark 2000; K. Richkus, unpubl. data). Therefore, pintails are less adapted to deal with nest loss than other species such as mallards.

Key Threats

The prairie grasslands of North America are one of the most impacted ecosystems in the world. According to Archibold and Wilson's (1980) original estimation of late-19th century survey maps, over 90% of southern Saskatchewan was grassland; by the mid-1990s, native grassland had been reduced to less than 28%. Hence, it is not surprising that grassland birds have exhibited population declines greater than any other avian guild on the continent (Vickery and Herkert 2001). Upland habitat changes in the PPR of Alberta, Saskatchewan, Manitoba, North Dakota, and South Dakota – the primary breeding grounds for pintails (Bellrose 1980; Miller and Duncan 1999) – generally have been considered responsible for the pintail decline and their failure to respond to improved water conditions (Bethke and Nudds 1995; Miller and Duncan 1999). Specifically, the fragmentation and loss of breeding habitat due to changes in prairie agriculture (Bethke and Nudds 1995) and an associated decline in nest success (Beauchamp et al. 1996) have been hypothesized as reasons for declining pintail populations.

In an effort to better understand how landuse changes may have impacted pintails, Podruzny et al. (2002) examined data from the Canadian PPR from 1961 to 1996 to investigate spatial and temporal covariation of pintail numbers with environmental factors (pond numbers, precipitation) and agriculture at various spatial scales. They found that pintail settling was better explained by using information about specific agricultural practices compared to overall increases in farmland acreage. Specifically, they found that pintails have declined most strongly in areas where summerfallow also declined most during the period examined. Summerfallow is typically not tilled until spring seeding of other cropland is completed, generally in late May or early June (Ford and Krall 1979). Therefore, pintail nests initiated in summerfallow would be undisturbed by cultivation and may have a greater chance to hatch. Conversion to continuous cropping (i.e., intensification) places all nests in spring stubble at risk of destruction by cultivation. Approximately 3.3 million hectares of summerfallow were converted to continuous cropping between 1981 and 1996 in the three Prairie Provinces (McNabb 1996; Carlyle 1997). Carlyle (1997) characterized the decline of summerfallow as the largest and most economically and environmentally significant change in agricultural land use in the Canadian prairie sduring the past quarter century. Because the decline in summerfallow occurred concurrently with the period of the most recent pintail decline (Figure 2), Podruzny et al. (2002) suggest that changes in cropping practices since the 1970s, specifically summerfallow conversion more so than cultivation of remnant prairie, has substantially degraded the reproductive capacity of prairie landscapes for pintails.

SETTING GEOGRAPHIC PRIORITIES

Conservation planners must determine where to target their conservation work to ensure that maximum gain is obtained. To aid in our targeting efforts, DUC developed a model using geographic information system technology and USFWS/CWS spring waterfowl survey data to estimate the average distribution of breeding pintail pairs in prairie Canada (Figure 3). We chose to target all our programs, except low cost extension initiatives, to landscapes with at least six pairs of pintails per square mile to ensure that we were targeting our programs to those landscapes most likely to be important to pintails.

Digital land cover data were used to help spatially target protection versus restoration-based conservation actions. Current waterfowl research suggests that nest success is correlated with the amount of perennial cover in a 16 square mile area (Ducks Unlimited, unpubl. data). Therefore, perennial cover (hay, grassland, pasture, etc.) from the digital land cover (30 m x 30 m pixel size) was summarized to a larger scale. This product was then used in conjunction with the breeding pair map to target the best geographic locations as well as to help identify whether the landscape was primarily intact or intensively cropped.

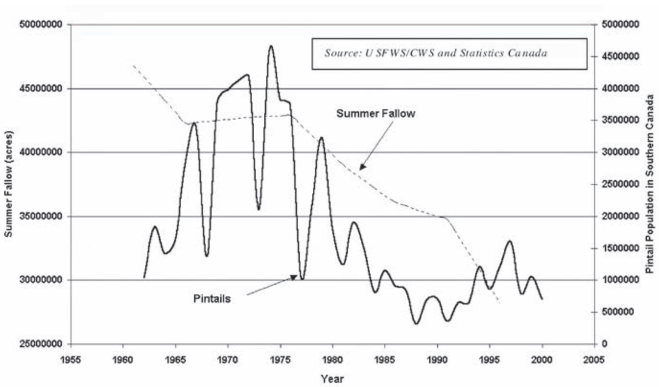

Figure 2. Summerfallow acres in prairie Canada and northern pintail population trends from 1961 to 2001.

DETERMINATION OF HABITAT OBJECTIVES

An important step in conservation planning is the setting of conservation goals. A population goal for pintails was established under the NAWMP based on average population estimates during the 1970s. Because we believe that the primary limiting factor for pintails is reduced productivity due to habitat loss and modification, we made the assumption that the habitat base in the 1970s was capable of sustaining that population. Hence, we used the 1970s landscape as our baseline on which to establish our habitat goals. We used data from the Statistics Canada quinquennial Census of Agriculture and looked at acreage changes from 1971 to 2001 in cropland, summerfallow, hayland, etc. in key pintail landscapes (areas with six or more pairs as described above). We used this analysis, along with estimated rates of loss of native habitat during a similar time period, to help determine our goals for habitat enhancement and conservation of native habitat. Nearly six million acres of existing grassland will need to be conserved and another five million acres of annually tilled cropland will require management under a "pintail friendly" agricultural regime to achieve the population goal. Along with upland habitat targets, we also have a "no wetland loss" goal in all of our pintail target areas. Further refinements of these objectives will occur using a recently developed Waterfowl Productivity Model (Ducks Unlimited Canada, unpubl. data), which estimates pintail productivity based on landscape composition.

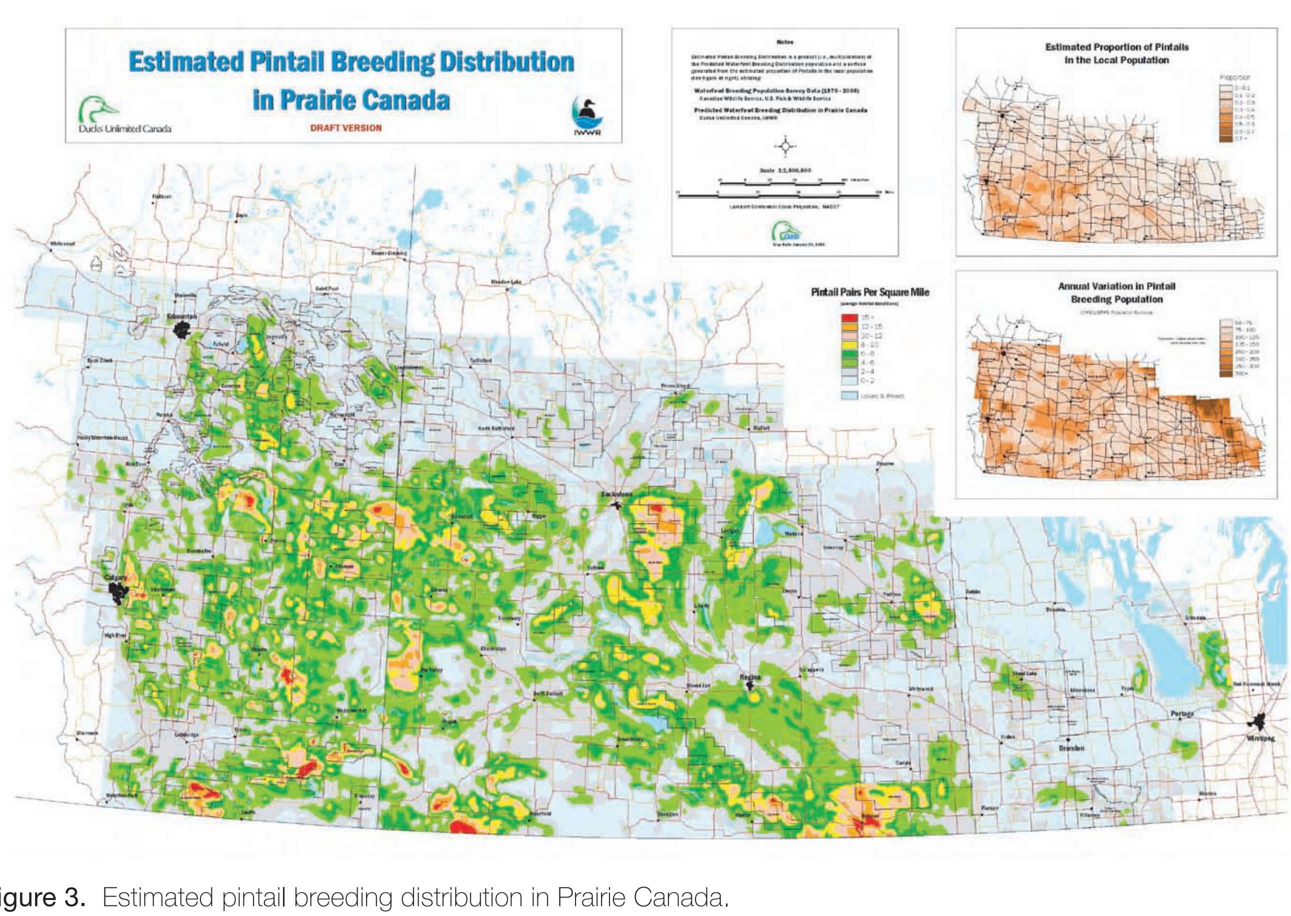

Figure 3. Estimated pintail breeding distribution in Prairie Canada.

CONSERVATION TOOLS

Upon setting our habitat goals, we realized that the conservation program would need to include both conservation of existing natural habitat and modification of annually cropped landscapes. This challenged us to find workable agricultural solutions that would impact large acreages. To better inform our management decisions, we launched two pintail-focused research studies in Saskatchewan. The first study was conducted in cooperation with the Saskatchewan Wetland Conservation Corporation and examined the potential conservation value of a “cropland conversion program”, where cropland would be converted to hayland. In this two-year study, over 2,000 acres of hayland were searched for pintail nests each year. We found that pintails on average hatched 1 nest every 142 acres (McMaster et al., in review) or nearly 10 times that typically observed in spring-seeded cropland. This suggested that conversion of cropland to perennial forages could provide managers with a useful tool to improve pintail productivity.

The second study focused on pintail productivity in fall-seeded cereal fields. Given that pintails often nest in cropland, DUC recognized the potential that fall-seeded crops (fall rye, winter wheat) might provide as an alternative practice that would reduce destruction of nests by tillage. Nearly 4,000 acres each of both fall-crops and spring-seeded fields were searched over the two-year study. The results were compelling. Pintails on average hatched 1 nest every 72 acres in fall-seeded crops versus 1 nest every 1,332 acres in spring-seeded cropland (Devries and Sallows 2000). Both higher nest densities and higher hatching success contributed to the increased pintail production in fall-seeded crops. This research provides a firm basis for promoting fall-seeded cereal crops as a pintail-friendly cropping alternative in areas where cropland intensification has encroached on traditional pintail breeding areas.

IMPLEMENTATION STRATEGY

The implementation strategy for the Pintail Initiative is multi-faceted and involves not only direct conservation action (land purchase, conservation easements, etc.) but also more extensive efforts. For example, we have demonstrated the benefits of fall-cereals to pintails, but integrating fall-cereals into the agricultural landscape at a biologically meaningful scale is challenging. We quickly learned that although fall rye was easy to grow and could produce impressive yields, the price per bushel was not high enough to encourage more producers to grow it. Ducks Unlimited explored other markets for fall rye, including the extraction of gums to be used as a thickening agent in foods, but so far have met with limited success.

Winter wheat has provided a different challenge. Although the price per bushel is similar to spring wheat, winter wheat has typically been more difficult for producers to grow and in the 1980s, many producers faced winter wheat crop failures. To help overcome this stigma, Ducks Unlimited partnered with Dr. Brian Fowler from the University of Saskatchewan to develop a manual on proven production practices. Although improved agronomic practices reduced the risk of failure, winter wheat varieties with improved cold-hardiness were still needed. Ducks Unlimited Canada subsequently established an Eco-Agricultural Research Chair at the University of Saskatchewan in 1998. The first tenure was awarded to winter wheat breeder Dr. Brian Fowler. Dr. Fowler’s research program has been very successful with 90% of the winter wheat varieties currently grown on the prairies originating from his lab.

Winter wheat acreage has steadily increased since DUC’s first involvement in 1991 (Figure 4). Improved varieties, development of proven production systems, good growing conditions, and increasing grower awareness led to over 700,000 acres of winter wheat being planted in western Canada this fall (2003). This represents an increase of over 500% since the inception of DUC’s efforts. Given the slow but sustainable growth occurring in winter wheat acreage, we are optimistic about the future potential of this crop on the prairies.

Policy has the ability to affect large acreages, either negatively or positively. The new Agriculture Policy Framework (APF), currently being implemented by Agriculture and Agri-Food Canada (AAFC), has the potential to provide positive habitat results on the landscape. Greencover Canada is the first program launched last year and targets marginal cropland for conversion back to grassland. The APF will also see the development of Environmental Farm Plans and the promotion of Beneficial Management Practices to improve the health of agricultural landscapes. DUC is actively working with AAFC to maximize the benefits for waterfowl and other wildlife.

ADAPTIVE MANAGEMENT

We recognize potential weaknesses in our planning process based on inherent assumptions and accept that this is part of the conservation planning process. Although the Pintail Initiative is only recently underway, plans to evaluate the proposed habitat programs and to test the biological models used in planning have begun. Information from these evaluations will help to refine program objectives, targeting, design, and implementation.

CONCLUSION

Past experience dictates that solutions to large-scale conservation problems are not likely to be found in the conservation of site-specific features. We have outlined six key steps in the development of landscape-scale conservation plans. We suggest that the utilization of such

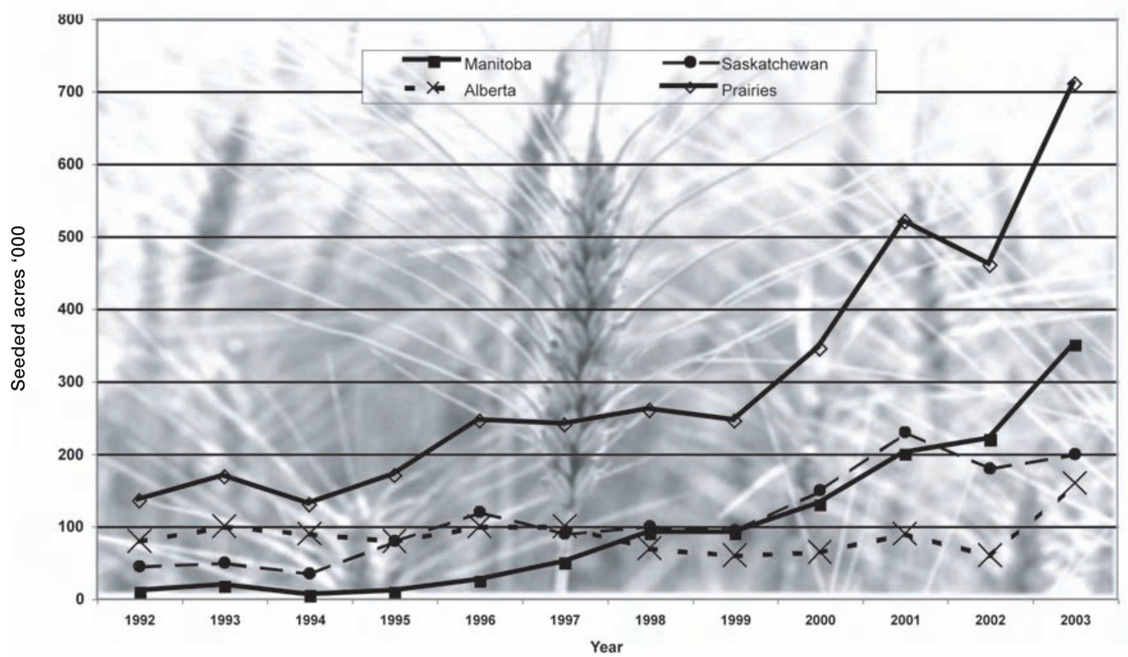

Figure 4. Winter wheat seeded acreage in prairie Canada from 1992 to 2003.

an approach will provide well thought-out plans with clear measures of success and the ability to refine program details through adaptive management.

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APPLICATION OF AN ECOSYSTEM-BASED STEWARDSHIP APPROACH TO THE CONSERVATION OF GRASSLAND BIRD HABITAT IN SASKATCHEWAN

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Abstract: We developed an adaptive framework for implementing conservation actions for grassland birds in Saskatchewan using a geographic information system (GIS) process that integrated conceptual and empirical models of grassland songbird biology with gap analysis. Grassland Bird Conservation Areas (GBCA) are derived from a conceptual model, supported by empirical models and directed studies, which postulates that relatively large grassland areas support viable populations of area-sensitive bird species when they are comprised of minimal hostile (e.g., trees) and edge habitat.

We used a digital land cover classification to identify patches of grassland (including native grassland, seeded tame pasture, hayland, and shrub classes) meeting GBCA criteria and subdivided these into three types: large (>640 ac or 256 ha), medium (160-639 ac or 64-255 ha), or small (40-159 ac or 16-63 ha). We overlaid GBCAs with protected areas and the risk of cultivation to create a decision support matrix that prioritized conservation activities within each ecodistrict. The options for conservation activities included the following: (1) communications (media campaign) to increase public awareness of the value of native prairie (2) securement of existing native prairie through voluntary and paid agreements (3) improved management of existing native prairie through workshops and demonstration projects and (4) conversion of cropland to grassland through tame and native seeding. In 2002, Saskatchewan Watershed Authority (SWA) staff targeted native prairie enhancement funding towards the Dirt Hills Ecodistrict, where the decision matrix determined that improved management of the existing native prairie is the priority implementation activity.

In addition to developing enhancement projects that improved the condition of native prairie through various management practices, SWA staff used GIS-generated maps to identify gaps between GBCAs. These intervening landowners were contacted regarding enhancement projects that would convert this land to permanent cover, thereby connecting small or medium GBCAs to create larger GBCAs. This new permanent cover also provides early-season grazing to improve the condition of existing native prairie through deferred grazing.

BACKGROUND

Approximately 83% of Saskatchewan's native grassland has been lost since European settlement (Samson and Knopf 1994). Native grassland in Saskatchewan provides breeding habitat for more species of high priority grassland birds than tame grassland habitats, but these tame grasslands do have considerable habitat value for some species (McMaster and Davis, unpubl. data). The majority of the remaining native grassland in Saskatchewan is privately owned and managed; therefore, implementation of conservation programs requires voluntary participation of landowners. This paper outlines a process to integrate conceptual and empirical models of grassland songbird biology with gap analysis to provide an adaptive framework for prioritizing and implementing conservation actions for grassland birds in Saskatchewan. In addition to the framework itself, examples of its implementation by the Saskatchewan Watershed Authority (SWA) are also included.

PRIORITIZATION

Conceptual Model - Grassland Bird Conservation Areas

To our knowledge, the first attempt at modeling grassland bird conservation areas (GBCA) was presented in the Partners in Flight (PIF) plan for the Northern Tall Grass Prairie (Fitzgerald et al. 1998). The model parameters were developed from the habitat needs of the greater prairie chicken and involved a core patch of habitat which, in combination with a one-mile buffer of the surrounding habitat matrix, constituted the GBCA.

Our approach differs somewhat from PIF in that we consider patch size and shape, as opposed to the area surrounding the patch, to be the most important metrics in selecting critical habitat for area-sensitive grassland birds. For the purposes of our work in Saskatchewan, the necessary land cover information was taken from classified Landsat TM imagery. This information was input into a "moving window" spatial analysis procedure in a geographic information system (GIS) in order to identify square habitat patches that contained at least 95% grass (included native grassland, seeded tame pasture, hayland, and shrub classes). These GBCAs were subdivided into three types: large (>640 ac or 256 ha), medium (160-639 ac or 64-255 ha), or small (40-159 ac or 16-63 ha). Our analysis showed that the majority of grassland habitat meeting the criteria of the GBCA is in large blocks (Figures 1 and 2).

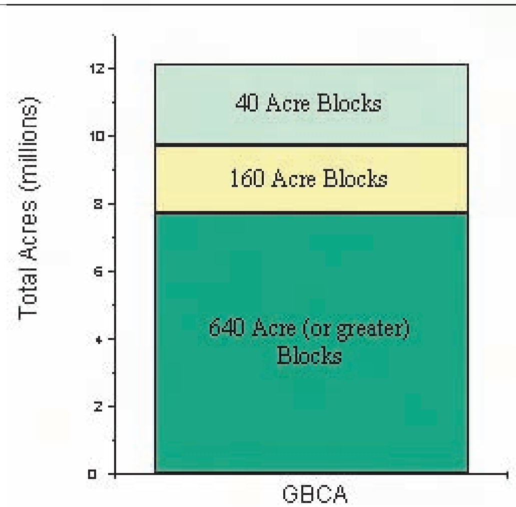

Figure 1. Total number of acres by block size selected as Grassland Bird Conservation Areas.

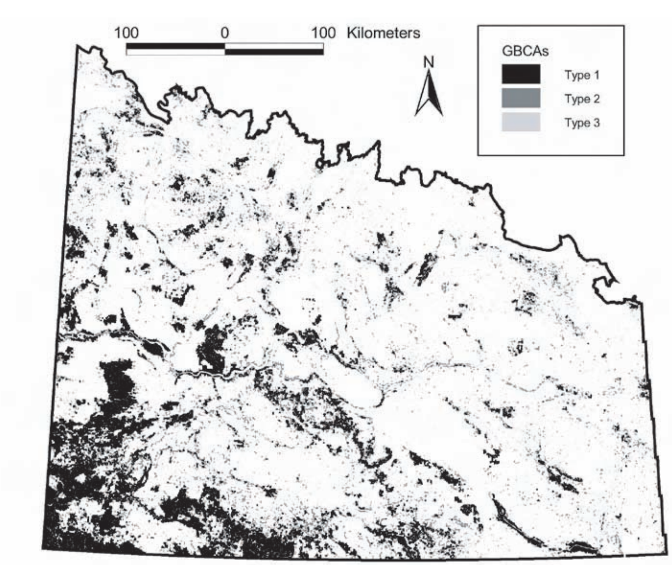

Figure 2. Map of Grassland Bird Conservation Areas for the Prairie Ecozone of Saskatchewan. Black = large GBCA, dark grey = medium GBCA, light grey = small GBCA.

Empirical Predictive Model

A predictive model was developed in order to better target conservation activities to the needs of a particular species of interest; in this case the threatened Sprague's pipit (SPPI; known to be a native grassland specialist). Point count data from a grassland bird survey conducted by the Saskatchewan Wetland Conservation Corporation in 1994 (1,554 point counts along 85 routes) were inputted into the model. We calculated land cover variables for the model (using 400-m buffers around each point) including percent cover of native grassland, cropland, tame forage, trees, and wetlands. We also calculated the linear distance of road, mean elevation, mean slope, easting, and northing. The presence/absence of SPPI was modeled using logistic regression weighted by the dependence of points within routes using correlation matrices. The most parsimonious model using Akaike's Information Criterion was % Native Grassland + % Tame Grassland + Easting + Elevation – Trees. We used 1994 Breeding Bird Survey (BBS) data to validate the model and found it performed very well in predicting the occurrence of SPPI (area under ROC curve = 0.908 and Cohen's Kappa = 0.602). The probability of occurrence across habitats in southern Saskatchewan was then mapped as a raster layer in the GIS (Figure 3). The model predicted that SPPI are more likely to occur in the large GBCAs (Table 1).

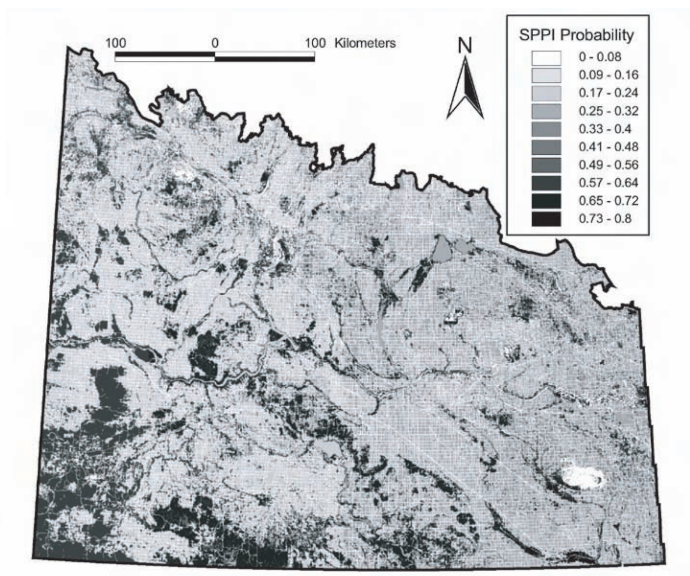

Figure 3. Map of the probability of occurrence of Sprague's pipit within the Prairie Ecozone of southern Saskatchewan.

Table 1. Mean probability of Sprague's pipit occurrence by Grassland Bird Conservation Area Type.

GBCA Type	Mean Probability ± St. Dev.
Large	0.61 ± 0.11
Medium	0.48 ± 0.14
Small	0.38 ± 0.13
Non-GBCA	0.18 ± 0.09

Table 2. Decision matrix for implementation activities including (1) communications or media campaign to increase public awareness of the value of native prairie, (2) securement of existing native prairie through voluntary and paid agreements, (3) improved management of existing native prairie through workshops and demonstration projects, and (4) conversion of cropland to grassland through tame and native seeding.

			Priority Activities			
% GBCA	Threat of Loss	Protection	1	2	3	4
Low	Low	Low	Conversion	Management	Securement	Communication
Low	Low	High	Conversion	Management	Communication	Securement
Low	High	Low	Conversion	Securement	Communication	Management
Low	Low	High	Conversion	Securement	Management	Communication
High	Low	Low	Management	Securement	Communication	Conversion
High	Low	High	Management	Communication	Securement	Conversion
High	High	Low	Management	Securement	Communication	Conversion
High	High	High	Management	Communication	Securement	Conversion

Protection Level Analysis

Protected and threatened areas were overlaid on GBCAs, including protected (International Union for the Conservation of Nature; IUCN Ranks I to V), unprotected (unranked by IUCN), threatened areas (Canada Land Inventory (CLI) Soil Capability for Agriculture (SCA) classes 1-4), and areas not threatened (CLISCA classes 5-7). Note that Agriculture and Agrifood Canada's CLISCA has 7 classes used to rate agricultural land capability, with class 1 lands having the highest and 7 the lowest capability to support agricultural land use (Agriculture and Agri-Food Canada 1998).

IMPLEMENTATION

Ecodistricts were classified into high or low categories relative to the amount of GBCAs present, the level of cultivation threat to the GBCAs, and the proportion of protected GBCAs. Four conservation activities were prioritised relative to the classification of the ecodistricts. Using a decision matrix (Table 2), each ecodistrict was then assigned one of four implementation activities.

The Dirt Hills Ecodistrict (Figure 4) was selected for conservation activities due to its high percentage of large GBCAs and low levels of protection as well as high SPPI occurrence probability. The decision matrix indicated that management would be the highest priority activity for the Dirt Hills Ecodistrict, given the low threat levels. Conversion of cropland was also listed in the matrix as a priority activity (although lower down on the list) and is often a necessary component of improvement projects. SWA staff began to implement demonstration projects with landowners in this ecodistrict that would improve the condition of native prairie and increase the size of GBCAs through conversion. GIS was used to generate maps that identified land uses and locations where cropland conversion would increase the size of a GBCA to the next size category.

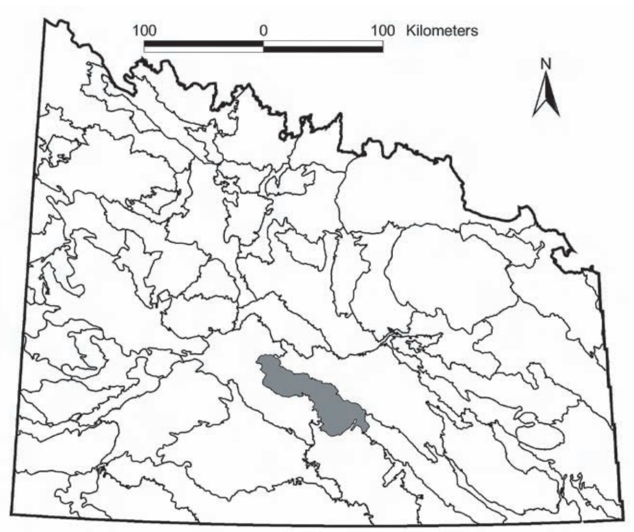

Figure 4. Map of Prairie Ecozone in Saskatchewan showing ecodistrict boundaries and the Dirt Hills Ecodistrict (dark grey).

Landowners who held native prairie and land identified for GBCA expansion were determined. Discussions with these producers were held with the purpose of initiating a demonstration project to seed permanent cover that would both increase GBCA size and allow for deferred grazing on native prairie. These are win-win projects where the landowner benefits from the improved condition of his native prairie, and grassland birds benefit from a larger GBCA. Seven projects are currently in progress. In total, 465 acres of cropland have been seeded to perennial forages. This new permanent cover will convert one small GBCA to a medium-sized GBCA, expand an existing medium GBCA and an existing large GBCA, connect two medium GBCAs to create a large GBCA, and connect two small and one medium GBCA to create a large GBCA (Figure 5). In addition, eight miles of fence were constructed to improve grazing distribution on native prairie. Approximately 4,370 acres of native prairie will be improved through these projects.

Not only does this adaptive framework provide a planning method that can be applied to a broad range of conservation situations, but the delivery of stewardship activities according to the framework provides an excellent example of the implementation of a planning process.

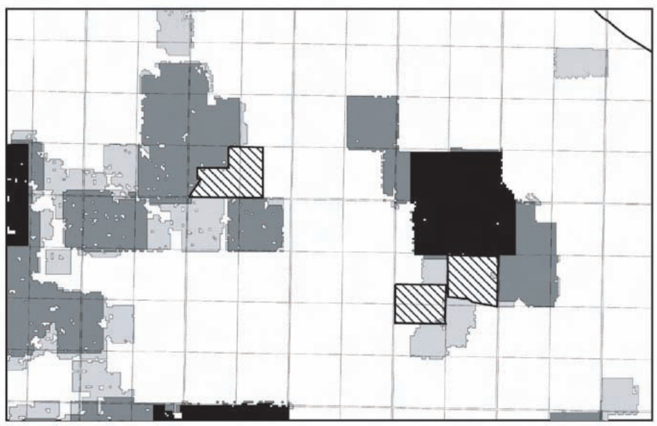

Figure 5. Areas seeded to grass in order to increase GBCA. Black = large GBCA, dark grey = medium GBCA, light grey = small GBCA, cross-hatching = areas of cropland seeded to grassland. Light grey lines are quarter section boundaries.

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OPERATION BURROWING OWL: CONSERVING OWLS AND GRASSLAND HABITAT IN SASKATCHEWAN

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Abstract: Operation Burrowing Owl (OBO) was initiated in 1987 in response to declining burrowing owl populations across southern Saskatchewan. The program depends on rural landowners that voluntarily conserve habitat for this endangered owl and participate in an annual spring census that contributes to population monitoring efforts across the prairies. Currently, 475 rural private and public landowners participate in the program, conserving over 61,000 ha of pastureland suitable for burrowing owls. From 1987-1999, landowner retention in the program was 75% five years after enrollment (with less than 2% withdrawing after five years of participation), even though about 70% of the landowners no longer had owls. Beginning in 2000, OBO provided funding support to 34 landowners interested in enhancing burrowing owl habitat by seeding 1,930 ha of targeted cultivated land to perennial pasture. The annual census (with number of pairs corrected for non-reporting members) indicated a 92% decline in number of pairs over 16 years from 1988 (1032 pairs, 352 OBO landowners) to 2003 (86 pairs, 446 OBO landowners). In addition, colonies of burrowing owls have nearly disappeared. From 1987-1993, an average of 26 sites (range = 10-42 or 5%-11% of sites) annually supported ≥5 pairs of owls; whereas from 1994-2003, almost no sites (range = 0-3 sites or 0-0.5% of OBO sites) supported ≥5 pairs of owls. In 2002 and 2003, annual increases in owl pairs of 35% (52 to 70 pairs) and 23% (70 to 86 pairs), respectively, occurred at OBO sites (number of pairs is corrected for non-reporting members). These increases may have been due to more favorable natural conditions for the owls during their life cycle, more favorable conditions resulting from conservation activities, or a combination of these factors.

The OBO program in Saskatchewan was evaluated for its effectiveness in conserving grassland habitat from 1986-1993. Within the Regina-Weyburn study area, size and agricultural soil suitability were used to classify 108 OBO sites from 1987-1988 and 98 randomly selected non-OBO sites that were grassland in 1986. The 1986 area of grassland was compared with grassland area calculated from digitized 1993 LANDSAT imagery. Grassland retention in 1993 was significantly higher at OBO sites at 66% than at random sites at 49%, demonstrating that the voluntary OBO program effectively conserved habitat. In addition, grassland retention was significantly lower on non-OBO sites with better agricultural soils and for sites <12 ha in size. Site type (OBO or random), parcel size, and their interaction, followed by agricultural soil suitability, had the greatest effects on grassland retention. During an era of accelerated grassland loss, OBO strongly and positively affected conservation of grassland sites most at risk (i.e., sites <12 ha in size and with good to excellent agricultural soils). This study demonstrates that a voluntary stewardship program is an effective conservation tool.

INTRODUCTION

Conserving Owls and Grassland Habitat

Burrowing owls *(Athene cunicularia)* are unique among owls in that they nest in abandoned burrows of mammals, usually Richardson's ground squirrel *(Spermophilus richardsonii)* or badger *(Taxidea taxus)* in western Canada. These owls nest as solitary pairs or in small loose colonies in open short-grass pastures or prairie of varying size (<1 ha to thousands of ha) and use short-grass pastures or taller grass-forb areas for hunting (Haug and Oliphant 1990; Haug et al. 1993; Clayton and Schmutz 1999). Many owls are found in small tracts of land because most native prairie habitat in Saskatchewan has been lost to cultivation. By 2000, only 20% of former grasslands in Saskatchewan remained as natural habitat, and in highly arable areas of the province, only 2% of natural grasslands remained (Hammermeister et al. 2001). Accompanying the disappearance of grasslands are habitat fragmentation and changes in plant and animal species composition. Habitat loss, degradation, and fragmentation, and the associated low productivity and high mortality have been identified as primary causes contributing to the burrowing owl's decline in Saskatchewan (e.g., Wellicome and Haug 1995; Warnock 1997; Clayton and Schmutz 1999; Todd et al. 2003). The range of this owl in Saskatchewan has been shrinking southward and westward since the 1940s (Houston et al. 1996), and the Committee on the Status of Endangered Wildlife in Canada classified the burrowing owl as Endangered in 1995 (Wellicome and Haug 1995).

Because almost all arable land in Canada's prairie landscape is privately owned, conservation initiatives largely depend on, or are driven by, landowners. The need for public awareness and habitat protection was demonstrated in 1986, when a study of the Regina Plain (considered to be the core of burrowing owl range in Saskatchewan) found owls on only 13 of 703 grassland plots searched and found that suitable burrowing owl nesting habitat was vanishing rapidly (Hjertaas and Lyon 1987). In response to this study, Operation Burrowing Owl (OBO) was launched in 1987 to protect those grassland parcels used by nesting burrowing owls from cultivation. OBO is now one of the longest running voluntary habitat stewardship programs in Canada. Although privately held lands were initially targeted, participants now also include stewards of public lands, including provincial, community, and federal (i.e., Prairie Farm Rehabilitation Administration, PFRA) pastures and urban centres. Nature Saskatchewan (formerly Saskatchewan Natural History Society), with support from other agencies, has delivered OBO since 1990. The burrowing owl has become a conservation symbol through this program, and the objectives of OBO have broadened to recognize the burrowing owl's role as an ambassador to garner support for further conservation goals, including conservation and restoration of prairie habitat for other species.

The current objectives of the OBO program are as follows:

1. to conserve prairie habitat for the endangered burrowing owl and other species through voluntary stewardship actions and agreements with landowners, conservation easements, and public recognition of the role of landowners in conserving habitat;
2. to assist landowners with grassland habitat enhancement and restoration through seeding cropland to grassland to enlarge pastures and reduce fragmentation, as well as preservation of newly planted and native prairie through strategic fencing and water development for livestock;
3. to provide environmental education on the value of the conservation of wildlife habitat and ecologically significant lands, as well as to raise the profile of the burrowing owl and other prairie species and their habitat requirements;
4. to evaluate the program's conservation success by monitoring the owl population and grassland retention through an annual census at OBO sites; and
5. to support research studies determining factors driving population declines of the owl and other prairie species at risk.

The works of Hjertaas (1997) and Skeel et al. (2001) in describing and summarizing the OBO program are presented and updated in this paper.

Operation Burrowing Owl Evaluation

Voluntary habitat stewardship programs are increasingly used as part of species at risk habitat protection strategies in Canada (Environment Canada 2002). The remaining native prairie habitat, while only a fraction of its former area, comprises an area too large for formal protection solely through acquisition and is typically privately owned. Accordingly, stewardship by landowners, both voluntary and through conservation easements, is the most desired and practical way to conserve this habitat. Voluntary stewardship is the more economical and locally accepted option, although it may offer less security than a conservation easement.

Kleiman et al. (2000) stated the need for performance evaluations of conservation programs to determine and improve their effectiveness. The direct evaluation of habitat conservation programs through comparison with historical datasets is rare but increasingly important. Whether or not voluntary stewardship programs are successful in conserving habitat, however, has yet to be established. Warnock and Skeel (2004) examined whether the OBO program achieved conservation of grassland habitat by using a historical dataset (Hjertaas and Lyon 1987) as a control sample, and this work is summarized below.

METHODS

Voluntary Agreements

The core of Operation Burrowing Owl is a one-page voluntary agreement that OBO staff discuss and sign with landowners who have burrowing owls nesting on their property in the first year of contact (Hjertaas 1997). The OBO agreement is a "handshake" agreement and can be cancelled by the member at any time. Participating landowners agree to report annually the number of burrowing owls on their site and agree not to cultivate the described area. Each agreement covers all or part of a quarter-section (65 ha), and landowners with owls on more than one location (quarter-section) sign an agreement for each location. Public lands are an exception, with one agreement signed for the entire area enrolled rather than for each quarter-section. All landowners are encouraged to continue participating in OBO, even if owls do not return to nest, and thus to continue conserving habitat and reporting numbers (or absence) of owls. Agreements were initially renewed after a period of five years, but starting in 1994, the agreements became indefinite and expire only upon request. In recognition of their participation, landowners also receive either a certificate or an OBO gate sign with their name (most request a sign). Landowners receive a certificate of recognition after every five years of participation. Participants also receive outreach material, including an annual newsletter about the burrowing owl, other prairie species, and articles relevant to landowners.

Conservation Extension

Starting in 1999, OBO members were invited to apply for incentives to enhance and restore burrowing owl habitats on their land. This program helps approved landowners convert cultivated land back to grassland by purchasing seed mixtures for native or tame grass. Two highly invasive exotic species, crested wheatgrass *(Agropyron cristatum)* and smooth bromegrass *(Bromus inermis)*, are excluded from mixtures. Assistance with fencing and water development are also now offered to protect native pasture through deferred grazing management.

Land targeted for extension is located near sites that recently supported breeding burrowing owls and near existing pastures, especially in highly fragmented areas. Nature Saskatchewan (OBO) shares resources with the Saskatchewan Watershed Authority to deliver habitat enhancement and restoration work. Conservation easements are also promoted to landowners.

Public Awareness

The OBO program is widely promoted through an annual fall newsletter to participants and others, a winter update and spring census mail out to participants as well as brochures, advertisements in rural newspapers, and presentations to schools, nature clubs, landowner meetings, and other groups. Articles on the burrowing owl and on OBO appear in the newsletters of other agencies, and media coverage is solicited. Promotional tools have included owl-shaped refrigerator magnets, t-shirts, a poster, a portable display, youth and adult versions of slide shows, and fact sheets on Operation Burrowing Owl and conservation, burrowing owl behaviour and biology, and burrowing owl research. Burrowing owl road signs, similar to other highway wildlife warning signs, alert drivers to exercise care along stretches of road with nearby nesting owls. Signs feature a black line drawing of an owl on a yellow background with a tab reading "Next 2 km" beneath.

Annual Census

To determine the number of owls at each site, census cards are mailed to all OBO participants every June. Reported owls and hectares enrolled in the program for a given year are based on participants in the program as of 30 June. A toll-free "HOOT Line" (1-800-667-HOOT), introduced in 1991, facilitates reporting. Landowners are also asked if they are interested in converting additional land to pasture, receiving information on conservation easements, enrolling additional hectares in the program, or receiving roadside warning signs. Landowners who do not mail in their census card or respond otherwise are contacted by phone for information (every year except 1996). Note that the OBO database was restructured in 1994, and all OBO data entries were proofed against original records. Small discrepancies occurred between annual OBO summaries and the updated database. Because our results are based on the current database, some of our numbers differ slightly from those reported by Hjertaas (1997).

OBO Evaluation

The study area for Warnock and Skeel (2004) was located in southern Saskatchewan, Canada, represented by the Weyburn (62E) and Regina (72I) 1:250,000 map areas of the National Topographic Survey of Canada (Figure 1). These map sheets represent areas containing relatively high numbers (10-15) of known occupied burrowing owl sites during the 1987-1993 period (Wellicome and Haug 1995). Our study area was the same as Hjertaas and Lyon's (1987) from which the control dataset was derived. The landscape composition in the study area was the following: 83% cropland, 11% native grassland, 3% tame pasture, 2% tree/shrub, and 1% water/other. About 75% of the native grassland is found on land that is severely limited or unsuitable for crop production (Hammermeister et al. 2001).

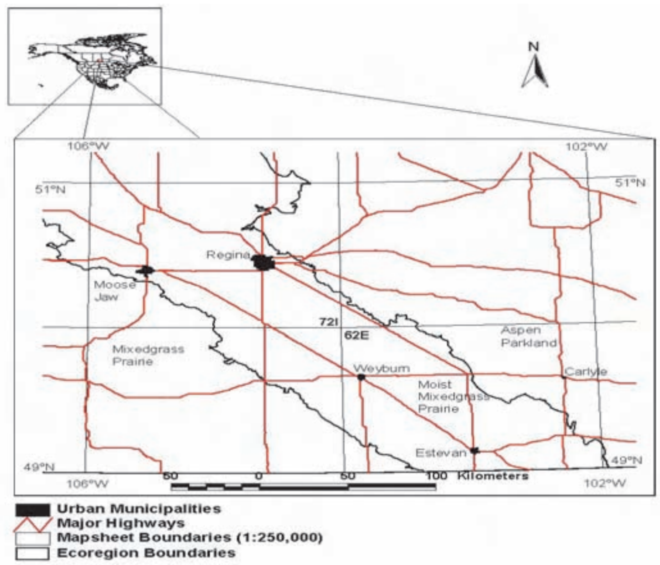

Figure 1. Map of the Regina and Weyburn study area in Saskatchewan, Canada.

In 1988, 108 private grassland parcels were enrolled in the OBO program in the study area. By 1992-1993, 67 of the original 108 parcels remained in the program (Warnock and Skeel 2004). The other parcels were withdrawn from the program because of confirmed cultivation of the habitat (90% of the withdrawn parcels) or when change of ownership occurred (Nature Saskatchewan, unpubl. data). Ninety-eight of 882 grassland parcels surveyed by Hjertaas and Lyon (1987) were systematically selected as random sites (Warnock and Skeel 2004). These selected random sites were all privately owned, were not known to support burrowing owls, and had similar habitat and soil types as OBO sites.

The 1993 land use of OBO and random sites was determined from 1992 and 1993 Southern Saskatchewan Digital Land Cover Maps with LANDSAT imagery sites and classified into 24 cover classes according to standard procedures (Warnock and Skeel 2004). The area of grassland habitat in 1993 was calculated as the sum of native grassland, tame grassland (including haylands), and shrub habitats. These habitats were judged by D. Hjertaas (Saskatchewan Environment, pers. comm.) to best correspond to burrowing owl grassland habitat as determined in Hjertaas and Lyon (1987). The 1986 grassland area of OBO sites was obtained from 1987-1988 OBO voluntary habitat stewardship agreements (Warnock and Skeel 2004), and the grassland area for random sites was obtained from D. Hjertaas (Saskatchewan

Environment, unpubl. data). The 1993 grassland area for the selected random sites was then compared to the 1986 grassland area for the same sites.

The retention of grassland at sites was calculated as the proportion of 1986 area remaining in grassland in 1993 (Warnock and Skeel 2004). A value of 0 meant no grassland was retained and a value of 1 indicated the entire grassland was retained. All OBO and random sites were assigned to one of three size classes (<2 ha, 2-12 ha, >12 ha) according to parcel size following Hjertaas and Lyon (1987).

Land system and soil type for each site was identified from land system maps (Stelfox 1979; Flory 1980) and soil survey maps (Mitchell et al. 1944). Land system-soil type combinations were created and were grouped into three agricultural soil suitability classes for analyses: Class 1- very fertile, low relief sites; Class 2 - modestly fertile, low relief sites; and Class 3 - sites with fertility limited by salinity or drainage or sites with high relief, stoniness, or susceptibility to erosion (Warnock and Skeel 2004).

The accuracy of the digital land cover maps from satellite imagery was assessed by verifying a sample of 96 OBO and random sites; a correction factor was then determined and applied (Warnock and Skeel 2004). The map was deemed accurate if the size of grassland at a site did not differ more than 10-20% from the site verification. Percent accuracy was calculated as (number of sites 'correct'/number of sites checked) X 100. Corrected percent accuracy of the data was calculated as [(% correctly classified by satellite X number of sites not checked + number of sites checked)/ total number of sites] X 100. Verification of a sample of sites suggested that the Southern Saskatchewan Digital Land Cover Map accuracy was 78%, even with the seven-year time lag between when the imagery was created and verified (Warnock and Skeel 2004). Through verification of 47% of grassland sites, the estimated accuracy of the data set was improved from 78% to 88%. The digital land cover data indicated complete grassland loss when grassland was found to be intact at 18% of the sites, underestimated the extent of grassland by an average of 50% at 4% of sites, and did not overestimate the extent of grassland at any sites. The proportions from this apparent bias were used to adjust grassland retention for 21 sites (Warnock and Skeel 2004).

In order to evaluate the effectiveness of OBO sites in conserving grassland habitat, OBO sites were compared to random sites. General multiple analyses of variance (ANOVA) were used to determine which independent variables (site type, parcel size, agricultural soil suitability) and independent variable interactions contributed to grassland retention (Warnock and Skeel 2004). The ANOVAs appeared robust with respect to deviations from normality (Warnock and Skeel 2004). Additional General Linear Model Analyses of Variance and t-tests (with Bonferroni adjustments) for independent samples of individual comparisons were completed to determine which conditions led to statistical significance. Individual comparisons among levels of site type, parcel size, and agricultural soil suitability class were completed with t-tests for independent samples.

RESULTS AND DISCUSSION

OBO Membership

The OBO program began with 293 landowners in 1987 and grew steadily to 499 members by 1991 (Figure 2). Most members are private landowners (97% in 2003-2004), and the remainder are stewards of public lands. Membership in OBO remained relatively constant after 1991, fluctuating between 457 and 501 participants, as some new landowners with owls joined the program each year, while others left the program. New participants generally resulted from changes in owl distribution or through media efforts and recruitment efforts. Landowners leaving the OBO program usually did so because they wanted to cultivate formerly protected areas or they no longer owned the land. Although not having owls for several years caused some landowners to leave the program, most continued to participate. Of the 675 individuals who joined the OBO program from 1987-1994, 504 (75%) of these were still enrolled five years after joining, even though approximately 70% of them no longer had owls. In addition, members that remained in the program for at least five years tended to remain until at least 1999 (<2% attrition rate for those enrolled for more than five years).

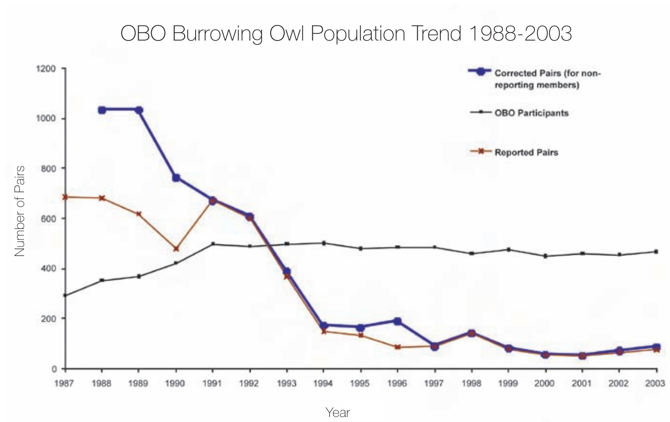

Figure 2. Operation Burrowing Owl population trend from 1987 to 2003.

The proportion of OBO members returning their yearly census cards varied between 1990 and 2003, ranging from a high of 60% in 1993 to a low of 19% in 2000 and has generally been <25% since 1998. Response via the toll-free HOOT-line introduced in 1991 has remained low at 2-4%. Providing postage-paid OBO census cards from 1991 to 1995 (except 1992 when all members were contacted directly) did not improve the return rate of cards. Returns may have decreased in recent years because members now expect to be phoned if they do not mail their census card.

Habitat Conservation

The total area enrolled by private landowners in the OBO program increased by 257% over 16 years, from 8,692 ha in 1987 to 22,338 ha in 2003. At public sites, 44 ha were enrolled in 1987, increasing to 38,920 ha by 2003 (the vast majority in 3 PFRA pastures). The total area of private and public sites enrolled in 2003 was 61,258 ha. Approximately 60% of the land enrolled in 1987 was still enrolled in 2000.

Since 2000, 38 landowners were approved through OBO for habitat-enhancement incentives that resulted in seeding a total of 2,045 ha of cropland to perennial pasture, constructing 27 km of fence, and completing 4 remote watering systems to ensure the health of newly planted pasture and native prairie. The effectiveness of habitat enhancement activities by the OBO and other programs will be evaluated for effectiveness in burrowing owl conservation through owl population monitoring.

Population Trend

Although the number of OBO participants grew during the initial four years of the program and levelled off thereafter, the known number of burrowing owls on OBO sites declined at an alarming rate until the mid 1990s, after which the decline rate was lower with some population fluctuation (Figure 2). A modest but encouraging increase has occurred over the last two years. In 2002, 66 pairs of owls were reported (by 46 of 430 members) compared to 51 pairs in 2001 (by 29 of 447 members). In 2003, 75 pairs of owls were reported (by 45 of 446 members). These numbers are still considerably fewer than the 681 pairs reported by the 352 members in 1988 and do not account for non-responding members.

A more accurate estimate of the total number of owls on all OBO sites each year can be determined by correcting for non-responding members (i.e., unknowns). The annual census with number of pairs corrected for non-reporting members indicated a 92% decline in number of pairs over 16 years from 1032 pairs in 1988 (352 OBO landowners) to 86 pairs in 2003 (446 OBO landowners). This represents an average population decline of 15% per year. In 2002 and 2003, annual increases in estimated owl pairs of 35% (52 pairs in 2001 to 70 pairs in 2002) and 23% (70 pairs in 2002 to 86 pairs in 2003), respectively, occurred at OBO sites (number of OBO landowners 461 and 456 in 2001 and 2002, respectively). Mapping of pairs for 1987-2001 indicates the disappearance of active breeding owl sites over the entire burrowing owl range within Saskatchewan (OBO, unpubl. data).

Intensive field studies by researchers on the Regina Plain corroborated the dramatic decline in the burrowing owl population through the 1980s and 1990s (James et al. 1997; Wellicome et al. 1997). The percent annual decline estimated from OBO data (1991-1999) did not differ compared to the percent annual decline measured by biologists on the Regina Plain, supporting the reliability of the OBO data (paired t-test, p=0.66; J. Hoyt and T. Wellicome, unpubl. data).

Trends in Pairs per Site

Colonies of burrowing owls have nearly disappeared from OBO sites (Table 1). During 1987-1993, sites with ≥5 pairs of owls were fairly common, averaging 26 sites annually (range = 10-42 sites; 5-11% of OBO sites); however, almost no sites (range = 0-3 sites; 0-0.5% of OBO sites) from 1994-2003 supported ≥5 pairs of owls. No sites had a colony of ≥11 pairs after 1992. In 1988, the year after the OBO program began, 19% of sites had no owls, but 43% of sites had more than 1 pair of owls. By comparison in 2003, there were no burrowing owls at 92% of sites, and only a few sites (3%) had more than 1 pair of owls. This is important as a larger colony of owls is likely more persistent than a few owls. Sites reported during 1987-2000 occupied by one pair of owls seemed more likely to become unoccupied the following year (34%) than sites that originally had two (23%) or more pairs (6%). New landowners (with owl pairs) join the OBO program each year, and their reports are included in the annual owl totals.

Table 1. Percent of OBO sites that supported colonies of different sizes.

Year	Number of Sites	% of Sites with a Given Number of Pairs							
		0	1	2	3	4	5	6-10	11+
1987	418	-	61	21	7	4	3	3	-
1988	378	19	37	22	11	3	2	4	1
1989	383	31	26	15	13	4	4	5	2
1990	343	41	29	13	6	3	3	3	1
1991	496	46	25	9	11	3	2	3	1
1992	488	53	23	11	4	4	2	2	1
1993	509	71	17	6	3	2	1	1	-
1994	422	80	12	6	1	1	-	-	-
1995	440	83	10	5	1	-	-	-	-
1996	223	77	15	4	3	-	-	1	-
1997	598	89	8	2	-	1	-	-	-
1998	599	86	7	4	2	1	-	0.5	-
1999	610	92	5	2	0.7	-	-	-	-
2000	605	94	5	1	0.3	-	0.2	-	-
2001	603	95	3	1	0.6	-	-	-	-
2002	582	91	6	2	-	0.2	-	0.2	-
2003	584	92	5	2	0.2	0.3	0.2	0.2	-

Sources of Error

Rates of decline calculated from OBO data are approximate and are subject to inaccuracies such as miscounting, annual movement of owls, changes in number of sites monitored from year to year, and changes in program delivery. Counts are likely accurate for sites with few owls (<5 pairs), and prior to 1993, attempts were made to have a biologist verify sites with >5 pairs (Hjertaas 1997). Because all sites are occupied when they are initially included in the OBO program, a decline on monitored sites might occur over time even given a stable population if owls move between years from OBO sites to previously unoccupied sites (Rich 1984; Hjertaas 1997). Some owls move to nearby sites and are not noticed or not reported. This bias is at least partially offset by the enrolment of landowners that report owls for the first time (Wellicome and Haug 1995).

Factors Contributing to the Decline

Factors that reduce habitat quality, decrease productivity, or increase mortality cause burrowing owl population declines (Wellicome and Haug 1995). In Saskatchewan, habitat change (loss, fragmentation, and degradation) appears to have adversely affected the population (James and Fox 1987; Wellicome and Haug 1995; Warnock 1997; Clayton and Schmutz 1999; Poulin 2003; Todd et al. 2003). Conversion of grassland to cropland over the last century resulted in the loss of over 75% of native prairie in Saskatchewan (Hammermeister et al. 2001). In addition, habitat quality for burrowing owls has been reduced by fragmentation of large expanses of prairie, decreased prey availability, and a reduction in burrow providers (Wellicome and Haug 1995). Fragmentation likely results in greater predation pressure because of increased edge habitat (Wellicome and Haug 1995), and fragmented habitats may also affect dispersal and pairing success of the owls (Wellicome and Haug 1995; Todd et al. 2003). Food shortage contributes to low survival of nestlings (Wellicome 2000) and may increase predation on juveniles and adults by reducing alternate prey for predators (Todd et al. 2003). Other mortality factors include collisions with vehicles (Todd 2001) and pesticides that suppress prey populations and directly affect burrowing owls (James and Fox 1987).

Effectiveness of OBO in Grassland Retention

OBO had a significant positive impact on grassland retention at enrolled sites during an era of accelerated grassland loss in the area. Grassland retention at OBO sites from 1986 to 1993 averaged 66% and was significantly higher than at random sites where retention averaged only 49% (Table 2). These retention rates are for all parcel size and agricultural soil suitability classes combined. OBO's impact could be somewhat overestimated because OBO landowners were not a fully random sample of landowners (i.e., biased towards those who had owls, were willing to sign a voluntary agreement, and may have had a stronger commitment to conservation). Because OBO sites comprised only 0.7% of the remaining grasslands in 1987 in the study area, the program's overall effect in the area was limited. One-way ANOVAs indicated that site type (OBO or random), parcel size, and agricultural soil suitability had potentially important impacts on grassland retention. When these independent variables were considered together, site type ($F_{2, 179}$ = 11.21, p = 0.000), parcel size ($F_{2, 179}$ = 4.56, p = 0.012), and their interaction ($F_{4, 179}$ = 3.89, p = 0.005) had the greatest effects on grassland retention. Agricultural soil suitability also had a marginally significant effect on grassland retention ($F_{2, 179}$ = 2.61, p = 0.076). Specifically, grassland retention at OBO sites was significantly higher than at random sites for smaller grassland parcels (<12 ha) and grassland parcels with excellent (Class 1) to average (Class 2) agricultural soils, but did not differ at the larger sites or sites with poor (Class 3) soils.

Table 2. Comparisons of grassland retention between OBO and random sites. Retention is calculated as a proportion, varying from 0 (total loss) to 1 (complete retention).

Variable Group	OBO Sites			Random Sites			Significance		
	Mean	SE	n	Mean	SE	n	F	df	p
All Sites	0.66	0.06	108	0.49	0.07	98	2.81	204	0.005
Parcel Size[1]									
< 2 ha	0.69	0.13	25	0.23	0.11	29	4.08	52	<0.001
2-12 ha	0.62	0.11	36	0.38	0.11	36	-2.20	70	0.031
> 12 ha	0.68	0.09	47	0.82	0.10	33	1.60	78	0.113
Agricultural Soil Suitability[2]									
Class 1	0.54	0.12	34	0.25	0.11	33	-2.78	65	0.007
Class 2	0.76	0.09	52	0.49	0.11	41	2.92	91	0.004
Class 3	0.63	0.14	22	0.80	0.13	24	1.41	44	0.166

[1]Significance of grassland retention with parcel size at OBO sites: $F_{2, 58}$ = 1.58, p = 0.213. Significance at random sites: F2, 89 = 11.02, p < 0.001.

[2]Significance of grassland retention with agricultural soil suitability at OBO sites: $F_{2, 99}$ = 2.52, p = 0.086. Significance at random sites: $F_{2, 95}$ = 11.63, p = 0.000.

The types of sites where OBO was effective at grassland conservation were at greater risk from cultivation: grassland retention at random sites was significantly less at both smaller sites and sites with better soils. Specifically, large random sites (>12 ha) had higher grassland retention at 82% than smaller random sites at 32% (<12 ha, mean = 0.32, SE = 0.10, n = 65, t_{96} = -5.81, p < 0.001). The two smaller parcel size classes did not differ (t_{63} = -1.37, p = 0.176). In contrast, grassland retention at OBO sites did not differ significantly with parcel size or agricultural soil suitability (Table 2). These results demonstrate the important effect of the OBO program in conserving smaller parcels and sites with better agricultural soils. Because conservation of burrowing owls may have been an important consideration to landowners, grassland retention may have been increased at these sites. As owls disappeared, increased conservation awareness by OBO participants may have resulted in retention and maintenance of sites, even where there were no longer owls.

Smaller parcels may be at a greater risk because they are logistically easier to cultivate or they have little economic value to the landowner as grassland. Similarly, better agricultural soils are at greater risk of cultivation for economic reasons. Currently, only 10% of remaining native grassland in Saskatchewan occurs on land with high productive potential, while 75% of remaining native grassland occurs on land that is severely limited or unsuitable for crop production (Hammermeister et al. 2001). In contrast, OBO had a negligible effect on grassland retention on larger grassland parcels (>12 ha) and grassland parcels with poor agricultural soils (Table 2). These types of sites were at lower risk from cultivation, as demonstrated by high grassland retention at random sites. However, future changes in agricultural practices and climatic and economic conditions (government policies, crop prices) could contribute to changes in the risk of cultivation of these grassland sites. Our results suggest that, for the present, the OBO program should focus on conservation of more vulnerable grassland sites (small size and/or good agricultural soils) to provide nesting habitat for burrowing owls, which can nest on sites as small as one hectare or less (Haug et al. 1993; Clayton and Schmutz 1999). An examination of which sites promote the highest owl productivity, in addition to the vulnerability of sites, would also be necessary in targeting OBO.

Fortuitously, the OBO program was initiated at a time when grassland loss in the study area was accelerated. The annual 3.2% loss of privately owned grasslands for 1979-1986 (based on Hjertaas and Lyon 1987) increased to 6.0 % per year for 1987-1993 (Warnock and Skeel 2004). The latter rate is comparable to rates reported during this period by Adams and Didiuk (1993) and in Agricultural Census Data (unpubl. data). In addition, the percentage of grassland parcels lost significantly increased from 22.7% during 1979-1986 to 42.0% during 1987-1993.

Landowner retention within the entire study area was lower at 62% during 1987-1993 (Nature Saskatchewan, unpubl. data) than the 75% OBO landowner retention (Skeel et al. 2001), suggesting an increase in the rate of grassland loss, likely due to overall better agricultural soils in the study area. Cultivation of grasslands followed by change of ownership was the main reason for withdrawal from the OBO program. During the 1987-1993 period, there were strong incentives to break marginal land and disincentives to convert land back to pasture (Warnock and Skeel 2004). Landowners needed to maximize cultivated acreages to maximize economic benefits from agricultural programs and policies. The landscape impacts of removal of farm subsidies and changes in government farm policies are still evolving with both positive and negative effects (Bradshaw and Smith 1997; Smith and Hoppe 2000).

CONCLUSION

The success of the OBO program in conserving habitat has depended on and will continue to depend on increasing landowner awareness and maintaining a long-term commitment by landowners to retain habitat. Charismatic species often motivate conservation at many levels. Landowners may be more willing to undertake habitat conservation and enhancement if they can associate the results of their actions with specific species responses (Wilson 1992). Through the OBO and other stewardship and monitoring programs, the burrowing owl has become a visible, well-known ambassador for prairie habitat conservation. Thus, maintaining populations may be important in encouraging landowner commitment. Landowner retention in OBO and other voluntary stewardship programs will likely depend on financial and conservation incentives, as well as maintaining interest through relevant educational means and personal contact. The OBO model has proven to be a cost-effective stewardship program.

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SPECIES LISTS TO SIGNATURES: CREATING PARTNERSHIPS FOR PRAIRIE STEWARDSHIP IN MANITOBA

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Abstract: The Manitoba Critical Wildlife Habitat Program and Manitoba Habitat Heritage Corporation have developed programs to conserve the native mixed-grass prairie grasslands in southwestern Manitoba. These programs permanently protect habitats and promote agricultural landuse practices that are economically productive while at the same time sustain or enhance the health of the native prairie ecosystem. The agencies work together closely to target stewardship activities and develop positive relationships with landowners through their program delivery activities.

INTRODUCTION

The mixed-grass prairie grassland is a precious feature of the landscape of southwestern Manitoba. It holds a wealth of biodiversity and endless opportunity for discovery. Its awesome beauty is the inspiration for sculptures and poems and serves as the backdrop for numerous vibrant rural communities. The grassland has also sustained generations of ranchers with its grazing value. Unfortunately, the mixed-grass prairie is also a threatened habitat and home to a growing number of species at risk. Estimates indicate that less than 25% of mixed-grass prairie remains, with most in a fragmented and degraded state due to inappropriate management.

This paper discusses two agencies and their complimentary programs that target and promote stewardship activities to effectively conserve mixed-grass prairie in Manitoba. The delivery of these programs involves working with landowners to encourage compatible agricultural practices. Mixed-grass prairie, for the purposes of these programs, includes all grasslands in the Prairie Ecozone of Manitoba with a mixed-grass prairie component.

THE AGENCIES

The Critical Wildlife Habitat Program (1989)

The Critical Wildlife Habitat Program is a cost-shared program involving Manitoba Conservation, the Manitoba Habitat Heritage Corporation (MHHC), and a variety of other agencies that are involved on a project-specific basis. The Critical Wildlife Habitat Program goal is to identify, preserve, and manage the remaining critical wildlife habitats in Manitoba. The conservation of native grasslands and the habitats of unique, rare, and endangered species are program priorities. The program currently receives support from a number of agencies, including the federal Habitat Stewardship Program for Species at Risk. The Mixed-grass Prairie Inventory and Mixed-grass Prairie Grazing Project fall under the Critical Wildlife Habitat Program.

The Manitoba Habitat Heritage Corporation (1985)

The MHHC is a provincial Crown Corporation with a mandate to conserve, restore, and enhance fish and wildlife habitat. The MHHC seeks to accomplish its mandate by working in partnership with private landowners, farm organizations, corporations, conservation groups, and government agencies. The MHHC acts as the provincial coordinating organization for the North American Waterfowl Management Plan and delivers waterfowl and riparian management programs. It receives support from the federal Habitat Stewardship Program for its Integrated Conservation Agreements Project.

THE PROGRAMS

Mixed-grass Prairie Inventory Project

The Critical Wildlife Habitat Program initiated an inventory in 1996 to identify and rank the remaining areas of mixed-grass prairie in Manitoba. The objective of this project was to identify the extent and quality of remaining parcels of mixed-grass prairie in Manitoba by systematically surveying the known range of mixed-grass prairie. Several related inventories were conducted prior to 1996, and this combined information was used to help determine priority areas for a more comprehensive inventory.

The areas targeted for survey contained larger tracts of prairie, contained potential habitat for species at risk, or had a higher risk for agricultural modification. The identification of sites within these areas involved consulting remotely sensed images, soil surveys, aerial photographs, and forest resource inventories, as well as landowner and agency referrals.

Owners of selected lands were contacted to request permission to access their property for the inventory. Each parcel surveyed was separated into vegetation communities as described by the Manitoba Conservation Data Centre (Greenall 1996). The upland grassland community at each site was assigned a grade ranging from "A" to "D" using the Conservation Data Centre grading guidelines. A grade of "A" indicates exceptional quality habitat, and "D" indicates a poor quality site that requires extensive management adjustments to return to a higher quality. The assessments were based on species composition, amount of bare ground, litter buildup, type and degree of land use, as well as other observations related to the quality of the prairie habitat. Occurrences of species at risk and other special features were also noted.

To date, approximately 150,000 acres of mixed-grass prairie habitat have been inventoried, with just over half considered good quality prairie (i.e., grade of "C-" or better). Occurrences of hairy prairie clover *(Dalea villosa)* were recorded in 2001, and a substantial increase in the known extent of buffalograss *(Buchlöe dactyloides)* was identified in 2002. These species are currently listed as Threatened by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). A number of non-listed, provincially rare plant species were regularly recorded during the inventories. Rare birds, such as Sprague's pipit *(Anthus spragueii)* which is listed by COSEWIC as Threatened and Baird's sparrow *(Ammodramus bairdii)* which is listed as Endangered under Manitoba's Endangered Species Act, were also frequently recorded in some areas.

The factors that continually degrade the prairie were encountered repeatedly on a large portion of the inventoried lands. The main threats to mixed-grass prairie as determined from this inventory were as follows:

- cultivation, primarily where potatoes are grown;
- alien invasive species, primarily leafy spurge;
- aspen encroachment; and
- improper grazing management.

The data collected through the Mixed-grass Prairie Inventory were provided to the MHHC for use in targeting the delivery of their Conservation Agreements Program. MHHC uses the data to evaluate potential agreements as well as to provide landowners with site-specific information about the value of their land as wildlife habitat. This information helps landowners make informed management decisions.

Although a portion of the remaining native prairie occurs on Crown or other public agency land, the majority is under private ownership. Approaching landowners for permission to access their property is often the first contact between the agency and landowners and the first step toward building cooperative relationships. Potential participants for the Mixed-grass Prairie Grazing Project are also identified and recommended through the Mixed-grass Prairie Inventory, based on size and quality of habitat as well as the attitude of the landowner.

Mixed-grass Prairie Grazing Project

In 1997, improper grazing was considered to be the greatest threat to the remaining mixed-grass prairie in Manitoba. Producers traditionally based their grassland management on livestock numbers instead of the biology of the grass, and this often resulted in premature grazing and over-stocking. Improper grazing has led to a change in the species composition of remaining grasslands with an increase in the abundance non-native plant species and in the area dominated by shrubs. These changes have degraded the quality of the remaining prairie, impacted associated wildlife species, and reduced economic returns to the landowner. To address this issue, a cooperative grazing management project was developed, which involved various conservation organizations concerned with grazing management.

The project investigated a variety of successful grazing systems currently used in North America. The work of Dr. Llewellyn Manske at the Dickinson Research Centre of North Dakota State University was selected as the model for developing recommendations for grazing management of native pasture in Manitoba (see Manske 1994). The twice-over rotational grazing system is a grazing management practice that maximizes vegetation production and cattle performance by using appropriate timing to meet the biological requirements of the native grass based on the regional growing conditions. It is an economically profitable, ecologically sustainable grazing management practice that provides many benefits to the prairie ecosystem, including improved ground cover, reduced soil erosion, and increased soil microbial activity. This system had been used effectively in North Dakota to maintain and enhance native plant community structure while increasing livestock weight gains. The goal of this grazing management project, which ran until 2002, was to conserve the native mixed-grass prairie ecosystem by promoting agricultural activities that incorporate wise land stewardship.

Proven grazing methods with both demonstrated benefits to native grasslands and increased economic gains to the producer were then promoted by developing demonstration projects in the mixed-grass prairie zone of agro-Manitoba as part of an interagency partnership coordinated by the Critical Wildlife Habitat Program. The Mixed-grass Prairie Grazing Demonstration Project was designed to introduce the twice-over rotational grazing system to Manitoba cattle producers and to demonstrate its benefits to livestock as well as native vegetation and wildlife. The Critical Wildlife Habitat Program worked with six private landowners throughout the region to set up mixed-grass prairie grazing demonstration project sites on their land. A monitoring schedule was implemented to measure changes in the plant community structure, songbird populations, and cattle weight gains for each site. This demonstration project showed that the twice-over grazing improved diversity and density of desirable native vegetation and grassland bird species and resulted in increased weight gains for livestock. The project also served to show the benefits of this management system to local landowners and communities, a very important component to the extension efforts as many producers need to see a successful local example of a given practice before they will consider implementation within their own operation. Because of these positive results, the current Mixed-grass Prairie Grazing Project was developed in 2002 to engage more landowners in this practice and, in so doing, benefit additional mixed-grass prairie habitat.

The Mixed-grass Prairie Grazing Project is a voluntary program that provides financial and technical assistance to private landowners who commit to managing their native pasture using the twice-over rotational grazing system. This project seeks to enroll ten cattle producers per year, each signing a five-year agreement. To date, 12 producers have signed on, improving the management of approximately 5,000 acres of mixed-grass prairie. Six of these agreements involve confirmed occurrences of species at risk and all contain good quality mixed-grass prairie that is suitable habitat for species at risk.

One of the strengths of this project is its extension component. Creating dialogue helps to advance awareness of the issues within target communities and makes local producers aware of the resources available. Group tours and workshops are held regularly to recruit new participants, to encourage interaction among agencies and landowners, and to demonstrate the benefits of these projects for both the landowner and the prairie ecosystem.

The MHHC Conservation Agreement Program

This project seeks to secure native habitat of species at risk through conservation agreements with landowners. The *Conservation Agreements Act* was passed in 1997 enabling eligible conservation agencies to "hold" a conservation interest on private land. The MHHC has used conservation agreements as its primary habitat securement tool. The MHHC currently has three Conservation Agreement Programs, one donated and two purchased. The purchased Conservation Agreement Programs specifically target wetlands and associated native upland habitats for waterfowl, as well as native grasslands or riparian areas associated with species at risk. These conservation agreements place restrictive caveats on the land title. The restrictions placed on the specified habitat areas are selected to protect the ecological integrity of the habitat while allowing activities that are consistent with this goal.

Potential projects are evaluated by rating a number of criteria designed to reflect the relative significance of the habitat to observed species at risk, the vulnerability of the habitat to disturbance or destruction, and the broader landscape value of the habitat. Higher weighting is given to sites with confirmed occurrences of COSEWIC- or Manitoba-listed listed species or where such species have been observed in close proximity. Higher weightings are also given for larger and higher quality habitats. COSEWIC and Manitoba endangered species observations are acquired with the cooperation of the Manitoba Conservation Data Centre. This information is updated as additional inventories are completed and new species observations are entered into the georeferenced database. Mixed-grass Prairie Inventory data is entered annually and is used along with the species observation data to assess the conservation agreement proposal, including the level of restriction that should be specified in the agreement.

To date, the MHHC holds 121 conservation agreements on over 17,000 ac with 47 of these agreements specifically targeting habitats associated with species at risk. The success of the MHHC's Conservation Agreement Program depends on the ability of the MHHC to effectively target the securement program.

ON THE LANDSCAPE

Success in reaching the goal of long-term protection of prairie habitats and their associated species at risk lies in the method of delivering stewardship programs on the landscape, especially in creating excellent working relationships with the landowners. Good cooperation between delivery agencies and programs is key to effectively identifying priority areas for conservation activities; however, there are several factors that may impede these activities during the delivery process and beyond.

In the case of the Mixed-grass Prairie Grazing Project, the financial incentive offered by the Critical Wildlife Habitat Program only covers a portion of the landowner's costs for implementing the twice-over rotational grazing system. In addition, these lands support habitats that are confirmed or potential homes to species at risk, and the implications of having species at risk on their land are of concern to many landowners. The delivery agency commits to numerous meetings and pasture visits to ensure that the landowner is comfortable with the staff and to provide the opportunity to address concerns in a timely manner. As a result, these producers have agreed to change their management practices despite the financial cost, showing their confidence in the program.

The success of MHHC's Conservation Agreement Program also depends on establishing positive relationships with landowners. The comfort level between the landowner and the agent of the organization is critical when considering the long-term securement and establishment of an "interest" by a third party on private land. This relationship is initiated at the time of the inventory and fostered through subsequent stewardship efforts. In some cases, development of these relationships and subsequent signing of an agreement may take months or years. Program delivery also benefits immensely from a non-intrusive approach that emphasizes the cooperative and voluntary nature of the agreements.

All participating landowners share an ethic to conserve the prairie on their land. For many, their family has used and enjoyed the land for generations, and they want to leave it in a natural state for the next generation.

Others simply appreciate the value of sustaining prairie biodiversity. Most, however, also depend on the income derived from use of their land, and this weighs heavily in their decision to participate in a given program. Programs have been designed to recognize that the health of the prairie ecosystem can be sustained or enhanced while continuing compatible agricultural practices such as managed grazing. The program structure and communication methods are designed to accommodate the landowner's needs.

Many landowners also appear hesitant to trust government conservation agencies, and entering into a contract or agreement requires a degree of faith on the part of the landowner, given the many hardships rural agricultural communities are facing. Failing to appreciate such sensitivities could be detrimental to these programs as well as future initiatives.

Professionalism and sensitivity at each step of the communication process are rewarded with successful, long-term relationships based on mutual trust and respect. In many cases, the interaction becomes like a friendship, and many cooperators become advocates for the project. For example, participants in the initial Mixed-grass Prairie Grazing Demonstration Project continue to promote the twice-over rotational grazing system on behalf of the Critical Wildlife Habitat Program, even though the program is now completed. They generously share their experiences with their neighbours and other landowners, including things they should have done differently, their increased economic returns, as well as the conservation benefits to the grassland ecosystem on their land.

SUMMARY

Creating successful partnerships is the key to the success of the Critical Wildlife Habitat Program and the MHHC in delivering programs to manage and conserve native mixed-grass prairie habitat in Manitoba. The agencies collaborate by sharing species data and other knowledge to effectively target conservation activities such as grazing projects and conservation agreement initiatives.

The vast majority of mixed-grass prairie lands is under private control so increased understanding and involvement of landowners is crucial to effectively conserve these areas. This includes enlisting their cooperation for voluntary stewardship activities, which is facilitated by using appropriate communication methods and delivery processes. Using inventory records helps to show the landowners the actual importance of the habitat they are managing, and extension activities demonstrate the benefits of improved management to both the habitat and their operation.

Although the number of species and prairie acres protected is impressive, the relationships developed during delivery of the programs on the landscape truly reflect the success of these stewardship programs in Manitoba.

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LANDSCAPE FACTORS AND ALIEN GRASS INVASIONS IN THE CANADIAN PRAIRIES

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Abstract: Biodiversity of native grasslands in the prairie ecozone is threatened by the invasion of non-native (alien) perennial grasses from seeded pastures, roadside ditches, reclaimed wells, and pipeline rights-of-way. Crested wheatgrass *(Agropyron cristatum)* and smooth brome *(Bromus inermis)* are the alien invasive species of primary concern in the semi-arid mixed-grass prairie and subhumid fescue prairie ecoregions, respectively. To determine how soil type, slope, and grazing influence the persistence and spread of these grasses in these two ecoregions, field investigations were carried out in 2002 and 2003. Approximately 100 km of pipeline rights-of-way (ROW) were divided into segments where changes in soil, slope, or grazing occurred, and both the cover and distance off-ROW were measured for both species of alien invasive grass. Results indicate both species have a wide range of tolerance to soil type, whereas slope angle/aspect and grazing strongly influence invasion. In particular, livestock grazing reduces the cover and suppresses the invasion of both species. The information generated from these investigations can help managers develop monitoring and control plans and help planners develop predictive models of invasion susceptibility at the landscape scale.

INTRODUCTION

Linear roadway and utility right-of-way (ROW) construction is a major driver behind landscape fragmentation and average patch size reduction (Forman 1995). Prior to the mid-1900s, roadside ditches and other disturbed grounds were left to naturally revegetate from surrounding vegetation. Since the mid-1900s, revegetation has frequently involved seeding non-native (alien) plants for more rapid erosion control and supplementary forage, and these species are easily established and aggressive competitors that spread quickly (Forman et al. 2003). The "reclaimed" areas essentially become corridors for alien grass invasions into increasingly smaller patches of native vegetation (Gelbard and Harrison 2003). The interaction between linear developments and alien species invasions could increase shrinkage and attrition of natural vegetation patches over time.

Canada's most extensively fragmented landscape is the prairie ecozone. The remaining patches of native vegetation are usually small and subject to further fragmentation by cross-fencing, access roads to borrow pits or petroleum wells, and buried cables or pipelines (James et al. 1999). Since climate and soils vary across the ecozone, different species have been selected to revegetate these disturbed areas. Smooth brome *(Bromus inermis)* is a rhizomatous grass, best adapted for subhumid aspen parklands, and crested wheatgrass *(Agropyron cristatum)* is a bunchgrass adapted for semi-arid mixed-grass prairie (Hill et al. 2000). Although most commonly associated with soil disturbances in the Northern Great Plains (Kotanen et al. 1998; Larson et al. 2001), both species will also spread into adjacent native grassland and reduce plant community diversity (Wilson 1989; Nernberg and Dale 1997; Heidinga and Wilson 2002). Heterogeneity of the underlying landscape and human management thereupon likely affect the location and rate of invasion, but little research has been conducted to date into the effect of these factors. Uncertainty regarding the response of invasive species to these factors will continue to hamper effective management for conservation and restoration (Byers et al. 2002).

We present summaries of two investigations conducted by University of Alberta graduate students, stemming from a larger research program into the ecology and management of invasive grasses. For each of smooth brome and crested wheatgrass, there were two research objectives relevant to invasion rates. First, the realized niche of each species was defined within an ecoregion by describing the landscape-scale factors that inhibit or promote persistence and invasion. Second, the interactions between invasion rates and patch sizes were explored through 100-year simulation models.

METHODS

In 2002 and 2003, two 25-year-old buried pipeline ROWs were surveyed in central and southern Alberta where crested wheatgrass or smooth brome had been seeded along segments bisecting patches of native vegetation. The cover on-site and the cover or distance invaded off-site were recorded for both species along each ROW. Invasion rates for smooth brome could not be measured because stands originating from the ROW or other source populations could not be distinguished. These responses were related to soil or plant community types, slope gradient or aspect, and grazing intensity. Approximately 69 km was surveyed on-foot in the mixed-grass prairie ecoregion and 19 km in aspen parkland, with individual sampling unit lengths between 10 and 4,000 m, depending upon the factor of interest. For grazing intensity, sampling units were based on discrete pastures (fence to fence), whereas for soil or plant community types, the segments comprising a contiguous polygon were aggregated into single units. Treatments for each factor were considered discrete and response differences among treatments were identified with one-way analyses of variance. Slope gradient and aspect segments were grouped into classes and used as independent variables for linear regression analysis of the relationship between cover and invasion responses.

Invasion simulation models were generated for rectangular patches of varying size using invasion rates estimated from the above investigations and other sources. The assumptions behind the models were as follows: (1) the invasive species completely surrounds the patch at time 0; (2) the invasive species already occupies a portion of the patch assuming road allowances occur on all four sides of two-section patches, two sides of quarter section or legal subdivision (LSD) patches, or absent from one hectare patches (see Forman et al. 2003); and (3) the invasion progresses like a wave with no outlying satellite populations (see Moody and Mack 1988). These assumptions were necessary to simplify the model. Although assuming the invader surrounds all sides of the patch may increase the proportion of the patch invaded over time, this is counterbalanced by the absence of satellite population formation and coalescence over time. Thus, the models represent a conservative compromise.

RESULTS AND DISCUSSION

Realized Niche of Smooth Brome and Crested Wheatgrass

Biologically, these two alien grasses reproduce and disperse differently. Crested wheatgrass requires seed dispersal and successful establishment of new plants for invasion to occur, and factors that limit seed production or seedling germination and establishment should strongly inhibit invasion. Conversely, smooth brome requires lateral growth of rhizomes and vertical development of ramets from established clones for invasion to occur, and factors that limit the rhizome elongation or ramet survival should strongly inhibit invasion. Seed rain densities of crested wheatgrass are high relative to co-occurring native species (200 to >2,000 seeds/m^2; Ambrose and Wilson 2003; Wilson and Partel 2003), whereas seed banks of smooth brome are relatively small (<50 seeds/m^2; Willms and Quinton 1995; Brown 1997). Patches of smooth brome can and do initiate from seed dispersal and establishment events, but these events are rare relative to annual rhizomatous encroachment (Wilson and Stubbendieck 2000).

Increased grazing intensity appears to be a common denominator for inhibiting persistence of smooth brome and also invasion by crested wheatgrass (Figure 1). The direct effect of grazing is to limit seed head development and thus seed dispersal. Indirectly, grazing dries soil by increasing solar insolation and transpiration rates and decreasing water infiltration. Reduced moisture availability can further reduce survival of seedlings or ramets. Grazing has reduced the cover and reproductive output of both species in other studies (Willms and Quinton 1995; Brown 1997; Wilson and Partel 2003).

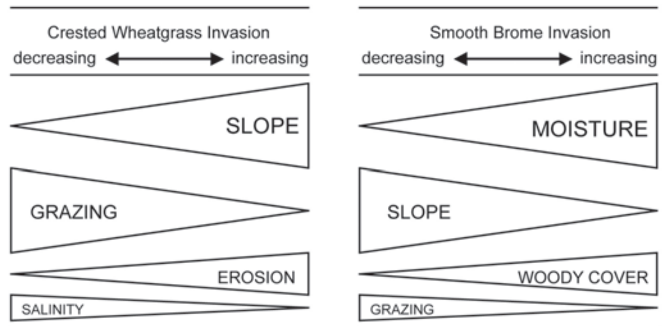

Figure 1. Relative importance of landscape-scale factors in promoting or inhibiting invasion of crested wheatgrass in mixed-grass prairie and smooth brome in aspen parkland-fescue prairie.

The dominant factor for smooth brome invasion was moisture limitations for lateral growth and seedling survival (supported by Wilson and Stubbendieck 2000). Sites most susceptible to invasion were northerly aspects and toe slopes or communities that support cooler and moister microclimates (Baines 1973). Grazing may further modify these moisture relationships, but abiotic limits of slope aspect and angle were more important in the distribution of plant community types and smooth brome cover. Similarly, Stohlgren et al. (1999) found the relationship between alien species richness and soil resource availability was more strongly related to elevation and soil texture than to long-term grazing. Smooth brome is also associated with woody plants, but this association appears due to shared moisture requirements rather than to facilitation. In tall grass prairie, smooth brome increased with grazing after light competitors were removed (Smith and Knapp 1999). Although invasion rates were not measured directly, the habitat responses could be used to adjust existing estimates of smooth brome spread. Patches at Wanuskewin Heritage Park in Saskatoon spread a maximum of 0.63 m/yr, with a mean of 0.18 m/yr in ungrazed, transitional black to dark-brown chernozemic soil (D. Sharman, unpubl. data). Assuming this landscape supports the most ideal habitat for smooth brome, other landscape factors will reduce invasion rates proportionally.

The dominant factors for crested wheatgrass invasion were seed production, dispersal, and safe site availability. Sites most susceptible to invasion were steep slopes with more bare ground, increased wind speed and overland water flow, and lower grazing intensity. Grazing interacts with slope angle; livestock are less likely to frequent slopes, and thus grazing intensity declines inversely with slope gradient. Increased bare ground provides competition-free microsites for seedling establishment, and wind and water flows facilitate dispersal. Under the most ideal conditions (ungrazed mid-slope), a maximum invasion rate of 1 m/yr was observed, but the mean rate under these conditions was <0.20 m/yr (D. Henderson, unpubl. data). Note that these values are based on lateral invasion rates measured perpendicular to prevailing winds, and published estimates for sites downwind of source areas have estimated rates of 1 to 2 m/yr (Hull and Klomp 1966; Heidinga and Wilson 2002). Salinity was an additional limitation on persistence and invasion of crested wheatgrass, consistent with the known physiological tolerance of this species (Johnson 1990), but the landscape extent of highly saline soils is relatively small.

Landscape Fragmentation and Invasion

Most remaining native grassland patches are embedded within a matrix of cultivated and developed land dominated by alien grasses, primarily smooth brome, crested wheatgrass, and Kentucky blue grass (Grilz and Romo 1994). Smaller patches have a larger edge to area ratio and are more rapidly overcome by alien species invasions, whereas larger patches will retain a core area free from invaders for a much longer time simply due to dispersal limitations of the alien species (Forman 1995; Forman et al. 2003).

Conservative 100-year simulation estimates indicate that an invader will occupy up to 80% of one hectare or smaller patches and 8% of two-section patches (Figure 2). Maximum and minimum invasion rates were similar for both species, but mediated by different landscape processes. Grazing greatly reduced the proportion invaded by crested wheatgrass on the smallest patches, and xeric landscapes limited the spread of smooth brome. From a conservation perspective, larger patches appear to resist complete invasion for a longer period of time. Cully et al. (2003) cautions against devaluing small patches, because these patches continue to support some native species and represent opportunities for germplasm and experimental sites for restoration. However, from the restoration perspective, the proportion invaded is less important than the actual area, and larger patches have more absolute edge from which invasion can occur and a larger absolute area in need of restorative activities.

The simulation models are not perfect representations of reality for several reasons. The assumption that invasion rates are constant from year to year is not consistent with observations, and climate may be an important limiting factor (Bakker et al. 2003). Also, the assumption that invasion from the patch edge can occur with an equal probability is contrary to results indicating considerable heterogeneity, and the prevailing wind direction will additionally influence the pattern of crested wheatgrass invasion. Finally, satellite populations or nuclei of invasion can occur beyond the invading edge due to rare long-distance dispersal and establishment events (Moody and Mack 1988). The latter process will greatly increase the simulated rates of invasion and decrease the time necessary to completely occupy a patch (Mack et al. 2000).

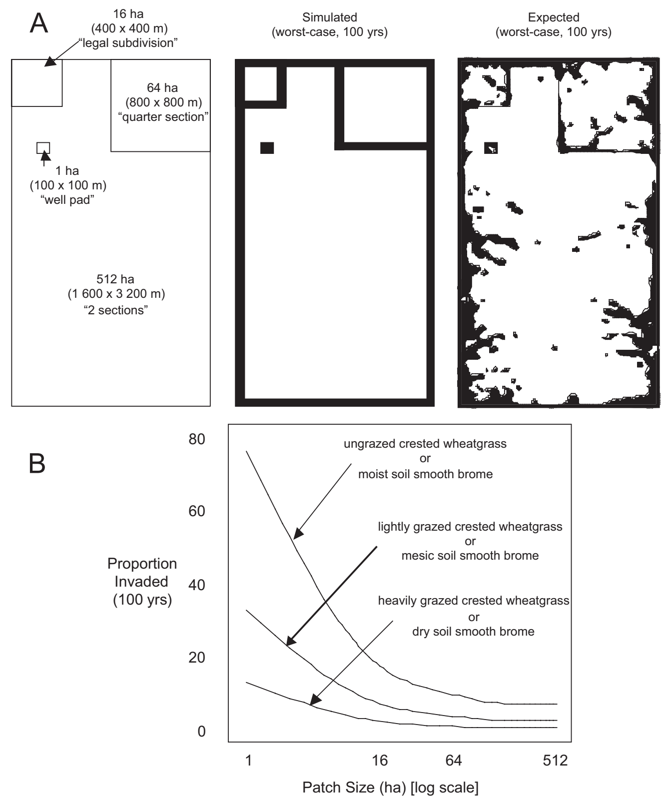

Figure 2. Interaction between patch size and invasion rate measured by the proportion of a patch invaded over 100 years. A illustrates patch sizes, simulated invasion patterns, and an expected heterogeneous pattern. B illustrates three scenarios for invasion under different grazing regimes for crested wheatgrass or moisture regimes for smooth brome.

Challenges for Conservation and Restoration

Conservation of native grasslands requires several policy actions to prevent further introductions and invasions. Technically, fragmentation is the greatest threat because it increases the rate of native grassland loss due to alien species invasion (Gelbard and Harrison 2003). New roadways or industrial ROWs should be constructed within or adjacent to existing disturbance corridors. Although this still increases the area disturbed, additional bisection and edge creation are avoided as a source for invasion. Administratively, provincial and municipal governments must prevent the use of alien invasive grasses in favour of native species for roadside revegetation and other reclamation projects. Planners should encourage multiple-use traffic on existing roadways and strive to decommission underused roads to stop and possibly reverse the fragmentation trend (Forman et al. 2003). These administrative changes are the largest problems to overcome (Mack et al. 2000).

Eradication of invasive grasses and restoration of native grasslands are both technical and economic struggles. The body of literature assessing alien species invasion patterns and processes, ecological and biodiversity impacts, and eradication/restoration methods is growing (Byers et al. 2002). Specifically, some headway has been achieved on the biology and suppression of crested wheatgrass (Romo et al. 1994; Bakker and Wilson 2003; Wilson and Partel 2003) and smooth brome (Brown 1990; Blankespoor and Larson 1994; Grilz and Romo 1994; Wilson and Stubbendieck 2000). However, funding agencies for agricultural (weed and rangeland) research do not classify economically valuable grasses as "weeds", and funding agencies for habitat or biodiversity conservation often lack expert knowledge in plant ecology for assessing the threats posed by invasive plants. Despite limited research funds, the control of invasive plants is consistently one of the top priorities and management expenditures at national parks across North America (Mack et al. 2000). Unfortunately, little headway will occur until the gap between information need and supply is bridged.

Our results suggest grazing may suppress smooth brome and crested wheatgrass, but other invasive grasses are capable of occupying the heavily grazed niches (Figure 3). Kentucky bluegrass *(Poa pratensis)* could potentially increase with heavy grazing of smooth brome or in accumulated litter beneath ungrazed crested wheatgrass (Curtis and Partch 1948). Similarly, high intensity grazing of crested wheatgrass could increase the proportion of dry, bare soil and promote invasion of two annual bromes: downy and Japanese *(Bromus tectorum* and B. *japonicus)* (D'Antonio and Meyerson 2002). At some future point, this handful of Eurasian grass species could dominate from the boreal fringe to the U.S. border. Our simulations present a 100-year view but more than 50 years have already elapsed, and increases in the numbers and extent of invasive species are expected in the future (McKinney 2002).

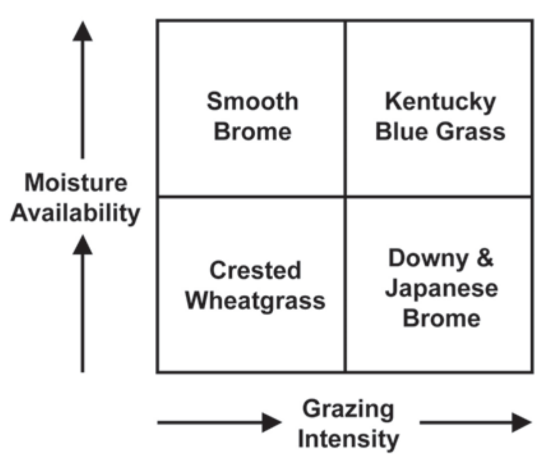

Figure 3. Conceptual representation of two realized niche dimensions (moisture and grazing) for five alien invasive grasses in the Canadian prairie ecozone.

ACKNOWLEDGEMENTS

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EFFECTS OF ASPEN PATCH SIZE ON BIRD DIVERSITY AND ABUNDANCE IN EAST-CENTRAL ALBERTA

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Abstract: Bird diversity and abundance are relatively high in aspen parkland habitats across the prairies. However, more than 95% of Alberta's aspen parkland has been disturbed, and most remnants are surrounded by agricultural activities. The goal of this study was to examine the influence of remnant aspen patch size on bird diversity and abundance. This study builds on principles from the theory of island biogeography, using aspen groves as islands.

From late May to late June of 2001 and 2002, 2 10-min, unlimited-radius point counts were conducted in the center of 32 mature, upland sites. These sites were located within 40 km of Camrose and avoided wetland and heavily grazed areas. Patches ranged from 0.01 to 24 ha in area, and the distance to the patch edge averaged 57 m (range=3-200 m).

Excluding waterfowl, shorebirds, and gulls, 42 species were observed. There were an average of 19.5 species (range=9-27) and 35.8 individuals (range=12-57) per site, with the least flycatcher being the most common (3.5 individuals per site, 97% of sites). Consistent with other studies in aspen and grassland habitats, both species diversity and abundance were positively correlated with patch size. Some species may have minimum patch size requirements. The distance to edge was positively correlated with the presence of interior species. The number of snags was positively correlated with the presence of bark insect-eating bird species. Light grazing occurred on 19% of sites, but grazing was not correlated with diversity, abundance, or patch size. Thus, area was an important predictor of abundance and presence, but habitat diversity, vegetation characteristics, and species requirements also influenced abundance and presence.

INTRODUCTION

Aspen forests have a high bird species diversity and abundance compared to other habitats (Winternitz 1980; Robbins et al. 1986), and this seems to be consistent for the aspen parkland in Alberta as well (Semenchuk 1992). The Parkland Natural Region in Alberta covers 12% of the province and includes three subregions: the Central Parkland (the focus of this paper), Foothills Parkland, and Peace River Parkland (Van Tighem 1993). In the Central Parkland, deciduous uplands (i.e., aspen forests) have higher bird species diversity than all other non-wetland habitats (Bilyk et al. 1998). However, less than 5% of Alberta's parkland remains in a natural condition (Van Tighem 1993) due to large-scale clearing (Achuff 1992). Most remnants are found on sites with rougher terrain or solonetzic soils and are surrounded by agricultural land. Although some work has been done in Saskatchewan (Johns 1993) and North Dakota (Grant and Berkey 1999), little research has documented the effects of the decline in habitat size on birds in this natural region.

Habitat size is a critical determinant of the presence and abundance of a variety of biological taxa, including birds (Cox and Moore 1993). Species-area curves for islands were helpful in formulating the theory of island biogeography (MacArthur and Wilson 1967), which explains differences in local immigration-extinction equilibria according to the size of islands and their proximity to source regions. Specifically, the number of species increases with island area and decreases with isolation. Figures plotting the log of species richness against the log of area typically produce straight lines. Island-like areas of isolated habitat, such as mountaintops and remnant forests (MacDonald 2003), should exhibit responses similar to true islands. Additional research has raised some concerns with this theory, including the role of intervening factors, the uniqueness among species and islands, and the role of varying habitats (Cox and Moore 1993; MacDonald 2003).

The goal of this two-year study was to examine the influence of patch size of remnant aspen forests on bird diversity and abundance in east-central Alberta, building on principles from the theory of island biogeography using aspen groves as islands (Hvenegaard 2003).

METHODS

Thirty-two sites within 40 km of Camrose were chosen for sampling. To minimize the influence of other variables, sites included only mature, upland aspen forests and avoided areas with adjacent wetlands and heavy cattle grazing (although sites with light grazing were included). The area of each patch was estimated from recent aerial photographs. Sampling points were selected close to the center of each site. From each sampling point, estimates were made of the distance to the forest edge (by pacing), slope (with clinometer), and aspect (with compass). Other visual estimates were made of canopy height and percent cover for the tree, shrub, and ground layers. The number of snags within a 10-m radius of the center was counted.

Birds were sampled from late May to late June in 2001 and 2002, the peak of breeding activity in the region. Two 10-min, unlimited-radius point counts were conducted each year at the sampling point in the center of each site. Any two visits to a site were separated by at least 10 days. All species identified by sight or sound were recorded at a given point count station on Forest Bird Monitoring Program forms produced by the Canadian Wildlife Service. All birds were recorded, regardless of their location inside, outside, or on the edge of the forest. Techniques closely followed that of Blondel et al. (1981) and Ralph et al. (1993).

Species abundance was taken as the highest number of individuals for each species from these four site visits. Species diversity was the total number of bird species observed at a given site. Waterfowl, shorebirds, and gulls were later excluded because their primary habitats do not include aspen forests. Data were analyzed with chi-square tests and one-way analyses of variance, with post hoc comparisons using Tukey's b test.

RESULTS

Overview of Sites and Species

The area of the aspen forests (i.e., patch size) averaged 6.2 ha (range=0.01-24 ha) on aerial photographs. The average distance from center to edge was 57 m (range=3-200 m). Only 6 of 32 sites had any slope; of these, the slope was always less than 10%. Thus, aspect did not vary among sites. Light cattle grazing occurred on 19% of sites. Trembling aspen was the dominant tree species in the patches sampled. The height of aspen canopy averaged 20.6 m (range=13-30 m). The average tree cover was 44%, shrub cover was 25%, and ground cover was 67%. Common shrub species included wild rose, raspberry, saskatoon berry, red-osier dogwood, buckbrush, pin cherry, and choke cherry. There were an average of 6 snags within a 10 m radius of the sampling point (range=0-17).

A total of 53 species were recorded, but after excluding waterfowl, shorebirds, and gulls, only 42 species were considered for analysis. An average of 19.5 species were recorded at each site (range=9-27, SD=3.5). The most common species, the least flycatcher, was encountered at 97% of the sites. Eleven other species were found at 75% or more of the sites, 6 species were found at 50-75% of sites, and 7 species were found at 25-49% of sites. An average of 35.8 individuals were recorded at each site (range=12-57, SD=9.8). The most abundant species were the least flycatcher (3.5 individuals per site), yellow warbler (2.9), northern oriole (2.1), house wren (2.1), and American robin (2.0).

Influence of Area

Species diversity was positively correlated with patch size (r=0.68, p=0.000). The $\log_{10}$ of species diversity was also positively correlated with patch size (r=0.63, p=0.000) and $\log_{10}$ of patch size (r=0.83, p=0.000). Species abundance was positively correlated with patch size (r=0.63, p=0.000). The $\log_{10}$ of species abundance was also positively correlated with patch size (r=0.59, p=0.000) and $\log_{10}$ of patch size (r=0.84, p=0.000). These trends are illustrated in Figure 1 and Table 1.

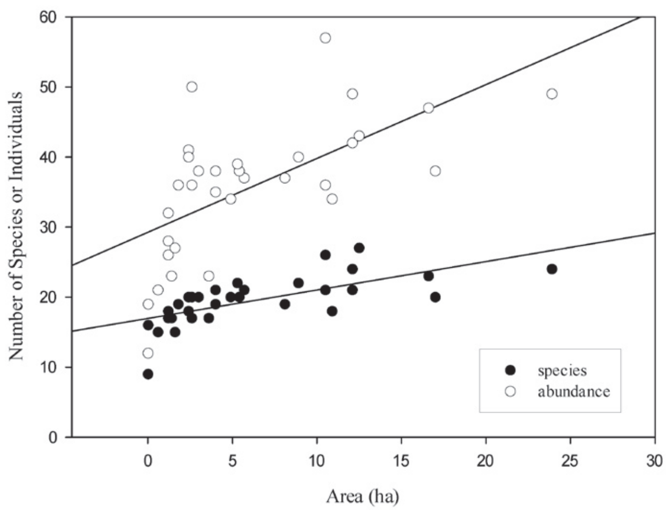

Figure 1. Influence of area on bird species diversity and abundance.

Table 1. Differences in bird species diversity and abundance among area classes of forest patches. Averages with the same superscripts are not significantly different.

Area Class (ha)	Average Number of Species	Average Number of Individuals
<1	13.3[a]	17.3[a]
1-2.5	17.6[b]	31.6[b]
2.5-5	19.1[b,c]	36.3[b,c]
5-10	20.8[b,c]	38.2[b,c]
>10	22.7[c]	43.9[c]
Statistics	F=12.2, p=.000	F=10.2, p=.000

Many interior species were more likely to be found in forests with larger areas. These include ruffed grouse, hairy woodpecker, western wood-peewee, red-eyed vireo, blue jay, ruby-crowned kinglet, white-throated sparrow, and hermit thrush. Some edge and grassland species, however, were more likely to be found at sites with smaller areas, including eastern kingbird, clay-colored sparrow, vesper sparrow, savannah sparrow, and brown-headed cowbird. These were likely to be recorded on the edge or outside of the patches.

Consistent with these findings, the distance to the patch edge was positively correlated with species diversity ($r=0.45$, $p=0.007$) and abundance ($r=0.52$, $p=0.002$). Interior species were more likely to be present (and with greater abundance) in forests with a longer distance to edge (e.g., ruffed grouse, great-horned owl, red-eyed vireo, white-throated sparrow, and hermit thrush). The opposite trend was found for grassland species such as the savannah sparrow.

Other Influences

Grazing was not correlated with diversity, abundance, or patch size. The number of snags was positively correlated with abundance ($r=0.41$, $p=0.021$), most notably for bark insect-eating species (e.g., downy woodpecker) or species liking open roost sites (e.g., eastern kingbird). Tree cover was negatively correlated with species diversity ($r=-0.45$, $p=0.006$) and abundance ($r=-0.38$, $p=0.015$), most notably for least flycatcher, warbling vireo, black-capped chickadee, and house wren. Shrub cover was not significantly correlated with total species diversity or abundance, but was positively correlated for hairy woodpecker and ruffed grouse. Ground cover was not correlated with total species diversity and abundance, but was negatively correlated for vesper sparrow and pine siskin. Isolation data have not yet been analyzed.

DISCUSSION AND CONCLUSIONS

Species diversity and abundance in this study were similar to studies of birds in other aspen forests of western North America (Flack 1976; Johns 1993; Westworth and Telfer 1993; Schiek et al. 1995; Grant and Berkey 1999). Similar to this study, research in Saskatchewan (Johns 1993) and South Dakota (Grant and Berkey 1999) also found that the area of aspen forests was a significant predictor of overall species diversity and abundance, especially for interior species (e.g., ruffed grouse, red-eyed vireo, hairy woodpecker). Grant and Berkey (1999) also found that area was negatively correlated with diversity and abundance for edge species, such as eastern kingbird, clay-colored sparrow, and vesper sparrow.

Without more extensive sampling, the minimum patch size requirements for area-dependent species cannot be predicted, but these results should be combined with other studies to draw conclusions. For example, in Saskatchewan, Johns (1993) found similar minimum patch size requirements for least flycatcher (0.2 ha), red-eyed vireo (0.2 ha), and hairy woodpecker (1 ha).

The influence of other vegetation variables (e.g., grazing, cover, snags) cannot be compared directly with other studies of aspen forests due to differences in measurement techniques and reporting. However, some of these variables (e.g., snags, cover) have an influence on collective and individual bird species diversity and abundance. For example, other habitat preference summaries support the finding that least flycatcher, warbling vireo, black-capped chickadee, and house wren are more often found in open woodlands (Ehrlich et al. 1988).

Bird density was not specifically measured in this study, since it used an unlimited radius point count method. The relationship between density and patch size, however, is not consistent in other studies and may involve many factors, such as level of forest thinning (Christian et al. 1996), amount of edge (Kroodsma 1984), forest age class (Westworth and Telfer 1993), and immigration dynamics of birds (Bowman et al. 2002).

In conclusion, area is an important predictor of the presence and abundance of birds, but the presence and abundance are also influenced by vegetation characteristics and species requirements. Previous studies as well as this research show the importance of protecting large patches of forest habitats, especially for area-dependent birds, in the Prairie Provinces where large aspen forests are already rare. Small patches are also important for many species as breeding sites, corridors, or migratory stopover locations. More research is required to determine the minimum patch size requirements of various species.

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PREDICTING INVASION BY AN INTRODUCED GRASS *(AGROPYRON CRISTATUM)*

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Abstract: Inadequate information on population growth and demographic processes limits our ability to predict long-term invasion patterns and contributes to the difficulty of controlling invasive species. Crested wheatgrass *(Agropyron cristatum)*, introduced to the Northern Great Plains from Russia, has been widely planted to reduce soil erosion because of its rapid establishment, but it also invades native prairie. Using matrix population models, I projected growth of *A. cristatum* populations in native prairie under selected management and water treatments to predict its invasion success. Tussocks of four size classes were clipped, treated with herbicide, or left untreated at three water supply levels for two years in order to generate population parameters for the models. Reproductive allocation, germination, and seedling survival were also studied. Population growth under the different management treatments was projected for 30 years. Water treatments were used to simulate among-year variation in precipitation. Untreated populations increased rapidly independent of precipitation and year. The growth of clipped populations increased the first year and decreased the second year, depending on precipitation and cumulative effects of the treatment. Herbicide-treated populations decreased independent of precipitation and year but may survive for up to ten years. Untreated populations produced a large number of seeds independent of precipitation and year, whereas clipped populations only produced seeds the first year. Herbicide-treated populations produced a very small number of seeds independent of precipitation and year. Germination increased with water supply. Matrix population models, integrating tiller growth, seed production, and establishment data of *A. cristatum*, allowed me to predict invasion under different conditions. The results demonstrate a strong management effect on *A. cristatum* invading native prairie. The choice of management may, therefore, have profound effects on the future state of the native prairie in the Northern Great Plains.

INTRODUCTION

Managing invasive plant species is always difficult (Cousens and Mortimer 1995), especially species invading native plant communities. Few studies have made connections between the theories on invasion ecology, quantitative field data, population growth models, and management. Invasion biology should address growth and demographic responses of invasive species under varying climate and management, since it is on the level of population dynamics that an invasion fails or succeeds (Parker 2000). Inadequate knowledge on growth and demographic response to variation in management and climate and, therefore, inability to predict long-term invasion and persistence may explain why most attempts to control invasive species have failed.

Demographic models provide an important tool to determine invasion success of introduced species (Parker 2000). I used size-structured matrix population models (Lefkovitch 1965; Caswell 2001) to describe demographic patterns and to project long-term growth of *Agropyron cristatum* populations in native prairie. To generate population parameters for the models, I projected *A. cristatum* under three management treatments including clipping to simulate grazing, herbicide application, and no treatment. Three water treatments representing either below average, average or above average precipitation were used to simulate among-year variation in growing-season precipitation in this area. Matrix population models have never been used to study invasions by non-native grasses in native prairie. However, models have been used successfully in demographic studies to predict invasion by invasive species (Parker 2000) and to evaluate the effect of control methods on invasive species (Bullock et al. 1994; Shea and Kelly 1998; McEvoy and Coombs 1999) or management effects on rare species (O'Connor 1993; Canales et al. 1994; Lennartsson and Oostermeijer 2001).

A. cristatum has been planted in abandoned fields across the Northern Great Plains as a restoration and soil protection method since the 1930s (Looman and Henrichs 1973). This species, introduced to North America from Russia, has been used because of its rapid establishment and spread, high coverage, and, therefore, ability to improve pastures and bind soil prone to erosion (Dillman 1946; Rogler 1960). As much as 10,000,000 hectares of the northern prairie may currently be covered by *A. cristatum* stands (Lesica and Deluca 1996). *A. cristatum* spreads by seeds only and produces large amounts of seed (Pyke 1990). Populations spread into native prairie adjacent to fields planted with *A. cristatum* (Hull and Klomp 1967; Heidinga and Wilson 2002), where it effectively establishes in persistent monocultures with low diversity (Marlette and Anderson 1986; Christian and Wilson 1999).

Simulated grazing and herbicide application were selected as management treatments for this study based on results from earlier studies of *A. cristatum*, where grazing (Cook et al. 1958; Robertson et al. 1970; Olson and Richards 1988a; Busso et al. 1989; Miller et al. 1990) and herbicide application (Wilson and Gerry 1995; Wilson 2002; Bakker et al. 2003) had a prominent negative effect on growth, seed production (Cook et al. 1958; Hyder and Sneva 1963), and persistence (Olson and Richards 1988b). According to results from earlier studies, however, herbicide application provides short-term control of *A. cristatum* only (Bakker et al. 1997; Wilson 2002; Bakker et al. 2003), while grazing may suppress growth on a much longer term (Robertson et al. 1970; Wilson and Pärtel 2003). Variation in water availability accounts for significant differences in emergence (Ambrose and Wilson 2003), seedling survival (McLean and Wikeem 1983), and growth of *A. cristatum* (Cook et al. 1958; Currie and Peterson 1966; Busso et al. 1989). Precipitation in this region varies greatly among years (Briggs and Knapp 1995), suggesting water availability is an important variable when projecting population growth by *A. cristatum.*

The combined effect of management and water treatments on tussock structure, growth, and seed production of *A. cristatum* is not well known. Grazing affects growth both negatively (Olson and Richards 1988a; 1988b; 1988c; Busso et al. 1989) and positively (Mueller and Richards 1986), while grazing in combination with drought reduced tiller growth after two years (Busso et al. 1989). Seed production is negatively affected by grazing (Cook et al. 1958; Hyder and Sneva 1963) but positively by high water availability (Miller et al. 1990). By using matrix population models, I was able to study the combined effect of simulated grazing, herbicide treatment, and water availability on germination, establishment, growth, and seed production in *A. cristatum.*

METHODS

Study Site

I worked in Grasslands National Park (49° 22' N, 107° 53' W) in southwestern Saskatchewan. The native vegetation is mixed-grass prairie dominated by blue grama grass *(Bouteloua gracilis)*, needle-and-thread grass (*Stipa comata*), and spikemoss *(Selaginella densa)* (Christian and Wilson 1999). Precipitation data from the nearest meteorological station about 6 km west of the study site showed an average precipitation of 222.7 mm over the 1937 to 2001 growing seasons (April-August; Environment Canada 2000). Due to high among-year variation in precipitation in this region (Briggs and Knapp 1995), however, the yearly amount of precipitation may differ significantly from the average. Total precipitation during the growing season of 2002 was well above average at 324.6 mm (Environment Canada 2002). Precipitation received at the study site in 2003 was measured using a rain collector (Davis Instruments 2000) connected to a HOBO event logger (Onset Computer Corporation 1999). Total precipitation during the growing season of 2003 was below average at 184 mm.

Study plots were established in native prairie where tussocks of *A. cristatum* had spread from an adjacent planted field and were growing at least one meter apart. A total of 360 tussocks of *A. cristatum* within an area of approximately 20,000 m^2 were classified into 4 size classes according to the number of live tillers. Circular plots 10 cm in diameter were established and separated by at least 4 m, with one tussock per plot. Size classes were determined according to the distribution of tussock sizes and were adjusted to minimize sampling and distribution error using Moloney's algorithm (Moloney 1986).

Treatments

I studied *A. cristatum* population responses under three management treatments, specifically simulated grazing, application of herbicide, and no treatment, as well as three water treatments producing a factorial design with two factors and three levels. Grazing was simulated by clipping all biomass in study plots 6 cm above ground on three occasions during May and June of 2002 and 2003, allowing shoots to regrow and seed heads to develop during the growing season. A herbicide *(Glyphosate)* was applied by wicking *A. cristatum* tussocks on one occasion in May of 2002 and 2003. Water was applied every two weeks from May to August of 2002 and 2003. The wet water treatment received water simulating the wettest growing season (383 mm in 1993) for the period over which data were available (1937-2001). The average water treatment received water simulating an average year during the same period (222.7 mm). The dry water treatment simulated water stress, for which plots were covered by rain-out shelters and received no precipitation.

Tiller Dynamics

Tillers that were live in 2001 (initial tussock size) were counted for each tussock in April 2002 before new tillers emerged. Live tillers on each tussock were counted in August 2002 and 2003.

Seed Production

I counted and collected all seed heads from each tussock. The average number of flowers per reproductive tiller for each tussock was estimated by counting spikelets of a maximum of five seed heads on each tussock. Each spikelet had on average 4.7 flowers, which agrees with earlier documentation (McGregor and Barkley 1986). I calculated the percentage of flowers containing a fully developed seed as well as the average number of developed seeds per tussock for each management and water treatment combination.

Germination and Seedling Survival

Seeds of *A. cristatum* were sown in 45 plots interspersed with the tussock plots. Each seed plot was paired with a control plot placed next to it in which no seeds were sown. The plots were at least 4 m apart and at least 1 m from tussocks of *A. cristatum*. Seed plots were enclosed in 10-cm diameter PVC tubes inserted into the ground to a depth of 4 cm to retain added water. The tubes were left 4 cm above ground to prevent seeds from blowing away (Ambrose 1999). Two hundred seeds were broadcast in each plot in May 2002. The same water treatments applied to tussock plots were applied to seed plots. No management treatments were applied to seed plots. Each plot of the dry treatment was covered by a 20 x 20 x 0.3 cm sheet of transparent acrylic sheeting fixed 4 cm above the top of the PVC tube (Ambrose 1999). Germinated seeds were counted during June to August 2002 and 2003. Live seedlings that had germinated in 2002 were counted in seed plots in August 2003.

Matrix Population Model and Life Cycle of *A. cristatum*

A size-structured matrix population model (Lefkovitch 1965) was constructed from probabilities of tussocks increasing or decreasing in size each year between 2001 and 2003 in response to management and water treatments. Size and stage structures rather than age structures are often useful when describing plant performance (Burgman et al. 1993; Caswell 2001) since they allow populations to be divided into classes of life stages or sizes and size classes to be influenced by any other size class in the matrix (Lefkovitch 1965; Burgman et al. 1993; O'Connor 1993). This makes this model especially suitable for this study since it allows tussocks to transfer from a larger size class to a smaller size class. Using the matrix population model, I calculated finite growth rate (l) and intrinsic growth rate (r) for *A. cristatum* populations under each management and water treatment combination. The value of l calculated using the matrix model indicates whether a population is decreasing ($\lambda \leq 1$), steady ($\lambda = 1$), or increasing ($\lambda > 1$) (Caswell 2001).

Long-term projections of *A. cristatum* in native prairie were completed for populations under the management treatments. Water treatments were used to build a model that simulated the variation in precipitation in this area during the period of 1937-2001. Projections of matrices were performed in Microsoft Excel (Microsoft Corporation 2001). Analyses of the transition matrices were performed using PopTools (Hood 2002).

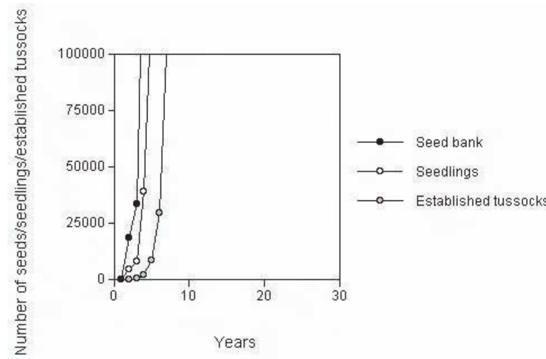

Figure 1. The increase in the number of seeds in the seed bank, seedlings, and tussocks in size class 1-4 of untreated *Agropyron cristatum* populations in both 2002 and 2003.

Table 1. Values for *Agropyron cristatum* populations under different management and water treatments combinations.

	No Treatment		Clipping		Herbicide	
Water Treatment	2002	2003	2002	2003	2002	2003
Wet	10.26	10.03	1.24	1.14	0.65	5.73
Average	6.05	5.42	1.15	1.0	0.49	0.49
Dry	2.62	2.64	1.03	0.6	0.28	0.28

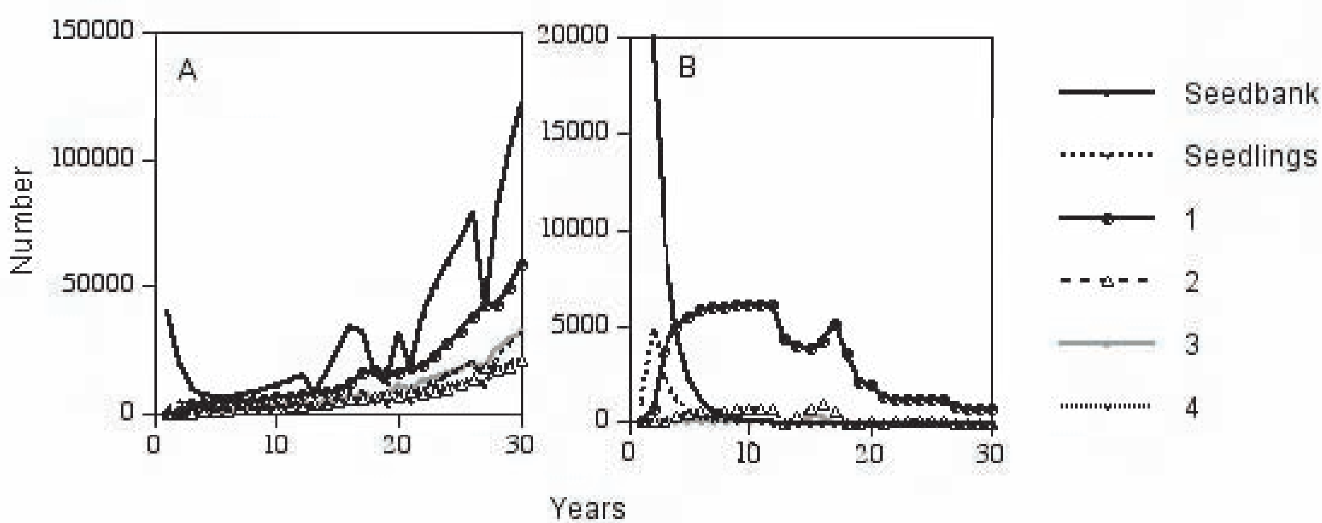

Figure 2. Clipped *Agropyron cristatum* populations, including the number of seeds in the seed bank, seedlings, and tussocks in size class 1-4, increased in 2002 (A) but decreased in 2003 (B).

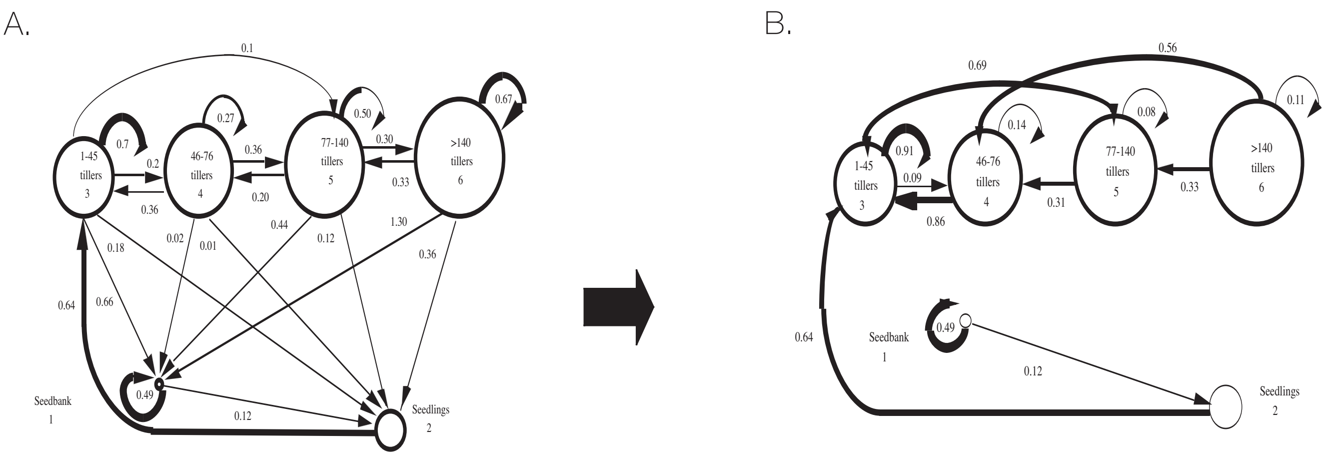

Figure 3. Clipped *Agropyron cristatum* populations produced seeds in 2002 (A), but not in 2003 (B). Clipping had little effect on tussock size in 2002 but decreased the size of tussocks in 2003.

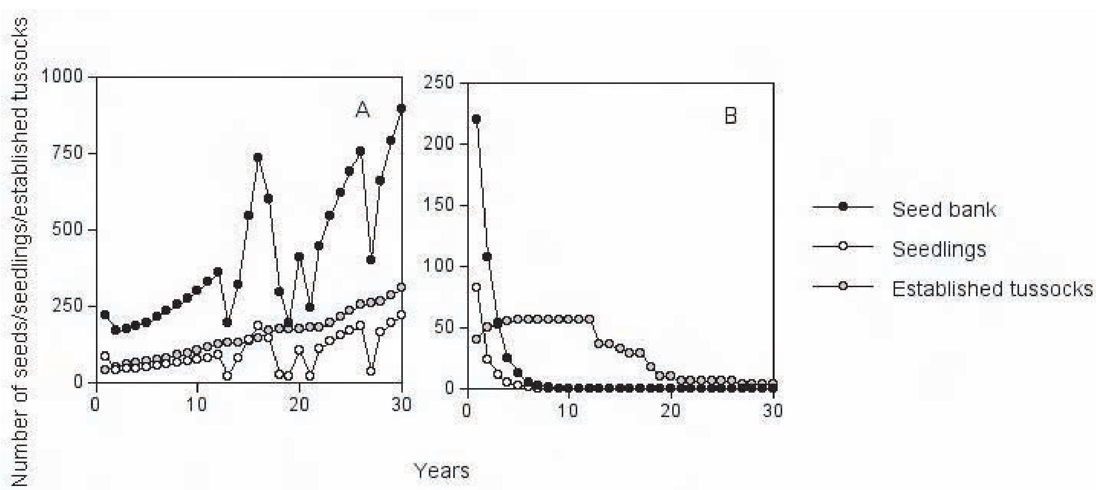

Figure 4. Herbicide treated *Agropyron cristatum* populations, including the number of seeds in the seedbank, seedlings, and tussocks in size class 1-4, decreased in both 2002 and 2003.

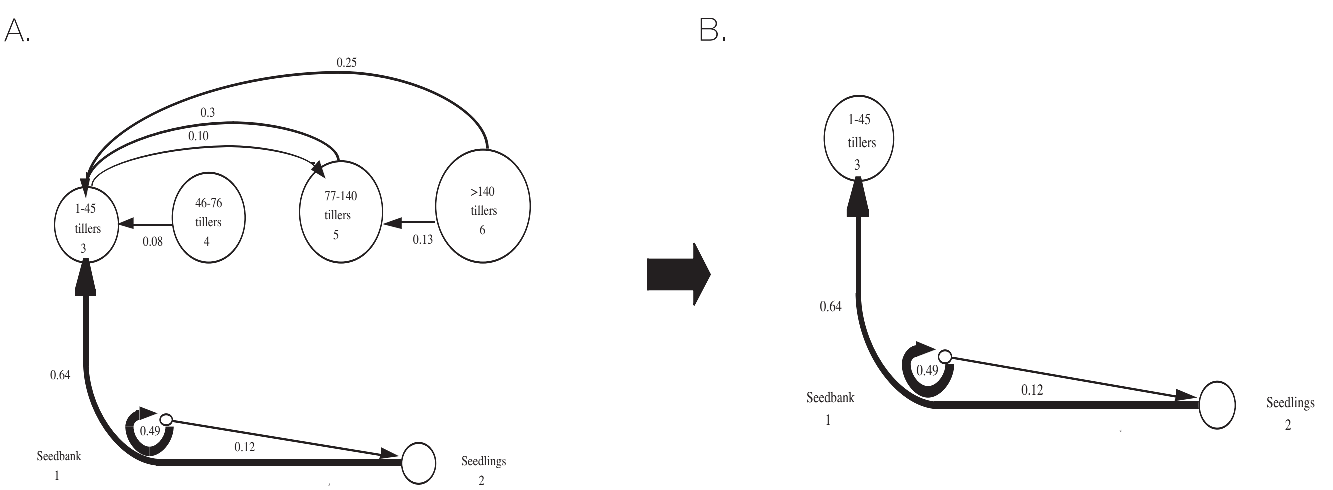

Figure 5. Herbicide-treated *Agropyron cristatum* populations produced no seeds and tussocks decreased in size in both 2002 (A) and 2003 (B).

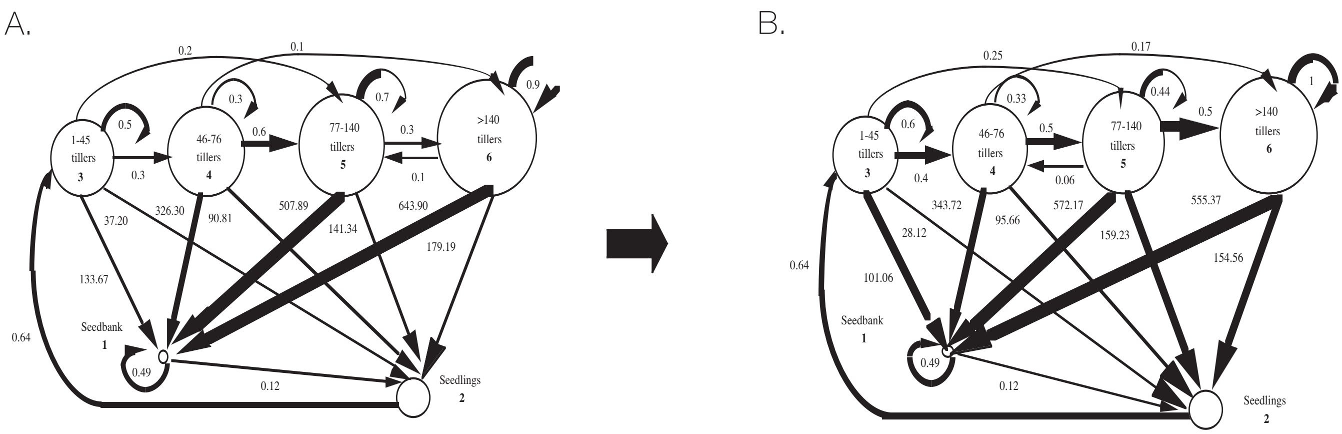

Figure 6. Untreated *Agropyron cristatum* populations produced a large amount of seed and tussocks increased in size in both 2002 (A) and 2003 (B).

RESULTS

Untreated populations of *A. cristatum* increased rapidly over 30 years when using data from either 2002 or 2003 (Figure 1; Table 1). Clipped *A. cristatum* populations increased over 30 years when using data from the first year, but decreased when using data from the second year (Figure 2; Table 1). Clipped tussocks produced few seeds in the fall when clipped in the spring in 2002 and produced no seeds in 2003 (Figure 3). Clipping had little effect on the tussock size in 2002, but tussocks decreased in size during 2003 (Figure 3). Herbicide-treated *A. cristatum* populations decreased over 30 years using data from either 2002 or 2003 (Figure 4; Table 1). Herbicide-treated tussocks decreased in both 2002 and 2003 (Figure 5).

DISCUSSION

Untreated populations of *A. cristatum* increased rapidly regardless of year, but the growth rate increased dramatically under wet conditions. The rapid increase was due to large seed production per tussock, high germination rate, and seedling survival (Figure 6), suggesting that seed removal should be the most effective method to control spread. Clipped tussocks produced seed in the first year only and decreased in size during 2003, but not in 2002 (Figure 3), suggesting that the effect of defoliation on seed production is cumulative. The fact that the first growing season received above the average amount of precipitation and that the second growing season received below the average amount may explain the difference in performance of clipped tussocks as well. Control of seed dispersal has widely been used as a method to manage invasive species (Solecki 1989; Turner et al. 1996; Sheppard et al. 2002). Defoliation has shown to be a successful long-term method to reduce growth and seed production of invasive species (Meyer and Schmid 1999; Bellingham and Coomes 2003), especially if the native vegetation is adapted to grazing (Brabec and Pysek 2000). The nature of spread and the large seed production of *A. cristatum* (Pyke 1990) suggest that defoliation and consumption of seeds through grazing is the most effective long-term method to control the spread of *A. cristatum* from planted fields and already-invaded prairie into native pristine prairie. The control of spread through grazing may be especially successful in dry years, but should be applied over the long term due to the persistent seed bank.

Herbicide-treated tussocks set few seeds and decreased in size both in 2002 and in 2003 (Figure 5). Due to their large seed bank (Marlette and Anderson 1986) and to their inconsistent response to herbicides among years (Wilson and Pärtel 2003), populations treated with herbicide may persist for many years. Herbicides applied to *A. cristatum* populations established in native prairie may also negatively affect native species. This suggests that herbicide treatment is unsuitable for control of *A. cristatum* spreading into native prairie, but that it may be useful in short-term suppression of monocultures while restoring planted fields with native species.

The results demonstrate a strong management effect on *A. cristatum* invading native prairie. The choice of management may, therefore, have profound effects on the future state of the native prairie in the Northern Great Plains.

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RE-ESTABLISHMENT OF A MIXED NATIVE GRASSLAND IN SOUTHWEST SASKATCHEWAN: POTENTIAL GRAZING IMPACTS

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Abstract: In the last 150 years, the prairie grassland ecosystem has been greatly reduced. The remaining native prairie resources are still threatened through continued expansion of disruptive human activity. These continual expansion pressures are increasing the likelihood that fragmentation of the remaining native land resource will persist and even increase. The recent introduction of the five-year Greencover program associated with the federal government's new Agriculture Policy Framework shows the renewed and increased recognition of the importance that native and perennial grasslands play in Canada (e.g., on the environment, biodiversity, and agricultural livestock and forage economy). Little research has been conducted on revegetation or re-establishment of agricultural land back to a more native prairie ecosystem in Saskatchewan. Recently, a study on re-establishing mixed native grassland in southwest Saskatchewan on previously annually cultivated land was initiated with funding support from a number of federal, provincial, industry, and conservation-minded organizations. Since the majority of the remaining native grassland in Saskatchewan occurs on range and pasture lands, any strategies to prevent further reduction of this land base or the ability to increase native range and pasture lands would be beneficial to preserving and improving our native prairie resource.

INTRODUCTION

In the last 150 years, large changes have occurred in the central grassland ecosystems due to agricultural expansion and urbanization. Currently, estimates indicate that the mixed- and short-grass prairies in North America have been reduced to 20 to 30% of their former extent. This is evident in Saskatchewan where an estimated 80% of the prairie has been lost, and in areas of prime cropland, where less than 2% of the original native prairie remains (Gauthier et al. 2003). The World Wildlife Fund listed North American prairie as one of the most endangered habitats in a recent assessment of natural habitats (World Wildlife Fund Canada 2003). Furthermore, there is an increased likelihood that fragmentation of the native habitat caused by urban development, oil and gas extraction, and agricultural practices will occur in the future. Since the majority of the remaining native grassland in Saskatchewan occurs on rangelands and pastures, any strategies to prevent further reduction of this land base or to increase native rangelands and pasture lands would be beneficial to preserving and improving our native prairie resource.

Ranching and livestock production has helped protect the prairie against fragmentation because ranchers need large blocks of land for their cattle (Gauthier et al. 2003). Since native prairie has evolved under such natural disturbances as fire, drought, and grazing, domestic livestock grazing appears to be a sustainable use of Northern Great Plain grasslands. Research studies (Milchunas et al. 1988; Lauenroth et al. 1994; Bai et al. 2001) have reported that proper grazing management by domestic livestock has minimal or no adverse effects on plant community or soil characteristics, and in some cases, grazing by ungulates may help with nutrient cycling and plant diversity. However, the potential effects and benefits of grazing by domestic cattle have not consistently been observed, perhaps due to differences in grazing intensity, evolutionary history of the site, and climatic regimes. Milchunas et al. (1990) concluded plant communities that have co-evolved with large native herbivores for thousands of years will more likely have a negative response to the removal of grazers rather than to grazing by domestic livestock as has been demonstrated for the short-grass steppe ecoregion.

The largest prairie ecoregion in Saskatchewan is the mixed grassland. The native vegetation in this ecoregion is often referred to as "short grasses" (blue grama grass and June grass) and "mid to tall grasses" (wheatgrasses, needle-and-thread, and porcupine grass), along with pasture sage and club moss. The balance between mid and short grasses varies with climate, soil, and grazing pressure. Over 50% of the remaining native grassland in Saskatchewan occurs in the mixed grassland ecoregion. About 31% of the land area is occupied by native grassland and 62% is cultivated. Large areas of the mixed grassland are uneconomical for crop production due to poor soils and dry environmental conditions. Thus, ranching and livestock production play a significant role in conserving and managing the prairie ecosystem and contributing to the rural and provincial economy (Saskatchewan PCAP 2003). As more cultivated cropland on the brown chernozem soil zone becomes economically marginal due to changing market conditions, the growing of forages (tame and native) for cattle grazing and forage production on such land becomes more attractive. Renewed and growing interest in native plant species in Canada over the last decade has resulted in a number of public, industry, and government (i.e., Saskatchewan Conservation Cover Program and the Federal Greencover Program) initiatives to preserve, maintain, and even increase the amount of land containing native plant species. In Saskatchewan, an estimated 110,000 ha (275,000 ac) of land will be converted to forages as a result of the Greencover Program. Although not all the acreages will be seeded to native, research and technical information will be needed on how to best establish and utilize the native forage/pasture resource. We may not be able to restore land back to the original biodiversity of the mixed prairie (i.e., containing several hundred species of grasses, forbs, and shrubs); however, a viable alternative may be seeding a few available native species mixtures that have good potential animal utilization and yet also provide improved ecological biodiversity and environmental benefits.

Tilman et al. (2001) found within plots located in Minnesota that biodiversity increased plant community productivity and provided greater adaptation to climatic variation. Diverse seed mixes with species maturing at different times throughout the growing season also have the potential to provide the nutritional quality desirable for livestock and wildlife maintenance and production over a greater portion of the growing season than a monoculture (Cook 1972; Wilson 1982; Jones and Wilson 1987).

Aside from the importance that native prairie grasslands play as a repository for biodiversity, as wildlife habitat, and as a grazing resource, the restoration and maintenance of native prairie grasslands can also provide an important opportunity to mitigate greenhouse gas concerns through carbon sequestration. Dormaar (1989) and Dormaar et al. (1995) found that the quality of soil organic matter (SOC) in native grasslands was superior to that occurring in soils under cultivation and under certain introduced grass species (e.g., crested wheatgrass). Soil organic carbon in rangeland soils may exceed all above-ground portions of a temperate forest, and this can be increased by returning previously cultivated land back into grasslands. In addition, higher SOC has been observed for rangeland under good grazing management versus under a non-grazing treatment, thus grazing management may offer a very practical option for increasing SOC (Janzen et al. 2000).

Little research has been conducted on agricultural land to re-establish a more native prairie ecosystem in Saskatchewan and to determine the land's carbon sequestration potential. In addition, large knowledge gaps exist on the production potential of seeded native species and carbon sequestration potential under various grazing intensities (none, low, and high). Many cattle producers have considered and are interested in the better use of existing native rangeland and the potential of re-seeding native species on land for summer, fall, and winter grazing options (Iwaasa et al. 2002; Jefferson et al. In press). Saskatchewan alone has about 5,000,000 hectares (12 ,500,000 acres) of native range, and it is anticipated that additional land will be seeded to native species. Because information is needed on the re-establishment of native species on agricultural land under grazing, a new research study was initiated at Agriculture and Agri-Food Canada's Semiarid Prairie Agricultural Research Centre (AAFC-SPARC) in 2001. This new multi-faceted study has been successful in developing a number of traditional and non-traditional partnerships that will evaluate the following objectives:

1. Evaluate the differences in animal performance and environmental benefit between two native seed mixtures (simple and diverse seed mixture);
2. Evaluate the impact of cattle grazing (low and high stocking rates), non-grazing (enclosures), and seed mixtures on native stand establishment and long-term plant community stability, plant/species (biological) diversity, forage production, and microbial and biochemical properties of the soil;
3. Evaluate the opportunities grazing management may provide to increase carbon sequestration potential of a perennial native pasture compared to annual/fallow crop rotation;
4. Develop a management plan that determines the costs and benefits of reintroducing a perennial native pasture back on land that has been annually cropped;
5. Evaluate the effect of optimum date of seeding, moisture levels, and seral adaptation of the native species on establishment characteristics; and
6. Evaluate the effect of different native vegetation and grazing treatments on diversity, abundance, and distribution of grasshoppers and beetles.

MATERIALS AND METHODS

Site Selection and Preparation

Thirty-four hectares (85 ac) of land that was cultivated since the 1920s was utilized in this study. The 34 ha of land was divided into 16 pastures, each about 2.1 ha in size. Soil classification was mostly Swinton orthic brown chernozems with some Haverhill soils occurring on the knolls and convexities near runways. Soil texture was largely silt loam for the Swinton soils and loam on the Haverhill soils. Swinton and Haverhill loams would be class three and four croplands, respectively. Prior to the start of the research study, the land was seeded into barley and harvested as green feed in July to minimize the presence of volunteer cereals in the planting year. Also prior to seeding the native species, the research land was sprayed with Roundup Renew in the fall (September 2000, 2.5 L/ha) and spring (May 2001, 3.75 L/ha) for perennial and annual weed control.

Large Pasture Seeding

Eight pastures were randomly seeded to either a simple or complex native seed mixture using a Bourgault air seeder. The simple seed mix consisted of 6 cool-season grasses and 1 forb species, while the complex seed mix contained 11 grass species (cool- and warm-season), 1 forb, and 2 shrubs (Table 1). Seeding was done into

Table 1. Species contained in simple and complex native seed mixtures. All scientific names are as per Looman and Best (1987).

Mixture	Common name	Scientific name
Simple	Western wheatgrass	*Pascopyrum smithii*
	Northern wheatgrass	*Elymus lanceolatus*
	Green needlegrass	*Stipa viridula*
	Awned wheatgrass	*Elymus subsecundum*
	June grass	*Koeleria gracilis*
	Slender wheatgrass	*Elymus trachycaulum*
	Purple prairie clover	*Petalostemum purpureum*
Complex	Western wheatgrass	*Pascopyrum smithii*
	Northern wheatgrass	*Elymus lanceolatus*
	Green needlegrass	*Stipa viridula*
	Canada wildrye	*Elymus canadensis*
	Little bluestem	*Andropogon scoparius*
	Needle-and-thread	*Stipa comata*
	June grass	*Koeleria gracilis*
	Blue grama	*Bouteloua gracilis*
	Prairie sandreed	*Calamovilfa longifolia*
	Purple prairie clover	*Petalostemum purpureum*
	Slender wheatgrass	*Elymus trachycaulum*
	Nuttallii saltbush	*Atriplex nuttalii*
	Winterfat	*Eurotia lanata*

the weed-free standing stubble. This technique can be especially valuable in drier areas where the snow-catch in the stubble can improve surface moisture condition and assist seed germination. The seeding rate for the simple mixture was 9.5 kg/ha (25 pure live seeds (PLS) per 0.30 m^2) using a 22.5 cm row spacing and seeding depth of about 6.2 mm. To facilitate the seeding, 18 kg/ha of 11-51-00 fertilizer was used as a seed carrier to prevent seed bridging. The complex seeding mixture rate was 9 kg/ha (33 PLS per 0.30 m^2) using the same row spacing and seeding depth and approximately 34 kg/ha of 11-51-00 fertilizer. Further weed control (e.g., flixweed) on the 16 pastures was required in July and 1 L/ha of Buctril M was applied and provided effective weed control with no apparent damage to the native seedlings. Some of the pastures also had wild oat weed concerns, and these pastures were mowed and green material hauled away to reduce plant competition and prevent the wild oats from forming seed heads. Due to high grasshopper infestation, Decis insecticide was aerially applied at a rate of 0.15 L/ha. Two shrubs, winterfat and saltbush, were seeded in November using a hand-held broadcaster at a rate of 11.75 PLS per m^2 onto the complex seeded pastures.

Grazing and Forage Sampling

Pasture treatments consisted of a 2 x 2 factorial design with four replications: two pasture mixes (simple and complex) and two grazing utilization levels (low at 40-50% utilization and high at 60-75% utlization). The planned stocking rate for the low utilization was 4 steers per pasture (1.4 AU/ha) and the high was 8 steers per pasture (2.7 AU/ha). The higher stocking rate was reduced to 6 steers per pasture (2.0 AU/ha) in 2002 due to the initial drought conditions. In 2002 and 2003, 8 pastures contained either 6 or 8 steers each (total 48 or 64 steers), with 4 pastures grazed at the low and the other 4 pastures grazed at the high utilization level. Similarly, the remaining 8 pastures each contained 4 steers (total 32 steers) and were also randomly allocated to the 2 different grazing utilization levels. Each steer group was blocked according to body weight, and therefore average body weights for all groups were similar.

Before the grazing season started, 4 movable pasture cages, each 0.9 x 1.5 m in size, were randomly distributed on each pasture to be used to measure peak pasture forage yields for the season (Cook and Stubbendieck 1986). Forage yields were taken in July, August, and again in September, because the pasture sward consisted mostly of cool-season grasses with various proportions of other species (i.e., warm-season grasses and a forb). In addition to the 4 pasture cages that were moved each grazing season, each pasture also contained a permanent grazing enclosure (3.6 x 3.6 m) located near the middle of the pasture. This larger exclosure totally excluded cattle grazing and represented a non-grazing treatment. Estimations of available yields were determined using a procedure from Cook and Stubbendieck (1986) in which representative 1 m^2 quadrat samples were taken near each of the four pasture cages. Native and weed plant material were separated for each sample, and dry matter (DM) production and forage quality analyses were conducted. All steers were weighed after a 12 h shrink prior to being placed on pasture. Weigh periods (every 3-4 weeks) occurred after first grazing and throughout the study in which the steers were weighed and a 5% shrink (based on previous research experiences) was used. Once the pasture utilization level for each pasture was achieved based on visual estimation, the steers were removed from the pasture and weighed after a 12 h shrink. Residual pasture yields for each previously grazed pasture were determined using a 1 m^2 quadrat to accurately determine pasture utilization (Cook and Stubbendieck 1986). Eight samples were taken near each of the four pasture cages, and native and weed plant materials were separated and DM production and forage quality analyses were conducted for each sample.

Large Pasture Species Composition

Plant species composition for each of the 16 pastures was evaluated in the period from September to the beginning of October. Species compositions were estimated using a 0.25 m^2 quadrat at 10 sites per pasture. Percent canopy and basal cover for each species were determined using a procedure from Cook and Stubbendieck (1986) in which measurements were assessed in each quadrat. Within 3 m of each percent canopy measurement, another 0.25 m^2 quadrat was used and plant material clippings were taken. Plant material within this quadrat was harvested to a height of 2.5 cm from the ground. Native and weed plant material were separated, dried, and composited (10 samples). Forage quality analyses were determined for weed and native forage samples.

Forage Analyses

Forage quality analyses were performed on all pasture samples (i.e., available yields and species compositions, etc.). All forage material was dried in a forced air oven for 48 h. Samples were ground through a 1 mm screen Wiley mill grinder. Percent organic matter (OM), organic matter digestibility (OMD), crude protein (CP), neutral detergent fibre (NDF), acid detergent fibre (ADF), and minerals (N and P) were determined using Standard Operating Procedures Forage Laboratory (2001).

RESULTS AND DISCUSSION

Assessment of Seeding Success

The drought of 2001 and the very cool and dry spring of 2002 renewed concerns of another drought forecast. By midsummer, however abundant moisture was received far above normal long-term averages. Based on the results from the density or plant count measurements, plant counts among the 16 pastures ranged from 3.1 to 7.4 plants per 0.3 m^2 (overall mean = 5.2 plants per 0.3 m^2). Successful stand establishment (4 to 5 plants per 0.3 m^2; Wark et al. 1995) was achieved in 12 out of the 16 pastures. The remaining 4 pastures had plant counts greater than 3 plants per 0.3 m^2, which was considered quite acceptable but required re-evaluation the following year. Results from this study showed that a Bourgault air seeder can be successfully used to seed a diverse mixture of native grass species into standing stubble; however, careful monitoring of the seeding is needed to ensure a uniform flow of seed and prevent seed bridging problems which can result in skips and seeding misses. This may have occurred in Pasture 7, in which half of the pasture was not seeded while the other half had successful stand establishment. Successful native stand establishment was also facilitated by good pre- and post-planting weed control. Of the 14 grass, forb, and shrub species seeded, only 2 species (June grass and saltbush) were not observed in the pastures. Wheatgrasses, green needlegrass (GNG), needle-and-thread grass (NTG), blue grama (BG), little bluestem (LBS), and purple prairie clover (PPC) were commonly observed. In contrast to previous research conducted at AAFC-SPARC, successful establishment of warm-season grasses was not a problem. The absence of June grass seedlings in the pastures was possibly due to its low pure live seed percentage (65%). However, both GNG (59%) and LBS (44%) had lower PLS values and yet were commonly observed throughout the large pastures. June grass produces high volume of seed, but the seed can have low viability (Looman 1978) and germination (Tannas, pers. comm.). The observed poor germination of saltbush may also be due to its low PLS value (46%) and seed dormancy.

Large Pastures Species Composition

In 2002, the differences observed in species composition were the result of inclusion of a particular species

Table 2. Mean species composition, top of canopy, basal, and bare ground of grazed areas and enclosures. All values are calculated from transect sampling using a 0.25 m^2 quadrat (24 September to 8 October 2002) and are expressed as percent of space examined.

Site	Species/item[1]											
	WWG	NWG	AWG	LBS	PPC	PSR	SWG	GNG	NTG	CWR	BG	JG	WF
Grazed	5.3	8.9	5.7	1.0	<0.1	0.2	7.2	0.4	0.6	0.1	1.3	<0.01	0.0
Enclosure	2.7	31.3	7.5	0.7	0.1	0.0	3.1	0.0	0.6	0.0	1.3	0.0	0.0
	WOT	TPW	PPW	BWW	TLS	BYG	RPW	FOX	TG	KW	FB	FW	RT
Grazed	0.3	1.2	0.0	2.5	8.5	6.5	0.3	0.7	0.4	0.3	1.3	1.5	1.9
Enclosure	0.6	2.0	0.0	2.5	9.0	1.0	0.1	0.1	0.0	0.0	0.0	2.5	2.0
	K	ST	LQ	ALF	MBRO	OTH							
Grazed	2.9	1.5	0.1	8.5	1.1	0.4							
Enclosure	3.8	1.5	0.0	5.4	1.9	1.9							
	CANOPY	BASAL	BARE GRND	TRASH	LITTER								
Grazed	60.1	8.1	6.6	2.5	1.5								
Enclosure	73.1	6.3	8.1	2.8	1.6								

[1]WWG = western wheatgrass, NWG =northern wheatgrass, AWG = awned wheatgrass, LBS = little bluestem, PPC = purple prairie clover, PSR = prairie sandreed, SWG = slender wheatgrass, GNG = green needle grass, NTG = needle-and-thread grass, CWR = Canadian wildrye, BG = blue grama, JG = June grass, WF = winterfat, WOT = wild oats, TPW = tumble pigweed, PPW = prostrate pigweed, BWW = biennial wormwood, TLS = thyme leaved spurge, BYG = barnyard grass, RPW = red root pigweed, FOX = green foxtail, TG = tumble grass, KW = knotweed, FB = foxtail barley, FW = flixweed, RT = Russian thistle, K = kochia, ST = sow thistle, LQ = lambs quarter, ALF = alfalfa, OTH = other, MBRO = meadow bromegrass.

in a seed mix. At this early date, differences already occurred between the grazed and ungrazed portions (Table 2). Species that increased within the enclosures included northern wheatgrass (NWG), PPC, awned wheatgrass (AWG), and flixweed. Northern wheatgrass was the dominant species for the enclosures. Species that decreased within the enclosures included western wheatgrass (WWG), prairie sand reed (PSR), slender wheatgrass (SWG), GNG, barnyard grass, and alfalfa. The reduction in these species may be due to sensitivity to light reduction, as weather data indicate water should have been non-limiting for most of the growing season. If this continues, diversity within the enclosures will decrease. The canopy within the enclosures was also more closed with a difference of 13% from the grazed portions of the pastures. The weed component (Table 3) appeared evenly distributed between the two stocking densities. Seeded grasses and legumes contributed more to the cover in high stocking density pastures, while the grasses were found more in the low stocking density pastures, perhaps due to decrease competition for the light resource. There was an undesirable and statistically significant increase in sow thistle under the heavier stocking density (2% vs. 1%), and this will have to be monitored. Unfortunately, the 2003 species composition data for the large pastures are still being analyzed and are not yet available.

Table 3. Species composition totals for grassy weeds, weedy forbs, grass, shrubs, and legumes as a function of stocking rate. Species groups were calculated from transect sampling using a 0.25 m^2 quadrat (24 September to 8 October 2002), and all values are expressed as % of space examined. None of the values are statistically different at the 0.05 level as determined by the Tukey's test.

Group	Low stocking density	High stocking density
Grassy weeds	11.8	8.6
Weedy forbs	24.8	28.5
Grass	29.7	31.6
Legumes	0.01	0.03
Bare ground	33.7	31.3

Forage Production and Quality

Mean available pasture production results (kg/ha) for the 2002 (beginning of July) and 2003 (end of June) seasons are shown in Figure 1. Higher forage biomass production was expected with the highly productive wheatgrasses that made up a greater proportion of the simple seed mixes compared to the complex mixes. However, forage production differences between the simple and complex seed mix after four years may be reduced as forage production from certain wheatgrasses declines (i.e., slender and awned wheatgrasses; Tannas, pers. comm.).

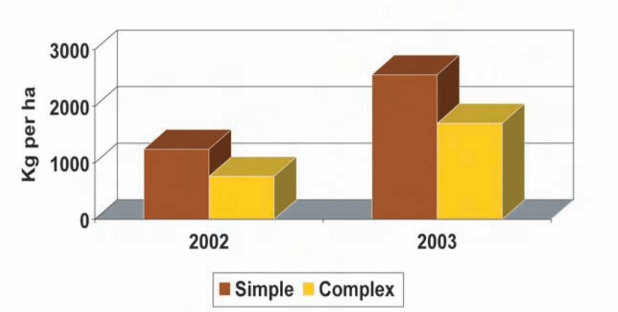

Figure 1. Pasture dry matter production in kg/ha.

The mean available pasture production of the simple seed mix was consistently higher ($p<0.05$) than the complex seed mix for the July and August 2002 sampling period (Table 4). For the September sampling period, the available pasture production for the simple seed mix also was numerically higher than the complex mix. Again, higher biomass for the simple mixture was expected since the wheatgrass species made up a higher proportion of the simple seed mixture (61%) compared to the complex seed mixture (30%). The wheatgrasses contained in the simple mix are cool-season, aggressive, and high producing, with most of their above-ground production occurring in July. About 30% of the complex seed mixture consisted of a warm-season forb (PPC) and several grasses (i.e., BG and LBS). Much of the forage production associated with warm-season species occurs in late summer and early fall and may explain the additional forage production observed during August and September.

Forage quality measurements (OMD%, NDF%, and ADF%) are only available for samples collected in 2002 since the 2003 forage samples are still being analyzed. The 2002 forage quality measurements were similar between the two mixtures for the July and August sampling periods (Table 4). Abouguendia (1988) also reported similar OMD, NDF, and ADF values between cool- and warm-season grasses at similar seasons of growth. Crude protein values were lower than expected for the two seeding mixtures for all three sampling months and lower than previously reported. Abouguendia (1998) reported mean CP values for cool- and warm-season grasses from July to September ranging from 8.7 to 7.2% and 8.6 to 6.6%, respectively. Clarke and Tisdale (1945) also reported higher CP values for similar grass species and stages of maturities. High precipitation in 2002 should have increased plant growth resulting in increased fibre for structural purposes; however, increased fibre can lead to a dilution effect for crude protein (Wilson 1982; Jones and Wilson 1987). The climatic conditions under which samples were collected by the aforementioned authors are unknown, though sampling procedure, site, and environmental differences among the research studies may provide a possible explanation. Warm-season forages start growing later in the season than the cool season forages and therefore provide new vegetative growth and less mature forage

Table 4. Mean forage production and quality measurements for simple and complex seed mixtures harvested throughout the growing season from July to September in 2002. Values with different letters within the same growing season are statistically different at the 0.05 level.

	Forage production and quality values[1]				
Season of Growth and Seed Mixture	Available Forage Yield (kg/ha)	OMD (%)	CP (%)	NDF (%)	ADF (%)
July					
simple	1240[b]	50.2	7.4	63	36.4
complex	757[a]	51.0	7.9	62.9	37.1
August					
simple	2558[b]	44.3	4.1[a]	66.8	41.8
complex	1697[a]	45.8	4.9[b]	65.4	40.5
September					
simple	2488	36.6[a]	3.8[a]	NA	NA
complex	1885	39.6[b]	4.8[b]	NA	NA

[1]OMD = organic matter digestibility; CP = crude protein; NDF = neutral detergent fibre; ADF = acid detergent fibre; and NA = results not available.

material. As a result, OMD and CP values were higher ($p<0.05$) and the fibre contents were numerically lower for the complex compared to the simple seed mixture for samples collected in August and September (Table 4). Preliminary results from this study showed that a mixture of desirable grass and forb species (i.e., cool and warm species) can improve the nutritional composition of the forage and extend the grazing season.

Yearling Steer Grazing Performance

Steer average daily gains (kg/d) for the 2002 and 2003 grazing seasons are listed in Figure 2. The overall mean average daily gain (ADG) values ranged from 0.54 to 0.73 kg/d, which is comparable to the 0.7 to 1.14 kg/d achieved on dryland tame pastures (Hand 1996). The animal performance in 2003 was considerably less than in 2002, and this can be attributed to environmental conditions observed during July and August. The July and August temperatures were the third warmest and precipitations were the third lowest over a 118-year period. This definitely influenced forage growth and quality and, as expected, animal gains. However, steer performances (Figure 2) on the complex seed mixture in both 2002 and 2003 were consistently higher than the simple mixture, and this was probably due to the better nutritional composition of the warm-season grasses that become available during the midsummer period. In agreement, several studies have concluded that the incorporation of warm-season grasses into a pasture system can improve animal performance during the summer months compared with grazing only a cool-season pasture (Hall et al. 1982; Jackson 1999).

Only the grazing data from 2002 have been analyzed statistically at this time, and there were no significant ($p>0.10$) interactions for any of the grazing production values. Therefore, only the main effects on seeding mixture and pasture utilization are reported. Average daily gain

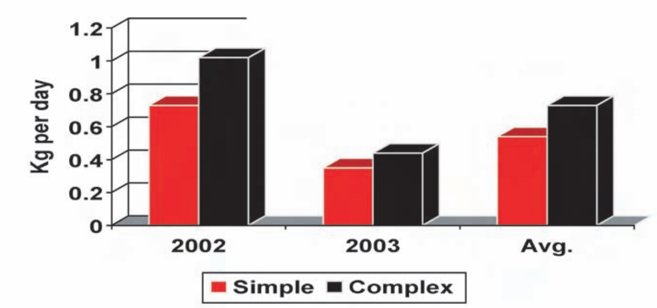

Figure 2. Average daily gain in kg/d of yearling grazing cattle.

values did not differ statistically ($p>0.10$) between seed mixtures. The ADG values for the simple and complex seed mixtures were 0.73 and 1.02 kg/ha, respectively. Different pasture utilization levels did not affect ADG, but higher ($p<0.05$) grazing days were observed for the low versus the high pasture utilization. The ADG values for the low and high pasture utilization were 0.75 and 1.0 kg/ha, respectively. Actual mean pasture utilization levels for the low and high utilizations were 44.3% and 66%, respectively, and these utilization values were within the desired target range for both low (40 to 50%) and high (60 to 75%) levels.

CONCLUSION

Effective pre- and post-plant weed control provided adequate weed suppression to promote successful native grass stand establishment. The simple seed mixture consistently had higher biomass production compared to the complex mix. However, forage quality was either similar or better for the complex mixture compared to the simple mix. Differences in biomass production between the two native mixtures will likely lessen as short-lived species in the simple mix decline and later seral species in the complex mix increase. Average daily gains observed over 2002 to 2003 were comparable to those achieved on dryland tame pastures and mean values ranged from 0.54 to 0.73 kg/d. Preliminary results from this study showed the benefit of a diverse pasture mix over a simpler seed mix. In 2002, the diverse seed mix had similar or better pasture nutritional composition longer into the grazing season. Species composition within the large pasture studies indicates the potential onset of a loss of diversity. Biomass production within pastures seeded to the simple mix had a greater grass component. Increasing the stocking density appears to have decreased the weed portion of the biomass production.

ACKNOWLEDGEMENTS

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POSTER ABSTRACTS

POTENTIAL CORE AREAS FOR LARGE SCALE CONSERVATION IN THE NORTHERN GREAT PLAINS

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Abstract: Successful restoration of the species, landscapes, and processes present in the Northern Great Plains when Lewis and Clark crossed the region will require conservation work at scales that are seldom contemplated. Such restoration will depend on significant involvement of local human communities. These communities will require social and economic benefits for their efforts. The Northern Plains Conservation Network's ecoregional assessment outlines a future for this region that integrates conservation with the renewal of human communities and economies. Our ecoregional assessment identifies ten terrestrial landscapes, containing some of the largest blocks of untilled prairie in North America. Within these landscapes, outstanding opportunities exist to restore large-scale ecological processes and provide habitat for significant populations of native wildlife and a suite of endangered, sensitive, and keystone species. Our analysis also identifies 23 outstanding reaches of Northern Great Plains rivers and streams. Some of the longest reaches of undammed rivers in North America exist here, providing opportunities to conserve habitat for fish, other aquatic species, and riparian species. Restoration of these landscapes must incorporate socio-economic aspirations of local people. Working cooperatively, restoration can support socio-economic benefits, including public access to lands with abundant wildlife. This will require sound stewardship of lands across ownership boundaries, respect for the cultural and spiritual beliefs of First Nations/Native Americans and others, and local/regional/national partnerships. We can start to implement this vision as follows:

- expand the amount of land managed for conservation from the current 1.5%;
- promote ecologically sustainable management that prevents further loss of native prairie, limits spread of weeds and pests, and adopts grazing practices that restore and maintain habitat and species diversity;
- restore populations of native species, including bison; and
- ensure that river flows support all aquatic and riparian species.

MONITORING MAMMALS, BIRDS, AMPHIBIANS, FISH, PLANTS, MOSSES, LICHENS, HABITATS, AND LANDSCAPES: THE ABMP, A BROAD-SCALE LONG-TERM MULTI-TAXA BIODIVERSITY MONITORING PROGRAM FOR ALBERTA

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Harry Stelfox
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Abstract: To minimize the risks of biodiversity loss associated with human development and to meet provincial, national, and international commitments about biodiversity, the government, industries, and academia in Alberta have jointly developed the Alberta Biodiversity Monitoring Program (ABMP). This program will be capable of detecting broad regional changes in biodiversity over time as they relate to changes in human land use. The ABMP is based on a systematic grid of approximately 1,650 sites spaced 20 km apart throughout Alberta. Field sampling protocols for terrestrial biota (trees, shrubs, herbs, grasses, mosses, lichens, arthropods, birds, and mammals) and aquatic biota (benthic algae, benthic invertebrates, phytoplankton, zooplankton, amphibians, and fish) were developed between 1998 and 2001 and peer reviewed by national and international experts. Remote sensing and computer interpretation protocols are presently being developed to identify vegetation polygons, landscape patterns, and human disturbances at multiple spatial scales. Prototype testing for the ABMP began in 2003 and will continue for the next three years. Based on results from the prototype, adjustments will be made to the field and remote sensing protocols to make these more effective and to increase cost efficiency for the ABMP. Data from the prototype will be used to estimate components of variance (within site variance, between site variance, and between year variance) for selected species, species groups, and habitats and to evaluate whether the ABMP has the statistical power to detect a 3% change per year after a 10-year period. In addition, data from the prototype will be used to develop reporting mechanisms, products, and services that are needed by land and resource managers. Finally, a web-based system to store, manage, manipulate, and disseminate the data collected during the ABMP will be developed. Implementation of the ABMP is anticipated for 2007.

STAKEHOLDER INVOLVEMENT IN CONSERVATION OF SPECIES AT RISK: ALBERTA'S ENDANGERED SPECIES CONSERVATION COMMITTEE

Robin Gutsell
Alberta Sustainable Resource Development

Abstract: Alberta's Minister responsible for wildlife created a committee in 1998 to advise him on matters related to the identification, conservation, and recovery of species at risk in Alberta. The Endangered Species Conservation Committee is composed of a variety of stakeholders, broadly representing a cross-section of the interests of Albertans. The committee and its scientific arm, the Scientific Subcommittee, have since evaluated and made recommendations on the status of over 40 species. Despite occasionally disparate perspectives, the committee successfully brings its varied interests together to create a "balance of bias", aimed toward the common goal of conserving Alberta's species at risk. Alberta's species recovery process similarly integrates stakeholder input. In this way, those interested in or affected by the management of at-risk species have an opportunity for input, leading to realistic and workable solutions that benefit species at risk.

CONSERVING PRIORITY LANDBIRDS IN THE GRASSLAND AND ASPEN PARKLAND: THE PRAIRIE PARTNERS IN FLIGHT PLAN

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Canadian Wildlife Service, Prairie and Northern Region

Abstract: To address both local and global long-term population declines in landbird species found across the grassland and aspen parkland regions of Manitoba, Saskatchewan, and Alberta, Prairie Partners in Flight is completing a Landbird Conservation Plan for the Prairie Pothole Region. Members of the regional working group used a standardized assessment process that incorporates population trends, distributions, threats, relative abundance, and local stewardship responsibility to identify 25 landbird species most in need of conservation attention. Although some priority species are associated with wetland or woodland habitats on the prairies, such as Nelson's sharp-tailed sparrow or long-eared owl, most species use some component of grassland habitat. This emphasizes the importance of good management of both native and tame grassland and conservation of landbird habitat values. The plan synthesizes our current knowledge about the ecology of these priority species, their distributions, habitat requirements, and response to management activities, and outlines knowledge gaps or related research questions which should be addressed to better monitor and manage landbird species and habitats. Ecologically based population objectives have been established for each priority species. Finally, the plan suggests six recommended strategies to help achieve these objectives and ultimately the conservation of our prairie landbird resource.

THE NORTHERN PRAIRIE AND PARKLAND WATERBIRD CONSERVATION PLAN

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Canadian Wildlife Service

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Abstract: The Northern Prairie and Parkland Region (NP&PR) contains millions of wetland basins that harbor large proportions of many North American waterbird populations. However, knowledge of waterbirds in the NP&PR is limited, and there has been little previous direction for waterbird conservation planning or management. Canadian and U.S. partners developed the NP&P Waterbird Conservation Plan under the auspices of the North American Waterbird Conservation Plan to provide an overview of the status and current knowledge of waterbirds and waterbird habitat in the Region and to outline strategies and priorities for monitoring, research, and management. The plan recognizes the loss and degradation of wetlands and surrounding upland habitat, primarily due to agriculture, as the highest priority conservation issue affecting waterbirds. Thirty-nine breeding and one migrant species are the focus of the plan. The least tern and whooping crane are listed as endangered species in the NP&PR, and the plan identifies western grebe, Franklin's gull, black tern, horned grebe, American bittern, yellow rail, and king rail as species of high concern. The plan recognizes that a landscape approach is needed to help integrate conservation planning for waterbirds with that of other species. Key recommendations include the following:

- initiation of standardized, region-wide surveys for colonial and non-colonial species;
- development of estimates of distribution, abundance, and population trends;
- development understanding of waterbird habitat requirements at local and landscape levels;
- development of NP&PR-wide spatially-explicit habitat models for waterbirds;
- completion of NP&PR-wide wetland inventory;
- completion of NP&PR-wide upland habitat inventory; and
- development of a standardized, accessible database for population survey data.

Plan implementation will induce waterbird conservation in the Northern Prairie & Parkland Region.

ALBERTA PLANTWATCH – A BUDDING PROGRAM

Elisabeth Beaubien and Krista Kegume
Alberta Plantwatch

Abstract: Flowers that bloom in response to heat can help researchers monitor the effects of climate change, and Albertans have been recording bloom times since 1973. Alberta Plantwatch is a coordinated program, based at the University of Alberta Devonian Botanic Garden, to track 21 indicator plant species as they bloom each spring. Participants include teachers, ranchers, junior forest wardens, naturalists, and backyard gardeners. Observers record bloom dates in their area and then report them by mail or over the internet. Data collected within a large geographical area and over decades can help researchers detect environmental changes over time. Phenological data on the timing of life cycle events has many benefits. For example, it can be used in wildlife management to predict deer populations because fawn success is dependent on an early spring; in farming to decide when to plant, fertilize, harvest, or control for pests; and in tourism to determine the best time to fly fish, observe mountain wildlife, or photograph wildflowers. Plantwatch is a unique way for participants to learn about the biodiversity in their area. One observer commented, "I've lived on this ranch for 30 years and just discovered early blue violets!" Another said, "Thank you for the opportunity to be useful while having fun!"

TESTING THE EFFICACY OF SCENT DETECTION DOGS FOR DETERMINING THE PRESENCE OF BLACK-FOOTED FERRETS AT A REINTRODUCTION SITE IN SOUTH DAKOTA

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South Dakota State University

Alice Whitelaw and Aimee Hurt
Working Dogs for Conservation

Kenneth Higgins
US Geological Survey

John Shivik
USDA Wildlife Services, National Wildlife Research Center, and Utah State University

Abstract: As one of North America's most endangered mammals, the black-footed ferret recovery has significantly progressed since their rediscovery in 1981. There are currently eight reintroduced populations spanning from Montana to Mexico and coinciding with the range of prairie dogs. Although each reintroduction site shares the commonality of prairie dogs, each site also has unique habitat characteristics that can make monitoring these populations difficult. Spotlighting from vehicles is the most widely used method to monitor these populations to date; however, high vegetation, rough topography, and large expanses of area to cover (some 5,000 ha) make efforts costly and time consuming. In a pilot study, we tested the efficacy of scent dogs to detect black-footed ferret scat and found that four dogs correctly identified 83% of plots as containing ferret scat. We are currently examining the use of dogs to detect ferret presence at the Conata Basin reintroduction site in southwestern South Dakota. Two of the dogs used in the pilot study will be searching eleven prairie dog towns, seven of which have resident ferrets inhabiting them, and four that have no record of ferret presence. Spotlight searches will be conducted during the same time frame as the dog searches to provide baseline data from which to compare the accuracy of the dogs.

PIPING PLOVER POPULATION CHANGES IN SASKATCHEWAN

Lori Dunlop
Nature Saskatchewan

Abstract: The 2001 International Piping Plover Census in Saskatchewan took place June 1-20, 2001. This was the third census of its kind, and it occurs every five years to monitor the population trend of this endangered species. A total of 805 adults were counted in Saskatchewan in 2001, a 40.3% decrease from 1996 (1,348 birds) and a 31.3% decrease from 1991 (1,172 birds). Overall, a total of 5,938 birds were counted across North America in 2001. This represents a 0.4% increase from the 1996 total of 5,913 and a 7.6% increase from the 1991 total of 5,488 birds. The number of piping plovers in Saskatchewan accounted for 27.1% of the total number of plovers across the Great Plains (2,966 birds), down from 41.1% of the 1996 total (3,284 birds) and 33.8% of the 1991 total (3,469 birds). Excellent habitat conditions in portions of the American Northern Great Plains likely contributed to birds stopping and not continuing into the Canadian prairies.

Saskatchewan is one of the last strongholds of the piping plover in the Great Plains. Endangered species are often an indication that an ecosystem is in trouble. The piping plover was the primary target species of this census; however, other species also inhabit shorelines. Many prairie and arctic nesting shorebirds and waterfowl, as well as arthropods and other riparian species, are affected by human encroachment on shorelines and are currently or may soon be in decline. By enhancing these areas for piping plovers, other species that rely on these habitats should benefit as well.

PRAIRIE GRASSLANDS AS POST-BREEDING HABITAT FOR PRAIRIE FALCONS FROM IDAHO

Karen Steenhof, Mark R. Fuller, Michael N. Kochert, and Kirk K. Bates
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Abstract: Satellite telemetry data suggest that the Northern Great Plains is an important post-breeding area for prairie falcons that nest in the Snake River Birds of Prey National Conservation Area (NCA) in southwest Idaho. Of 33 female prairie falcons who survived the nesting season in the NCA with working radios, 27 (82%) moved directly to summering areas in the Northern Great Plains (Montana, Saskatchewan, the Dakotas, and Alberta). Southwest Saskatchewan, southeast Alberta, and eastern Montana seem to be especially important use areas. Most of the areas that prairie falcons used from July through October are privately owned grassland or cropland habitats. Conservation of the Snake River's prairie falcons must be an international venture that requires cooperation of agencies from both the US and Canada. In addition, successful management of prairie falcon habitat on a range-wide scale must involve private landowners as well as state, provincial, and federal agencies. Programs to preserve and maintain grassland habitats on private lands throughout western North America may be crucial in safeguarding prairie falcon habitat in years to come.

HABITAT ANALYSIS FOR ORD'S KANGAROO RAT *(DIPODOMYS ORDII)* IN THE MIDDLE SAND HILLS OF ALBERTA

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Abstract: Ord's kangaroo rat *(Dipodomys ordii)* is currently listed as an Endangered species within the Province of Alberta. Although their presence is well documented within Alberta, some uncertainty remains regarding their distribution throughout the southeastern portion of the province. Knowledge of species distribution is essential for creating and implementing successful conservation management plans. We used satellite imagery and a geographic information system (GIS) to accurately and efficiently model kangaroo rat habitat within southeastern Alberta. The model was designed using presence data collected from June 2000 to May 2001 in the CFB Suffield National Wildlife Area and adjacent areas. We related the presence data to GIS habitat layers to create a resource selection function model that describes the probability of use of an area by the species. The input habitat variables consisted of various GIS layers depicting exposed dunes and other sandy areas, roads, topography (i.e., slope and aspect), plus measures of vegetation reflectance derived from multispectral satellite imagery (i.e., greenness and wetness). We estimated the resource selection function using logistic regression and the Akaike Information Criteria (AIC) selection method. The AIC provided the means to select the best logistic model to explain the presence data, while the use of logistic regression provided the function coefficients that were used to estimate resource use by kangaroo rats within the study area. We then validated the model using a subset of the presence data that were not used to develop the resource selection function. After verifying the reliability of the model, we applied it within the entire known range of kangaroo rats in Alberta to predict the relative abundance of the species. A product of this work is a map of the predicted distribution of kangaroo rats across their range in Alberta.

OBSERVATIONS ON THE DISTRIBUTION, ABUNDANCE, AND ECOLOGY OF THE NORTHERN SCORPION *(PARUROCTONUS BOREUS)* IN SOUTHERN ALBERTA, 1983-2003

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Abstract: The northern scorpion (*Paruroctonus boreus*; Class Arachnida, Order Scorpiones, Family Vaejovidae) is found in 12 US states, from the Mexican border to southwestern Canada, and is the only species of true scorpion found in Canada. In southern Alberta, this species occurs in the valleys of the Oldman, St. Mary's, Milk, and South Saskatchewan Rivers, though specimens have been recorded from as far north as the Red Deer River (1974; G. Hilchie, pers. comm.). In addition, this species has been collected in the southern Okanagan Valley of British Columbia (R. Cannings, pers. comm.) and southwestern Saskatchewan near the Alberta border (Estuary and Leader area; K. Roney, pers. comm.). Populations near Medicine Hat and Milk River are usually the most numerous and active (pers. obs.; S. Schultz, pers. comm.). *P. boreus* is known to be cold-hardy over its range in Canada and at high elevations in the US. In southern Alberta, individuals are usually found in open, dry, eroded riverbank slopes (usually not north-facing), where they inhabit rock fissures in sandstone or shale or in spaces under surface stones. *P. boreus* individually confined in containers in the field or lab readily consume immature grasshoppers, crickets, ground spiders, and Lepidoptera (immature and adult).

Personal observations (annual, but not regularly scheduled and stratified sampling) indicated that population density was relatively high during the dry, warm years of 1983-1988 and 2000-2001. During the intervening moister, cooler period (1989-1998), northern scorpions were found at lower densities in southern Alberta, requiring longer search times, if found at all. Record rain in southern Alberta in mid-June 2002 may be the cause of reduced populations later in 2002 and 2003. In some cases, this species has invaded homes in the Lethbridge area, including during relatively moist years. Pitfall trapping is an inefficient method of collecting or sampling the northern scorpion, and directed searches (day or night) involving turning over stones generally yield more positive results.

ARIZONA TO SASKATCHEWAN: AN UNUSUAL DISPERSAL AND RENEST OF A BURROWING OWL

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Abstract: Burrowing owls *(Athene cunicularia hypugaea)* are known long distance migrants. Previous band recoveries and aerial telemetry records indicated two migration patterns: one through the Great Plains to Texas and Mexico and the second through the western states and British Columbia to the Pacific coast states. On 30 April 2003, an adult female was banded in Tucson, Arizona with a USFWS band and an anodized black band with letters HM inscribed. She had a vascularized brood patch and was accompanied a male who was banded at the same time. On 12 July 2003, the female was seen on the Nashlyn Prairie Farm Rehabilitation Administration pasture in southern Saskatchewan. On 18 July 2003, she was trapped with an unbanded male and seven young. We estimate that she laid the first egg of this brood on 20 May 2003 based on backdating the age of the young. Thus, in 20 days or less, this second-year female burrowing owl migrated from Arizona to Saskatchewan, a previously undescribed route for this species, and she renested approximately 1,860 km north of her original nest, likely a record distance for any bird species to renest.

DIET OF THE BURROWING OWL *(ATHENE CUNICULARIA HYPUGAEA)* IN THE WINTER IN CENTRAL MEXICO

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Canadian Wildlife Service

Abstract: The western burrowing owl *(Athene cunicularia hypugaea)* is declining in parts of its range in North America, but very little information is available on the ecology of this species in Mexico in either winter or summer. There is only one study on the diet for a breeding population in Chihuahua. Thus, we studied the winter diet of burrowing owls in central Mexico near the city of Irapuato, Guanajuato over two winters. We analyzed 440 regurgitated pellets representing 33.7% of those collected in 1999-2000 (882) and 2000-2001 (442). We identified 1,494 items in both periods from 64 active burrows visited at intervals of 15-30 days. Each pellet contained on average 3.61 individual prey items from 23 separate taxa. The diet composition based on frequency of occurrence was invertebrates (77.91%), followed by small mammals (20.95%), and birds (1.14%). Among invertebrates, Orthoptera was the main prey represented by crickets and grasshoppers. Arachnida, Coleoptera, Dermaptera, Lepidoptera and others formed the remainder of the invertebrate portion. The mammalian diet was largely represented by rodents, followed by shrews and bats. The monthly pattern of prey consumption remained constant between the two winters: invertebrate consumption decreased in mid-winter, while small mammal consumption increased.

STABLE ISOTOPES AND SOLVING MIGRATORY MYSTERIES OF BIRDS OF PREY

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Geoffrey L. Holroyd
Canadian Wildlife Service

Karlis Muehlenbachs
Department of Earth and Atmospheric Sciences, University of Alberta

Abstract: Most research on threatened or endangered bird species takes place on their breeding grounds, as during the breeding season, birds are easier to locate and study. Our knowledge of what happens to migratory birds after the breeding season is relatively limited; however, information on migratory routes and over-wintering locations would allow for year-round conservation. In addition, accurate population modeling requires the separation of inter-year mortality from permanent emigration. Telemetry and mark-recapture techniques are traditional methods of monitoring the inter-year movements of birds. The usefulness of radio- or satellite-tracking is limited by sample sizes, logistics, and expense, while mark-recapture methods such as bird banding are less expensive, but the rarity of the recapture of migratory birds also limits sample sizes. Band recovery studies also likely miss important long-distance dispersal events. Stable isotope analysis (SIA) of feathers provides a method for tracking migrations, determining wintering grounds, and estimating inter-year dispersal patterns at scales greater than single populations or study areas. With the application of SIA, we determined that a banding station on the Gulf Coast of Texas could be used to remotely monitor the populations of peregrine falcons *(Falco peregrinus)* breeding in the western Arctic. We also determined that burrowing owls *(Athene cunicularia hypugaea)* breeding in Canada spend their winters in southern Texas to central Mexico. Finally, we demonstrated that burrowing owls have a low degree of breeding-site fidelity and disperse between breeding seasons at larger scales than previously suspected. The latter discovery will lead to a readjustment of current over-winter mortality rates and more accurate population models for the conservation of burrowing owls.

THE HISTORICAL EFFECTS OF FLUCTUATING WATER LEVELS ON PIPING PLOVER *(CHARADRIUS MELODUS)* REPRODUCTION AT LAKE DIEFENBAKER, SASKATCHEWAN

Sam Barry and Sharilyn Westworth
Canadian Wildlife Service

Abstract: Results from the 2001 International Piping Plover Census show that the prairie piping plover population has exhibited a 32% decline since the first International Census was conducted in 1991. One threat contributing to the decline is fluctuation in water levels that occur during the peak breeding period on managed reservoirs. Lake Diefenbaker is an important breeding location for the endangered piping plover, and up to 5% of the world's population has been found on this reservoir. To acknowledge the importance of the lake and the impacts that fluctuating water levels can have on plover reproduction, several partners assembled and drafted a Diefenbaker Conservation Plan, which recommends that a July 1st target water level of 555.3 m should not be exceeded. We examined 35 years of May 1 to July 31 water level rises in the reservoir in conjunction with 9 years of known nest elevations and hatch dates. We explored the relevance of the July 1st target level, how frequently it was missed, and the proportion of nests that were flooded. We found that complete flooding of 75% of piping plover nests occurs relatively infrequently over 35 years of records: the norm is <50%. There is much variation in water levels on July 1st depending on the snowpack in the Rockies and the rate at which the meltwaters come into the basin. We also examined beach area during the 10-day critical period after hatch and related it to fledging success.

CATTLE GRAZING IMPACTS ON RIPARIAN VEGETATION VARY THROUGH FIVE ELEVATIONAL ECOREGIONS IN SOUTHWESTERN ALBERTA

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Abstract: The impacts of cattle grazing on riparian zones along two streams in southwestern Alberta, Yarrow and Drywood Creeks, were examined from their alpine headwaters through the subalpine, montane, parkland, and fescue prairie ecoregions. Comparisons of vegetation characteristics across two grazing intensities revealed that cattle grazing had negative impacts in all five elevational ecoregions. In general, species composition was negatively impacted, as grazed transects (moderately or heavily grazed) were less diverse with lower species richness than ungrazed (ungrazed or lightly grazed) transects. Woody species were less dense and older shrubs were shorter along grazed transects. Additionally the percentages of obligate species (species occurrence restricted to each grazing intensity) and S3 rank (threatened) species and their percent cover were lower. The percent cover of weedy species and yarrow *(Achillea millefolium)*, a grazing response increaser, was higher along grazed transects. Physical characteristics were also impacted by cattle as substrate was coarser and substrate pH was more acidic on grazed transects. There were variations between the ecoregions in terms of which vegetation type was most responsive to grazing. In the fescue prairie and montane ecoregions, both woody and herbaceous vegetation indicated the impacts of cattle grazing. In the parkland ecoregion, woody species were more sensitive and therefore better indicators of grazing impacts. In the subalpine and treeless alpine ecoregion, herbaceous vegetation characteristics were more sensitive grazing impact indicators. Similarity indices revealed that species composition was most impacted in the subalpine and alpine ecoregions, in spite of their relatively short history of grazing compared to the other ecoregions. This study revealed the differing grazing sensitivities of various ecoregions and indicates that riparian management plans for cattle grazing should be adjusted accordingly.

COLLABORATIVE DECISION MAKING AND ADAPTIVE MANAGEMENT FOR SAGE GROUSE RECOVERY IN SOUTHEASTERN ALBERTA

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Dale Eslinger
Alberta Sustainable Resource Development

Abstract: The Canadian *Species at Risk Act* (2003) calls for consultation and collaboration with governments and stakeholders during the endangered species recovery planning process. However, there are no stipulations in the Act or its supporting documents that recommend how collaboration may be achieved. Collaborative resource management (CRM) is a recent phenomenon emerging from the social sciences and law referring to multi-party decision-making processes using a participatory approach. Combining CRM with adaptive resource management (ARM: a systematic process for continually improving management policies and practices by learning from the outcomes of operational programs) offers a planning process involving value-based decisions that are informed and guided by science. We applied the principles of CRM and ARM in a planning process for sage grouse *(Centrocersus urophasianus)*. Most sage grouse habitat in Alberta occurs on private agricultural land or land leased for grazing and oil and gas development. Past recovery efforts have been hampered by inadequate involvement of stakeholders during planning. We implemented an inclusive planning process in which government managers, the petroleum industry, environmental interests, and the local ranching community were engaged as a Recovery Action Team. In addition, a technical group was established to provide scientific expertise and to develop decision support and management experiment models. Experts on the technical group represented the fields of biology, population and habitat ecology, water and range management, landscape ecology, systems dynamic modeling, and resource economics. We review the planning process, evaluate its effectiveness, and provide recommendations for improving stakeholder engagement in participatory planning. The process generated practical management actions for species recovery, while considering values of people and industries using the same landscape.

NORTHERN MIXED GRASS PRAIRIE CONSERVATION PLANNING INITIATIVE – A TRANSBOUNDARY PARTNERSHIP

Pauline Erickson, Pat Fargey, Steve Forrest, Margaret Green, Brian Martin, Sue Michalsky, Joel Nicholson, Lindsay Rodger, Karin Smith Fargey

Abstract: The Northern Mixed Grass (NMG) Prairie, a component of the North American Great Plains, cover approximately 700,000 km^2 and span two Canadian provinces and five US states. Historic and current landuse practices have significantly impacted Great Plains species, with over 74% of Great Plains vertebrates listed as imperiled by one or more federal, state, or provincial governments. The area of southeast Alberta, southwest Saskatchewan, and northcentral Montana, totalling approximately 28,000 km^2, contains some of the most intact grasslands remaining in the mixed-grass prairie ecosystem. This area contains 11% of Canada's species at risk and numerous species of conservation concern in the United States. Important ecological linkages and migratory species that frequently cross political boundaries require an integrated international approach for successful conservation. Planning initiatives must work at an appropriate scale to meaningfully conserve and restore the native habitats, species, and ecological processes relevant to NMG conservation, particularly in this biologically important transboundary area.

The NMG Multi-Site Conservation Planning Initiative began in January 2003 engaging 17 federal, provincial, state, and non-governmental partners from Alberta, Saskatchewan, and Montana which resulted in the involvement of over 35 participants. The planning partners have participated in a facilitated landscape-scale, multidisciplinary, science-based conservation planning workshop series using The Nature Conservancy's Four S Planning Process. Four conservation site plans have been developed: the Alberta Milk River site, the Sage Creek/Southwest Pasture site, the Frenchman River Valley/Bitter Creek site, and the Transboundary wetlands site. Planning has involved the identification of conservation targets, assessment of the monitoring parameters of those targets, determination of the critical threats, and design of effective conservation strategies for conserving an ecologically functional northern mixed-grass prairie. Geographic information system analyses supporting the multi-site conservation planning effort have produced significant results with databases such as species occurrence, tillage risk, and land cover. The four multidisciplinary planning teams have identified common targets and viability attributes that will be used to develop common conservation strategies. In 2004, the partnership will explore plan implementation and integration of conservation efforts at all four sites. Future plans include a second series of workshops which will target site planning for additional sites of conservation value to the partners and which will further promote cooperative transboundary ecosystem-based conservation. The relationships built through the planning efforts have fostered joint research and communication between conservation agencies, organizations, communities, and individuals concerned about NMG prairie conservation.

MANAGEMENT OPTIONS FOR PREVENTING CRESTED WHEATGRASS INVASION

Darcy C. Henderson and M. Anne Naeth
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Abstract: Crested wheatgrass is a non-native (alien) species that invades semi-arid mixed-grass prairie and reduces biological diversity. Elimination of crested wheatgrass seed is most important for preventing invasion, and some seed control options may also facilitate eradication and native grassland restoration. A field experiment was initiated in 2001 to test how repeated grazing, mowing/haying, burning, and herbicide application affect crested wheatgrass seed production, seed bank density, and plant community composition. Results to date indicate treatments were sensitive to timing, and the identification of important phenological stages in crested wheatgrass was essential to effective control. Short-duration, high-intensity grazing and mowing/haying provided the least expensive and most effective control of seed production, while herbicide application appeared to speed the eradication and restoration process at a substantially higher economic cost. Burning, alone or in combination with herbicide, was not a useful treatment because it stimulated seed production and eliminated the fuel to support a second burn the following year. Stewards can adopt grazing and haying techniques for widespread prevention of invasion at little or no cost. However, native grassland restoration proves to be a long-term and costly endeavor.

CONTROLLING SMOOTH BROMEGRASS WITH WICK APPLICATORS AND GLYSOPHATE

Don Murphy
North Battleford, Saskatchewan

Abstract: A restoration project was undertaken to control smooth bromegrass in the moist mixed grassland ecosystem at NE 06-39-10-W3M. The restoration methods were guided by the application of the research project *Management Considerations for Controlling Smooth Brome in Fescue Prairie* authored by Perry Grilz and Jim Romo. The primary concern was that indiscriminate spraying would result in the destruction of the native plant groundcover and a loss of regenerative capacity. Two wick applicators were developed: the first was a hand-held wick applicator made from plumbing pipe or ABS, while the second was an adaptation of a push-type sprayer. The greatest success was achieved with the hand-held wick applicator. The bromegrass was treated with a 30% concentrate of glysophate in June 1998. The treated foliage was allowed to dry before removal. There was minimal damage to the understory of native plants, and the following year, the treated area had a small amount of bromegrass regrowth that was retreated. At present, there are only traces of the original stand of bromegrass. The sprayer-type wick applicator was used on an area one quarter acre in size using the same methodology. The sprayer applicator killed all existing vegetation in the application area. The area was burned to remove the thatch layer and underwent secondary succession, with lambs quarters and Russian thistle common on the site. The treated area is now populated with needle-and-thread grass, green needle grass, pasture sage, etc. The area has not yet fully recovered five years following treatment. Wick applicators show promise to minimize the restorative efforts required when controlling smooth bromegrass in mixed-grass prairie. Wick applicators provide a weed control option that results in fewer weedy species and minimizes the loss of species diversity on the site.

THE RIPARIAN HEALTH INITIATIVE: STEWARDSHIP THROUGH COOPERATION

Melanie Dubois-Claussen and Tim Sopuck

Manitoba Habitat Heritage Corporation

Abstract: The Riparian Health Initiative (RHI) is an innovative approach to stream and lake stewardship outreach. This program ensures that all stewardship activities for riparian and associated lands in agro-Manitoba are delivered in the most efficient, effective manner possible and provide the widest possible benefits for the environment, agricultural producers, and rural communities. Specifically, the RHI has:

1. established provincial (Riparian Health Council) and regional structures (Regional Working Groups) to facilitate communication and coordination of partner activities focusing on cooperative programming for riparian and associated lands in agro-Manitoba, and
2. strengthened the link between stewardship, extension, technology transfer, benchmark data collection, and performance monitoring elements.

The Riparian Health Council (RHC) is made up of the decision-making staff of the RHI partners and ensures ongoing interaction and coordination of groups involved with riparian initiatives. Chaired by the Manitoba Cattle Producers Association, the RHC includes representation from the agricultural industry, government, and conservation agencies. Regional Working Groups are found in each agricultural region and include support and delivery staff of the RHI partners. The RHI is working through its partnerships to:

1. improve coordination and integration of stewardship initiatives for riparian and associated lands;
2. ensure greater integration of coordination, delivery, landscape benchmark data, and program performance monitoring efforts for riparian and associated lands to improve overall effectiveness, efficiency, and relevance of programs for producers; and
3. create a framework to coordinate the long-term delivery of riparian stewardship programs in the agricultural landscape.

STEWARDSHIP ON NCC PROPERTIES: FROM A TO S

Kimberly Good and Renny Grilz
Nature Conservancy of Canada, Saskatchewan Region

Abstract: The Nature Conservancy of Canada (NCC), Alberta Region has a three-year-old Stewardship Department. The department is responsible for ensuring the properties that NCC owns or has an interest in are accomplishing the goals for which they were acquired. The following steps are involved in stewarding a property:

1. Assessment – initial site visit to determine the conservation requirements and challenges of a specific property;
2. Budget – written outline of immediate and future stewardship costs;
3. Baseline – a field-based report on vegetative communities, wildlife usage, health assessments, management concerns, and recommendations;
4. Monitoring – annual visits to a site followed by a written report documenting the condition of a property;
5. Management plan – documentation of conservation goals and techniques to achieve goals; and
6. Site management – activities carried out on properties to achieve goals (i.e., fencing, water development, weed management, signage, etc.).

This poster further details each of these steps and describes how stewarding individual properties fits into NCC's national and regional stewardship protocols.

THE SASKATCHEWAN PRAIRIE CONSERVATION ACTION PLAN AND PARTNERS STEWARDSHIP EDUCATION PROGRAMS FOR ELEMENTARY SCHOOL AUDIENCES: A FUN AND GAMES APPROACH TO LEARNING

Karyn Scalise
Saskatchewan Prairie Conservation Action Plan

Kim Epp
Saskatchewan Burrowing Owl Interpretive Centre

Abstract: The Eco-Extravaganza (Eco-X) uses a "fun and games" approach to educating Kindergarten to Grade 6 students about native prairie, riparian areas, water resources, and wildlife with an emphasis on species at risk that occur in Eco-X target areas. Activities include a game show, skits, games, and songs. Evaluations indicate very high levels of satisfaction among teachers due to the interactive nature of the activities, our presenters, and our enthusiastic, upbeat, and positive approach to educating students about native prairie stewardship. Since 2000, the Eco-X has evolved to become a full-day program. The anticipated reach of the program by March 2004 is expected to exceed 65 schools and over 5,700 students, primarily from rural communities.

Grasslands National Park initiated the Eco-X in 2000 and original partners included the Prairie Conservation Action Plan (PCAP), Saskatchewan Watershed Authority (SWA) and the Saskatchewan Burrowing Owl Interpretive Centre (SBOIC). The program grew by 2003 to also include Ducks Unlimited Canada, Environment Canada – Canadian Wildlife Service, Agriculture and Agri-Food Canada – Prairie Farm Rehabilitation Administration, and Nature Saskatchewan. The team approach ensures that conservation and agricultural partners work together to deliver consistent, integrated messages to school audiences based on the common ground shared by these sectors and the need for cooperation among them. Another advantage of the team approach is the resource sharing among partners that results in efficient program planning and delivery.

The PCAP and the SBOIC initiated the Owls and Cows Tour in 2001 featuring two of the most popular Eco-X activities. SWA became a delivery partner in 2002. The Owls and Cows Tour educates students about native prairie and riparian areas and illustrates how burrowing owls and other wildlife species depend on the native prairie that also supports Saskatchewan's cattle industry. As of March 2003, the Owls and Cows Tour visited 158 schools, located primarily in rural Saskatchewan, and reached over 11,400 Grade 3 to 6 students. Evaluations for this program have also been outstanding with high praise received for the interactive nature of the activities, our presenters, and the messages delivered to the students regarding the positive and important role played by ranchers and mixed farmers in prairie conservation.

WILD ALBERTA – THE ROLE OF THE PROVINCIAL MUSEUM OF ALBERTA IN ENVIRONMENTAL CONSERVATION AND STEWARDSHIP

Mark Steinhilber
Provincial Museum of Alberta

Abstract: The new Wild Alberta gallery at the Provincial Museum of Alberta was created to highlight the impact of human activity on our wild spaces. Produced in collaboration with the Federation of Alberta Naturalists, the Alberta Conservation Association, Ducks Unlimited Canada, and numerous other partners and sponsors, this exhibit serves to raise awareness of conservation issues in the province. Environmental challenges, solutions to problems, and individual stewardship are prominent messages throughout the exhibit. It is intended to be a source of information to help Albertans make informed environmental decisions. The interpretive panels accompanying each diorama include a discussion of conservation issues relating to the scene depicted and a naturalist's notebook that showcases a research project relevant to the display. In the prairies section, presentations on species at risk and peripheral species address the need for conservation of our rare and endangered wildlife and discuss some of the ongoing work in this area. As visitors near the end of the gallery tour, they are explicitly challenged to consider what they can do to protect the environment. A final component entitled "Wild Alberta Now" provides up-to-date information on a variety of provincial conservation and research projects via electronic presentations, news articles, and fact sheets. Plans are in the works to expand the interpretive programming in the gallery to include regularly scheduled public lectures, seminars, and panel discussions dealing with environmental issues.

ASSESSMENT OF LONG-TERM TALL GRASS PRAIRIE RESTORATION IN SOUTHERN MANITOBA

Alexis Knispel and Stéphane McLachlan
Department of Environment and Geography, University of Manitoba

Abstract: Among the most threatened habitats in North America, tall grass prairie continues to be degraded by agriculture, fire suppression, and encroachment of exotic and woody vegetation. Restoration is used increasingly to mitigate this decline. The Beaudry tall grass prairie restoration was initiated in 1987 and is now the largest and longest-standing restoration of its kind in Canada, though no formal monitoring has occurred. In 2002, we assessed the Beaudry restoration: our objectives were to determine the effects of restoration age on diversity, community composition, and similarity to reference sites. We also examined temporal changes in functional group composition and identified traits associated with species vulnerability and success in the restoration. Restoration sites in three age classes were compared with reference sites and with farmland that will be the site of future restoration. Restoration sites remained distinct from both reference sites and the agricultural site. The similarity of restoration to reference sites generally increased over time, particularly for native graminoids. Native forb diversity increased initially but decreased in older restorations, whereas native graminoid richness did not change. In contrast, exotic forb diversity decreased and graminoid diversity increased with restoration age. Sexually reproducing species decreased and vegetatively reproducing species increased over time. The former was characterized by exotics with short life spans and minimal root development. However, a few perennial exotics are wind-dispersed and vegetatively reproducing as are many native species. These successful species, including native *Andropogon gerardii* and exotic *Bromus inermis*, are likely to persist in the restoration. In contrast, vulnerable species tended to be forbs and reliant on seed for reproduction. Though restoration generally had a desirable effect on vegetation, sites will likely need ongoing rehabilitation. Management activities that increase seedling recruitment and propagule availability of vulnerable forb species will increase the native diversity of restored tall grass prairie.

PALLISER'S COUNTRY GRASSLAND HERITAGE REGION: STRENGTHENING THE CULTURAL AND NATURAL HERITAGE OF SOUTHWESTERN ALBERTA AND SOUTHEASTERN SASKATCHEWAN BY SUPPORTING THE POSITIVE EFFORTS OF LANDOWNERS

Rob Gardner
Medicine Hat, Alberta

Abstract: Between the Cypress Hills and the American border lies a vast native grassland with abundant wildlife and a strong ranching tradition. Ranchers in southwestern Saskatchewan and southeastern Alberta have a proud history of conserving the region's native grassland. Their intimate experience with the grassland makes them ideally suited to be stewards of this heritage. However, limited resources sometimes prevent them from carrying out activities specifically aimed at wildlife management. On the other hand, conservation organizations are increasingly recognizing that the remaining grassland requires strong support. Both the landscape and the threatened species therein are becoming priorities. Through discussions with residents, Palliser's Country will develop a common vision of the region to informally coordinate the efforts of the many organizations working in the area and promote the area as a "heritage region". The project will primarily portray the close relationship between people and the prairie environment, and the important conservation efforts being carried out by the residents will be recognized. Palliser's Country builds on the common ground held by ranchers and conservationists, seeking additional support for conservation in the region while strengthening the cultural heritage and economy. No change in land disposition is being suggested. The heritage region will enable Canadians to get back in touch with the rural lifestyle and understand what makes the grassland important and worth protecting. Events and programs will bring people to the prairie in carefully controlled situations and enable better communication. The heritage region will focus on action, not planning. Several organizations have already prepared plans, and many of the activities suggested in these plans can be implemented as soon as funders and landowners are brought together.

LEK OCCUPANCY BY GREATER SAGE-GROUSE IN RELATION TO HABITAT IN SASKATCHEWAN

Sue McAdam
Saskatchewan Environmental Resource Management

Abstract: The Endangered greater sage-grouse populations in Saskatchewan have decreased considerably since the 1980s. Habitat conversion, habitat quality, over-hunting, and livestock grazing have been identified as factors affecting sage grouse populations. I investigated whether there was a difference in range condition, species composition, and structure within 3.2 km of occupied leks compared to abandoned leks. Native grass cover greatly exceeded that recommended for productive sage grouse habitat in both treatments. Excess grass cover was shown to contribute to reduced nesting success in Alberta, which has more silver sagebrush cover than Saskatchewan. Forb cover met the minimum recommended for productive habitat around occupied leks and exceeded the minimum around abandoned leks. Greater cover of native forbs, native grasses, cryptograms, and litter contributed to greater visual obscurity of individual sagebrush plants around abandoned leks compared to occupied leks. Silver sagebrush was present in more large quadrats, had greater individual crown area, and had more cover around occupied leks than around abandoned leks. Sagebrush cover in Saskatchewan is well below the minimum recommended for productive sage grouse habitat. Inadequate sagebrush cover and size appear to be the most important factors in lek abandonment in Saskatchewan. Increased variability around abandoned leks also suggests that sage grouse may be selecting a narrower range of habitat types. Prairie Farm Rehabilitation Administration pastures were in good to excellent range condition. No significant differences in range conditions were found with lek occupancy. Pasture management can provide patchy habitat with increased sagebrush cover for sage grouse.

ENDANGERED SPECIES EDUCATION PROGRAM AND POSTER CONTEST: AN ALBERTA WILDERNESS ASSOCIATION PROJECT

Christyann Olson and Nigel Douglas
Alberta Wilderness Association

Abstract: The Alberta Wilderness Association partners with the University of Calgary Masters of Teaching Program each fall to provide a community work placement for 16 student teachers. The program provides an orientation to the student teachers and prepares them to provide an educational program to students throughout the Calgary and surrounding area school system. More than 2,500 school-aged children were introduced to the new *Species at Risk Act* and the topic of endangered species in 2003. As part of the program, students were invited to participate in a poster contest. The posters were judged and some of the winning entries are presented in this poster. Children were able to demonstrate an understanding of the concerns for endangered species, the need to protect them, and the actions that individuals can take to be part of the conservation of endangered species.

KEEPING THE WILD IN THE WEST: RAPPORTEUR'S SUMMARY

Cheryl Bradley

It falls to me, the rapporteur,
To listen up and be sure
To catch each theme and each key trend
And summarize it in the end
Of this our seventh gatherin'.

My ears are full, my heart is too
For we have shared so much, it's true
Together we have a common quest
Of keeping the wild in the west;
For all of us an oblige noblesse.

Our scope is prairie which we see
Has disregard for boundary
Of province, state and nation, so
From Canada to Mexico
We are sharing what we know.

We call different places home
From many walks of life we come
Urban and rural, ranchers and farmers,
Biologists and naturalists, managers and planners,
Young and older, teachers and learners.

A Minister from afar and Alderman here too
Said "we need more folks like you"
Our future as a society
Is tied to the health of the prairie
Including its biodiversity.

But oh, the challenges are so darn huge
Great human forces do construe
To change this landscape so finite
More people, roads, cows, crops and light
Cumulative effects are out of sight.

Species adapted to native prairie
Its fire, its drought, its herbivory
Are put at great risk when the ecosystem
Is so out of whack due to actions of men
What can they endure? How great is our sin?

Some work on research and science to show
What parts are lost in the tinkering we do?
We evaluate species, their numbers and trends
Define factors which could mean the end
Of our feathered, scaled, glabrous or soft hairy friends.

Some work on networks designed to protect
Large cores and corridors of habitat
We need to think big to meet the test
Of keeping all of the wild in the west
Protect the biggest and best of what's left!

Some work on landscape's big balance sheet
We document change, the effects that it metes
Out to the prairie. How much is lost?
What are the trends? What are the costs
Or benefits to us who impact the most?

Some inventory our natural wealth
We work on benchmarks and measures of health
Place principles and practices in the hands
Of ranchers and other managers of lands
Cause attitude shifts and improved management plans.

Some of us work on our own property
We take stewardship seriously
We balance our own interest with the public good
Protect homes for wildlife 'cuz we feel we should
Knowing health of the land links to our livelihood.

Some of us work on private conservancy
Linking sellers and buyers who will agree
To manage land for nature's needs uppermost
Some in perpetuity, no matter the host
It's more than just dancing, it's sharing the toast.

Some work on restoring as the raison d'etre
Healing the sores will make the prairie better
We minimize impact as a first approach
Reintroduce natives and carefully coach
Kill aggressive invaders so they won't encroach.

Two decades ago we began making plans
For prairie conservation on Canadian plains
Together we've set goals, objectives and actions
We've worked really hard not to break into factions
To find common ground and consensus directions.

We've heard that the big plan is the fractal shore
There are plans within plans going on ever more
Transboundary and ecoregional
Watershed plans and intermunicipal
Ranch and park and endangered species all.

We're reminded in conservation we should be humble
Our decisions should rest on a three-legged stool
Environment, economy, culture all three
Need to be considered for sustainability
And antennae alert for nature's complexity.

Water, say some, is the thread to connect
Urban dwellers with the quest to protect
Native prairie, for environmental services it provides
About 33 trillion dollars world-wide
Release a flow of incentives to the countryside!

Governance, say some, is where change must start
To influence the whole, not just manage the parts
Reduce fragmentation of jurisdictional responsibility
Address the lack of government's capacity

To stay the course in a four-year pulse democracy.
We've come four hundred strong to Calgary
We honour contributions to conserving prairie
Awards to farmers, researcher and naturalist
Recognition for dedication, thanks for giving your best
To ensure that we're keeping the wild in the west.

Key words I have heard a dozen times or more
'Communicate', 'cooperate', reach out to others more
Not just among ourselves but to all society
We may be most effective in our own 'community'
Be 'strategic', progress is not just lots of activity.

But oh, the challenges are so huge
What about succession? What about youth?
Some call for young leaders to take the reins
Of keeping the wild in the western Great Plains
All these young faces show they wait in the wings.

I hope I've rapported your wisdom truly
Now I am done, you'll hear no more from me
Except to advise – to your own self be true
And if you get weary and the challenge seems to huge
Walk out in wild prairie, she'll give back to you.

Thank you to Mike Quinn for the inspiration. My apologies to cowboy poets everywhere.

7TH PRAIRIE CONSERVATION AND ENDANGERED SPECIES CONFERENCE CLOSING REMARKS

Chantal Simmons
Conference Co-Chair

When I was asked to provide closing remarks for this conference, I was initially stupefied as to what I could say. I had always been the kind of attendee in past conferences who was itching to get through the closing remarks as quickly as possible. With this attitude, I obviously did not retain many of the messages that were expressed at these moments. As I composed what I would say today, I realized how much impact closing remarks could or could not have depending on the message and, of course, the messenger. So with this said, I apologize in advance for not following any existing template.

I do not purport to be an expert at anything. I am not a scientist nor am I from an agricultural background that allows me to inspire you on a content or substantive perspective. However, I do have something of value to say and to challenge you from the perspective of a person with a genuine interest in collaborative prairie conservation efforts; consider the following words as you leave the 7th Prairie Conservation and Endangered Species Conference.

The first question I put to myself, and to you, is "what did I learn?" I learned there is some really good science being undertaken by some brilliant people. I listened to a few presentations describing research concerned with plants, birds, and habitat in general, including ideas around development transfer rights and rural diversification, just to name a few. The message I heard was related to the data created by the science. Specifically, prairie species and habitat, big and small, are not doing so well. I listened to many questions around what we can do to change this situation. I observed the dynamic, energized interaction between people of varying backgrounds, whether they were from conservation, industry, government, or land user. This conference proactively sought and continues to seek out that diverse mix of perspectives that I compare to a healthy, rich ecosystem. I hope this aspect never changes. I also learned a few life teachings, like making sure to wear black pants if there is a chance of having a pee in them! I learned in life that I qualify to become one of Cleve Wershler's minions, a position I am so sure is coveted.

With all that I learned, my next question to myself and to you is "what am I going to do?" We all want to leave this conference with the inspiration to make a difference in the prairies while we can. This is where my challenges to you come into play – there are two of them.

Challenge 1 — from a content or conservation-related view
For those of you who have devoted time, effort, knowledge, and more to this cause, I challenge you to simply keep at it. I know this is a challenge when the results of your visions are difficult, if not seemingly impossible, to attain in today's context. Your inspiration should come from the sheer fact that your messages are reaching people – people like me. Do not lose momentum, do not lose faith, because you really are making a difference.

For those of you who are first-timers at such a conference (like me) or if you are not necessarily well versed in conservation "speak" (again, like me), I challenge you to do one thing between now and the next prairie conservation conference. Join an organization committed to prairie conservation, such as one of the many represented here. Take on a pet project at work that is dear to your heart but that has previously been on hold while you attend to other life priorities. In the words of Monte Hummel, be a "do dog". I say this because you are the untapped resources these more experienced folks need in order to realize their goals of conservation. You are interested, energized people with something to contribute. Whether the goal is protection or restoration of habitat or education, a multitude of skills is needed to achieve them. It is not only youth that can contribute; middle-agers and beyond have much to offer based on life experiences and should look forward to leading others by example.

Challenge 2 – from a people and resources view
The second challenge revolves around our next conference to be held in Regina in 2007, and it touches on my last point about untapped resources. Look around you at the people you see every day that are not necessarily part of the conservation community, your family, your work colleagues, your neighbours, and your friends. These are people on the periphery of conservation efforts through you. I challenge you to bring them along to this next conference or possibly a similar one before then that would expose these people to this great and noble cause. Convince them to come. Incense them to come. Just have them come to Regina. I am sure that doing this will only breed more momentum and new ideas. For those of you that may doubt that this is effective, I tell you that I am proof that this works. I am a federal government employee whose job description has nothing to do with the subject matter here, and I am not from the prairies either so have no background related to them. But yet I stand here delivering closing remarks at a conference I have never attended before, convinced and committed to contributing to the cause of prairie conservation. Why is that? There are many factors, but most of all, I point to the effect of listening to genuine concern from genuine and decent people about a beautiful landscape that is threatened. I am enlightened by this experience, and I darn well intend to do something coming out of this conference. These are my challenges.

I hope you give them as much consideration as the effort I have put towards posing them to you.

Some thanks are in order in wrapping up my remarks. I can never overstate the words of appreciation and respect to every single organizing committee member who have each volunteered hundreds of hours over two years to give us this conference. I guess now that the conference is ending, I have the honour of calling them my friends. The conference coordinator – Christyann Olson – and her group of volunteers, mostly from the AWA, were exceptional in the delivery of services beyond expectations; thank you so much for your dedication, patience, and hard work. Our sponsors deserve recognition for contributing to the breadth of activities that we were able to provide for very low registration fees. Finally, a big thank you to all of you, in part for sitting through my rambling remarks, but mostly for being here over the last three days. I cannot emphasize enough how amazed I am by the quality of the conference, which I can mainly attribute to the human factor – key in our future successes. In the words of an unnamed committee member last night who may have had a bit too much wine, "This is the best 'frickin' conference I have ever been to." I cannot disagree.

With that said, I wish you all safe travel today as you make your way home. I remind you of your challenges and urge you to do something to make a difference. See you all in Regina in 2007.

AUTHOR INDEX

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No. 1 Alberta Birds 1961-1970. T.S. Sadler and M.T. Myres. 314 pp. (out of print)

No. 2 Mammals of the Edmonton Area. 1979. Hugh C. Smith. 34 pp. (out of print)

No. 3 A Bibliography of Alberta Ornithology. 1981. Martin K. McNicholl, Philip H.R. Stepney, Peter C. Boxall and David E. Spalding. 380 pp. (out of print)

No. 4 Plants and the Blackfoot. 1982. Alex Johnston. 106 pp. (out of print)

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