BANFF, ALBERTA, CANADA

MAY 27-30, 2008

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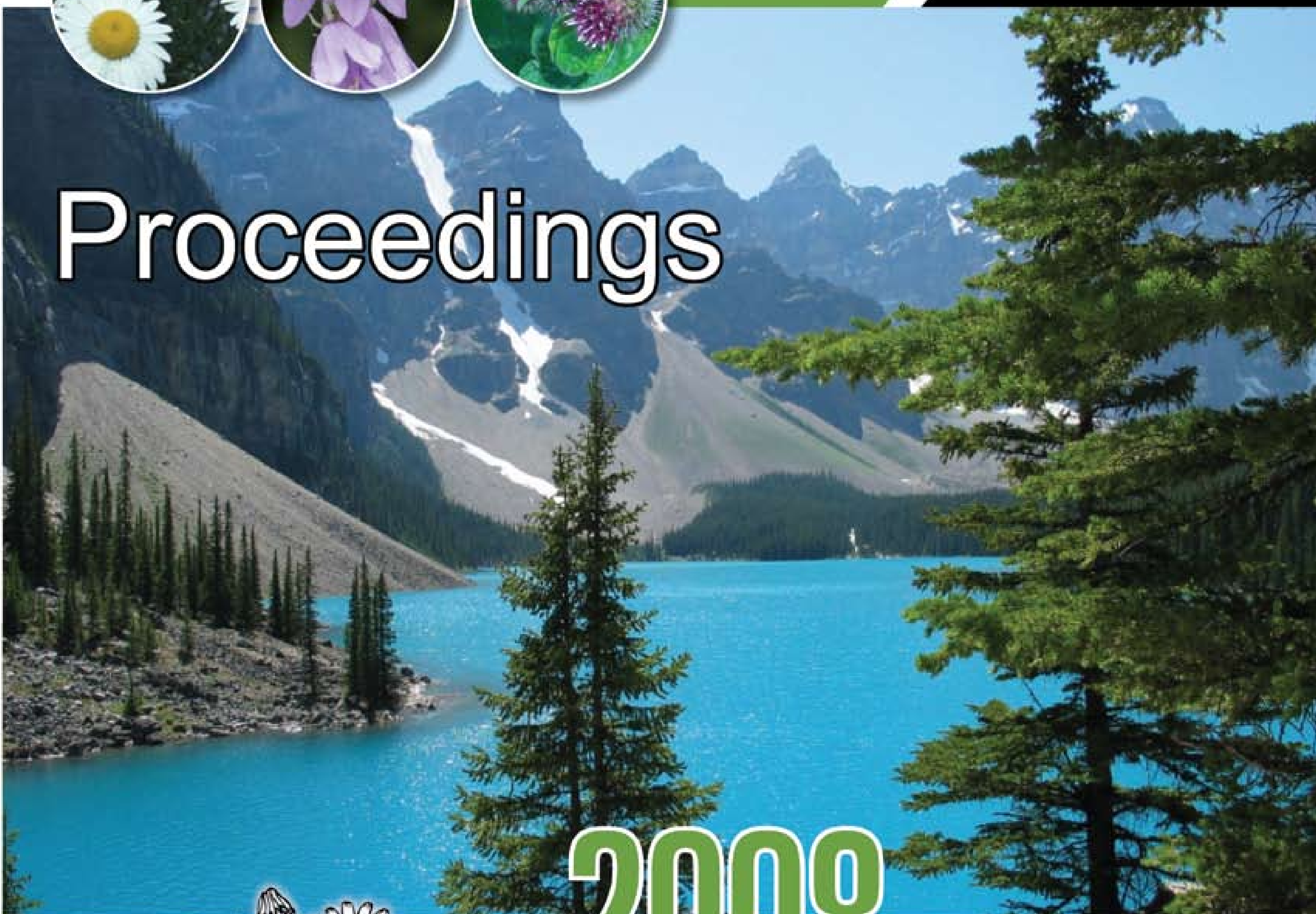

Proceedings

2008 WEEDS ACROSS BORDERS

CONGRESO MALEZAS SIN FRONTERAS

MAUVAISES HERBES SANS FRONTIÈRES

2008 WEEDS ACROSS BORDERS

CONGRESO MALEZAS SIN FRONTERAS

MAUVAISES HERBES SANS FRONTIÈRES

Proceedings of the Weeds Across Borders 2008 Conference

May 27–30, 2008 – Banff, Alberta, Canada

The view from the North

Edited by Stephen J. Darbyshire and Raj Prasad

Alberta Invasive Plants Council

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2008 WEEDS ACROSS BORDERS

BANFF, ALBERTA, CANADA
MAY 27-30, 2008

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MAUVAISES HERBES SANS FRONTIÈRES

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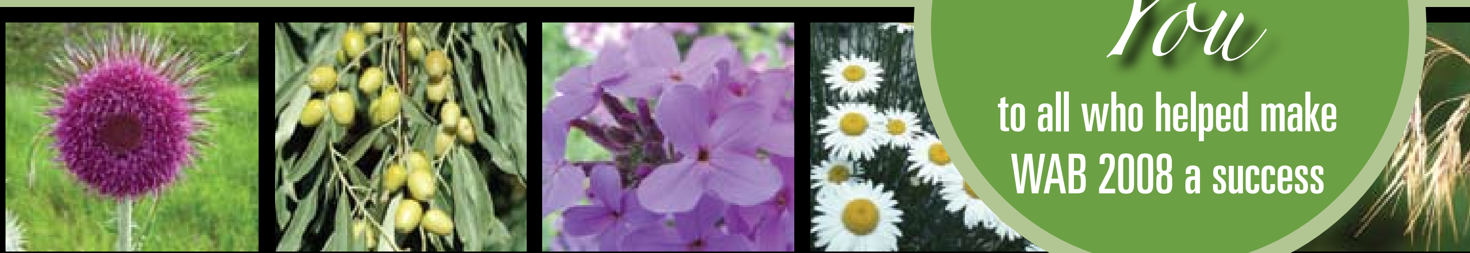
Thank You

to all who helped make WAB 2008 a success



Acknowledgements

Many thanks to all those who attended and presented at the conference, as well as sponsors and volunteers whose efforts were invaluable to the success of the Weeds Across Borders meeting. Special thanks to Stephen Darbyshire, Claire Wilson, Ken Allison, Anna Lyon, Sheilah Kennedy, Gail Wallin, Jodi Romyn, Bonnie Harper-Lore, Kim Nielsen, Cory Lindgren, Crystal Klym, Dianne Schoepp, Donald McLennan, Larry Walker, Michelle Aasgard, Raj Prasad, Linda Wilson, Lisa Guest, Andrew Stiles, Kim Neilsen and Heather Dempsey for assistance with the planning, registration, proceedings, field tour and many, many other aspects of running a conference of this magnitude. For a complete list of sponsors and partner agencies whose generosity allowed the Weeds Across Borders conference to be such a success, please visit http://www.invasiveplants.ab.ca/funding.htm or see the sponsor page in these proceedings.

On behalf of the Alberta Invasive Plants Council and the North American Weed Management Association, in recognizing the work of the Organizing Committee, it would only be appropriate to pay special tribute to Karen Sundquist for her tireless and dedicated contribution to the conference. Karen's assistance and guidance was invaluable and without it, WAB 2008 would not have enjoyed the success it did. At WAB Karen received the 2008 NAWMA Appreciation Award: "Recognizing her hard work and dedication for a successful 2008 Weeds Across Borders Conference".

WAB 2008 Organization Committee

Andrew Stiles
Anna Lyon
Bonnie L. Harper-Lore
Claire Wilson
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Gail Wallin
Heather Dempsey
Jodi Romyn
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Raj Prasad
Sheilah Kennedy
Stephen Darbyshire

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Lu Ziola, of some production! (Edmonton, Alberta), was instrumental in the production and layout of the Proceedings. Her efforts have turned the bare facts into something attractive and functional.

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Preface:
Proceedings of the Weeds Across Borders 2008 Conference, Banff, Alberta Canada, May 28–30th, 2008

Stephen Darbyshire

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Plants form the foundation of not only our environment and prosperity, but literally life as we know it. Through their ability to capture carbon from the atmosphere and release oxygen, they have provided us with the essentials of life (food, raw materials and ecological services) that enable the development and support of human civilization. Their impact on our world is incalculable, but just as we benefit in so many ways from some plants, our endeavours are hindered by others. These nuisance plants (plants out of place) are broadly referred to as "weeds"; plants that interfere with human activities, interests or welfare. As pointed out by Francisco Espinosa-García, however, our relationships with plants tend to be very complicated. One person may benefit greatly from the presence of a particular plant, while another finds the same species a pestilence. The effects of weeds are as varied as our activities, some being obstacles to agriculture/forestry production, some interfering with landscape or habitat management, some degrading societal infrastructures, some compromising ecological services, and some even directly affecting human health.

In recent decades, trends in globalization have increased both the traffic between the world's floristic regions and the pathways facilitating plant dispersal. At the same time that human activities have been spreading and establishing plants into new areas, we have developed a greater knowledge and appreciation of the ways in which competitive non-indigenous plant species affect the environment and impinge on societal concerns, such as their modification of ecological processes and biological diversity. Thus, as the number of weeds has been increasing, we are also beginning to better appreciate the extent to which they can affect our prosperity.

In the management of our environment, balancing our desires and needs with the complex global processes, weeds are more than just a minor nuisance. In that plants grow, or not, in response to environmental conditions, any impact we have on other physical or biological factors of the environment will have effects on weeds, and vice versa (e.g., Lewis Ziska and Cat Shrier and Ana Coelho Maran).

Since the world is "shrinking" through our every increasing ability to move people and goods around the globe, and while plants are oblivious to our artificial political and management boundaries, the problems created by weeds require broad cooperative and integrated approaches. Managing vegetation and controlling weeds effectively entails substantial on-going efforts throughout all levels of our society from government regulation and enforcement (e.g., Al Tasker, Indira Singh, Cory Lindgren and Claire Wilson, etc.), industry participation (e.g., Atty Bressler) to backyard planting and weed-pulling (e.g., Sylvan Kaufman and David Barnes). Because weed control is important to all of us, breaking through the political and social borders that separate our interests is vital. As Bob Parsons notes, we need scalable "coordinated weed management areas" which are not defined by jurisdictional boundaries and can be applied across the continent. This statement applies equally to our social organization: "We need scalable coordinated weed management **networks** which are not defined by jurisdictional boundaries".

At this fourth international **Weeds Across Borders** conference, managers, regulators and researchers came together from across North America to share information and discuss problems and solutions associated with the "trans-border" impacts and management of the plants we consider weeds. The conference was divided into 9 sessions (see the table of contents), plus a field tour and a keynote address at the banquet.

Sharing knowledge and successes and forging partnerships is an important process for effective management of the weed problems which trouble us all, no matter which side of "the border" we live or work on. Information is a powerful tool for understanding, planning and predicting, but to be effectively used it must be organized. Many of the presentations reported on initiatives of information management, including those by Val Miller and Richard Old. The handmaiden to the information tool, is "education", where information delivery to a greater population can bring about awareness and behaviour changes (e.g., Polly Knowlton Cockett and Nelroy Jackson). Many of the presentations stressed the roles, organization and successes of multi-level partnerships (e.g., Crystal Klym and Gail Wallen, Anna Lyon et al., and, Dawn LaFleur et al.). While all these actions are important, it is equally important that we continually ask critical questions about our goals and processes in order to evaluate what we are doing and why. As our keynote speaker Brendon Larson pointed out, perception and framing is critical in problem solving – the way we approach the "problem of weeds" will influence solution processes and outcomes.

It is hoped that the conference and its proceedings will provide not only an understanding of some aspects of the "weed problem", but will engender new and coordinated approaches to vegetation management, and inspire new visions and partnerships across our self-imposed borders.

Weeds Across Borders 2008 – Conference Schedule

Tuesday, May 27th

4:00 p.m. Registration opens

5:00 p.m. Alberta Invasive Plants Council Annual General Meeting

7:00 p.m. Welcome Reception

Wednesday, May 28th

8:00 a.m. Welcome to Weeds Across Borders 2008 View from the North
Bonnie Harper-Lore & Karen Sunquist

8:15 a.m. Official Welcome to Weeds Across Borders 2008 View from the North
Kevin VanTigem, Superintendent, Banff National Park

SESSION 1: Status Reports

8:20 a.m. **Canada** – A Federal Response to Invasive Plants in Canada
Cory Lindgren & Claire Wilson

8:45 a.m. **United States of America** – Status of the Invasive Species Program in the United States of America in 2008
George Beck

9:10 a.m. **Mexico** – Invasive Weeds in Mexico: Overview of Awareness, Management and Legal Aspects
Francisco Espinosa Garcia

9:35 a.m. **North American Plant Protection Organization**
Ian McDonell

10:00 a.m. Break

SESSION 2: Cooperation and Partnerships

10:20 a.m. Weeds Across Borders Partnerships
Anna Lyon

10:40 a.m. First Nation Partnerships in Invasive Plant Management
Merci Hillis & Bob Drinkwater

11:00 a.m. A new approach to fight IS in New York State
Hilary Oles

11:20 a.m. National Invasive Weed Awareness Week (NIWAW)
Nelroy E. Jackson

11:45 a.m. Housekeeping Announcement and Poster Viewing

12:00 p.m. Lunch

SESSION 3: Applied Research Reports

1:00 p.m. Vegetative Management Using Controlled Sheep Grazing
Lisa Surber

1:20 p.m. Ecology, Biology and Control of Exotic Invasive Weeds on Federal Lands
Raj Prasad

1:40 p.m. Addressing the Invasive Aquatic Flowering Rush (*Butomus umbellatus*) in Headwaters of the Columbia River System
Mara Johnson

2:00 p.m. Weed Science Society of America
Anne Légère

SESSION 4: New Issues

2:20 p.m. Promoting Native Alternatives to Invasive Plants
Sylvan Kaufman

2:40 p.m. Predicting Invasive Plant Incursions & Early Detection Response Planning
Cory Lindgren

3:00 p.m. Break and Housekeeping Announcements

3:20 p.m. Computer Aided Plant ID
Richard Old

4:30 p.m. Federal Canadian and US Invasive Plants Committee: Structure and Function
Networking Session

Thursday, May 29th

SESSION 5: Field Tour

8:30 a.m. Depart
Gravel/borrow Pit Standards
Adrianne Peterson

Cooperation – The Key to Success
Bob Parsons

Glacier/Waterton International Partnership
Dawn Lafleur & Cyndi Dixon

6:00 p.m. Banquet
Keynote: 13 Ways to Juggle Our Conception of Invasive Species
Brendon Larson

Friday, May 30th

SESSION 6: Early Detection and Rapid Response

8:00 a.m. Housekeeping Announcements

8:15 a.m. Innovative Tools for the Transfer of Invasive Plant Management Technology
Judy Shearer

8:35 a.m. 2008 Update on Development of the U.S. National Early Detection and Rapid Response System for Invasive Plants – Thoughs on the Establishment of a North American Early Warning System for Invasive Plants
Randy Westbrooks

8:55 a.m. EDRR and the US Federal Incident Command Center
Al Tasker

9:15 a.m. Could New England's Early Detection Network Benefit Eastern Canada?
Leslie Mehrhoff & Randy Westbrooks

9:35 a.m. Building an Early Detection and Rapid Response Framework for BC - Successes and Challenges
Crystal Klym

10:00 a.m. Break

SESSION 7: Best Management Tools and Practices

10:20 a.m. Addressing the Threat of Invasive Alien Species in Alberta: A Tool for Assessing Risk & Prioritizing Response
Scott Millar

10:40 a.m. Weed Management in Alberta's Oil and Gas Industry
Kim Mackenzie & Atty Bressler

11:00 a.m. Invasive Alien Plant Program (IAPP) in BC
Val Miller

11:20 a.m. The Weeds of Mexico Website
Heike Vibrans

11:45 a.m. Poster Viewing

12:00 p.m. Lunch

SESSION 8: Economic and Ecological Impacts: Today and in the Future

1:00 p.m. Invasive Weeds and Climate Change: Threats and Consequences
Lewis Ziska

1:20 p.m. Natives Gone Wild: Climate Change and a History of a Yukon Invasion
Bruce Bennett

1:40 p.m. The National Wildlife Refuge System
Jenny Erickson

2:00 p.m. Break

SESSION 9: Public Policy and Awareness

2:20 p.m. Ecological Stewardship in the Urban Prairie
Polly Knowlton Cockett

2:40 p.m. Aquatic Weeds 101: What Terrestrial Managers Should Know
Al Cofrancesco

3:00 p.m. Phreatophytes Control for Water Supply Enhancement in Alberta
Cat Shrier

3:20 p.m. How Weeds Cross Borders
Indira Singh

3:40 p.m. Wrap Up

Introduction

Bonnie L. Harper-Lore
Federal Interagency Committee for Management of Noxious and Exotic Weeds

What you should know about this conference is it began in the 1990s as an attempt to share information among United States federal agencies in the partnership known as the FICMNEW[1]. The FICMNEW group was founded in 1994 by numerous U.S. agencies who recognized that weeds do not respect political boundaries, and that no single agency has enough resources to prevent and control weed invasions. As one of FICMNEW's initiatives the Weeds Across Borders conference was created to reach out across the continent to share information about weeds and encourage partnerships that would cross all political boundaries including international borders.

We now know that invasive species are a global issue and will require more information-sharing and larger partnerships. Weeds Across Borders (WAB) is just one piece of this global effort. Not only is WAB a networking venue for potential horizontal and vertical partnerships, it has become a conference that inspires the region in which it meets. Thus far WAB has met in Arizona (2002), Minnesota (2004), Sonora, Mexico (2006), and Alberta, Canada (2008).

In truth, these regions already knew that prevention and control of invasive weeds is a major problem, long before they hosted the respective conferences. Consequently, each recognized the value of the conference and volunteered to share what they have learned in their region with the rest of the continent. It was with great enthusiasm that Alberta took up the challenge to host the 2008 conference on the first night of the 2006 WAB in Hermosillo, Sonora.

1 FICMNEW is the acronym for the Federal Interagency Committee for Management of Noxious and Exotic Weeds. It includes 16 U.S. federal agencies.

The Alberta Invasive Plants Council (AIPC) has existed formally since 2004. However, the region was already active in the 1990s and the regional partnership of the AIPC was built on the efforts of many. It was inevitable that this active group would take the lead in hosting WAB 2008 and sharing their spectacular Rocky Mountain backdrop in Banff.

All Weeds Across Borders conferences have had comfortable and practical similarities in their format:

- no concurrent sessions — so everyone hears the same information
- hand-picked speakers to share applied research, policy changes, and best practices
- an all-day field trip to show on-the-ground practices, while providing networking opportunities

Each conference has been purposefully limited to less than 150 so that attendees can connect with the entire group of scientists, policy-makers, educators and practitioners in meeting potential partners from federal, state, and local agencies across many borders. No country or agency has the time or resources to learn all they need by themselves and a recurring theme at all the WAB conferences has been the importance of partnerships.

The 2008 Weeds Across Borders was no exception. The setting was new, but the high-energy exchanges continued among Mexico, the U.S. and Canada. Beyond the information agenda, we discussed a possible Memorandum of Understanding (MOU), a trilateral agreement first raised by an ad hoc group in 2004. With the help of the U.S. State Department, we presented a draft MOU for consideration. A committee of six volunteers will review and report back in 2010. In the meantime, existing momentum materialized in a Banff Accord, a simple cooperative statement signed by attendees. Weeds Across Borders will continue to inspire increased collaboration and continental cooperation with the 2010 conference set for Shepherdstown, West Virginia.

Responding to Invasive Plants in Canada (2005–2008)

Cory Lindgren

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Abstract

Invasive plants are those harmful plant species whose introduction or spread threatens the environment, the economy, or society, including human health. Increases in international trade, travel, transport and tourism have created new and unique pathways for the intentional and unintentional introduction of invasive plants. Currently, about 24% of Canada's flora is comprised of introduced plant species, and about 38% of these (462 species) have been reported as weedy or invasive. Available data suggests that about 58% of invasive alien plants in Canada are the result of intentional introductions.

The Government of Canada and its Provincial and Territorial counterparts introduced An Invasive Alien Species Strategy for Canada in September 2004. While Environment Canada is the lead federal department, the Strategy is carried out in cooperation with federal, provincial and territorial governments, as well as non-governmental agencies,

Resumen

Las plantas invasoras son especies dañinas cuya introducción o propagación amenaza el medio ambiente, la economía o la sociedad, incluyendo la salud humana. El aumento del comercio tradicional, el transporte y el turismo han creado vías nuevas y únicas para la introducción intencional y no intencional de plantas invasoras. En la actualidad, alrededor del 24% de la flora de Canadá está constituida por especies de plantas que fueron introducidas y alrededor de 38% de éstas (462 especies) se consideran malezas o invasoras. Los datos disponibles sugieren que alrededor del 58% de las plantas invasoras en Canadá han sido introducidas intencionalmente.

El Gobierno de Canadá y sus homólogos provinciales y territoriales presentaron una estrategia nacional sobre las especies exóticas invasoras para Canadá (An Invasive Alien Species Strategy for Canada) en septiembre de 2004. Si bien el Ministerio del

academic institutions, and individual Canadians. The Canadian Food Inspection Agency (CFIA) is providing leadership in the implementation of the Strategy as it relates to invasive plants and plant pests.

The CFIA and its partners have initiated a number of projects that will comprise an overall invasive plant program for Canada. A Canadian Invasive Plant Framework will identify priority actions and roles and responsibilities of key partners and stakeholders under five implementation strategies — risk analysis, science, legislation and regulations, education and outreach, and international cooperation. International pest risk analysis methods are being reviewed and adapted for use in assessing and screening potential invasive plants, including intentionally imported plants for planting. Other projects include: preliminary surveys for invasive plants in Ontario and Nova Scotia, risk management responses to woolly cupgrass in Quebec and jointed goatgrass in Ontario, development of a Plants of Canada database, and development of an invasive species website with Environment Canada. The CFIA is also jointly involved in administering a funding program, the *Invasive Alien Species Partnership Program*, to support Canadians in addressing invasive alien species, including invasive plants.

Medio Ambiente de Canadá es el ministerio federal líder, la Estrategia se lleva a cabo en cooperación con los Gobiernos federales, provinciales y territoriales, así como con organismos no gubernamentales, instituciones académicas y canadienses particulares. La Agencia de Inspección Alimentaria de Canadá (AIAC) dirige la aplicación de la Estrategia referida a plantas invasoras y a plagas y patógenos de plantas.

La AIAC y sus asociados han iniciado varios proyectos, que incluirán un programa general para Canadá destinado a las plantas invasoras. Un Marco Canadiense para Plantas Invasoras identificará las acciones prioritarias y los papeles y responsabilidades de los participantes e interesados clave en virtud de cinco estrategias de implementación: análisis de riesgo, ciencia, legislación y reglamentos, educación y promoción y cooperación internacional. Se están revisando y adaptando los métodos internacionales de evaluación de riesgo para utilizarlos en la evaluación y la detección precoz de plantas invasoras, incluyendo los vegetales importados intencionalmente para plantar. Otros proyectos incluyen: investigaciones preliminares sobre vegetales invasores en Ontario y Nueva Escocia, respuestas de manejo de riesgo para la *Eriochloa villosa* ("woolly cupgrass") en Quebec y la *Aegilops cylindrica* ("jointed goatgrass") en Ontario, el desarrollo de una base de datos sobre las plantas de Canadá, y el desarrollo de una website sobre especies exóticas invasoras con el Ministerio del Medio Ambiente. La AIAC participa también en la administración conjunta de un programa de subvenciones, el Programa de Cooperación sobre Plantas Exóticas Invasoras, destinado a ayudar a los canadienses a enfrentar el problema que ocasiona este tipo de vegetales.

Invasive plants are those harmful plant species whose introduction or spread threatens our environment, the economy, or society, including the well being of Canadians. Many of the barriers that have traditionally restricted the introduction, spread, and impacts of invasive plants have been removed or altered. Exponential increases in travel, tourism and trade, the increased transport speeds at which commodities and people traverse the globe, increased numbers of ports of entry, expanded exports and imports into new international markets, increased interest in the use of new and exotic plants by gardeners, and increased access to foreign ecosystems with new species, have all contributed to increases in new invasive plant introductions (Mullin et al. 2000).

It is widely recognized that climate change and invasive species are two of the most significant variables contributing to global environmental change, and that climate change is extending the distributions of invasive plants (Rahel and Olden 2008, Ziska 2009). The Intergovernmental Panel on Climate Change (IPCC) reported that climate change will extend the geographic ranges of species northward and upward in altitude (IPCC 2002). The IPCC further reported that increases in atmospheric CO_2 favour invasive plants allowing them to capitalize on global warming and we can expect increases in their numbers, further threatening ecosystems (IPCC 2002). In general, climate change will likely result in new invasive plants establishing and spreading into regions of Canada where they were previously unable to survive. Climate change will also: allow once benign species to become invasive (e.g., the mountain pine beetle, *Dendroctonus ponderosae*, in western Canada); alter pathways of introduction and international travel; increase the demand for new exotic garden plants based on changing plant hardiness zones; and, require managers and policy makers to find new strategies to control species that were not traditionally problematic, thereby increasing the overall economic costs to Canada (Hellmann et al. 2008, McKenney et al. 2007, Rahel and Olden 2008, Van der Veken et al. 2008).

With the removal of many of the traditional barriers that have limited introductions of invasive plants, together with climate change scenarios, Canada can expect more invasive plants in the future. This paper summarizes some Government of Canada initiatives aimed at responding to the issue of invasive plants.

An Invasive Alien Species Strategy for Canada

The Government of Canada in partnership with its Provincial and Territorial counterparts, published An Invasive Alien Species Strategy for Canada in September 2004 (Government of Canada 2004). Environment Canada is the lead federal department for the Strategy which is being delivered in cooperation with federal, provincial and territorial governments, as well as non-governmental agencies, academic institutions, and individual Canadians. The Canadian Food Inspection Agency (CFIA) is providing leadership in the implementation of the Strategy as it relates to invasive plants and plant pests. In response to invasive plants, the CFIA and its partners have initiated a number of projects that will provide the foundations for an overall invasive plant program for Canada.

The Canadian Food Inspection Agency

The Canadian Food Inspection Agency (CFIA) was established in its current form in 1997 to safeguard Canada's food supply and the plants and animals upon which safe and high-quality food depends. The CFIA is the Government of Canada's key science-based regulatory agency and Canada's National Plant Protection Organization. Invasive alien species are recognized as a cross-commodity issue involving various branches and sections within the CFIA including Plant Health, Plant Production, Plant Biosafety, and Science Branch as well as Communications and Operations. In 2005, the CFIA received five years of funding to implement portions of *An Invasive Alien Species Strategy for Canada*. The agency has responded by forming a new Invasive Alien Species section that is responsible for leading the development of an invasive plants program as well as developing regulatory responses to invasive species in general.

Invasive Alien Plants in Canada Report

A benchmark publication, *Invasive Alien Plants in Canada* was completed in 2008 (CFIA 2008). The report describes the kinds of invasive plants found in Canada, where they occur, what effects they have, and some of the actions that are being taken to deal with them. There are 1,229 alien vascular plant species in Canada, adding up to roughly one-quarter of the national flora. Of these, 486 are considered weedy or invasive. The number of invasive plant species varies widely by province and territory with the most found in Ontario (441) and Quebec (395), followed by British Columbia (368), while Nunavut has the fewest (16) (Figure 1). Over 80% of the invasive alien plants in Canada originated from Europe, western Russia, the Mediterranean and northern Africa. About 58% of invasive alien plants in Canada are the result of intentional introductions with the majority of these being introduced as ornamental or landscaping plants. Other species have been introduced unintentionally as weed seeds in imported seeds, grains and soil or attached to vehicles and machinery. *Invasive Alien Plants in Canada* is available both as a summary report and as a longer technical report through the Canadian Food Inspection Agency's Invasive Plants Section.

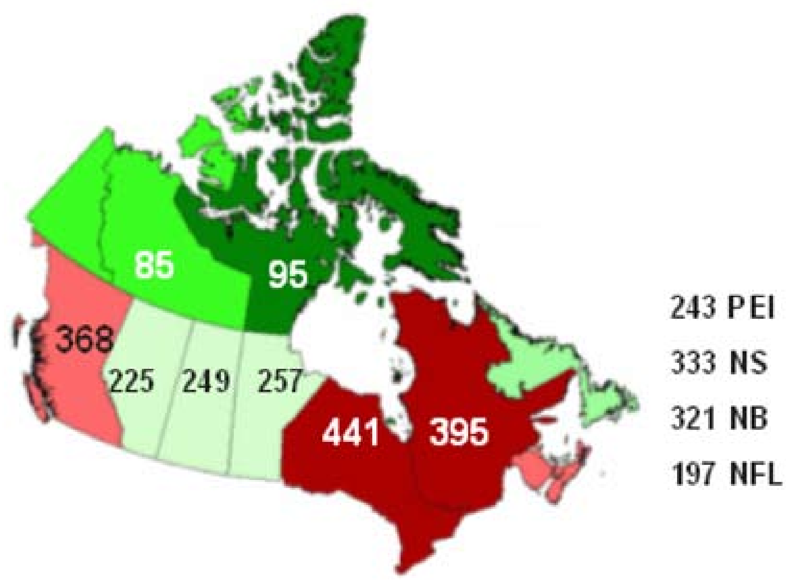

Figure 1. The number of invasive plant species in Canada varies widely by province and territory. Ontario, Quebec, and British Columbia have the most while Nunavut has the fewest (CFIA 2008).

Canadian Invasive Plant Framework

The CFIA is leading the development of a Canadian Invasive Plant Framework (CIPF). A Canadian Invasive Plant Framework will provide proactive national direction and coordination demonstrating that Canadians are world leaders in plant health protection, committed to working cooperatively towards protecting our resource base and biological diversity, and protecting our import and export trade markets from the influences of invasive plants. The objective of the CIPF will be to outline the roles and responsibilities of governments, non-government organizations, and Canadians in the prevention, early detection, response, and management of invasive plants. The Framework will be implemented in partnership with government agencies, non-government partners, and external stakeholders whose input and feedback into the development of the CIPF will be essential. Responding to invasive plants in Canada is a shared responsibility that will require unique and strong partnerships, a blending of regulatory and non-regulatory cultures, and a sharing of new technology and best practices. The framework will identify priority actions and roles and responsibilities of key partners and stakeholders under five implementation strategies – risk analysis, science, legislation and regulations, education and outreach, and international cooperation. The remainder of this paper outlines some of the diverse activities relating to invasive plants that have already been initiated as the CIPF is under development, and which will ultimately form components of the framework.

Pest Risk Analysis

Pest risk analysis is the process by which the CFIA evaluates species that may be introduced intentionally or unintentionally into Canada, in order to prevent new introductions of pests, including weeds and invasive plants. Pest risk analysis includes risk assessment and risk management. Risk analyses are initiated when there is a new pest situation either in Canada or abroad that has implications for Canada, or when there is a new trade situation that presents risks not previously addressed.

Risk assessments compile and summarize relevant information to assist with decisions about which species should be regulated, and what regulatory measures might be appropriate. Currently, the CFIA uses a structured, semi-quantitative approach to risk assessment that is based on international standards (e.g., IPPC 2 006). This approach is designed primarily to address unintentional introductions of plant pests (e.g.: weed seeds in grain shipments; insects in wood packaging; plant diseases in imported nursery stock; etc.). Risk assessments may be conducted for a single pest (e.g., woolly cupgrass) or for all pests potentially associated with a commodity (e.g., flax seed from New Zealand). Overall risk for a given pest is calculated as a combination of probability of introduction and consequences of introduction, as follows:


PEST RISK ASSESSMENT

FLAX SEED FROM NEW ZEALAND

CFIA ACIA

Risk = probability × consequences

Probability of introduction addresses the likelihood of a pest (weed) entering, becoming established, and spreading in Canada. Consequences of introduction include potential economic, environmental, and social effects of pest introduction. Risk is expressed qualitatively ("negligible", "low", "medium" or "high") and the word ratings are converted to numbers to calculate an overall rating for risk. Guidelines and examples are provided for each stage of the process to help ensure consistency between risk assessments and assessors. The final product is a researched and peer-reviewed document that includes a fact sheet summarizing the available information on the species, in addition to the risk assessment component.

More recently, the CFIA has begun researching alternative methods for weed risk assessment, designed for pre-import screening of live plants for planting and/or propagation. Current risk assessment methods are well suited to addressing unintentionally introduced plants, but are too extensive and time consuming to be of practical use for screening new plant species proposed for import. This would require a screening tool, or abbreviated risk assessment system to determine which species may be imported and which ones should be excluded. A streamlined screening tool that requires less time and documentation would minimize impacts on trade and facilitate compliance.

Two countries (Australia, New Zealand) and the State of Hawai´i have already implemented measures for screening new species of plants for potential invasiveness. The method used is a weed risk assessment system developed in Australia (Pheloung et al. 1999). This is a spreadsheet-based system consisting of 49 questions that address aspects of climatic suitability and potential for weediness or invasiveness in the area of concern. Answers are scored, and an overall score is generated for each species, to determine whether it will be accepted for import, rejected, or held back for further study. There is ongoing research to test the accuracy of the system in different parts of the world. The system is of considerable interest to Canada, and the CFIA has initiated a project to test it in Canada, following the work that has been done in Australia and New Zealand (Pheloung et al. 1999), Hawaii (Daehler and Carino 2000; Daehler et al. 2004), Florida (Gordon et al. 2008), the Czech Republic (Křivánek and Pyšek 2006), and Japan (Nishida et al. 2007). This work will determine whether the system could be effectively used in Canada as a method of screening new proposed plant introductions.

At the North American level, the CFIA is also involved in drafting guidelines for the North American Plant Protection Organization (NAPPO) on the subject of pre-import screening for plants for planting. The draft guidelines (*RSPM No. 32: Pest Risk Assessment for Plants for Planting as Quarantine Pests*) is currently under final review and is anticipated to be finalized and adopted by Canada, the United States, and Mexico in October 2008.

Weed species for which CFIA risk assessments have been completed or are currently in progress include: *Aegilops cylindrica* (jointed goat grass); *Arundo donax* L. (giant reed); *Cabomba caroliniana* A. Gray (fanwort); *Crupina vulgaris* Cass. (common crupina); *Echium plantigineum* L. (Paterson's curse); *Eriochloa villosa* (woolly cup grass); *Halogeton glomeratus* (M. Bieb.) C. A.

Mey. (salt-lover); *Miscanthus* spp. (*M. sacchariflorus* (Maxim.) Benth., *M. sinensis* Anderson and *M. (giganteus* Hodkinson & Renvoize); *Nassella trichotoma* (Nees.) Hack. ex Arechav. (serrated tussock); *Nymphoides peltata* (S. G. Gmel.) Kuntze (yellow floating heart); *Persicaria perfoliata* (L.) H. Gross (mile-a-minute-weed); *Pueraria montana* (Lour.) Merr. (kudzu); *Soliva sessilis* (carpet burrweed); *Tamarix* spp. (salt-cedar); and, *Trapa natans* L. (European water chestnut).

Weed risk assessment is part of the overall risk analysis approach that also includes risk management. Risk management explores available options to reduce the risk of a potential pest. Risk Management Documents (RMDs) have been completed or are under development for a number of the above species.

Surveys for Invasive Plants

In 2007, surveys were conducted in Ontario and Nova Scotia at high risk entry sites for high risk invasive plants (i.e., "hot spots for hot species"). Survey efforts focused on "hot spots" such as ports, grain elevators, railways, and campgrounds, where commodities may be loaded or unloaded. The CFIA has also partnered with the Ministry of Agriculture in Quebec (Le ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec) to respond to an incursion of woolly cupgrass (*Eriochloa villosa* (Thunb.) Kunth). Eradication and survey plans have been developed. Woolly cupgrass was first found in Quebec in 2001 and is an annual weed of agronomic crops. Surveys have also taken place in Ontario and Manitoba for jointed goatgrass (*Aegilops cylindrica* Host), which is an introduced annual weed in wheat crops in the United States. Additional initiatives include surveys in western Canada for saltcedar (*Tamarix* spp.) and supporting survey work for carpet burweed (*Soliva sessilis* Ruiz & Pavón) in British Columbia.

Plants of Canada Database

The CFIA, in partnership with the Canadian Forest Service is working on a complete, up-to-date, searchable database of plant species in Canada, that includes basic information about identity, distribution, habitat, biology and other plant characteristics. This database will increase the accessibility and accuracy of information about plants in Canada that is fundamental to the implementation of *An Invasive Alien Species Strategy for Canada*. The database is currently under development and will undergo an internal trial period this year. It is hoped that it will ultimately be made available to the public, on the invasive alien species web portal (described below).

New Invasive Alien Species Website

A new invasive alien species (IAS) website is currently being developed by the CFIA and Environment Canada. The web portal will provide Canadians, federal and provincial governments, international governments, industry, and non-governmental organizations with information on the Government of Canada's efforts to reduce the impacts of invasive plants on our environment, economy, and society including human health.

It is anticipated that the IAS web portal will: facilitate access to information for Canadians; serve as a gateway to links to federal web sites with existing IAS web information; promote information sharing among the various Canadian organizations involved with IAS; allow government institutions to quickly centralize information about various IAS; help to implement the public education portion of *An Invasive Alien Species Strategy for Canada*; and, improve understanding of the Government of Canada efforts to reduce the impacts of invasive alien species on human health and society, the environment, and the economy. Some existing Government of Canada IAS websites and links:

- The Canadian Food Inspection Agency — Invasive Alien Species website
- Environment Canada — Invasive Alien Species in Canada website
- Fisheries and Oceans Canada — Aquatic Invasive Species website
- Canadian Forest Service — Alien Forest Pests website

Invasive Alien Species Partnership Program

An important component of the Invasive Alien Species Strategy for Canada is the $5-million dollar, 5-year Invasive Alien Species Partnership Program (IASPP). This is a funding program, jointly administered by the CFIA, Environment Canada, and the Department of Fisheries and Oceans Canada. The Partnership Program supports non-federal initiatives that address invasive alien species including invasive plants. Since 2005, the program has invested approximately $3-million dollars in 78 projects that engage Canadians in preventing, detecting and managing invasive alien species. In addition, thirty-three new projects have been approved for the 2008/09 fiscal year. The IASPP will be accepting proposals for new projects again in the fall of 2008. For additional information visit: www.ec.gc.ca/eee-ias/

Invasive Plant Councils

Responding to invasive plants is a shared responsibility between all levels of government, non-government partners, and stakeholders. The capacity to address invasive plants in Canada has grown as provinces and territories are forming invasive plant councils (IPCs) and invasive species councils, to respond to regional issues. In western Canada, there is the British Columbia Invasive Plant Council, the Alberta Invasive Plant Council, the Yukon Invasive Plant Committee, and more recently both Saskatchewan and Manitoba have formed Invasive Species Councils. Ontario has formed an Ontario Terrestrial Invasive Plant Council, and meetings have been held in Quebec and in the Atlantic Provinces with regards to forming regional councils. The Government of Canada supports and encourages the formation of invasive plant councils as they will provide important linkages between government and the regions. In many cases, both federal and provincial/territorial representatives participate on IPCs. Many of the councils have received financial support from the Government of Canada's Invasive Species Partnership Program.

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Biography

Cory Lindgren is a Senior Program Specialist with the Invasive Alien Species section of the Canadian Food Inspection Agency leading the development of a Canadian Invasive Plants Framework. He has worked with invasive alien species for over 16 years and published numerous papers in peer-reviewed journals including Biological Control, the Canadian Field-Naturalist, Journal of Aquatic Plant Management, and Weed Technology; and, contributed chapters to books such as the Alien Invaders in Canada's Waters, Wetlands, and Forests. Past work includes work with Cornell University to collect classical biological control agents from Europe and release against Purple Loosestrife in Canada. Currently a member of a technical advisory group with the North American Plant Protection Organization.

Claire Wilson was born and raised in Ottawa, Ontario. She has a B. Sc. (Hon.) in Biology and Environmental Science and an M. Sc. in Watershed Ecosystems (Plant Ecology/Agriculture), both from Trent University in Peterborough, Ontario. For the last eight years she has worked in the Plant Health Risk Assessment Unit of the Canadian Food Inspection Agency, first in Ottawa and now based in Dartmouth, Nova Scotia. Her responsibilities include researching methods for predicting plant invasiveness, writing pest risk assessments for weeds and/or invasive plants, and providing technical information on weed species in Canada or abroad in support of import and export programs for plants and plant products. She was also involved with the development of Canada's National Invasive Alien Species Strategy, and the related Action Plan for Invasive Alien Plants and Plant Pests.

Status of the Invasive Species Program in the United States of America in 2008

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Abstract

Invasive weeds and invasive species are an extremely important contemporary environmental issue. Much effort has been exercised over the past 20 years by many people to get local, state, and federal government agencies and the general public to embrace this issue and take action. The formation of the National Invasive Species Council in 1999 was a huge step forward in the United States. A new Administration in 2000 altered progress primarily because of money being spent overseas, but catastrophic fires and soaring oil prices caused a shift in natural resource management priorities. This caused a paucity of fiscal resources to be available, which impeded but did not terminate progress. Industry concern over regulations that might be imposed to thwart invasive species created new challenges and opportunities to work collectively to develop concepts and programs that can be accepted willingly by parties directly and indirectly affected by this issue. State and county governments are becoming more engaged in invasive species management and are setting an example for the federal government, including Congress, to follow. To definitively solve the invasive species problem

Resumen

Las malezas invasoras y las especies invasoras son un asunto ambiental contemporáneo extremadamente importante. Muchas personas han realizado muchos esfuerzos los últimos 20 años para conseguir que este problema sea reconocido y se tomen acciones por parte de agencias a escala local, estatal, federal y por el público general. La formación del Consejo Nacional sobre Especies Invasivas en 1999 fue un avance enorme en los Estados Unidos. Una nueva Administración en 2000 alteró el progreso sobre todo debido al dinero que gastó en el extranjero, pero los incendios catastróficos y los precios altísimos del petróleo causaron un cambio en sus prioridades de manejo de recursos naturales. Esto causó baja disponibilidad de recursos fiscales, que interfirió, pero no terminó, con el progreso. Las preocupaciones de la industria sobre regulaciones excesivas para impedir la entrada y expansión de especies invasoras crearon nuevos retos y oportunidades para trabajar colectivamente para desarrollar los conceptos y los programas que las partes afectadas puedan aceptar voluntariamente. Los gobiernos del estados y condados cada vez se involucran más con el manejo de especies invasivas

and provide for effective management in the future, all levels of government must be engaged as well as private industry and these entities must be supported if not prodded along by an educated general public.

y se están convirtiendo en un ejemplo a seguir para el gobierno federal, incluyendo el Congreso. Para solucionar definitivamente el problema de las especies invasoras y proveer un manejo eficaz en el futuro, todos los niveles del gobierno deben ser involucrados al igual que la industria privada, y estas entidades deben ser apoyadas, si no es que acicateadas, por un público general educado.

Brief History

Many people have worked for many years to bring the United States invasive species program to where it is today. However, the US invasive species program began in earnest with a fateful trip to Washington, D.C., in December 1996. Drs. Dan Simberloff (University of Tennessee), Phyllis Windle (Union of Concerned Scientists), George Beck (Colorado State University), and Mr. Don Schmitz (Florida Department of Environmental Protection) and Mr. George Hittle (Wyoming Department of Agriculture) visited with President Bill Clinton's science advisors about the invasive weed problem on federally managed lands especially in the western US President Clinton's science advisors suggested that federal agencies were addressing the problem but we politely, yet adamantly, disagreed. A letter to Vice-President Al Gore was produced as an outcome of this meeting describing the invasive species problem in the United States and the need for the federal government to take the lead and effectively contend with the entire issue. The letter was signed by 500 US scientists and out of this came Executive Order 13112, Invasive Species. The Executive Order created the National Invasive Species Council (NISC) in 1999, which was first comprised of the Secretaries of Agriculture, Interior, Commerce, State, Transportation, Defense, Treasury, Health and Human Services, and the Administrators of the Environmental Protection Agency and the US Agency for International Development. The Secretaries of Agriculture, Interior, and Commerce were designated as co-chairs of the National Invasive Species Council. Executive Order 13112 also created the Invasive Species Advisory Committee (ISAC), which is comprised of US citizens representing various industries, scientific disciplines, and interests, and provides advice to NISC on invasive species issues. A new Administration was elected in 2000 and while a significant portion of the federal budget was re-directed overseas, progress on invasive species slowed, but did not stop. For example, the Secretary of Homeland Security and the Director of the National Aeronautics and Space Administration recently were added as members of NISC in recognition of the breadth of the invasive species problem.

The National Invasive Species Management Plan was created in 2001 by the first ISAC and the federal partner agencies. This document provides guidance to federal agencies about invasive species and their management. It was a comprehensive blueprint for federal action on invasive species and acts as the primary coordination tool. The plan called for 170 actions to be implemented within nine categories and to date about 100 of these have been implemented or completed. The plan is required to be updated every 5 years and the next 5-year plan was completed in early 2008 and was circulated widely for public comment. The new plan is constructed around five strategic goals: 1) prevention; 2) early detection and rapid response;

3) control and management; 4) restoration; and, 5) organization and collaboration. The 2008 plan is not a comprehensive list of federal actions but instead a targeted set of strategic action plans with objectives and implementation tasks intended to be completed over the next 5 years. The success of the new plan clearly hinges on funds available from the federal budget for its implementation.

Where Are We Today?

What constitutes an invasive species is still quite contentious in the United States today from a public policy perspective. Many industries and private property rights advocates feel threatened by the issue, especially public policy development by state and federal governments. Some industries have unwittingly contributed to the problem in the past and some continue to do so. All are awaiting development of regulations associated with invasive species and all indicate they want to be part of the solution and not be part of the problem. The definition of an invasive species continues to be the source of tension. The third ISAC spent 2.5 years developing a document to explain what we mean and perhaps more importantly what we do not mean by an invasive species. Industry representatives on ISAC repeatedly indicated their willingness to adhere to reasonable and legitimate regulations that are based upon sound science, but some still are concerned over capricious and arbitrary rules and designations. Thus while industry wants to help solve the invasive species problem, they also want to proceed cautiously with appropriate justification.

The considerable energy and excitement about invasive species in Washington, D.C., is reassuring and suggests we can make progress on effectively contending with invasive species. This energy and concern, however, has not translated well to field levels of federal land management agencies largely because of conflicting priorities within middle- and upper-federal management and Administrative leadership. Some agencies are proceeding better than others and this often is due to leadership. For example, the Colorado State Conservationist with the US Department of Agriculture-Natural Resource Conservation Service created an Invasive Plant Program and awarded over $2.5 million in incentives over the past 2.5 years to stimulate the formation of weed management areas within Colorado. Federal invasive species programs seem to be best developed in those states with strong state invasive species programs; for example in Florida, Hawai‘i, Idaho, and Montana. There seems to be no national consensus on invasive species in the U.S. and while national leadership within the federal government (e.g., “federal line officers”) is fair, invasive species are simply a conflicting priority among the highest levels of the Administration. This is manifest in the federal budget. Money seems to be the largest impediment to federal agencies making progress on the invasive species issue; for example, US federal natural resource agencies have seen their entire budgets erode 25 to 50% over the past few years. The US Congress too appears to be struggling with decisions about what to do with invasive species. Currently there are 89 bills on invasive species in Congress and none are comprehensive relative to taxa or geography and only one has passed in this current session. Even when Congress passed bills in previous sessions, the new laws received little to no appropriations.

What Are the Solutions for Continued Progress?

If the United States is to continue making progress on invasive species, much less accelerate progress, state governments must become better engaged on the issue. Many states have well-developed invasive or noxious weed programs and laws, the efforts around which should be combined with all other invasive taxa to create all-taxa invasive species programs. Governors must assume leadership roles and fund programs within their borders and then create cooperative agreements with neighboring states to form regional cooperative invasive species management areas. After building such programs at state and regional levels, Governors then should lobby the US Congress and Administration to develop and sufficiently fund comprehensive invasive species management programs to complement state programs. Well-developed and well-funded comprehensive state invasive species programs will foster a similar response at the federal level, which in turn will help to develop international programs.

Summary

The United States has made progress on developing a reasonable comprehensive invasive species program over the past 20 years but it seems that the overwhelming majority of the work remains to be accomplished. Government at all levels must work with all of American society, and industry in particular, to develop acceptable and meaningful invasive species programs. Education is of paramount importance and invasive species must become integral parts of environmental awareness programs for grade schools, colleges and universities, and adult education. To definitively solve the invasive species problem and provide for effective management in the future, all levels of the US government must be engaged as well as private industry and these entities must be supported if not prodded along by an educated general public. The citizens of the United States and our government in particular should set an appropriate and strong example about invasive species internationally.

Biography

George Beck is a professor of weed science in the Department of Bioagricultural Sciences and Pest Management at Colorado State University (CSU). His appointment is split between Cooperative Extension (67%) and the Agricultural Experiment Station (33%) and he has been at CSU for 22 years. George works exclusively on invasive weeds. Numerous experiments are conducted each year on invasive weed management and ecology by George's students and research associate. George also has spent considerable time helping to develop policy on invasive weeds at the state and national levels by helping to write weed laws and making annual trips to Washington, DC, to educate the federal government and Congress about invasive weeds. George also is a member of the Invasive Species Advisory Committee for the National Invasive Species Council and serves on several advisory committees for the state of Colorado.

Invasive Weeds in Mexico: Overview of Awareness, Management and Legal Aspects

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Abstract

The status of the awareness, knowledge, management and societal involvement in invasive weeds in Mexico is reviewed. The invasive species awareness in Mexico is very limited, and it is concentrated mainly in a governmental commission and in a handful of university scientists. This is probably due to the relatively slow process in which exotic weeds become pests, gaining attention when mitigation or nothing can be done to control their effects. The invasive weeds identity and distribution at a national scale are reasonably known, but this knowledge, along with the invasive species abundance and impacts, is scanty, anecdotal or absent at a regional scale. The number of research projects or research products dealing with invasive weeds is very low considering the biodiversity and extension of Mexico. The legislation on invasive exotic weeds prevention covers only noxious species as contaminants in crop seeds for cultivation, but not as contaminants in grains or seeds for human or livestock consumption. The quarantined species list is incomplete and needs actualization. The risk analysis

Resumen

Se expone un panorama del conocimiento, manejo y participación de la sociedad en el problema de las malezas invasoras en México. La conciencia sobre estas especies en México es muy limitada, y se concentra principalmente en una comisión gubernamental y pocos académicos. Esto se debe posiblemente a la lentitud del proceso en el que las malezas exóticas se convierten en plagas. Se conoce en general la identidad y distribución de las malezas exóticas a escala nacional, pero este conocimiento es escaso, anecdótico o ausente en una escala regional. Los proyectos de investigación, o productos de la investigación, que se ocupan de malezas invasoras son muy pocos considerando la biodiversidad y extensión de México. La legislación sobre la prevención de malezas invasivas sólo cubre las especies nocivas como contaminantes en el cultivo de semillas para el cultivo, pero no como contaminantes en los granos o semillas para consumo. La lista de especies cuarentenadas es incompleta y necesita actualización. La unidad de análisis de riesgo en la Seceretaría de Agricultura sólo se ocupa de todo tipo de plagas

unit in the agriculture ministry is mandated to address only agricultural pests or potential pests from all phyla, but it is severely undermanned. Activities on early detection, eradication, containment or mitigation are severely limited or absent for weed pests. Although there are regulations and government institutions responsible for these activities, they are ineffective due to lack of personnel and interest in the problem. Besides a National Strategy to deal with weeds, a big environmental education campaign is needed to obtain societal awareness and action to deal with invasive weeds.

agropecuarias, pero carece de personal. Las actividades de detección temprana, erradicación, contención o mitigación son muy limitadas o inexistentes para malezas invasivas. Aunque existen reglamentos e instituciones gubernamentales encargadas de estas actividades, estos son ineficaces por la falta de personal y de interés en el problema. Además de una estrategia nacional para hacer frente a las malezas, se necesita una gran campaña de educación ambiental para concienciar a la sociedad y obtener la acción social para hacer frente a las malezas invasoras.

Introduction

> "No single agency has the authority, resources, expertise, or mandate to (unilaterally) deal with new invaders that are spreading in tandem with societal growth and development."
>
> (Westbrooks and Eplee in press)

At the very beginning, invasive weeds awareness is a process that culminates when invasives are very troublesome and they are very difficult or impossible to eradicate; the only viable counter measures left are containment and mitigation, both of them at a considerable cost. Thus, only when a lot of people have been affected by an invasive, the resulting awareness can be applied to early detection and eradication of other weed species. This new awareness can be used to prevent or manage further invasions only when the authority and/or the society become conscious of the global phenomenon of invasions (i.e., the recent successful invasion is the result of globalization and that many more potential invaders are already in the country or may enter it). It is also necessary to have all stakeholders recognizing the frequently not so obvious long-term environmental and economic damages caused by invasive weeds. Both top-down and bottom-up approaches are needed to raise awareness that can be transformed into management actions (Espinosa-García and Van Devender *in press*). Scientific information is essential to feed this process to identify the actual and potential invaders, to quantify or estimate the actual or potential damages attributed to the invaders, to estimate their actual and potential distribution, and to identify and or provide the best management options for these plants.

Invasive weed awareness in several sectors of society can be translated into actions to prevent and manage invasive weeds. Thus, by observing these actions, the awareness levels can be inferred to make a diagnostic of the status of the invasive weeds issue in the Mexican society. In this work, I will comment on some prevalent factors that influence invasive weed awareness in Mexico and then I will infer the invasive weed awareness in various sectors of society by looking at the actions corresponding to these sectors to prevent and/or manage invasive weeds (Table 1). Finally, I will review briefly the advances of the academic sector on invasive species in Mexico.

Table 1.
Invasive weed awareness must permeate in different sectors of society to be translated into actions.

Society Sector	Actions
Federal government Ministries State/province governments Municipal/County goverments	Invasive species policy Laws and regulations Law enforcement Coordination among govt. agencies Prevention design and operation Awareness rising Law-abiding compliance
Land managers and owners	Law-abiding compliance Early detection and eradication Containment, mitigation
Rural and urban society at large	Law-abiding compliance Early detection and eradication Containment, mitigation
Non-government Organizations	Facilitation and coordination of prevention, early detection and eradication Containment, mitigation Awareness raising
Academic sector	Scientific information on: Prevention, early detection and eradication Containment, mitigation Law-abiding compliance

General conditions that affect invasive plant awareness in Mexico

The Lag Phase in Plant Invasions

A great problem that interferes with weed invasive awareness is the invasion process of these plants. If the entrance and establishment of a newcomer are successful, the new plant population usually may spend years in the so called "lag phase", where the plant population is stable, no new populations are established and the newcomer may appear harmless or even useful (Williamson and Fitter 1996). For example, herbaceous invasives have spent 20–60 years in the lag phase, and the average lag phase for shrubs and trees is 131 and 170 years respectively, although there are examples of invasives with less than 10 years of lag phase (Kowarick 1995) (Table 2).

In contrast with other invasive organisms (insect pests, pathogens), the damaging effects of invasive weeds take much longer to be evident. Although there are a few examples of invasive weeds quickly becoming a problem, most have a long lag phase. Thus, it is easy to ignore the problem or postpone the necessary measures; in the worst case, a sector in the society may not want to take actions against the introduced plant due to the benefits that they obtain, and they can use the argument that in many years the plant has not caused any problem. Then, when the plant becomes troublesome, the reactive response arrives, but it is late, very expensive, and usually the only viable options are mitigation and containment.

The Weed Management Model Prevalent in Mexico

Weed management policy in Mexico is focused mainly in the regulation of herbicides and pays little or no attention at the field level (Arriaga *in press*, Espinosa-García and Vibrans *in press*). Although there are an intersecretariat commission (CICLOPLAFEST), three secretaries (SAGARPA, SEMERNAT, Health), five general laws (Federal level), and 13 regulations (Norma Oficial Mexicana) that regulate or have authority on herbicide or weed issues, the peasant or land manager decides how and when to apply weed management to his land. This individualistic model allows the establishment and dissemination of introduced invasive species, particularly along roads, property edges, or non-attended lands (Espinosa-García and Vibrans *in press*). This model combined with the lengthy lag phases of invasive plants results in recurrent invasions of weeds that are not eradicated.

The prevalent attitude towards environmental problems in the Mexican government

Mexico is a third world country with enormous problems that require urgent attention; they easily overshadow the potential problems caused by invasive plants in their lag phase, or the problems caused by them that are not human health problems. To make things worse, the non-written philosophy that prevails in the Mexican government dictates: a) a short-term vision focused on business; b) ignore environmental costs until they are impossible to evade; c) a reactive policy regarding environmental issues. Usually, environmental issues are seen as opposed to business or not worthy economically speaking; short-term money wins over environment.

Awareness at the Federal, State and Municipal Government Levels

Considering the general conditions that affect invasive weed awareness in Mexico, it is no surprise that invasive weeds are practically ignored by municipalities, states and most federal secretaries. This lack of awareness is reflected in the absence of concern about invasive weed problems at the state or municipal levels. At the federal level invasive weed awareness has been growing slowly, mainly as a reaction to international treaties dealing with commerce and biological diversity. These reactions started in the 1990's after Mexico signed the World Trade Agreement, the International Plant Protection Convention and the Convention of Biological Diversity.

Although Mexico signed the International Plant Protection Convention (IPPC) on May 26, 1976, the country started to work on plant protection legislation encouraged by the World

Table 2. Examples of the lag phase duration for invasive weeds

Bromus tectorum in USA	20 years + 20 years of logistic expansion (grass). Mack (1981).
Phellodendron amurense in USA	+100 years (tree). Niemiera and Von Holle (2007).
Hieracium pilosella in Britain	50 years (herb). Groves (2006).
Fallopia japonica in Britain	54 years (herb). Groves (2006).
Psidium guajava in the Galapagos	80 years in San Cristobal Island and 40 years in Santa Cruz Island (tree). Groves (2006).

Trade Organization, where "… the role envisioned for the IPPC was to *encourage international harmonization* and *elaborate international standards* to help *ensure that phytosanitary measures were not used as unjustified barriers to trade*" (IPCC 2006). For invasive plants, the new legislation included those of agricultural importance ignoring environmental weeds. A later revision of the IPPC to include the protection of non-cultivated flora was proposed in 1997. Mexico signed the new revised text on June 28, 2000, but it became into force on October 3, 2005. The North American Free Trade Agreement included the formation of a chapter of the IPPC, which is the North American Plant Protection Organization (NAPPO). This organization has worked to encourage new regulations in Mexico, United States and Canada regarding risk and pathway analysis for invasive species including invasive environmental weeds. The IPCC and NAPPO and the derived regulations have devolved mainly to the Secretary of Agriculture (SAGARPA) in Mexico. However, some of these regulations are not enforced properly (or not enforced at all) due to lack of personnel, that is the result of a policy of systematic reduction of qualified personnel in the departments concerned with plant protection in SAGARPA (Espinosa-García and Vibrans *in press*).

As a signatory of the international Convention on Biological Diversity (CDB), Mexico is required to study the invasive species and their effects in the country. CONABIO (National Commission for the study and use of Biodiversity), a federal agency, has been assigned the CDB compliance including the invasive species related requests. This agency contacted the academics whose research lines were related with invasive species, organized workshops and encouraged research on invasive species. The result of these actions has produced lists of invasive species and a prioritization of them (CONABIO 2008), that will be used as a contribution for the design of a national strategy for invasive species (also required by the CBD). Thus, the reactive invasive weed awareness in CONABIO has induced awareness in the academic sector, although the number of academics working on invasive species is very low. For example, the significant publication "Especies invasoras de alto impacto en la biodiversidad" (Invasive Species of High Impact on Biodiversity) was authored by 27 academics (IMTA et al. 2008), which represent the majority of people working with all kinds of invasive species for the whole country.

Few sectors in two secretaries, SAGARPA (agriculture) and SEMERNAT (environment), and CONABIO are aware of invasive weeds, but there is little or no coordination among them. SAGARPA occupies itself with invasive species economically important for agriculture or livestock and ignores environmental weeds, whereas CONABIO focuses on the invasive species affecting biodiversity and ecosystem services, ignoring the agricultural weeds. In my opinion, this is not the optimal strategy to deal with invasive weeds, because many environmental weeds affect also agricultural/livestock activities and both types of weeds may share introduction pathways. Additionally, within the federal government there are contradictory policies regarding invasive species, where some species are promoted in spite of their known effects as invasives elsewhere (Arriaga *in press*). Invasive weeds awareness raising programs for the general public do not exist.

Awareness in land managers, owners and rural and urban society at large

Invasive weed awareness in these sectors is practically non-existent. For the land managers, rural owners and rural society at large, weeds in general are seen as a nuisance or as useful plants, and they do not distinguish between native and introduced weeds (Espinosa-García and Díaz Perez 1996, Vieyra-Odilón and Vibrans 2001, Blanckaert et al. 2007). The invasive weeds that became a problem, such as *Eichhornia crassipes, Roetboellia cochinchinensis, Convolvulus arvensis* or *Sorghum halepense* are seen as noxious plants, but most people are not aware of their introduced status. This is due in part to the prevalent individualistic weed management model and the disarticulated or nonexistent activities of the government related to weedy plants (Arriaga *in press*, Espinosa-García and Vibrans *in press*).

In spite of the great concentration of introduced weeds in Mexican urban areas (for example, Mexico City (Vibrans 1998, Díaz-Betancourt 1999, Zavala et al. 2003), people see weeds as an undifferentiated group of undesirable or worthless plants.

For most urban and rural people the scientific name of a plant, its invasiveness or potential noxious effects are alien concepts. As a consequence, such plants as water hyacinth are freely sold, bought and introduced in water bodies. Proposed legislation forbidding commerce and introduction of water hyacinth to water bodies was written three years ago, but the initiative is frozen in Congress, and it seems that it will never be approved (Marisela Martínez, IMTA, personal communication). It is clear that a great deal is left to be done to raise awareness about invasive weeds in the general public.

Awareness in Non-Government Organizations

To the best of my knowledge, there are only two NGO's working in Mexico with invasive species, but they have done very significant work. Ignacio March, Director of The Nature Conservancy, Chapter Mexico (TNC) and CONABIO have been facilitating academic and federal representatives meetings to work on invasive species checklists for Mexico and for establishing national priorities to deal with invasive species. Both Ignacio and Marisela Martínez (Instituto Mexicano de Tecnología del Agua, SEMERNAT) were key in the production of the book about invasive species of importance for biodiversity in Mexico (CONABIO 2008). TNC has also played a key role in stopping a tamarisk (*Tamarix* sp.) plantation program lead by the government of the Federal District. The other NGO is Grupo de Ecología y Conservación de Islas A.C., that has been working in Baja California's islands eradicating invasive species successfully.

The involvement of many more NGO's is needed, but that probably will occur as more invasive weed awareness rises in Mexico.

Awareness in the Academic sector

Invasive weed awareness has been of little concern for academics in Mexico for a long time. The main concern for botanists has been the vegetation description and the inventory and conservation of the estimated 30,000 species of flowering plants in Mexico. The ecologists (that reached a significant number in the last quarter of the twentieth century), were more concerned with vegetation dynamics, habitat loss and fragmentation. Agronomists in turn, have been occupied with productivity increase and battling pests, weeds and pathogens. Unfortunately, some activities related with forages have been the responsible for introducing dozens of grasses, many of which now are noxious invasive species. Although there were some early publications on invasive plants, invasive weed research did not seriously begin until CONABIO (particularly the remarkable ecologist, Dr. José Sarukhán) stimulated it in the 1990's. I will describe the early work on invasive weeds and then I will present a brief overview of the advances of this topic in Mexico (see also: Espinosa-García and Van Devender *in press*, Espinosa-García and Vibrans *in press*, Espinosa-García et al. *in press*).

Early Developments on Invasive Weed Knowledge

Agronomists and peasants have long been aware of the weedy plants that affect their fields, crops and cattle. However, they do not differentiate between native and introduced species, and therefore, their management measures were the same for both groups. For most Mexican botanists, invasive plants have not been an issue prior to the 1990's, and in most cases simply pointing out the introduced nature of some of the plants that they collected. The earliest work on a spreading invasive species is that of Itie (1945) on *Melinis repens* (Natal grass), a deliberately introduced African forage grass that escaped from experimental lands and now occupies the roadsides of most highways in Mexico and grows within wild semiarid lands (Lozano-González et al. *in press*). Another early paper on invasives was that of Rzedowski (1959) on the spreading *Salsola kali* in the semiarid Mexican plateau. Several works reported on introduced species as new records for several regions (i.e., Lot et al. 1980), but few of them recognized the potential for naturalization and spread of the introduced weeds; for example the work of Espinosa (1981) on *Polygonum convolvulus*, *Kickxia elatine* and *Lamium amplexicaule*. A few other works were published on the ecology of invasive species before the 1990's, such as demography of *Eichhornia crassipes* (Niño-Sulkowska and Lot 1980), *Nicotiana glauca* (Hernández 1981) and *Hydrilla verticillata* (Novelo and Martínez 1989). A couple of remarkable botanists, Dr. Graciela Calderón de Rzedowski and Dr. Jerzy Rzedowski, have included among their wide interests, the detection and observation of introduced species. They published a paper including 33 introduced species of African origin, many of which are species of concern as agricultural or environmental weeds (Rzedowski and Calderón de Rzedowski 1990).

Recent Developments on Invasive Weed Knowledge

Although many floristic studies have started to recognize introduced weeds, most of them included such species in lists. A steady increase of papers related to invasive species started in 1995, recognizing new introduced species in Mexico (Vibrans 1995, 1996, 2003, Nava-Rojo et al. 2002, Rzedowski et al. 2003, Rzedowski and Calderón de Rzedowski 2005, Vibrans and Hanan-Alipi

2008), or producing lists of introduced species and analyses of their distribution for a region or for the whole country (Van Devender et al. 1997, Vibrans 1998, Espinosa-García et al. 2004a, Villaseñor and Espinosa-García 2004, Espinosa-García et al. *in press*, González-Elizondo et al. *in press*, León de la Luz et al. *in press*, Serrano-Cárdenas et al. *in press*, Van Devender et al. *in press*). An important advance for the public knowledge of weeds, including the invasives, is Heike Vibrans' Weeds of Mexico website, where high quality pictures and information is displayed for 800 species (Vibrans, this volume). Research on the influence of disturbance on the distribution of invasive species has been done in coastal dunes (Castillo and Moreno-Casasola 1996), wetlands (López-Rosas et al. 2006), urban habitats (Corral-Díaz and Pelayo *in press*), agricultural habitats (Blanckaert 2007, Martínez-Díaz and Jiménez-León *in press*), cattle ranching (Travieso-Bello et al. 2005) and mining activities and agriculture (Alfaro-Rodríguez and Arriaga 2006); also, there is a study on the factors that explain introduced weed species richness for Mexico (Espinosa-García et al. 2004b).

Research on invasive weeds' impact in Mexico is scarce (Espinosa-García et al. *in press*), although some recent papers on impacts of specific invasives have been published for *Echinochloa pyramidalis* in tropical wetlands (López-Rosas et al. 2005), *Brassica tournefortii* in the Sonoran Desert (Dimmit and Van Devender *in press*), and several studies on buffel grass (*Pennisetum ciliaris*) in the Sonoran Desert (overviewed in Espinosa-García and Van Devender *in press*).

The Weeds Across Borders (WAB) initiative has fostered research on invasive weeds in Mexico, and the most important example is the book "Invasive Plants on the Move. Controlling them in North America" that resulted from the third WAB conference held in Hermosillo in 2006 (Van Devender et al. *in press*). A national weed management strategy is one of the biggest challenges for Mexico (Espinosa-García and Vibrans *in press*), and a big step in that direction has been the publication of a book on priorities in Mexico for invasive species (IMTA et al. 2008), where potential high impact species are identified, and the incidence of some environmental weeds in natural ecosystems is recorded.

All the publications mentioned in this section are expected to increase invasive awareness in the academic and government sectors. This is a slow process considering that the academics involved in invasive weed research in Mexico are too few (a fast look at the references section will reveal many repeated names). This overview is by no means exhaustive, but to the best of my knowledge is representative of the published work done in Mexico. Many more scientists are needed to produce the needed information identified in Table 1, and very importantly to help in raising invasive weed awareness among the general public.

Concluding Remarks

Invasive weed awareness in Mexico is low, but steadily increasing in the academic sector and in parts of the federal government. The magnitude of the invasive species problem demands much more awareness in these sectors to produce the expected actions suggested in Table 1. However, even with all the government and academia working on invasive weeds, we must remember that "No single agency has the authority, resources, expertise, or mandate to (unilaterally) deal with new invaders that are spreading in tandem with societal growth and development." (Westbrooks and Eplee *in press*). Thus, a networking effort involving all sectors in society is needed and must be preceded by a huge effort to raise invasive weed awareness in the Mexican society.

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Biography

Born to Francisco Espinosa-Zaragoza and María Teresa García-Cortés in Mexico City on October 3, 1954. I received BSc and MSc degrees in Biology, at the Facultad de Ciencias, Universidad Nacional Autónoma de México under Professor José Sarukhán, and a PhD degree in Biology (1991) at the University of California, Santa Cruz, USA, under Professor Jean H. Langenheim. Currently a Research Scientist at the Centro de Investigaciones en Ecosistemas and the Instituto de Ecología at the National University of Mexico (position equivalent to a Professor in the USA). My research interests are weed and invasive plants ecology, chemical ecology of plant defense. Major contributions on weeds have been the books that I have authored or co-authored. Although those books are taxonomical or floristic in their scope, I have also been interested in weed use, evolution, ecology and biogeography. In those topics I have published several papers with my students and colleagues. In chemical ecology I have been interested in the defensive function of the chemicals produced by plants and how the great diversity of these chemicals work in their interactions among plants and with their consumers. In this field my major contributions relate the chemical ecology of conifer endophytes and to the ecological consequences of chemical variability of some crops and their wild relatives.

The North American Plant Protection Organization – Invasive Species Role

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Abstract

The North American Plant Protection Organization (NAPPO) is a Regional Plant Protection Organization created under the authority of the International Plant Protection Convention (IPPC) of the Food and Agriculture Organization (FAO) of the United Nations.

NAPPO coordinates the efforts among the National Plant Protection Organizations of Canada, the United States and Mexico to protect their plant resources from the entry, establishment and spread of regulated plant pests, while facilitating intra/interregional trade. This work is done mainly through the development of regional standards for phytosanitary measures.

NAPPO also contributes to the development of standards of the IPPC. A number of important North American phytosanitary standards have served as the basis for IPPC standards resulting in adoption by more than 100 countries.

Resumen

La Organización Norteamericana de Protección a las Plantas (NAPPO) es una Organización Regional de Protección Fitosanitaria creada conforme a la Convención Internacional de Protección Fitosanitaria (CIPF) de la Organización de las Naciones Unidas para la Agricultura y la Alimentación (FAO).

La NAPPO coordina los esfuerzos entre las organizaciones nacionales de protección a las plantas de Canadá, Estados Unidos y México para proteger sus recursos vegetales contra la entrada, el establecimiento y la diseminación de plagas reglamentadas de las plantas, mientras que se facilita el comercio dentro y entre regiones. Este trabajo se realiza principalmente mediante la elaboración de estándares regionales de medidas fitosanitarias.

La NAPPO también contribuye con la elaboración de estándares de la CIPF. Varios estándares importantes de medidas fitosanitarias de Norteamérica han sido la base de los estándares de la CIPF, los cuales han sido adoptados por más de 100 países.

Almost a decade ago, NAPPO established as one of its strategic goals, the incorporation of environmental perspectives, interests, and priorities into its decision making. In recent years both the IPPC and NAPPO have worked towards strengthening their ties with environmental organizations, in particular with regard to preventing the spread and introduction of invasive species.

NAPPO has established an Invasive Species Panel which is currently developing regional standards to 1) evaluate the invasiveness of plants (a screening tool); and 2) harmonize the approach to identify and rank pest introduction pathways.

NAPPO maintains an online Pest Alert System which provides up-to-date information on pest situations of significance to North America.

NAPPO also provides technical support to the Sanitary and Phytosanitary Committee of the North American Free Trade Agreement and to the Security and Prosperity Partnership of North America.

Hace casi una década, uno de los objetivos estratégicos que se impuso la NAPPO fue la inclusión de las perspectivas, intereses y prioridades ambientales en la toma de decisiones de la NAPPO. En los últimos años, tanto la CIPF como la NAPPO han trabajado hacia el fortalecimiento de sus vínculos con las organizaciones del medio ambiente, principalmente para prevenir la diseminación e introducción de especies invasoras.

La NAPPO ha establecido un Panel de Especies Invasoras, que en este momento está elaborando estándares regionales para: 1) evaluar la capacidad invasora de las plantas (una herramienta de prospección); y 2) armonizar el enfoque para identificar y clasificar a las vías de introducción de plagas.

La NAPPO mantiene un Sistema de Alerta Fitosanitaria en línea que provee información actualizada sobre situaciones de plagas de importancia para Norteamérica.

La NAPPO también provee apoyo técnico al Comité de Medidas Sanitarias y Fitosanitarias del Tratado de Libre Comercio de América del Norte y a la Alianza para la Seguridad y la Prosperidad de América del Norte.

The North American Plant Protection Organization (NAPPO) was created under Article IX of the International Plant Protection Convention (IPPC) of the Food and Agriculture Organization (FAO) of the United Nations. This trilateral relationship was formalized in a Cooperative Agreement between Canada, the United States and Mexico, signed in 1976 by Ministers/Secretaries of Agriculture of Canada, the United States and Mexico.

NAPPO is mandated to coordinate efforts among Canada, the U.S. and Mexico to prevent the entry, establishment and spread of quarantine pests and to limit the economic impact of regulated non-quarantine pests. At the same time NAPPO strives to facilitate international trade in plants, plant products and other regulated articles.

The main focus of the NAPPO work program is the development of regional phytosanitary standards and contributing to the development of international standards of the IPPC. This is done through science panels made up of members of the national plant protection organizations, non-government organizations and industry associations.

NAPPO has developed a number of regional standards which have become the basis for international standards. These include standards on Pest Risk Analysis, Pest Free Areas, Areas of Low Pest Prevalence, Preclearance, Plants for Planting and Transit. The most well known contribution to the IPPC standards was the NAPPO standard on wood packaging. It is now known as the International Standard for Phytosanitary Measures (ISPM) 15 and requires treatment of wood packaging moving in international trade to lower the risk of the spread and introduction of many quarantine pests, in particular wood boring insects.

NAPPO has also formed a panel on Invasive Species and is developing two new phytosanitary standards to strengthen the efforts to keep these pests out. One is related to evaluating the invasiveness of plants for planting; the other concerns identifying and prioritizing pest introduction pathways.

In its efforts to ensure that environmental considerations are included in its phytosanitary standards, NAPPO is working on strengthening its relationship with the North American Commission on Environmental Cooperation, the Nature Conservancy and other related environmental groups.

NAPPO collaborates with the other eight regional organizations of the IPPC and chairs the Inter-American Coordinating Group in Plant Protection which brings together phytosanitary experts of the Americas to discuss phytosanitary situations, pest control and eradication programs.

Strengthened ties and ongoing communication between NAPPO and Weeds Across Borders should be beneficial to both organizations as we work towards fulfilling common goals.

Weeds Cross Borders Project: a Canada-United States Collaboration

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1 Presenter.

Abstract

The "Weeds Cross Borders Project" is a partnership of land managers, agencies and regional invasive plant committees in the greater Okanagan region of Canada and the United States. Partners include the South Okanagan-Similkameen Invasive Plant Society, Okanogan County Noxious Weed Control Board, Boundary Weed Management Committee, Ferry County Noxious Weed Control Board, WSU Ferry County Extension, BC Ministry of Transportation and Washington State Department of Transportation. The project facilitates cooperation and improves coordination of the laws, regulations, policies and education that have differed in the past.

A Cooperative Weed Management Area was established to help prevent and control non-native invasive plant species that have an adverse effect on native plant communities, wildlife habitat and agricultural lands. The project provides an integrated and coordinated approach to invasive plant management, sharing resources for education, training, inventory and control. Invasive plants do not recognize our political boundaries, but freely travel our waterways, railways and highways, dispersing their seed along the way. Coordinating treatment and education across our borders is necessary to effectively control invasive plants in the long term over the entire geographic area. Since 2004, priority weeds are being inventoried and mapped along both sides of the border. Treatments of selected weeds included competitive vegetation seeding, hand-pulling, and cutting, biological control and herbicide applications. With public education deemed an essential component of the project, the partners developed an education/outreach program to effectively communicate invasive plant management issues, including the production of posters, press releases, new invader alerts, and a Cross Borders flyer that was distributed to thousands of landowners on both sides of the border.

Resumen

El " Proyecto de Malezas Cruzan Fronteras " es una asociación de manejadores de terrenos, agencias y el comités regionales sobre plantas invasivas en la región mayor de Okanagan de Canadá y los Estados Unidos. Los socios incluyen la Sociedad de Plantas Invasivas del Sur de Okanagan-Similkameen, el Buró de Control de Malezas Nocivas del Condado de Okanogan, el Comité de manejo de Malezas de Fronteras, el Buró de Control de Malezas del Condado de Ferry, la Oficina de Extensión del Condado de Ferry de WSU, el Ministerio del Transporte de BC y el Departamento de Transporte del estado de Washington. El proyecto facilita la cooperación y mejora la coordinación de las leyes, regulaciones, políticas y la educación que han diferido en el pasado.

Un Área Cooperativa de manejo de la Maleza fue establecida para ayudar a prevenir y controlar especies de plantas invasivas alóctonas que tienen un efecto adverso en comunidades vegetales autóctonas, el hábitat de fauna y tierras agrícolas. El proyecto proporciona un enfoque integrado y coordinado para el manejo de plantas invasivas, compartiendo los recursos para la educación, capacitación, inventario y control. Las plantas invasivas no reconocen nuestras fronteras políticas, pero viajan libremente en nuestras vías navegables, las vías férreas y las carreteras, diseminando su semilla en camino. La coordinación del tratamiento y la educación a través de nuestras fronteras es necesaria para controlar efectivamente, y a largo plazo, a las plantas invasivas en un área geográfica completa. Desde 2004, las malezas prioritarias son inventariadas y cartografiadas en ambos lados de la frontera. Los tratamientos de las malezas seleccionadas incluyeron sembrar vegetación competitiva, cortar o arrancar a mano, control biológico y aplicaciones de herbicidas. Ya que la educación pública se consideró un componente esencial del proyecto, los socios desarrollaron un programa de educación y difusión pública para comunicar efectivamente los asuntos de manejo de plantas invasivas, incluyendo la producción de carteles, comunicados de prensa, alertas sobre invasoras nuevas, y un volante de Cruzando Fronteras que fue distribuido a miles de propietarios de tierras en ambos lados de la frontera.

Introduction to Project

Invasive plants do not recognize political or any other boundaries. They freely travel our waterways, railways and highways, dispersing seed or other propagative parts along the way. The problem is that we have different legal requirements in Washington State and British Columbia (BC), and even between counties. The different requirements for weed control do not allow our programs to be as successful on their own. While we have worked cooperatively for many years, in 2004 we formalized our project, calling it the Cross Borders Cooperative Weed Management Project.

The people responsible for weed control programs within the project area are Lisa Scott (South Okanagan-Similkameen Invasive Plant Society), Barb Stewart (Boundary Weed Management Committee), Jim Davidson (Ferry County Noxious Weed Board), Dan Fagerlie (Washington State University (WSU) Ferry County Extension), James Morin (Washington State Department of Transport), Anna Lyon (Okanogan County Noxious Weed Control Board), Dave Ralph (BC Ministry of Agriculture and Lands), and Donna Falat (BC Ministry of Transportation).

While our project focuses mainly on the border area, it does extend to include all of Okanogan and Ferry Counties as well as all of the 2 adjacent Weed Districts in Canada,

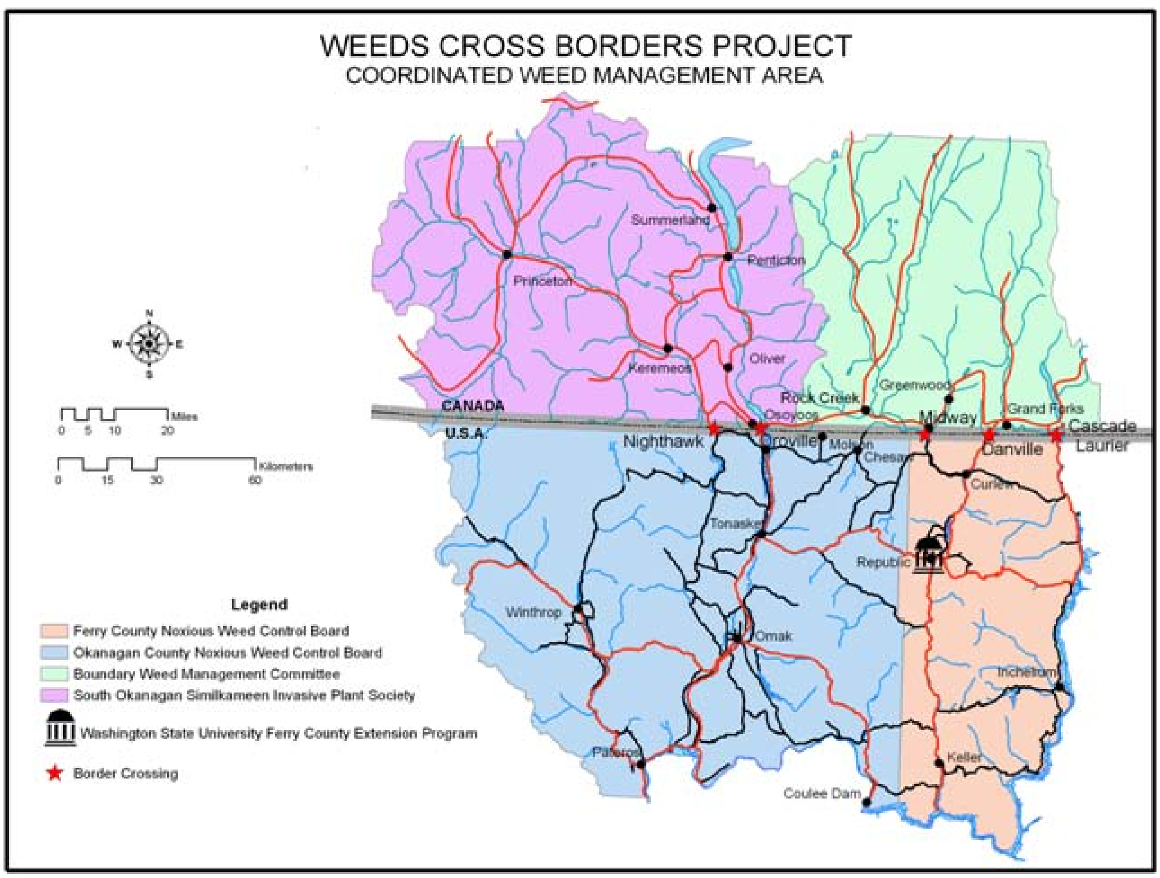

Figure 1. Weeds Cross Borders Cooperative Weed Management Project area.

extending north to Summerland and east into the Boundary area (Figure 1). We realize that what happens on one end of our area concerns what happens on the other areas. We have formed many partnerships during the course of our project, each partner having valuable input and resources that allow our project to be the success that it is.

Bonnie Harper Lore and the United States Federal Highway Administration provided funding, allowing us to get our joint memorandum of understanding signed, as well as initiate education processes and on the ground weed control efforts. Other funding sources have included; BC Inter-Ministry Invasive Plant Working Group; BC Ministry of Agriculture & Lands; Pulling Together Initiative; Canadian Invasive Alien Species Partnership Program; Washington Department of Transportation; and, United States Forest Service (USFS)-WSU IWCP, Forest Health, & Title III funding.

While our management efforts cover our entire areas, we realized that we would need to prioritize certain areas. Our main focus was determined to be the roads and highways connecting our areas, including State/Provincial Highways 3, 97, 20 and 21, and County Roads Toroda Creek, Chopaka and Nighthawk). We also included our joint waterways (Lake Osoyoos and Kettle River), and all along the border to provide a buffer area that will diminish spread.

Education

Our project targeted everyone from landowners to elected officials. We have worked to teach them about the weeds, their identification and control, and about our partnerships and how they can help in the effort to control invasive plants. Here are a few examples:

- We developed a series of press releases promoting the project and weed awareness.
- We have held field tours and classes on both sides of the border and invited each other and our respective constituencies. The customs and border patrols from both sides were educated about noxious weeds and what they could do to prevent spread. We have an example shown of a tour being conducted by Barb Stewart in the Boundary area of Grand Forks and another of a Hoary alyssum test plot tour being conducted by Dan Fagerlie (Figure 2).
- We worked jointly to prioritize, plan, and distribute flyers for the four regions in the Cross Borders area. In many cases we were able to find funding from partner projects or sources to produce:
  - 16,000 Weeds Cross Borders 8 page flyers, distributed in whole region and nationally in U.S.A. with duplication for distribution by and through the U.S. Federal Highway Administration.
  - 29,000 new invader “Hoary alyssum” alerts through USFS funding.
  - 15,000 weed identification booklets for early identification and rapid response.
  - 8,000 weed calendars working with local high schools. Calendars planned for 2009 and 2010 will focus on “weeds on the move” and “successful weed warriors”.


Figure 2. Field tour examining hoary alyssum.

- Laminated posters were developed and printed in our office, and distributed and displayed on both sides of the border for clientele education at fairs, community events, and workshops.
- Legislative Tours were organized in 2004, 05, and 07 with an audience of:
  - US Congressmen
  - US Senators
  - Washington State Representatives
  - Washington State Senators
  - Washington State Department of Agriculture
  - Washington State Department of Ecology
  - County Commissioners
  - Members of British Columbia Legislative Assembly
  - Minister of Water, Land and Air Protection
  - Minister of Agriculture
  - Minister of Transportation
  - Minister of Forests
- We are just ordering road signs stating "Weeds are a Pain in the Grass!" with contact and partner information, which will be 4 by 6 feet and put along the main highway corridors.
- Prevention efforts have been funded such as the "Weed Wash", with pictures showing the portable undercarriage wash unit of Sheilah Kennedy (S-K Environmental, Okanogan County), and some viable sprouted seeds.

- We are working in Collaboration with WSU-USFS Integrated Weed Control Project which has focussed on enhancement of the use of biological control agents, assisting Coordinated Weed Management Areas, and early identification and rapid response. This project has been and is funded by the USFS, with Gary Smith, from the Washington, DC, office playing a major role in helping it happen.
- On the US side we are also working in collaboration with Colville Confederated Tribes and their Weed Control Task Force.
- Our newest educational effort has been a "rack card" (Figure 3). These rack cards are being distributed through customs agents at border crossings and at some other locations.

Figure 3. Rack card for distribution at border crossings.

Priority Weeds

We have done inventories and mapping of priority species. Although each area has its own system to house the data, this information is shared between the areas to coordinate more effective control efforts. The Weeds Cross Borders Project uses a strong integrated pest management (IPM) program, including mowing, site specific herbicide treatments and recommendations, hand pull crews, revegetation and biological controls. Weed species of current concern include:

- Mirabilis – Wild four o'clock (*Mirabilis nyctaginea* (Michx.) MacMill.)
  – Washington State: Eradication required
  – Canada: No control required
  – Inventory, treatment and monitoring were done on the BC side along highways and irrigations ditches to reduce spread into Washington.
- Musk (Nodding) Thistle (*Carduus nutans* L.)
  – Washington State Law RCW 17-10: Mandatory to stop seed production
  – Canada: Focus on biological control
  – Since 1998, crews have been manually digging plants on either side of the border to reduce spread into Washington.
- Puncturevine (*Tribulus terrestris* L.)
  – Washington State: Class B Weed – no control required
  – Canada: Control required

  - To address the concern of spread north into BC, Okanogan County has treated Puncturevine along highways. They found that once they started treatment, County and State road managers started doing more, and landowners as well. So a small investment in treating a highly visible area resulted in a lot of work being done.
- Leafy Spurge (*Euphorbia esula* L.)
  - Washington State: Class B Designate – control required
  - Canada: Control required in BC
  - Ferry County found a patch in the Kettle River, just across the border, so we started looking upstream and, sure enough, we found a patch. In total 10 patches were found since 2003 and treated, and only one site had re-growth in 2007. We have successfully kept Leafy spurge out of the Kettle River System.
- Hoary Alyssum (*Berteroa incana* (L.) DC.)
  - Washington State and Canada: Control not required in most of project area
  - Since BC is controlling it in the West Boundary, Ferry County has been treating a buffer along the border in that area to reduce spread up into the Boundary.
- Purple Loosestrife (*Lythrum salicaria* L.)
  - Washington State: Control not required in most of project area
  - Canada: Not required control in project area
  - Purple Loosestrife is present around Osoyoos Lake which is partially in Washington and partially in BC. Biological control agent release and monitoring has been done and hopefully in time we will see suppression.

Action For the Future

- Monitoring and follow-up treatment
- Seek additional funding
- Apply for grants
- Spread the Word Faster than the Weeds!

Our Major Accomplishment

We have established a working relationship that allows us to see and work across the border in both directions, rather than see the border as the limit of our concerns.

First Nation Partnerships in Invasive Plant Management.
The Gitxsan First Nation – Northwest Invasive Plant Council Example

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Abstract

NWIPC (Northwest Invasive Plant Council) is piloting innovative approaches to improve efficiency and effectiveness of invasive plant management. Expectations are recruitment and retention of partners, including First Nations, will increase with improved programs. A single agency delivery model that integrates awareness, site reporting, planning, inventories, treatments, assessments and adjustments is being applied across a landscape of multiple jurisdictions for and by partners with diverse mandates. The Gitxsan First Nation implemented a program under the pilot. The successful Gitxsan program is being used as a model by other First Nations to develop partnerships. Single agency delivery can lead to successful First Nations partnerships.

Resumen

NWIPC (*Northwest Invasive Plant Council*) está dirigiendo enfoques innovadores prospectivos para mejorar la eficiencia y eficacia del control de las plantas invasivas. Se prevé que el reclutamiento y retención de aliados tales como las Primeras Naciones se incrementarán con los programas mejorados. Se está aplicando un modelo, encabezado por una sola agencia, que integra actividades de concientización, notificación de sitios, planificación, inventarios, tratamientos, evaluaciones y ajustes. El modelo se está aplicando a través de paisajes de jurisdicciones múltiples por y para entidades aliadas con diversos mandatos. La Primera Nación Gitxsan implementó un programa en el marco del proyecto piloto. El programa de los aborígenes gitxsan tuvo éxito y ahora está siendo utilizado como modelo por otras naciones aborígenes para crear alianzas de cooperación. Utilizar una agencia única para presentar estos modelos puede conducir a alianzas exitosas entre las Primeras Naciones aborígenes.

Introduction

In 1992 a group of stakeholders and interested parties were called together to discuss issues around the use of herbicides on public land in northwest British Columbia. The group quickly came to a consensus that invasive alien plants presented a serious risk to the integrity of many ecosystems in northwest BC and a coordinated approach to manage invasive plants was needed. Thus began the Northwest Invasive Plant Council (NWIPC).

Initial steps for NWIPC were to develop a shared inventory of invasive plants and strategic plan. From the strategic plan the operating principles of NWIPC are:

- Encourage the public to report invasive plant sightings.
- Inform the public about invasive plant programs so they can provide relevant comment.
- Develop and maintain a shared invasive plant inventory.
- Assess problems and threats that various invasive plants present to the environment and economy of the area.
- Categorize invasive plants and prioritize sites for control.
- Prevent the establishment of invasive plants not currently in the region.
- Prevent or minimize the spread of the invasive plants present in the region.
- Conduct invasive plant programs in the northwest and central BC using Integrated Pest Management principles as described in the "Invasive Plant Strategy for BC".
- Encourage all landowners, agencies and organizations operating in northwest and central BC to develop and implement invasive plant management programs.
- Manage and coordinate the activities and responsibilities of the various agencies and private landowners to ensure NWIPC goals are met.

As coordination and delivery of invasive plant management improved, additional areas and organisations joined NWIPC. NWIPC currently covers an area from Haida Gwaii, (the Queen Charlotte Islands), westward to the Rocky Mountains and from a southern boundary formed by various Regional District boundaries, running approximately along the 53° 20"N latitude, north to the Yukon Territory.

In 2004 the BC Provincial Government asked NWIPC if they would develop and test innovative approaches to improve efficiency and effectiveness of invasive plant management through a three year pilot project. NWIPC agreed and in 2005 NWIPC implemented a single agency delivery model for invasive plant management. The model integrates the various aspects of invasive plant management, including: awareness; planning; inventory; treatment; and, program assessment and adjustment. NWIPC became the agency responsible for delivery and support of all invasive plant activities in central and northwest BC.

Partners allocate their funds and staff resources through NWIPC to apply a strategic approach to invasive plant management with less emphasis paid to the mandates and jurisdictions of the various organisations and agencies. In 2005 eight partners contributed approximately $300,000 to a collective or pooled fund for inventory and treatment contracts. By 2007 thirteen partners contributed approximately $445,000 to the pooled funds. As well, $250,000 per year was provided by the provincial government to manage the pilot and involve areas and organisations not previously engaged in invasive plant management.

For the single agency delivery model to work it is necessary to have support and involvement of the area population and an understanding that NWIPC is the primary agency for invasive plant management. In central and northwest BC a large portion of the population, in particular the rural population, are the First Nations. The Gitxsan First Nation has been a member of NWIPC for over a decade and with the implementation of the pilot the Gitxsans took the opportunity to develop an invasive plant management program. The Gitxsan Program, 'Weeding Out the Invaders', uses the approach of integrating awareness, inventory, treatment and assessment through a partnership with NWIPC. Flexibility is gained when strategic approaches, rather than mandates and jurisdictions, underpin invasive plant programs and local decision making facilitates the partnership.

Three other First Nations have followed the Gitxsan model and entered into partnerships with NWIPC. An additional three First Nations are in discussions with NWIPC about partnerships and numerous other First Nations partnerships, approximately twenty, could be developed. These First Nations Partnerships have brought increased involvement and areas into the NWIPC giving better assurance that Early Detection Rapid Response, containment and rehabilitation goals will be met.

Weeding Out the Invaders, the Gitxsan First Nation Invasive Alien Plant Program

Background

Gitxsan people have lived on the territory since creation. Evidence supports more than 10,000 years of occupation by the Gitxsan. The English translation of the Gitxsan is "People of the River of Mist". There are approximately 13,000 members of the Gitxsan nation worldwide, with about 70% living on the traditional territories. The population is young compared to provincial and Canadian statistics with over 70% under the age of 30. Most Gitxsans live in five Gitxsan villages (Gitwangak, Gitsegukla, Gitanmaax, Glen Vowell, and Kispiox) and three provincial municipalities (Hazelton, New Hazelton, and South Hazelton). The Gitxsan people make up about 80% of the total population living on the territories. The remaining population is mostly of European descent. Settlement of the area by non-Gitxsan began around the turn of the century.

The Gitxsan traditional territories occupy an area of 30,000 square kilometres (about five times the size of Prince Edward Island) in northwest British Columbia. It is a land of rugged, glacier-capped mountains, lush forests and swift-flowing rivers heavily influenced by the north pacific ocean climate. The Babine, Bulkley, Kispiox and Skeena Rivers are all found in Gitxsan territory and are home to abundant salmon and steelhead runs. Spruce, sub alpine fir, hemlock, cedar and pine compose extensive forests on the territory. The rich ecosystem supports a wide variety of mammals and birds. Small mammals, such as marten, are abundant and are trapped for their fur. Deer, moose and mountain goat are often used as a source of food. The land is also home to healthy populations of black and grizzly bears (see: Gitxsan Chief's Office web site).

Along with the arrival of non-Gitxsan people in the territories is the arrival of invasive alien plants. The construction of the railway followed by a highway and roads for extraction of timber and minerals has introduced and are threatening to spread invasive plants throughout the Gitxsan territories. In order to address this threat the Gitxsan joined NWIPC the mid 1990s and in 2004 proposed to develop a Gitxsan invasive plant management program. The proposal received support and funding from the Gitxsan First Nation, NWIPC and the Provincial Government and through a partnership to develop a Gitxsan invasive plant program, "Weeding Out the Invaders", was started in 2005.

Governance

The Gitxsan use a House System for governance and the system operates across nine Watershed Authorities. The Weeding Out the Invaders Program is led by the Mid Skeena Watershed Authority. The program provides training and awareness across the 14 House groups within the Watersheds. As the project develops it increases awareness in the other Watersheds.

Goals

Weeding Out the Invaders has five goals:

- Train and develop skills in invasive plant management for the 14 House Groups of the Mid Skeena Watershed
- Increase awareness of invasive plant issues amongst Gitxsan people
- Conduct and maintain an inventory of invasive plants
- Develop and implement an invasive plant management program
- Monitor and manage invasive plants

Training and Development

In the summer of 2005 the Mid Skeena Watershed Authority posted jobs for invasive plant identification technicians. Marc Jenkins and Merci Hillis obtained the positions. Under the program a professional agrologist, Wendy Siemens, was retained to assist with training. Classroom and field training was provided on identification of invasive plants and to study for the Pesticide Applicator's exam.

Work started with pulling weeds in a ball field. This work was not that useful as the organisation of the program and training on strategies and purposes of the program were not sufficient. After the initial training, Graeme Johnstone, the NWIPC contractor for the area took the crew out to show the impacts of invasive plants and effects of herbicide treatments on invasive plants.

The training got interesting when the crew began to inventory and see the extent of invasive plants on the Gitxsan territories. An office was set up in the Kispiox Band Administration Building. Right next to this office the crew found a common tansy (*Tanacteum vulgare* L.) site. The realisation set in that the program wasn't just about controlling weeds in a ball park but was about protecting the Gitxsan territories from invasive plants. Training has continued as additional work loads and issues are undertaken.

Increasing Awareness About Invasive Plants

The focus for Weeding Out the Invaders is Gitxsan people, but a lot of the problems are on private properties, farms, railways, gardens, highways and forestry roads. Posters and pamphlets were obtained from NWIPC and displayed in the communities and at various events. Pioneer days in New Hazelton, a gathering for all surrounding communities to put up displays and sell goods, proved to be an excellent venue for reaching people. Booths were set up in 2005 and 2007 at this event. Newsletters were also put together and circulated. In 2007 Julie Morrison joined the program and worked with Merci Hillis to develop a PowerPoint™ presentation for the Gitxsan Hereditary Chiefs and the various communities.

A package has been put together for delivery to residents that have invasive plants in their yards. The package contains information on invasive plants, management or control and NWIPC programs such as the 50/50 program, community weed pulls and contact information for Weeding Out the Invaders and NWIPC. Further planning to better to communicate with Gitxsan and non-Gitxsan residents is needed.

One issue is the need to raise awareness of not only invasive plants tha are in the Gitxsan territories like Canada thistle (*Cirsium arvense* (L.) Scop.) and burdock (*Arctium* spp.) but also to raise awareness of invasive plants that have not arrive yet but are close by, like field scabious (*Knautia arvensis* (L.) Duby) and marsh thistle (*Cirsium palustre* (L.) Scop.).

Inventory of invasive plants in the Gitxsan Territories

A map was obtained from the Watershed Authority office that showed all the Watershed boundaries and other important features. This map was used to plan and keep track of where inventories were done and needed to be done. Initial inventory work was in the Mid Skeena watershed. Jack Sebastian, a member of the adjoining Suskwa Watershed, took the crew into that watershed to expand the inventory. Wendy Siemens was also brought back to do additional training on filling out inventory forms.

A systematic inventory of the Hazelton area, Kispiox Valley, Salmon River road, Date Creek, Suskwa River and surrounding areas was started to augment existing inventories. In 2005 the crew filled out the inventory forms and sent them to NWIPC Program Manager for entry into the data management system used in the BC Invasive Alien Plant Program (IAPP). In 2006 the project was late starting and though new areas and sites were inventoried most of the work was re-evaluation of 2005 sites. Following additional training in IAPP in the winter of 2007, inventory work continued and entry into IAPP was done by the Weeding Out the Invaders crew in 2007.

The crew found most invasive plants were along the main roads, rail line and utility corridors and within 30 to 40 kilometres up forestry and bush roads, but sometimes invasive plants were found in remote locations. So far most of the inventory has been done along roads and highways and a closer look off the roads is needed to see if invasive plants are spreading into the bush.

Managing Invasive Plants

So far all treatments of invasive plants by the Weeding Out the Invaders Program have been manual, cutting and hand pulling. There may be use of herbicides at sometime, but right now a lot of people in the territories, Gitxsan and non-Gitxsan, have concerns about herbicide use. Also, a lot of the invasive plants are along the many rivers and creeks in the territories and as such use of herbicides is limited.

The project started in 2005 and organisation of work was a struggle. There was manual control of burdock, sow thistle, and other species. The strategy that NWIPC uses to categorise invasive plants and prioritise sites was not clearly understood, decreasing the effectiveness of the program. In 2006 a late start put the focus mostly on re-inventory of the 2005 sites. The year 2007 was the turning point for the program and lots of well-planned and directed inventories and treatments were done. In 2007 over 30 sites of common tansy and thistles were treated and all data entry into IAPP was done by the program crew. Before and after treatment photos are often taken including numerous sites treated in the Kispiox Valley. The Kispiox Valley has a lot of logging, tourism and cattle traffic making it a prime area for the spread of invasive plants. The lower part of the valley has numerous common tansy sites and, more and more, small sites are showing up further up this valley and throughout the territories.

There were also treatments of numerous sites along the Canadian National Railway Company (CN) rail line. CN is a NWIPC partner and contributes to the pooled fund. The rail lines in the Hazelton area had infestations of four or more species of invasive plants. These sites were inventoried and some were treated.

Monitoring and Managing Invasive Plants - a program that treats the right invasive plants in the right places

The most important invasive plants are the ones that are not in the Gitxsan territories yet, but are close by. An example of such an invasive plant is the very destructive marsh thistle. There are marsh thistle infestations to the west of the territories in the Prince Rupert area. NWIPC is successfully containing these infestations and it is important for the program to identify and quickly treat any marsh thistle found in the Gitxsan territories. Common tansy is another invasive plant common in the Prince Rupert and Terrace areas that has arrived in the Gitxsan territories and is starting to cause problems. The program is attempting to stop the spread of common tansy.

Some invasive plants such as knapweeds (*Centaurea* spp.), though present for some time in the Gitxsan territories, have not been allowed to spread. Himalayan balsam (*Impatiens glandulifera* Royle) is a garden escape (Figure 1) that had spread prior to it being included as a strategically important plant in 2006–07. There is also one known Japanese knotweed (*Polygonum cuspidatum* Sieb. & Zucc.) site in the territories. The program will prevent further spread of these species with a long term goal to try and remove them from the Gitxsan territories.

Some species such as Canada thistle, hawkweeds (*Hieracium* spp.), sow thistles (*Sonchus* spp.) and burdock have been in the Gitxsan territories for many years and have managed to spread. The program will continue to inventory these species and try and assist people with strategies to manage and, in some instances, rehabilitate infested areas.

Reporting for the Weeding Out the Invaders program is to NWIPC and occurs on a monthly and annual basis. The annual report has recommendations for improvements. A lot has been learned since the start of the program and issues like late starts, no maps and difficulty accessing vehicles were challenging, but are hopefully being overcome. Some of the recommendations and changes include:

- Better communication with the Chiefs to be clear on what they want.
- Develop and use a PowerPoint™ presentation to get feed back on the use and possible use of tools like herbicides and mechanical treatments.
- Continue to encourage crew members and others involved in the program not to get frustrated at not being able to reach people or at the daunting task of taking care of such a huge amount of land.

Figure 1. Himalayan balsam escaping a garden.

The Future – Plans and Hopes

The hope and intent is to continue to expand the Weeding Out the Invaders Program and the partnership with NWIPC. Earlier starts in the season with more crews are needed to protect the Gitxsan territories from invasive alien plants. To accomplish this additional funding is needed and applications have been made and will continue to be made for additional funding. Work and contractual arrangements will continue and hopefully increase with NWIPC partners such as utility and timber companies. Raising awareness within the Gitxsan Nation and with others in the territories will also continue so that all the communities and Watersheds become involved in invasive plant programs.

Acknowledgements

There are a lot of people who have assisted with, and worked on, the Weeding out the Invaders Program. Some of the key individuals are: Wendy Siemens and Graeme Johnstone who showed the crews what an invasive management program actually was; Sadie Harris who is liaison to the Chiefs and supervisor; Ardythe Wilson and Myrtle Muldoe who developed and supported the proposal; the field workers, Marc Jenkins, Shawn Harris, Jack Sebastian, Julie Morrison and Merci Hillis; Bob Drinkwater, Andrea Eastham; and, the whole of NWIPC for having so much patience and for all the help and support they have given to the Gitxsan Nation on our quest to continue a successful invasive plant management program.

Additional References

Gitxsan Nation Chief's Office: http://www.gitxsan.com/html/who.htm
Invasive Plant Council of British Columbia: http://www.invasiveplantcouncilbc.ca/
Northwest Invasive Plant Council (NWIPC): http://www.nwipc.org

Biography

Merci Hillis is a Gitxsan First Nation in the Fireweed Clan out of the Wiigyet House. She has worked on the Gitxsan Invasive Plant Program: "Weeding Out the Invaders" since 2005 as the invasive plant identification technician. She has received training in invasive species identification, Invasive Alien Plant Program, IAPP, data management and inventory system and is certified as a Pesticide Applicator.

A New Approach to Fight Invasive Species in New York State

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Abstract

In 2003, the New York State Legislature called for a team to explore the economic and ecological pressures from invasive species and to provide recommendations to the Governor and Legislature by November 2005. The Task Force made twelve recommendations on how the State could strengthen its approach, which emphasized improved coordination and included having staff positions dedicated to invasive species, a comprehensive invasive species management plan, and an invasive species database. The Task Force also identified the need for dedicated funding for successful invasive species management. The State has since made steady progress in developing its invasive species program.

Resumen

En el 2003, el Poder Legislativo del Estado de Nueva York pidió que una comisión de estudio se encargara de analizar los efectos económicos y ecológicos de las especies invasivas y que presentara sus recomendaciones al Gobernador y al Poder Legislativo en noviembre del 2005. La comisión de estudio hizo 12 recomendaciones de las maneras en que dicho Estado podía fortalecer su enfoque, destacando la necesidad de mejorar la coordinación y contar con personal dedicado a las especies invasivas, de establecer un plan exhaustivo para el control de especies invasivas y de mantener una base de datos sobre especies invasivas. Asimismo, la comisión especial indicó que, para tener éxito, se necesitaba financiamiento asignado

1 Presenter.

Eight regional partnerships, *Partnerships for Regional Invasive Species Management*, are a cornerstone of the program. These partnerships are responsible for coordinating local actions involving early detection and rapid response, control, and education. Signature achievements in 2007 also included $5 million for invasive species management, establishing an eradication grant program, legislation establishing a New York Invasive Species Council and Advisory Committee, and the formation of a new Office of Invasive Species Coordination.

específicamente al control de las especies invasivas. Desde entonces, el Estado de Nueva York ha hecho constantes avances en el desarrollo de un programa propio para controlar especies invasivas. Ocho alianzas regionales – *Partnerships for Regional Invasive Species Management* – son la piedra angular del programa. Estas alianzas coordinan actividades locales dirigidas a temas tales como identificación temprana y respuesta rápida, control y educación de la población. Entre los principales acuerdos logrados en el 2007 se incluyen: un fondo de $5 millones de dólares para el manejo de especies invasivas, un programa de subvenciones para su erradicación, al igual que aprobar leyes para crear el Consejo de Nueva York para Especies Invasivas, y organizar una nueva Oficina de Coordinación para Especies Invasivas.

Introduction

In recent years, the potential harm caused by invasive plants, animals and pathogens has gained increasing awareness and understanding by all sectors of society. In order to prepare New York State for the many ecological, economic and human health threats posed by the ever-increasing list of invasive organisms, the Legislature created an Invasive Species Task Force (ISTF) in 2003. The ISTF had three primary goals: to assess the impacts of invasive species in New York; identify existing programs and resources; and, make recommendations on how the State could improve its fight against invasive species. The ISTF delivered its report in 2005 and began implementing its recommendations using funds available annually in the State budget via the Environmental Protection Fund (EPF). Most items involve contracts with non-State partners. The contracts typically commit funds for the first year of what are generally expected to be five year (or more) contractual relationships with single-source vendors. It should be noted that the use of EPF dollars will not provide State agencies with all of the resources they need to comprehensively and effectively manage invasive species threats and problems. Rather, it will provide State agencies and their partners with a well-coordinated and integrated foundation upon which a fully-functional system may be built over time.

The 12 Recommendations and Progress Reports on their Implementation

1. Establish a Permanent Leadership Structure to Coordinate Invasive Species Efforts.

In August 2007, legislation created a nine agency New York Invasive Species Council (NYISC) — the Council — supported by a 25 member non-governmental Invasive Species Advisory Committee. The Council is co-chaired by the New York State (NYS) Department of Environmental Conservation (NYSDEC) and the NYS Department of Agriculture and

Markets and is comprised of executive or senior management representatives. In December 2007, the NYSDEC established an Office of Invasive Species Coordination (OISC) within the Office of Natural Resources. The OISC helps State agencies meet the requirements of the invasive species legislation and administers the strategic direction of the Council. The Council, Advisory Committee, and Office of Invasive Species Coordination collectively coordinate the implementation of the 12 major recommendations presented in the *Final Report of the Invasive Species Task Force* (November 2005) (Figure 1).

2. Prepare and Implement a Comprehensive Invasive Species Management Plan.

The comprehensive invasive species management plan will be developed in two phases and address, among other things: integration among agencies and stakeholders; additional funding sources; and, additional regulatory authority. A Request for Proposals to implement the first phase of the plan's development will be published early in the Fall of 2008.

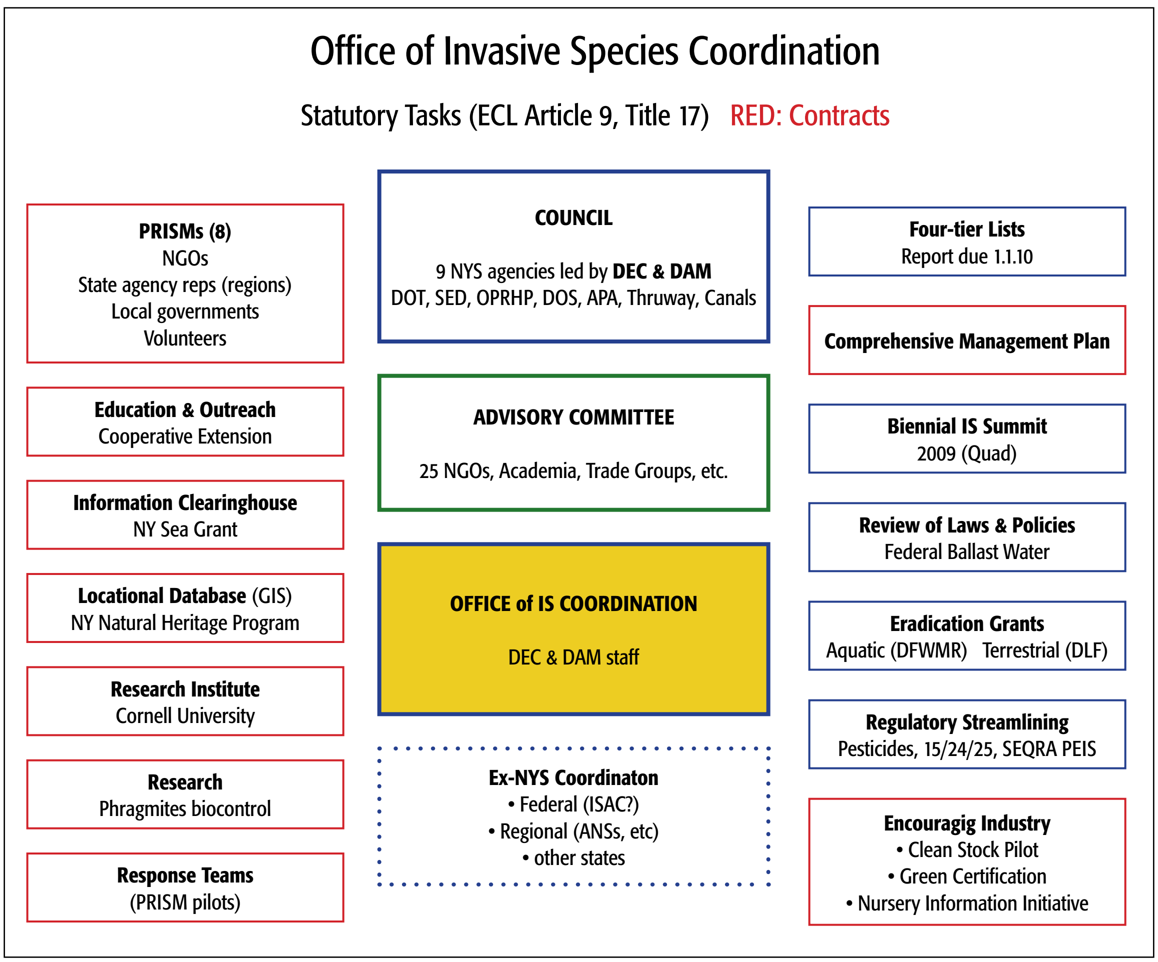

Figure 1. Organizational structure of invasive species coordination in New York State.

3. Allocate Appropriate Resources for Invasive Species Efforts.

The Office of Invasive Species Coordination is not able to provide all of the resources needed by the Department of Environmental Conservation or other State agencies to effectively manage the invasive species threat. One of the primary sources of funding to implement the 12 recommendations is the NYS Environmental Protection Fund. Initial funding for invasive species in the EPF was $1.0 million in State Fiscal Year 2005-06 and in 2008-09 was $5.0 million; the annual funding goal is $10.0 million (Figure 2). The Council will have the ultimate responsibility for securing the powers and resources needed by New York State.

4. Establish a Comprehensive Education and Outreach Effort.

New York State is working with Cornell Cooperative Extension to develop and deliver a comprehensive outreach and education program for invasive species. Cornell Cooperative Extension Invasive Species Specialists will develop a statewide program and provide a multi-disciplinary team to support each Partnership for Regional Invasive Species Management (PRISM) (see recommendation #12).

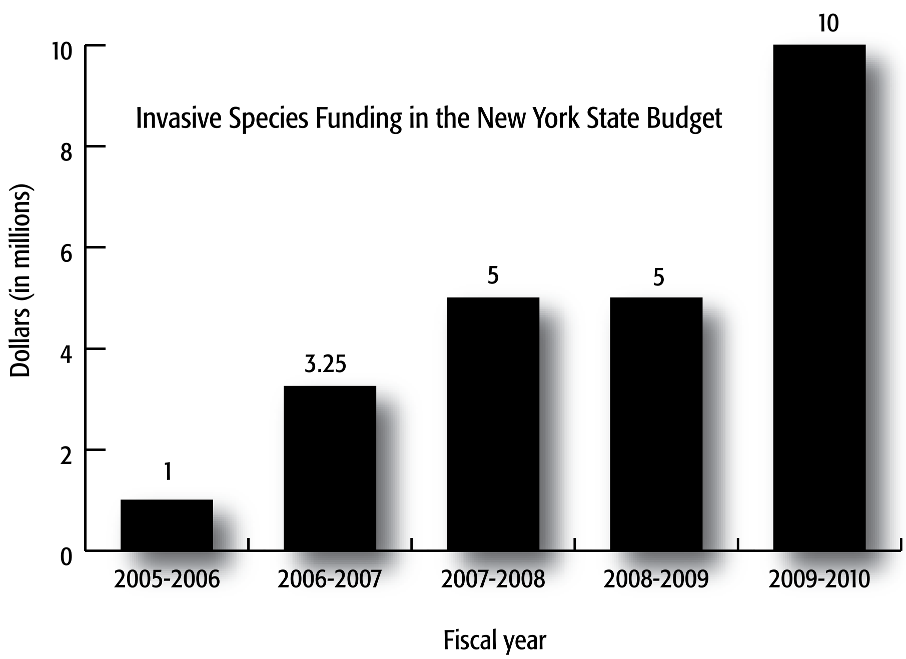

Figure 2. Funding for invasive species in the New York State Environmental Protection Fund since 2005. FY2005-2009 funds were secured. FY2009-2010 reflects an annual funding goal recommended by the New York State Invasive Species Task Force.

5. Integrate Databases and Information Clearinghouses.

New York State is contracting with the New York Natural Heritage Program to establish and maintain a statewide locational database for invasive species. The database will be an on-line, geographic information system-based, all-taxa invasive species mapping tool called iMapInvasives, which will focus on serving the needs of invasive species managers. The State is also contracting with New York Sea Grant to develop a web-based information clearinghouse to serve as the "library" for the biology and management of invasive species.

6. Convene a Regular Invasive Species Conference.

The Council will convene a biennial invasive species "summit" and participate in and/or support with funding, any conferences focused on invasive species issues as they are available. The Council is planning an invasive species summit for the Fall of 2009.

7. Formalize New York State Policy and Practices on Invasive Species.

The Office of Invasive Species Coordination will lead State agencies in a review of programs and practices to help prevent the spread of invasive species and to enable and encourage restoration of native species wherever practical. Actions will include: 1) phasing out uses of invasive species; 2) expanding use of natives; 3) promoting private and local government use of natives as alternatives to invasives; and, 4) wherever practical and where consistent with watershed and Invasive Species Management Area Plans, prohibiting and actively eliminating invasives at project sites funded or regulated by New York State. This task will be accomplished by a team of State agency representatives with guidance from other stakeholders.

8. Establish a Center for Invasive Species Research.

The Invasive Species Research Institute has been established through a contract with Cornell University and will serve the region and the State, stretching from the Great Lakes to the Mid-Atlantic to New England and southeastern Canada. The Institute will collaborate closely with the Council as well as with federal and regional entities involved in the coordination, prioritizing, and funding of invasive species research. Research funding decisions will be guided by the Council as advised by the Invasive Species Research Institute.

One of the research projects co-funded by EPF dollars and the New York State Department of Transportation is the development of a biological control program for the introduced *Phragmites australis* (Cav.) Steud. The funding will continue the project by Cornell University, initiated in 1998, for the next five years and will focus on the following objectives: host specificity testing; selection of release sites; development of a standardized monitoring protocol; development of mass production techniques; preparation of reports to obtain release permits; release of control agents; and, training of land managers in implementation of biocontrol.

9. Coordinate and Streamline Regulatory Processes.

Legislation requires all State agencies and authorities to reform relevant regulatory processes to remove unnecessary impediments to the restoration of invaded ecosystems and to facilitate the efficient application of best management practices. Legislation also requires the development of a four-tier system of species lists to identify those which are prohibited, regulated or unregulated, as well as a procedure for the review of unlisted species. This task requires commitment to a process that is inclusive of all stakeholders and is transparent to the public. This process has begun and is on schedule to be completed by 1 January 2010.

10. Encourage Non-regulatory Approaches to Prevention.

The State will support non-regulatory efforts by industries to minimize invasions. It initiated a pilot program to develop “clean stock” for use by the nursery and landscape industry. The State also allocated funds to support industry by helping to promote and market native and/or non-invasive species, especially if some widely used landscape plants are recommended for restrictions or even prohibition.

11. Influence Federal Actions to Support Invasive Species Prevention, Eradication and Control.

Because New York State cannot prevent invasions by itself, it will work with its Congressional Delegation, National Governors Association, Environmental Commissioners of States, federal agencies, and other bodies to influence federal actions, especially regarding legislation and funding.

12. Recognize and Fund Demonstration Projects.

New York State will continue funding efforts that would clearly demonstrate the possibilities for successful invasive species management. Such demonstration projects will include the full range of activities: prevention; monitoring and detection; information management; eradication and control; applied research; and, education and outreach. Funding, whether through competitive grants, contracts or other mechanisms, will be aimed at multi-year projects with durations sufficient to generate meaningful results. The principal entity for delivering these programs will be Partnerships for Regional Invasive Species Management (PRISM). Eight regional, “grass roots” partnerships to prevent and manage invasives are designated across the state (Figure 3). They provide the “core services”: organizing volunteers for prevention; monitoring and detection; information management; eradication and control; and, education and outreach. Another key program is the invasive species eradication grant program. The program funds projects to eradicate aquatic and terrestrial invasive populations on a local scale, and $1.0 million has been made available each year since 2005 to support the grant program.

Conclusion

The Invasive Species Task Force's *Final Report* provided an important blueprint for addressing invasive species control and it laid the foundation for tremendous statewide progress since 2005. During recent years, heightened institutional and public awareness about the need to collectively combat the spread and impacts of invasive species in the state has triggered response among governmental and non-governmental organizations. Funding, staffing, and coordination were instrumental to launching the initial implementation of the 12 recommendations and will be increasingly important as the state further develops its invasive species strategies and programs.

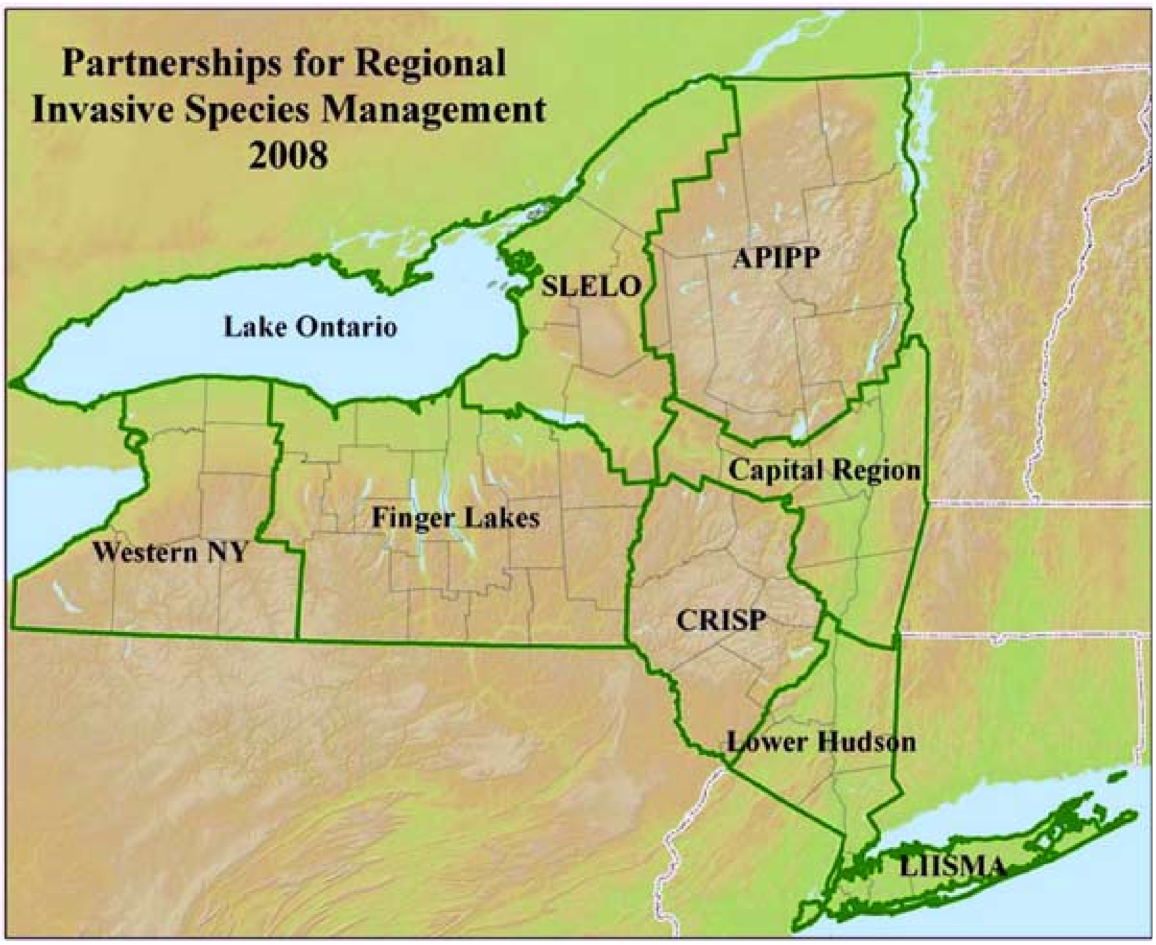

Figure 3. Geographic boundaries of New York State's eight Partnerships for Regional Invasive Species Management (PRISMs): APIPP (Adirondack Park Invasive Plant Program), CRISP (Catskill Regional Invasive Species Partnership), LIISMA (Long Island Invasive Species Management Area), SLELO (St. Lawrence–Eastern Lake Ontario).

NIWAW (National Invasive Weed Awareness Week)

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Abstract

National Invasive Weed Awareness Week (NIWAW) is observed in late February every year in Washington, DC. The original purpose of holding NIWAW was to raise awareness of the invasive weed or plant issue in the United States Congress, the White House and federal agencies. It has evolved over the last 9 years to include outreach to the public, especially children. NIWAW is organized by a group of volunteers from seven scientific societies, four NGOs, four associations, state and federal government agencies, six herbicide manufacturers and two vegetation management contractors, with a paid Director. Preparation for NIWAW takes a full year. About 150 people from all across the country attend NIWAW, and we have had some Canadian participation. The growth of NIWAW activities and attendance over the past 9 years has expanded the partnership base with wildlife groups and garden clubs, and the geographic breadth of the people and organizations participating in NIWAW.

The foremost congressional successes of NIWAW were passage of the Noxious Weed Control and Eradication Act of 2004 (Public Law

Resumen

La semana nacional de concientización sobre malezas (NIWAW) se celebra cada año a fines de febrero en Washington, D.C. El objetivo inicial de esta actividad fue fomentar en el Congreso de Estados Unidos, la Casa Blanca y las entidades federales una toma de conciencia sobre el problema de las malezas y plantas invasivas. En los últimos 9 años desde su inauguración ha evolucionado para incluir al público en general y especialmente para llevar su mensaje hasta los niños. Esta semana de concientización es organizada por un grupo de voluntarios provenientes de 7 sociedades científicas, 4 ONG, 4 asociaciones, diversas agencias estatales y federales, 6 fabricantes de herbicidas y 2 empresas de manejo de vegetación. El grupo funciona bajo el mando de un Director remunerado. Los preparativos toman un año completo. Cerca de 150 personas de todo el país participan en esta semana de concientización y hemos tenido algunos participantes canadienses. El aumento en los últimos 9 años de las actividades y del número de participantes durante esta semana de concientización ha ampliado la base de alianzas, incluyendo a agrupaciones de fauna silvestre y clubes de jardinería, al igual que una mayor

108-412) and the Salt Cedar and Russian Olive Control Demonstration Act (Public Law 109-320). Also, NIWAW has been raising awareness of weed science to the point where the Weed Science Society of America (WSSA) will begin to publish a peer reviewed scientific journal devoted specifically to *Invasive Plant Science and Management*. NIWAW provides the forum and opportunity for much exchange of information and ideas. Through NIWAW we have built a coalition of weed and invasive plant organizations, improved congressional as well as Administration awareness, and done public outreach via newspapers, radio, TV, and magazines. Through the use of diplomatic and political skills, we created a sense of urgency and importance and gained a voice in Washington.

variedad geográfica de las personas y organizaciones participantes.

Dos de los mayores éxitos ante el Congreso logrados por esta semana de concientización fueron dos leyes promulgadas en 2004: una para el control y erradicación de malezas nocivas (*Noxious Weed Control and Eradication Act / Public Law 108-412*) y otra (*Salt Cedar and Russian Olive Control Demonstration Act (Public Law 109-320*) para el control del tamarisco (Tamarix spp.). Asimismo, esta semana de concientización ha realizado una labor de concientización tan eficaz que la Sociedad Estadounidense de Ciencia de Malezas (Weed Science Society of America, o WSSA) empezó a publicar una revista científica especializada y dedicada exclusivamente a las ciencia y manejo de las plantas invasivas. Esta semana de concientización es un foro y una oportunidad para numerosos intercambios de información e ideas. Gracias a esta semana de concientización creamos una coalición de organizaciones especializadas en malezas y plantas invasivas, y mejorado el grado de conciencia sobre el problema en el Congreso y en la administración pública. Asimismo, se realizó una labor de información al público a través de la prensa, la radio, la televisión y varias revistas. A través del uso de habilidades diplomáticas y políticas, logramos crear un sentimiento de urgencia e importancia y además ganamos una voz en Washington.

What is National Invasive Weed Awareness Week?

National Invasive Weed Awareness Week (NIWAW) is a series of events and activities including training, briefings by federal Department and Agency staff, Congressional visits and presentations from the field. The NIWAW website is hosted by the North American Weed Management Association at http://www.nawma.org/niwaw/NIWAW%20IX/niwaw_index.htm.

NIWAW is observed annually in late February in Washington, DC, during the week following the week with Presidents Day. The original purpose of holding NIWAW was to raise awareness of the invasive weed or plant issue in the United States Congress, the White House Administration and Federal Agencies. It has evolved over the last 9 years to include awareness and outreach to the public, especially children.

NIWAW Organization

NIWAW is organized by a group of volunteers in the Invasive Weed Awareness Coalition (IWAC). IWAC was formed to provide a forum for all organizations interested in increased funding and greater public awareness for the Invasive Weed/Plant issue to work together. Industry was interested in increased, safer, and better use of herbicides on federal lands. The weed science societies were interested in improved weed management on federal lands and increased funding for weed science research. The Federal Interagency Committee for the Management of Noxious and Exotic Weeds (FICMNEW) wanted more cooperation with state and county weed managers.

IWAC has included individuals from scientific societies, NGOs, associations, state and federal government agencies, herbicide manufacturers, herbicide distributors and vegetation management contractors. These groups include: Weed Science Society of America (WSSA); Aquatic Plant Management Society (APMS); Northeast Weed Science Society (NEWSS); North Central Weed Science Society (NCWSS); Western Society of Weed Science (WSWS); Southern Weed Science Society (SWSS); Ecological Society of America (ESA); Union of Concerned Scientists (UCS); The Nature Conservancy (TNC); Western Weed Coordinating Committee (WWCC); Intermountain Weed Advisory Council (INWAC); North American Weed Management Association (NAWMA); United States Department of Agriculture (USDA) Animal and Plant Health Inspection Service (APHIS); Army Corps of Engineers (ACOE); Armed Forces Pest Management Board (AFPMB); Bureau of Land Management (BLM); Fish and Wildlife Service (FWS); National Park Service (NPS); National Resource Conservation Service (NRCS); USDA Forest Service (USFS); United States Geological Service (USGS); BASF; Dow AgroSciences; DuPont; Monsanto; SePRO; and, Syngenta. We have had support from other federal agencies such as Aquatic Nuisance Species Task Force (ANSTF), National Invasive Species Council (NISC), Agricultural Research Service (ARS), Economic Research Service (ERS), Bureau of Reclamation (BOR), Bureau of Indian Affairs (BIA), Cooperative State Research Education and Extension Service (CSREES), Environmental Protection Agency (EPA), and Federal Highway Administration (FHA). Support has also been received from the Aquatic Ecosystem Restoration Foundation (AERF), Responsible Industry for a Sound Environment (RISE), and National Fish and Wildlife Foundation (NFWF), Center for Invasive Plant Management (CIPM), and the United States Botanic Garden.

Preparation for NIWAW takes a full year. People from all across the US attend NIWAW, and we have had some Canadian participation. The growth of NIWAW activities and attendance over the past 9 years has expanded the geographic breadth of the people and organizations participating in NIWAW. Annual attendance has grown from about 30 to about 150. The partnership base has extended to wildlife groups and garden clubs.

NIWAW Activities

Activities during NIWAW week have included: kickoff session; Kids' Day; Orientation Session; USDA briefings; United States Department of the Interior (DOI) briefings; and agency meetings; meeting with NGOs; NISC briefing; ACOE meeting; FICMNEW meeting; an evening reception; exhibits and posters; legislative visits in Congress; public outreach; media training; and, legislative visit training. The logo that was developed is shown below.

NIWAW has also been able to serve as an umbrella and convenient host venue for: the National Association of Exotic Pest Plant Council (NAEPPC) meeting; the Natural Areas Association (NAA) Invasive Species planning meeting; the Cooperative Weed Management Area Association (CWMA) planning meeting; NAWMA and AERF board meetings; and, the Be PlantWise meeting.

NIWAW

NIWAW Awards

Individuals and organizations who have contributed greatly to the arena of invasive weed/ plant science and management are given awards each year. The awards are sponsored by IWAC, FICMNEW, Pulling Together Initiative (PTI is administered by NFWF), and NAWMA. Many people and projects have been recognized for innovations or dedicated career service to the cause of combating invasive species through this award program. The awards are presented during the evening reception and several distinguished guests have served as emcees (masters of ceremony).

NIWAW Successes

Through NIWAW, we have built a coalition of invasive weed and plant organizations that improved communication, coordination, efficacy, efficiency, and reduced duplication of effort. This has resulted in more and better access, more and better ideas, more resources, more people, greater credibility, and a more consistent message. NIWAW provides the forum and opportunity for much exchange of information and ideas. Through the use of diplomatic and political skills, we created a sense of urgency and importance and gained a voice in Washington, DC.

NIWAW has improved Congressional awareness of the invasive plant issue. The foremost congressional successes of NIWAW were passage of the Noxious Weed Control and Eradication Act of 2004 (Public Law 108-412) and the Salt Cedar and Russian Olive Control Demonstration Act (Public Law 109-320). Unfortunately, neither law has been funded, indicating that we still have a lot of work to do in terms of securing appropriations, and increasing the federal funding for prevention, early detection and rapid response, and, control and management of invasive weeds.

Also, NIWAW has been raising awareness of weed science in the scientific and management community to the point where the WSSA has begun to publish a peer-reviewed scientific journal entitled *Invasive Plant Science and Management*.

Public awareness/outreach through newspapers, radio, TV, and magazines has increased. NIWAW produced a series of 27 success stories that highlighted invasive weed management projects all across the country. NIWAW has improved Administration awareness to the point where some federal managers requested to speak to us in 2008, after we had changed the format of the departmental briefings from formal presentations to roundtables.

NIWAW has begun to foster partnership and cooperation with wildlife groups and garden clubs. We expect that this association will increase the number of advocates for the invasive plant/ weed issue in Congress and the Administration.

NIWAW has supported the movement to increase the number and breadth of Cooperative Weed Management Areas (CWMA) in the eastern part of the US, following the successes of CWMAs in the West.

Challenges Facing the Coalition

We created a sense of urgency and importance and gained a voice in Washington, DC. But more needs to be done. NIWAW is seeking support for S1949 – the 100th Meridian Bill introduced by Senator Harry Reid and others. NIWAW – It's All About The Weeds!

We
Expect
Extra
Dollars
Soon

NIWAW – What can we always do?

DO THE DOABLE

Biography

Nelroy E. Jackson is a Weed Scientist who is a consultant. Nelroy currently serves of the Chair of the Invasive Weed Awareness Coalition and Director of National Invasive Weed Awareness Week (NIWAW). He is a former Vice-Chair of the Invasive Species Advisory Committee. He is a Past President and an Honorary Member of the California Weed Science Society. Nelroy has served on the Board of Directors of the Weed Science Society of America, the Western Society of Weed Science, and the Natural Areas Association. He is a founding Director of the California Exotic Pest Plant Council (now called the California Invasive Plant Council). Nelroy was instrumental in the development of Roundup and Rodeo herbicides for control of invasive plants in the United States. He retired as a Technical Development Manager for Monsanto Company in 2000. He earned a PhD in Soil Chemistry and Biochemistry from The Ohio State University in 1970.

Vegetative Management Using Controlled Sheep Grazing – The Montana Sheep Institute

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1 Presenter

Abstract

Today, sheep grazing is being rediscovered and honed as a viable and effective tool to address contemporary vegetation management challenges, like controlling invasive exotic weeds, and finding chemical-free ways to control weeds in organic agriculture. The Montana Sheep Institute's objective is to develop, implement and evaluate controlled sheep grazing strategies for managing large infestations of leafy spurge (*Euphorbia esula*) and spotted knapweed (*Centaurea maculosa*). Preliminary data suggest that 80 to 90% of the original ecological value of noxious weed-infested land can be reclaimed over a five-year period with controlled sheep grazing. Grazing prescriptions that concentrate on time, duration and density of grazing, combined with a training period can achieve 60 to 70% utilization of the target plant and limit the utilization of native grass to 30 to 40%. A preliminary comparison from leafy spurge project sites indicate that, leafy spurge composition decreased about 7% per year of grazing while the grass component of the landscape increased by 6%. Over time this type of grazing will favor the re-establishment of grass and forb component of the landscape.

Resumen

Hoy en día, el pastoreo de ovejas se está redescubriendo y usando nuevamente como una herramienta efectiva para afrontar los retos en el manejo de flora contemporáneo. Algunos de estos retos son controlar malezas exóticas invadidas y encontrar maneras para controlar malezas sin químicos en agricultura orgánica. El objetivo de la Institución de las Ovejas de Montana es desarrollar, implantar, y revisar estrategias de pastoreo de ovejas para controlar grandes invasiones de lechetrezna frondosa (*Euphorbia esula*) y centaurea maculosa. Datos preliminares indican que de un 80 a un 90% del valor original ecológico de la tierra invadida por malezas nocivas puede ser recuperado en un periodo de cinco años con el pastoreo controlado por ovejas. Prácticas que se enfocan en el tiempo, la duración y la densidad del pastoreo, combinadas con un periodo de entrenamiento pueden conseguir una utilización de 60 a 70% de la planta principal y limitar la utilización de la hierba nativa a un 30 a 40%. Una comparación preliminar de lugares de proyectos de lechetrezna frondosa indica que el pastoreo disminuyó la composición de lechetrezna cerca de un 7% por año, mientras que el componente de la hierba de pradera aumentó por un 6%. En un tiempo, este tipo de pasto ayudará al reestablecimiento del componente de la hierba y de las hierbas de grandes hojas de la pradera.

Introduction

One of the greatest threats to public and agricultural lands is the spread of noxious weeds. Invasive plants such as leafy spurge (*Euphorbia esula* L.) and spotted knapweed (*Centaurea maculosa* Lam.) "overrun" and destroy grazing land, trigger soil erosion, decrease availability of water, reduce biodiversity and cost agriculture millions of dollars each year. Currently, these noxious weeds infest millions of acres of farm and public land in 26 northern states and six Canadian provinces (Sedivec et al. 1995, Tyser and Key, 1988). These two weeds not only make land unfit for crops and cattle grazing, they threaten native plant populations, decrease rangeland plant diversity and degrade wildlife habitat and associated recreation (Hirsch and Leitch 1996, Leistritz et al. 1992).

Sheep may provide the most economical and environmentally sound alternative to chemical control of the encroachment of noxious weeds. Lacey et al. (1985) reported that sheep grazing substantially reduces leafy spurge density and biomass. Several reports (Cox 1989, Olson et al. 1993) suggest that sheep readily graze spotted knapweed and that sheep grazing may potentially be used in controlling the weed. Repeated (mid-June, mid-July, early September) short duration grazing reduced flower stem production of spotted knapweed on a knapweed-infested Idaho fescue (*Festuca idahoensis* Elmer) range site in southwestern Montana (Olson et al. 1993). In some years, sheep actually grazed spotted knapweed more than they grazed Idaho fescue.

Sheep are unique in that they will consume both leafy spurge and spotted knapweed and thus prescribed sheep grazing can be utilized as a tool to economically control these invasive plants as a component of a total weed management program. The Montana Sheep Institute's (MSI) objective is to develop, implement and evaluate controlled sheep grazing strategies for managing large infestations of leafy spurge and spotted knapweed.

Materials and Methods

Suitable sites located throughout Montana were identified, after which a sheep grazing plan was developed and initiated for each specific site. Prior to the initiation of the study, planning meetings were held that included the landowners, sheep producers, county agents, weed supervisors, agency groups such as the Bureau of Land Management (BLM), and the Montana Sheep Institute to develop stakeholder partnerships.

Montana Sheep Institute weed projects in 2007 directly involved over 40,000 ha of weed infested Montana rangeland and about 1000 landowners. The MSI conducted 22 projects with 29 monitoring sites utilizing 30,000 sheep and goats from 31 sheep producers. Most projects are in third year of a five-year grazing protocol. Key project areas include 155 km of the Powder River, 40 km of the Yellowstone River, 13 km of the Madison River and key support of the management program for the "Bucksnort After-Fire project". Each project involves a group of both private (Montana sheep producers, land owners, local organizations) and public (BLM, State Fish and Game, regional Weed Boards) cooperators.

Three paired plots per research site were established with individual plots within each pair visually selected to be similar in soil, topography and vegetative type (USDA-USDI 1996). Prior to sheep grazing, an exclosure was placed on one plot within each pair and after grazing plots were sampled to establish utilization of target weed versus other forage.

At some sites, photographic and vegetative production monitoring were performed prior to sheep grazing in order to capture an undisturbed view of the vegetation. A 1 × 1 m plot was staked so that the four sides ran north, south, east, and west. Photographic plots were identified with geospacial coordinates (GPS). Photographic monitoring was also done on approximately the same date every calendar year in order to capture the vegetation in a similar stage of growth each year making the photos comparable across years. Photographs were taken of the plot and of the landscape in all four directions. A transect was placed from the photo plot and five 50 × 50 cm quadrants located and clipped (USDA-USDI 1996). Transects were run in a different direction each year. The direction was held constant for all plots. Only current year's growth was clipped. Vegetation was separated by life form (i.e., perennial grass, annual grass, forbs, shrubs, and noxious weeds). Forages were dried at 60°C for 48 h and relative dry matter production in kg/ha of each life form was calculated.

Leafy spurge and spotted knapweed sites were divided into high, medium, and low levels of infestation based on the following calculation:

$$\text{\% infestation} = [(\text{kg of weed} / \text{kg of total forage production for the site}) \times 100]$$

Data were analyzed for level of infestation, year, and year × % infestation (SAS Inst. Inc., Cary, NC).

Following the summer grazing season, meetings were held with all stakeholders to discuss results of monitoring, potential successes, and opportunities for improvements.

Results

Leafy Spurge

Results from 2003 through 2007 at leafy spurge monitoring sites are summarized in Table 1 and Figure 1. Total forage productivity was similar across site infestation level classifications and averaged 967.9 kg/ha. Sites with high leafy spurge infestations had less grass productivity than medium and low infestations (223, 446 and 739 kg/ha, respectively). The forb component represented very little of the vegetation profile and was basically nonexistent on all test sites. Relative utilization of leafy spurge was higher than that of the grasses (about 65% versus 35%, respectively). These data reinforce what happens if we allow these non-native weeds to continue to invade and dominate the landscape. The first and most critical issue is that as these weeds invade the landscape the forb component is eliminated from the landscape. Forbs are a critical component of a healthy wildlife habitat. Secondly, the noxious weed component gradually replaces the grass component until landscape diversity is compromised. The landscape trend is to a monoculture of the non-native invasive plant. Many sites investigated in this project have

Table 1.
Forage differences between high, medium and low infestation levels in kg of dry forage per ha on plots prior to sheep grazing.

Infestation level (% weed)	Leafy spurge sites (n = 28)			Spotted Knapweed sites (n = 10)		
	Weed	Grass	Forb	Weed	Grass	Forb
High (100–67%)	677.8[a]	223.4[a]	65.0[a]	555.2[a]	231.9[a]	29.1[a]
Medium (66–33%)	462.9[b]	445.8[b]	58.2[a]	428.2[a]	259.2[a]	118.8[a]
Low (32–0%)	133.4[c]	739.2[c]	98.1[a]	27.9[b]	554.2[b]	217.9[b]

a, b, c Columns with different letters are significantly different at the P ≤ 0.05 level.

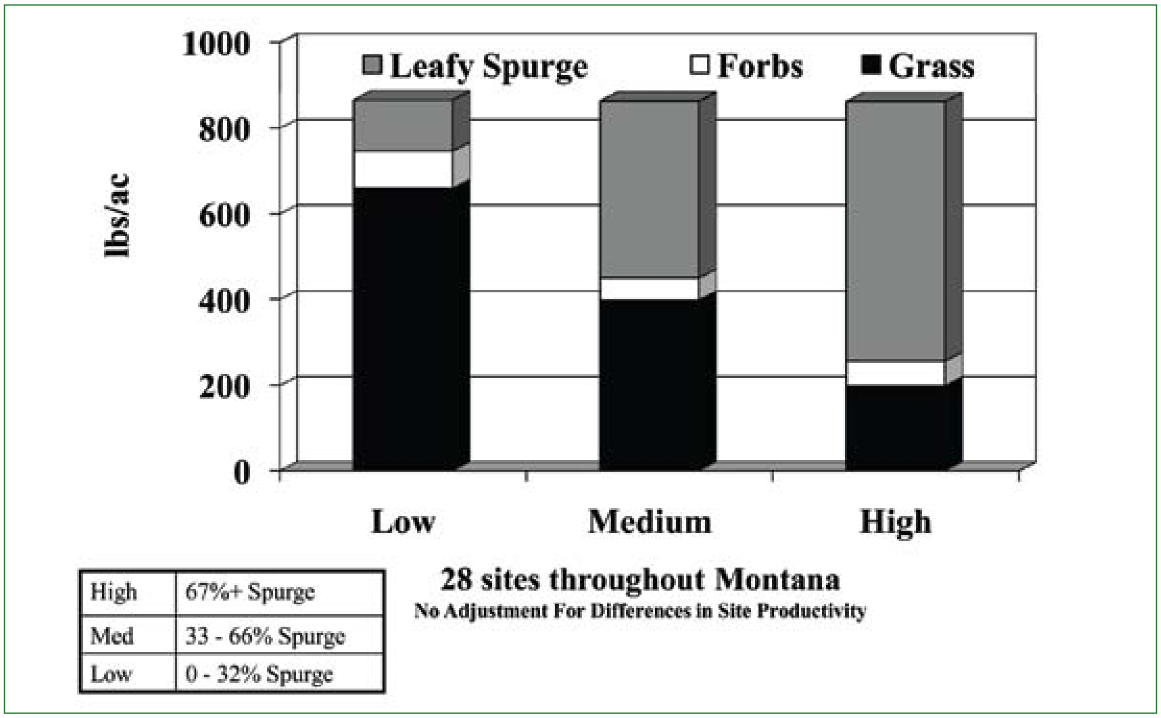

Figure 1. Relative composition of leafy spurge, grass and forbs (2003–2007 data).

been altered because of high weed infestation levels. Most traditional weed control methods (i.e., herbicides) would be economically prohibitive under the current infestation conditions. For instance, it has been estimated that to control the weed problem with herbicides in Missoula County alone, it would cost about $12 million per year for 5 years. Our data also demonstrate that under a controlled grazing régime, sheep will selectively graze leafy spurge. In our studies, we were able to achieve 60–70% utilization of the leafy spurge and limit the utilization of the grass to 30–40%. Over time, this type of grazing should favor the re- establishment of grass and forb component of the landscape.

Table 2.
The percent change in composition of forage plots after successive years of sheep grazing.

Number of plots	Number of years grazed	% Forage composition		
		Leafy Spurge	Grass	Forb
16	0	49.1[a]	43.7[a]	7.1
12	1	40.5[a]	50.2[ab]	9.3
14	2	36.6[b]	54.3[abc]	9
5	3	28.4[bc]	67.6[bc]	4
6	4	15.8[c]	68[c]	16.3

[a, b, c] Columns with different letters are significantly different at the $P \leq 0.05$ level.

The percent change in composition of forage plots after successive years of sheep grazing is presented in Table 2. Analysis indicated the amount of leafy spurge decreased by 7%, and grass increased by 5% at the sheep grazing sites.

Spotted Knapweed

Table 1 and Figure 2 summarize results for 10 sites where spotted knapweed was the target weed. Although the total productivity of these sites was lower than the leafy spurge sites (807 versus 968 kg/ha, respectively), forage composition trends were similar. Total forage productivity was similar between sites with differing degrees of infestation. As sites became more infested, grass production declined with 554 kg/ha at low infestation sites versus an average of 246 kg/ha at medium and highly infested sites. Conversely, spotted knapweed increased with 28 kg/ha at low infestation sites versus an average of 492 kg/ha at medium and highly infested sites. It appears that with spotted knapweed, there seems to be a more prevalent or distinct trend to a monoculture as infestation becomes more severe. Spotted knapweed is utilized at a higher level than is grass. These data suggest that sheep can be used to selectively graze spotted knapweed and their effectiveness as a weed management tool for spotted knapweed may be most effective at medium to high infestation rates.

One of the major components to the success of these projects is the shared project planning and evaluation. In each case, the project development involved a series of meetings with all stakeholders (i.e., private landowners, government land agencies, county officials, and sheep producers) to identify problems, formulate potential solutions, and discuss results of monitoring, potential successes, and opportunities for improvements. In addition, all stakeholders had individual responsibilities associated with the summer grazing project and data collection and evaluation process and these roles added to the success of MSI projects. The key to the success of MSI vegetation management projects is the shared ownership between MSI and local and state land managers.

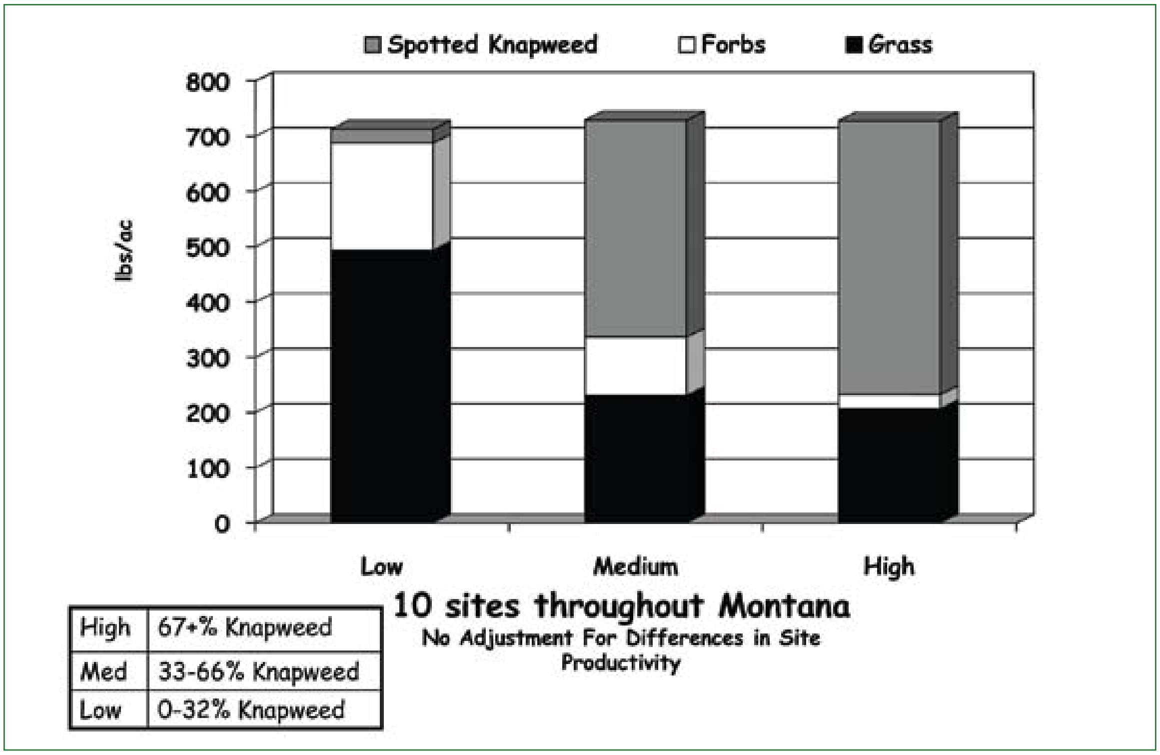

Figure 2. Relative composition of spotted knapweed, grass and forbs (2003–2007 data).

Implications

The Montana Sheep Institute is an example of how to develop positive working relationships between stakeholders involved in weed and land management. Data collected from MSI projects suggest that over time controlled sheep grazing should favour the re-establishment of grass and forb vegetation components and lessen the negative impacts of the noxious weed component in the landscape.

Acknowledgments

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Biography

Lisa Surber was born and raised on a ranch near Medicine Hat, Alberta, Canada. She obtained her Bachelor's, Master's and Ph.D. in Animal Science and Range Sciences from Montana State University. Lisa is currently a research scientist in the Montana Sheep Institute at MSU in Bozeman. In her position, Lisa is involved in many research and extension projects including ultrasound determination of ribeye area and landscape scale weed grazing projects across Montana with Leafy Spurge, Spotted Knapweed, and Dalmatian Toadflax.

Ecology, Biology and Control of Exotic-Invasive Weeds in Forestry – Management of Gorse (*Ulex europaeus* L.) on Federal Lands in Victoria, British Columbia, Canada

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Abstract

Scotch broom (*Cytisus scoparius*), Gorse (*Ulex europaeus*) Daphne (*Daphne laureola*) and English ivy (*Hedera helix*), are four prominent, invasive plants that pose a serious threat to Garry oak and associated ecosystems in British Columbia. These plants colonize disturbed areas quickly, form monospecific stands, persist for a long time and defy easy eradication. They inhibit the growth of native plants and ultimately arrest forest succession. Several federal departments have expressed great concerns regarding their rapid incursion and adverse impacts. Research was conducted to examine the population dynamics, phenology and control methods of these invasive plants on federal lands near Victoria, B.C. Of the several methods of control tested, including manual cutting, application of a herbicide (triclopyr), a fungal bioherbicide (*Chondrostereum purpureum*), and a commercial plastic mulch, it was found that some treatments (mulch and herbicide) provided 100% efficacy on resprouting behaviour

Resumen

La retama negra (*Cytisus scoparius*), la aulaga o tojo o aliaga (*Ulex europaeus*), la laureola (*Daphne laureola*) y la hiedra (*Hedera helix*) son cuatro de las principales plantas invasivas que son una grave amenaza para el roble Garry y los ecosistemas conexos en la provincia de Colombia Británica. Estas plantas colonizan con rapidez las áreas afectadas, formando masas vegetales que perduran largo tiempo y resisten la erradicación simple. Inhiben el crecimiento de las plantas autóctonas y a la larga detienen la sucesión forestal. Varias entidades federales han expresado una gran preocupación por su rápida incursión y las consecuencias adversas. Se realizaron investigaciones para estudiar la dinámica de reproducción, fenología y métodos de control a las plantas invasivas en terrenos federales cercanos a la ciudad de Victoria, en Colombia Británica. De los diversos métodos de control ensayados, la tala manual, la aplicación de un herbicida (triclopyr), la aplicación de un herbicida biológico fungal (*Chondrostereum purpureum*) y la of all four invasive species. While one bioherbicide (*Fusarium tumidum*) was very effective on Scotch broom under the greenhouse conditions, it was not tested under field conditions. *Chondrostereum purpureum* produced a variable response under the field conditions. Manual cutting was found to be the least effective. Also a novel prospective bioagent (*Phomopsis* sp.) was isolated from dying and dead samples of Daphne from the field and results from laboratory, greenhouse and field conditions suggest that it may hold great potential. Additional research is necessary to determine appropriate formulations of these bioagents as well as the effectiveness of the different and integrated treatments over a period of years. A new technology using superheated water (aquacide) to kill vegetative shoots of gorse did not offer long term control nor was it found to be cost effective. However, in this paper, only results on management of gorse are described and discussed.

colocación de una cubierta de plástico comercial; se encontró que ciertos métodos (cubierta plástica y herbicida) logran, con una eficiencia de 100%, modificar el comportamiento de regerminación de las cuatro especies invasivas. Aunque un herbicida (*Fusarium tumidum*) resultó muy eficaz contra la retama negra en condiciones de invernadero, no se hicieron pruebas aplicándolo sobre el terreno. El *Chondrostereum purpureum* obtuvo resultados variables cuando se le aplicó sobre el terreno. La tala manual fue el método menos eficaz. Asimismo, un prometedor agente biológico nuevo (*Phomopsis* sp.) se aisló de muestras moribundas y muertas de laureola recogidas del terreno; los resultados obtenidos en laboratorio, invernaderos y sobre el terreno sugieren un enorme potencial. Se necesita investigación adicional para determinar las fórmulas adecuadas de estos agentes biológicos, al igual que la efectividad de los variados tratamientos que son integrados durante cierto periodo de años. Una nueva tecnología que emplea agua súper calentada (*Aquacide*) para matar brotes vegetativos de aulaga no ofreció control a largo plazo ni demostró ser rentable. Solo los resultados del manejo de la augula son descritos y discutidos en este artículo.

Introduction

Many species of plants were introduced into North America for beneficial purposes but some of these exotics (Prasad et al. *in press*) have escaped, invaded and expanded their ranges into the new environment beyond usefulness. Scotch broom (*Cytisus scoparius* (L.) Link) and gorse are such alien weeds that were introduced into Vancouver Island in the last 150 years. They are very aggressive, invasive and have come to dominate many landscapes; roughly 10% of the Vancouver Island is infested with these species and this area is increasing each year (Prasad 2003). Of particular concern is their threat to the unique and endangered Garry oak (*Quercus garryana* Dougl.) ecosystem on south eastern Gulf Islands of British Columbia (Peterson and Prasad 1998). They quickly form dense thickets that can easily shade out native vegetation and reduce biodiversity.

On forested lands, these weeds interfere with fibre and timber production by the economic conifer species (Prasad 2000). They are nuisance species occupying desirable land and limit agriculture, grazing, recreation and other activities. Furthermore, gorse has high concentration volatile oils in branches and produces considerable biomass creating a Fire hazard (Clements et al. 2001). Therefore, a field experiment was carried to determine the effects of a bioherbicide containing *Chondrostereum purpureum* (Pers.) Pouzar (Cp), a chemical herbicide (triclopyr), a plastic mulch and a manual cutting method on resprouting behaviour in gorse.

Materials and Methods

Three sites were selected at the Rocky Point, Esquimalt, Victoria on Department of National Defense (DND) lands and only healthy gorse plants (3 m high, 5 cm diameter) were chosen for experiments. Gorse had been growing at the site for 10–20 years, had developed dense colonies, was 2–3 m tall with average stem diameter of 5 cm above the ground. At each site, six plots were established with a randomized block lay-out of all treatments, as follows: 1) cut and treated with sterile water, as control; 2) cut and treated with a blank formulation (without Cp); 3) cut and treated with Cp formulations; 4) cut and treated with triclopyr; 5) cut and covered with a plastic mulch; and, 6) uncut stems as check. Each plot was 3 (3 m containing 15 stems of cut or uncut gorse plants and was randomly selected to receive all treatments. Chosen stems were tagged and measured for their initial height and diameter; there were 45 variates of each treatment spread over 3 blocks. The formulation and application of Cp followed that of Prasad and Kushwaha (2001). Triclopyr herbicide was obtained from a local store and applied at 180 gm L^{-1}. All treatment solutions were delivered through a squeeze bottle at 3 ml per cut stem. For mulching, a commercial black plastic sheet (2 mm thick) was cut and fitted to each plot in such a way as to completely cover all cut stems. The plastic sheet was fastened to the ground with staples at each corner and in the middle of the plot. A few heavy stones were placed over the mulch to prevent its blowing away or disturbance by the wildlife. All stems were cut at 2.5 cm above the soil surface with a brush saw and all treatments were applied immediately on a rain-free day during July. The response was measured over 2 years. Data were analysed statistically by the LSD (least significant difference) method.

Results and Discussion

Figures 1 and 2 show the vigorous growth of gorse, note the dense thickets it forms and the growth up to 3–4 m. Figure 3 shows the distribution of gorse and scotch broom (yellow-brown colors) along the highway corridors and on the margins of Douglas fir plantations (green color) while Figure 4 shows the flowering habits of the gorse. As said earlier, one of the mechanisms of its invasiveness is in prolific flowering, seed set and production of seeds, about 18000 per plant per year, the seeds are contained in the pod which bursts to release the seeds (Figures 4 and 5). Other mechanisms of its invasiveness lie in: (a) reduced leaves (spines) to prevent rapid transpiration; (b) active photosynthesis in adverse conditions, and in winter months (5°C) by branches, and stems; (c) nitrogen fixation by roots; and, (d) absence of a natural parasite/predator complex. Therefore, there are no checks on its rapid spread into newer locations. Gorse


Figure 1. Dense thickets of gorse on Rocky Point.

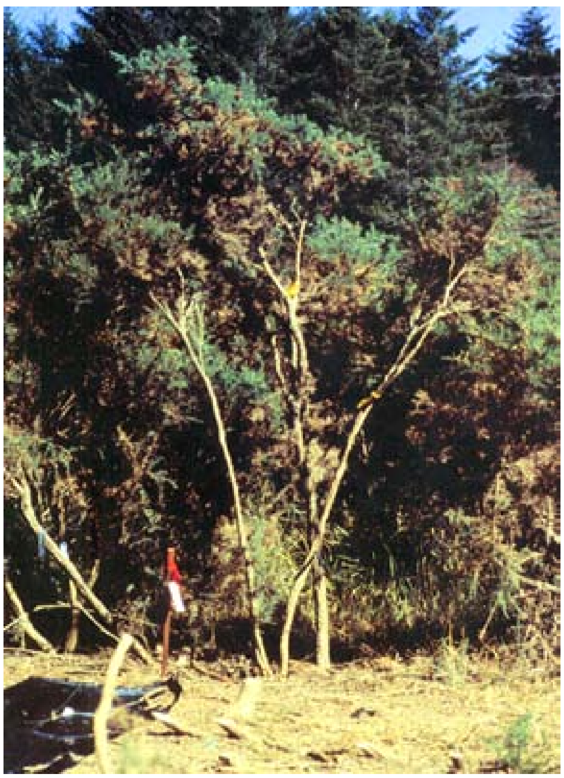
Figure 2. Fully grown gorse on federal land.

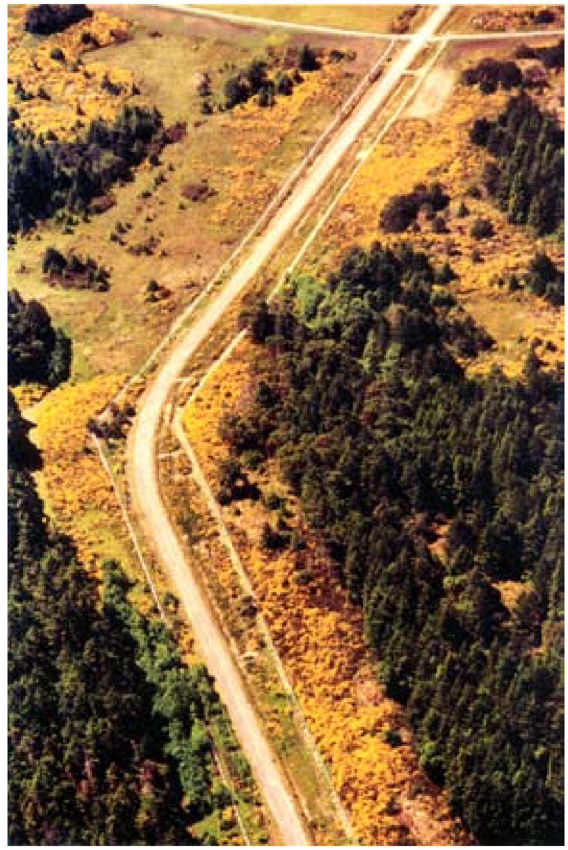
Figure 3. Distribution of gorse (brown) and Scotch broom (yellow) near highways and Douglas fir (green) plantation.


Figure 4. Prolific flowering and seed set in gorse.

can compete for space, light, nutrients and moisture with native vegetation such as grasses and Douglas fir and Garry oak trees in the ecosystems as shown in Figures 6, 7 and 8. One of the worst adverse impacts that gorse exerts is to produce large amounts of biomass which, when dried, becomes highly combustible as it contains volatile oils and becomes a source of fire hazard in the community (Figure 9).

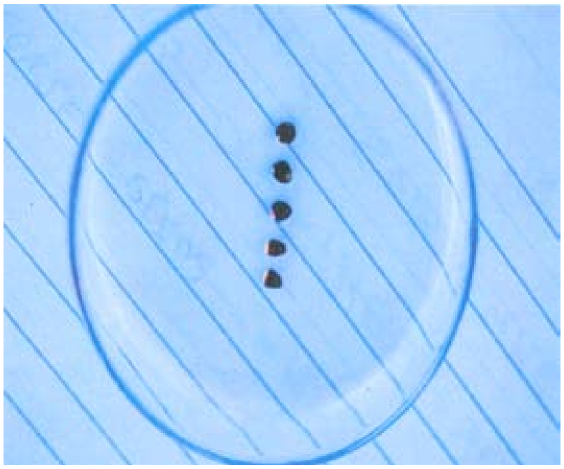

Figure 5. Seeds of gorse as sources of propagation.

Figure 6. Competition of gorse with conifers and Garry oak.

Figure 7. Extensive flowering, seed production and displacement of native grasses.

Figure 8. Showing adverse impacts of gorse on Garry oaks.

Figure 9. Dried biomass of gorse is a fire hazard.

Table 1. Influence of various treatments on resprouting of gorse stems after two years.

Treatment	Sprout height (cm)	Percentage
Cut stumps + sterile water	35.1	100
Cut stumps + blank	34.5	98.3
Cut stumps + bioherhicide (Cp)	18.2	51.9
Cut stumps + herbicide (triclopyr)	0	0
Cut stumps + mulching	0	0
Uncut stumps	15.2	43.3
LSD (0.05)	2.1	–

Results of the treatments for gorse are summarized in Table 1. As can be seen, only two treatments, namely mulching and the triclopyr treatment, provide the maximum advantage. Manual cutting is not effective as it induced vigorous resprouting, however, some reports (Prasad 2003) suggest that manual cutting carried out before flowering in early spring may reduce the rate of resprouting. Such labour intensive treatments are not cost- effective. Use of the bioherbicide provided only partial control (52%). Caution needs to be taken while employing these live agents as they are sensitive to environmental conditions (drought, ultra violet, sunlight and relative humidity). Therefore, efficacy of these bio-agents cannot be predicted or guaranteed and a proper formulation, timing and method of application and often re-treatments are required to ensure greater success (Prasad and Kushwaha 2001).

No one method can be relied upon for full cost-effective control of gorse, even though, the herbicide and mulching treatments prevented re-growth . Triclopyr has been found to be quite safe if applied on cut surfaces or as directed sprays (Prasad 2003), however, public concerns of use of chemical pesticides in urban or federal land close to aquatic and marine environment arouses scrutiny and controversy. The use of opaque plastic mulch was indeed effective after 6 months with initial re-sprouting, but eventually dying back. Whether mulching can be practical on a large operational scale remains to be seen. It seems an integrated approach, cutting before the flowering followed by herbicide or bioherbicide application at later stages to retard resprouting can be more successful. Mulching can be used to stimulate germination of seed banks (by increasing available moisture) and then causing the seedling growth to etiolate and die off under the mulch in absence of light. Further research is needed to delineate the best options for control of these exotic invasive weeds.

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Biography

Raj Prasad, who just retired from the Pacific Forestry Centre, Victoria, BC, is well known for his research on ecology, biology and control of weeds in forestry, and has published over 300 papers on pest management in forestry and is a co-editor of the standard Herbicide Handbook 6th Edition 1989 published by the Weed Science Society of America. He was honored by several Weed Science Societies (Weed Science Society of America, Asian-Pacific Weed Science Society, Indian Society of Weed Science) and Capital Regional District (Victoria, British Columbia) for his contributions to weed science and alien invasive weeds. Raj has supervised over 50 students and acted as Secretary- treasurer for the International Weed Science Society. He also holds a US Patent and a Canadian Patent jointly with others for his co-discovery and formulation development of bioherbicide (Chontrol) based on *Chondrosteum pupureum*. Raj was educated at University of Allahabad (B. Sc. Ag., M. Sc.), India, the University of Oxford (Ph. D.), UK, and the University of California at Davis (post-doctoral training in pest management).

Addressing the Invasive Aquatic Flowering Rush (*Butomus umbellatus*) in the Headwaters of the Columbia River System – A Multi-Partner, Interdisciplinary Project

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1 Presenter.

Abstract

Flowering rush (*Butomus umbellatus*) is an aquatic macrophyte native to Eurasia. First reported in North America in 1905 in the St. Lawrence River, it has spread through the states and provinces on the border of the United States and Canada. It can dominate irrigation systems, wetlands, the littoral zone of freshwater lakes, and river edges. In Montana, it has spread throughout Flathead Lake and down 90 km of Flathead River at the headwaters of the Columbia River system. Several partners united to work on an interdisciplinary project on flowering rush in the Flathead watershed of the upper Columbia River basin. The project combines public outreach, education, biology, genetics and dispersal research, mapping, and spatial modeling.

Resumen

El junco florido (*Butomus umbellatus*) es una planta macrófita acuática oriunda de Eurasia. Avistada por primera vez en América del Norte en 1905 en el río San Lorenzo, se ha propagado por todo el territorio de Estados Unidos y por las provincias del sur de Canadá. Puede llegar a dominar sistemas de irrigación, humedales, zonas litorales de lagos dulces y orillas de ríos. En Montana, se ha propagado por todo el lago Flathead y en unos 90 km al sur de dicho río, en las cabezas del sistema fluvial del río Columbia. Varias organizaciones han unido fuerzas en un proyecto interdisciplinario para combatir al junco florido en el sistema Flathead. El proyecto combina actividades de información al público, educación, biología e investigación sobre dispersión, al igual que de cartografía y elaboración de modelos espaciales.

Introduction

How do you ensure that the latest invasive plant research is incorporated into management decisions? Alternatively, how do you get scientists to study issues directly relevant to a pressing management problem? One solution that is being championed in northwest Montana is to seamlessly span these boundaries by forming a partnership of all of the major players in research, management, outreach, and education that surround a regional invasive plant of concern, flowering rush (*Butomus umbellatus* L.). In 2006, the Center for Invasive Plant Management (CIPM) was fortunate to be approached by Salish Kootenai College (SKC), the University of Montana (UM), and the Confederated Salish and Kootenai Tribes (CSKT) and asked to join an interdisciplinary collaboration to address the threat of flowering rush in the Flathead watershed of northwest Montana. The proposed integrated project, *Spatial Modeling of Invasive Flowering Rush in the Columbia River Headwaters*, was designed to better understand the current location, spatial extent, and biological potential of flowering rush in the south half of Flathead Lake, Flathead River, the Pablo National Wildlife Refuge (PNWF) and Flathead Irrigation Project canals and reservoirs. This invasive aquatic plant species has the potential to affect not only this area but the entire Columbia Basin. Prevention and early detection are the most economical and efficient means of invasive plant management. A key component of this project is the dissemination of information to assist others throughout the region to better address this species before it becomes widespread. This project provides a unique opportunity to demonstrate the strength of collaborations in addressing invasive plant issues by creating clear links between research, management, education and outreach.

Flowering Rush Background

Flowering rush is an obligatory, non-persistent emergent, wetland species and is an invasive aquatic macrophyte in North America. It is native to temperate Europe and western Asia (Tutin et al. 1980). It was first noted in North America about 1905 along the St. Lawrence River in Quebec (Fletcher 1908). By 1974 it had spread throughout Canada and the northern parts of the United States (Anderson et al. 1974). The current reported distribution in the Pacific Northwest is only six counties in Montana (MT), Idaho (ID) and Washington (WA) (Rice 2005) and specific locations in the provinces of British Columbia and Alberta (White et al. 1993). In the Pacific Northwest, the most northern documented flowering rush population in the wild is on the Sturgeon River in central Alberta (Scotter 1991). The first Montana collection was in 1964 from Peaceful Bay in the northwest corner of Flathead Lake (Rice 2005). Since 2004, Salish Kootenai College has been mapping flowering rush in Flathead Lake, lower Flathead River, Pablo National Wildlife Refuge and other adjacent areas.

Flowering rush is invasive throughout much of North America and Europe because it tends to form monotypic stands (Core 1941; Staniforth and Frego 1980; Hroudova et al. 1996; Lavoie et al. 2003). The impacts of these monotypic stands have been substantial in terms of recreation and irrigation but specific effects on native plants, invertebrates, fish and wildlife and culturally important species need more research. It has been identified in management documents in both Canada and the United States as a problem species. Flowering rush was identified as a Principal Invasive Alien species in wetlands in a Canadian Wildlife Service Publication in 1993 (White et al. 1993). In 2008, flowering rush was added to the Montana Noxious Weed List as a Category 3 species by the Montana Department of Agriculture. Flowering rush grows as both a non-persistent emergent plant in shallower areas such as along shorelines and as a submersed plant in deeper water of lakes and rivers. It may form dense stands that dominate wetlands, the littoral zone of freshwater lakes, and river edges. Flowering rush is most easily identified by its whitish pink flowering umbel. However, not all populations flower in abundance. The stems are green and could be mistaken for other large aquatic plants except that they are distinctly triangular in cross-section. Plants may grow to about five to six feet high and the leaf tips may be spirally twisted. Flowering rush has an extensive rhizome system and all populations appear to spread vegetatively from rhizome structures. Management and control options for this species have not been well-developed and site to site variability poses unique problems. Some mechanical and chemical methods have been proposed, but the use of aquatic herbicides in wetland, riparian, and lake habitats also poses unique complications. The ability of the species to spread by fragments causes complications with mechanical removal. Also lacking is information on ecological impacts of this species. The potential environmental or cultural impacts could include impairments to recreation, reduced species diversity or impacts to species of cultural importance, and reduced habitat for wildlife, aquatic species and native plants. This invader may also be restoring some ecological services such as reduction in shoreline erosion, waterfowl food production, and fisheries and invertebrate habitat previously provided by a diverse native wetland community destroyed by the construction and operation of the Kerr Dam hydroelectric facility that altered water levels in Flathead Lake.

Project Objectives

In order to collaboratively address the threat of flowering rush in the Flathead watershed, and upper Columbia River Basin, the partnership identified several primary objectives essential for success. The integrated project objectives included:

- Determine the phenology and dispersal of flowering rush in Flathead Lake
- Study genetics of flowering rush
- Inventory and map the infestation in Flathead Lake and River
- Develop a computer spatial model of Flathead Lake to predict the biological potential of flowering rush
- Develop management strategies for flowering rush
- Develop education and outreach programs

Accomplishments

Phenology and Dispersal

There are two genetic types of flowering rush: diploid and triploid (Krahulcova and Jarolimova 1993). The diploid type is fertile and self-compatible, and the triploid is sterile. Most populations in western North America are believed to be sterile, triploid populations. However, a study of nine populations in eastern Ontario, Canada, observed wide variation in reproductive strategies with many populations being highly fertile and some which produced no seeds (Eckert et al. 2000). Eckert et al. (2003) report that the sterile triploids in North America rarely produce flowers. Triploids can produce inflorescence bulblets, the diploids do not (Hroudova and Zakravsky 1993). The probability of invasiveness may also depend on the genetic type of a population. Hroudova et al. (1996) concluded that the triploid is adaptable to a wider range of habitat conditions and has traits that allow it to rapidly find and dominate new sites. The invasive populations that have been studied in the Czech and Slovak Republics are predominantly of the triploid form (Hroudova and Zakravsky 1993).

Depending on reproductive strategy, populations may reproduce and spread in four different ways: 1) seeds; 2) vegetative bulblets formed in the inflorescence; 3) vegetative bulblets formed on the side of rhizomes; and, 4) rhizome fragments from large plants. Seeds allow long distance dispersal by wind or over ice whereas rhizome bulblets and rhizome fragments spread by water. Humans and animals can assist in its spread such as humans purchasing them to plant in gardens, birds for seeds, and animals for rhizome bulblets and rhizome fragments (Gaiser 1949; Boutwell 1990). Also, depending on the reproductive strategy of a flowering rush population, widely different management actions may be used.

In order to better understand the local population of flowering rush and to maximize management strategies, researchers are undertaking studies to document basic plant phenology and dispersal characteristics in the Flathead system. Initial research of the phenology of flowering rush was conducted in 2007 and will be continued in 2008.

Past observations of flowering rush in Flathead Lake over the previous decade had not found any seed but lateral rhizome buds and rhizome fragments are common. This suggested that infestations in Flathead Lake may be a sterile triploid population. Preliminary results have confirmed that due to minimal flowering and apparent lack of viable seed production this population is indeed triploid and will likely reproduce primarily vegetatively. Research on other aspects of dispersal and phenology are continuing.

Genetics Testing

Salish Kootenai College and the University of Idaho have successfully acquired funding from the USDA-CSREES to conduct research to determine the karyotype of the local infestation and to compare it to other populations within the Columbia system. The local genotype does not appear to produce viable seed. However the sterile form has shown to be more invasive and pervasive than the seed-producing genotype in the eastern United States. Montanan State University will be participating as project evaluator on this effort as well as the spatial modeling and outreach piece. The genetics project will also evaluate invasive, native, and hybrid Eurasian water milfoil that has recently been identified in Montana and on the reservation. The University of Idaho is developing rapid assessment tools so positive identification is more feasible. An added bonus out of this work is the formation of an aquatic invasives working group composed of biologists, plant specialists, and weed control specialists to improve identification skills, organization for rapid response, and generally increase the knowledge of aquatic invasive plants.

Inventory

Unique challenges were presented in conducting the inventory of flowering rush since the plant grows both in shallow and deep areas of the lake and along the river system. It was decided that the best method would not only acquire information on the extent of the current population but would also collect sample points for the spatial model. Salish Kootenai College students undertook the inventory project. In 2007, field technicians successfully created standard methods for mapping and conducted preliminary surveys in southern Flathead Lake. They used boats to map transects that were approximately perpendicular to the shore line and included areas inside and outside of flowering rush infestations (Alvin Mitchell, pers. comm.). At this point in the mapping, the current known infestations cover at least 721 acres (Alvin Mitchell, pers. comm.). Mapping will continue in the 2008 season.

Spatial Model

The use of remotely sensed data and Geographic Information Systems (GIS) to model sites susceptible to invasion can be very cost-effective and useful, particularly in areas that are difficult to access such as shorelines and lake bottoms. A preliminary visual assessment of 1 meter color infrared (CIR) imagery collected during 2005 National Agriculture Imagery Program (NAIP) acquisition determined that there was potential to use this imagery to separate out denser populations of emergent flowering rush from other features based on its unique spectral signature (CSKT, National Wetlands Inventory (NWI) and aquatic weed mapping project). The goal was to use results of current infestation mapping in Flathead Lake and combine them with other GIS layers and site characterizations that include substrate type, water depth, and wave direction and energy to develop an elementary spatial model that would predict: 1) shoreline and littoral areas not likely to be invaded; and, 2) areas susceptible to future infestation. Preliminary GPS sampling points and ancillary data were taken in 2007 and methods for sampling in the 2008 season have been modified to optimize modeling.

The University of Montana Wildlife Spatial Analysis Lab and Salish Kootenai College are cooperating with the University of Montana Yellow Bay Biological Station, the Confederated Salish and Kootenai Tribes Wetlands Program, and the Tribal GIS Program to develop the spatial model. This model will provide managers with an estimate of the potential infestation and locations, and allow quantitative exploration of different management strategies.

Management Strategies

Unfortunately, due to the tremendous impact of flowering rush on recreation, landowners are already attempting to take management into their own hands without a thorough knowledge of the regulations or dispersal mechanisms of the species and may be doing more harm than good. Such reported activities have included raking, cutting, laying bottom materials, and inappropriate herbicide or algaecide applications. The partnership is using their understanding of the ecology and dispersal mechanisms of the Flathead population to conduct research on the most effective methods of control. A proposal was presented in April, 2008, to the Montana Noxious Weed Trust Fund to test various herbicides and hand-digging of flowering rush. The proposed project will assess the effects of the herbicide treatments on several aspects of the biology of flowering rush and non-target plants in the experimental treatment areas during plant emergence prior to flooding in the spring and as a foliar application on emergent stems later in the season. All field work will be conducted in Flathead Lake and the laboratory work at Salish Kootenai College.

SKC and UM have implemented the first phase of testing the efficacy of three aquatic herbicides on flowering rush. Three aquatic herbicides have been sprayed on three replicated blocks before the lake levels inundated the sites. This test is valuable to determine if these herbicides are effective when water is not a complicating factor. This summer, the test will be repeated during lake full-pool on exposed flowering rush. Some smaller demonstration trials at private docks and marinas will include the herbicide treatments and digging trials on small isolated populations.

Outreach and Education

All individuals in the partnership are working on promoting awareness and educating the public and professionals about flowering rush locally, regionally, nationally and internationally. After each presentation, partnership members share their presentations and feedback. This strategy results in continually enhanced presentations and a wide variety of outreach materials. Spreading the responsibility among all members also results in wider and more numerous outreach activities. Feedback has consistently shown that audiences were mostly unaware of this species or potential impacts except in the immediate Flathead area. The partnership's professional networking has resulted in connections with information on other populations of flowering rush within the Columbia Basin such as in the Aberdeen-Springfield Canal in Aberdeen, Idaho, findings of flowering rush by the state of Idaho where the Clark Fork enters Pend Oreille Lake and a new sighting recorded by the Washington Department of Ecology. Presentations since the start of the project include: local meetings in the Flathead area; the 2008 Montana Weed Control Association annual meeting in Great Falls, MT; the 2008 Invasive Species in Natural Areas Conference in Missoula, MT; the 2008 Inland Northwest Aquatic Riparian and Wetland Symposium in Spokane, WA; the 2008 Western Aquatic Plant Management Society meeting in Lake Tahoe, CA; and the 2008 Weed Across Borders Meeting in Banff, AB. Other outreach materials being developed include a video and a survey/educational piece. In 2008, funding was received from US Fish & Wildlife Service to have the Salish Kootenai College TV Station make a flowering rush video. Also, a basin wide survey of aquatic managers and plant specialists has been initiated to assess knowledge of the extent of flowering rush incursions within the Columbia River system. Salish Kootenai College and University of Montana are conducting a survey of managers, state and university herbarium, Tribes, and other interested public, distributed through contacts and networks such as the Western Invasives Network (http://www.westerninvasivesnetwork.org), seeking information about infestations downstream in the Columbia River system and the level of knowledge of this species. The surveyors also endeavor to educate and perform outreach by providing information on identification of the species and information on management and prevention with the survey questionnaire.

Outreach is also being conducted through press releases and web content on sites such as the Flathead Lakers (http://www.flatheadlakers.org) an organization that promotes clean water and healthy ecosystems in the Flathead Watershed of Montana.

Final Remarks

The partnership to address the threats from flowering rush in the Flathead Watershed is ongoing. At this point, it is apparent that the integrated partnership has strengthened all phases of the project. Outreach has been much greater with several members from different organizations sharing the responsibility. Outreach materials have received a greater diversity of perspectives in review and presentations have been enhanced by these different viewpoints. More professional networks have been tapped by using each organization's contacts. The connection and application between research and management has been streamlined and strengthened by cooperation in the development of both aspects of addressing this invasive plant. Finally, funding proposals to continue and expand the project have been more successful due to the representation of different groups in this partnership. In the fall of 2008, a thorough evaluation of the project will be conducted and it looks promising that it will be a model of success and hopefully be utilized to create similar effective partnerships. Ultimately, this partnership will create better solutions to addressing this invasive plant threat to this ecologically and culturally rich area.

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Biography

Mara Johnson, the Technology Transfer Coordinator for the Center for Invasive Plant Management, has worked on invasive plant issues throughout the Northwest from the field to the GIS lab. She specializes in creating and refining methods and tools for invasive plant technology transfer between scientists, land managers, policymakers and the public. Prior to her current position, she worked over 10 seasons as a biological field technician in WA, ID, OR, and MT. She received an M. S. degree in Forest Resources from the University of Idaho, Moscow. Following her graduate work, she worked as a Biologist and GIS Analyst for the Technology Transfer Unit of the Rocky Mountain Research Station in Boise, ID, before returning to Montana.

The Weed Science Society of America's Multi-Prong Strategy in Dealing with Weeds and Invasive Plants

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Abstract

Since its inception more than 50 years ago, the Weed Science Society of America (WSSA) has promoted research, education and extension outreach activities related to weeds and invasive plants; it has provided science-based information to the public and policy makers; and it has fostered awareness of weeds and their impacts on managed and natural ecosystems. In recent years, WSSA has increased its activities related to invasive plants by collaborating with numerous other organizations to raise awareness, stimulate research and find solutions to the problems created by invasive plants. Examples of such initiatives include the 2003 IPINAMS conference, participation and coordination in the past 9 National Invasive Weeds Awareness Weeks, and the launch of a new scientific journal, "Invasive Plant Science and Management" (IPSM). The

Resumen

Desde su inicio, hace más de 50 años, la Sociedad de la Ciencia de la Maleza de América (WSSA) ha promovido la investigación, educación y extensión relacionadas con las malezas y las plantas invasivas; ha proporcionado la información científica al público y a los políticos; y ha fomentado el conocimiento de las malezas y sus impactos a los ecosistemas artificiales y naturales. En años recientes, WSSA ha aumentado sus actividades relacionadas con las plantas invasivas en colaboración con numerosas organizaciones para levantar conciencia, estimular la investigación y encontrar soluciones a los problemas creados por las plantas invasivas. Ejemplos de tales iniciativas incluyen la conferencia 2003 IPINAMS, como también su participación y coordinación en nueve ocasiones de la "Semana de Concientización Nacional sobre las Malezas Invasivas", y el lanzamiento de una nueva

1 Presenter

unique aspect of IPSM is that it focuses not only on the biology and ecology of invasive plants, but also covers topics such as restoration, ecological and environmental impacts, cost/benefit analyses related to management, case studies, new invasive plant reports, and, compliance and regulatory legislation. These and other initiatives are reviewed to illustrate the various tools that are available to scientists, field practitioners, governmental agencies, policy makers, and educators, that is, to anyone with an interest in the development of invasive plant management programs nationally and throughout the world.

revista científica llamada 'Ciencia y Manejo de las Plantas Invasoras (IPSM)'. Un aspecto que caracteriza a IPSM es que se centra no solamente en la biología y la ecología de las plantas invasivas, sino también incluye la restauración, y el impacto y las consecuencias ecológicas al medio ambiente, los análisis de costo/beneficio relacionados al manejo, estudios de caso, nuevos informes sobre plantas invasivas y conformidad a la legislación reguladora. Estas y otras iniciativas son revisadas para ilustrar las varias herramientas que están disponibles a los científicos, técnicos de campo, agencias gubernamentales, políticos, y educadores, esto es, a cualquier persona que tenga un interés en el desarrollo de programas de manejo de plantas invasivas, tanto nacionalmente como a través del mundo.

Since its inception more than 50 years ago, the Weed Science Society of America (WSSA) has worked in close collaboration with other non-profit professional societies to develop knowledge and expertise about weeds and invasive plants. These national and regional societies include the Canadian Weed Science Society (CWSS), the Aquatic Plant Management Society (APMS), the Northeastern Weed Science Society (NEWSS), the North Central Weed Science Society (NCWSS), the Southern Weed Science Society (SWSS), and the Western Society of Weed Science (WSWS). Currently, these Societies capture the talents of approximately 4000 public and private professionals involved in universities, governmental departments and agencies, and the agrochemical and life science industry, mainly from the United States and Canada, but also from many countries worldwide.

Members from these societies provide science-based information on weeds and invasive plants and their impacts on managed and natural ecosystems to government regulators and policymakers, and to the public at large through their activities in research, education and outreach. WSSA acts as a catalyst for many of these activities. Below are just some examples of the various initiatives recently developed by WSSA and its partners to further promote the cause of sound management of weeds and invasive plants.

In recent years, WSSA has increased its activities related to invasive plants by collaborating with numerous organizations to raise awareness, stimulate research and find solutions to the problems created by these plants. Examples of such initiatives include: the 2003 Invasive Plants in Natural and Managed Systems (IPINAMS) conference, organized in partnership with the Ecological Society of America (ESA); and WSSA's participation and coordination of the past nine National Invasive Weeds Awareness Weeks (NIWAW) in Washington DC. WSSA is also currently preparing for joint meetings with the SWSS in Orlando, Florida in February 2009, and with the Society for Range Management (SRM) in Denver, Colorado in February 2010 to develop synergies in all ways possible.

The WSSA is engaged in a dialogue with regulators, policymakers and stakeholders through the ongoing contributions of its Director of Science Policy and the WSSA subject matter expert liaison with the U.S. Environmental Protection Agency (EPA) in Washington DC. Also involved in these discussions are members of the Board of Directors, members of various WSSA Committees such as the Science Policy Committee, the Public Awareness Committee, the Education Committee, and essentially each and every member depending on the issue at stake. Just in the recent year, the WSSA has interacted at various levels with a wide range of organizations in the United States, such as the EPA, the U.S. Department of Agriculture-Animal and Plant Health Inspection Service (APHIS), the U.S. Forest Service (USFS), the Council for Agricultural and Science Technology (CAST), the ESA, the SRM, The Nature Conservancy, and Wildlife Forever. Topics of interest have been wide ranging, from renewable fuel production to fire suppression and management, private property rights, climate change, endangered species, the Farm Bill, and the USDA-Agricultural Research Service National Program Leader for Weed Science.

As an example of the output of such collaborations is a CAST issue paper entitled "Biofuel Feedstocks: The Risk of Future Invasions" co-authored by several WSSA members. This document describes the potential risk of dedicated lignocellulose biofuel species becoming weedy or invasive, and provides a process to quantify and minimize this risk. This issue is of serious and immediate concern given the passage of the Energy Independence and Security Act (P.L. 110-140) by the U.S. Congress in December of 2007. This federal law mandates the production and use of 36 billion gallons of renewable fuels by 2022 (20 billion gallons of cellulosic-based ethanol; 15 billion gallons of corn ethanol; 1 billion gallons biodiesel). Another "weed/invasive" matter of major concern to many Congressional Members and their staff is cheatgrass (*Bromus tectorum* L.) in the West and cogongrass (*Imperata cylindrica* (L.) P. Beauv.) in the South because of their role as a fire vector. Firefighting costs in 2007 were $1.34 billion with the annual firefighting cost between 1998 and 2006 averaging $994 million. Needless to say, research on the ecology and management of these "fuel" species, likely involving many WSSA members, will be an essential first step to any policy development.

On a broader scale, the WSSA has recently increased its attempts to reach out to a wider audience, targeting for the first time the public at large. In fall 2007, through the efforts of the Public Awareness Committee, the WSSA launched a series of press releases to educate the broader public about the role and impact of weed science in everyday life. These press releases have been picked up by major news services and newspaper agencies across the U.S. A press release on climate change received over 200,000 web hits in less than a week. The press releases have covered topics ranging from troublesome weed species, to the flood in the U.S. mid-west, to weeding issues in Africa. Titles have included:

- Biofuel crops: Panacea or Pandora's box?
- Algae-harboring hydrilla causing bald eagle deaths in the Southeast
- Beetles help take bite out of the world's most aggressive weeds
- Tropical soda apple overshadows some agricultural industries in the sunshine state
- Giant cousin of the carrot plagues backyard gardeners with blisters and burns

These and other press releases can be found on WSSA's website (www.wssa.net).

The WSSA, like many scientific societies, has been heavily involved in the dissemination of knowledge through scientific publications of various formats. The flagship journals, “Weed Science” and “Weed Technology”, have served the weed science community at large for more than 55 and 20 years, respectively. In addition to these two journals, the WSSA has recently decided to publish a third journal in order to provide an appropriate publication outlet to the scientists and practitioners involved in developing the science and management of invasive plants. The first issue of the journal “Invasive Plant Science and Management” (IPSM) was launched in February 2008 at the WSSA annual meeting. The unique aspect of IPSM is that it focuses not only on the biology and ecology of invasive plants, but also considers contributions on topics such as restoration, ecological and environmental impacts, cost/benefit analyses related to management, case studies, new invasive plant reports, and compliance and regulatory legislation. It is, without a doubt, the journal of choice for anyone with interest in the science and management of invasive plants.

These and other initiatives encompass the various tools and activities that the WSSA makes available to scientists, field practitioners, governmental agencies, policy makers, and educators, that is, to anyone with an interest in the development of weed and invasive plant management programs nationally and throughout the world. The WSSA, in partnership with their affiliated weed science societies, is seeking increased collaboration with groups and organizations whose interests involve weeds and invasive plants. We strongly believe that we need to explore new ways to develop synergies and partnerships. None of us can do it alone.

Weeds won’t wait. Don’t hesitate.

Biography

During her near 30-year career as a research scientist with Agriculture and Agri-Food Canada, most of **Dr. Anne Légère’**s research activities have focussed on the agro-ecological impact of cropping practices on weed communities, mainly in field crops. More recently, her efforts have focussed on the effects of transgenic crops, with a particular interest in the introgression of transgenes in wild/weedy relatives. She was an Invited Associate Professor for two years at McGill University and Adjunct Professor at both Université Laval and University of Saskatchewan. She has been active in scientific organizations in various capacities, e.g.: Director of Publications and Acting Director of Education for the Weed Science Society of America; President of the Canadian Weed Science Society; and, Director of Publications for the Québec Society for the Protection of Plants. Through involvement with each of these groups, she has been repeatedly rewarded with the pleasure of meeting and working with truly outstanding people.

Promoting Native Alternatives to Invasive Plants

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Abstract

Increasing both the supply of and demand for native alternatives to invasive plants encourages the speedy adoption of practices that promote the health of ecological systems. Ecologists know that promoting native alternatives is critical to maintaining biodiversity in fragmented landscapes, but some consumers might be more attracted to the soundness of investment in hardy native plants, the greater variety of pretty butterflies and birds the native plants attract, and the regional and historic significance of native landscaping. The financial, aesthetic, and cultural utility of native plants reflects the marketing or demand side of ecological utility. Suppliers such as nurseries can market these advantages of native plants. Increasingly federal, state and local programs mandate the planting of native plants on public lands providing an education foundation for nurseries and consumers. Promoting native alternatives to nurseries and consumers will lead to more rapid adoption of ecologically appropriate landscaping practices.

Resumen

El aumento de la oferta y demanda para plantas nativas alternativas a plantas invasoras fomenta la adopción rápida de prácticas que promueven la salud de los sistemas ecológicos. Los ecólogos saben que promover alternativas nativas es crítico para mantener biodiversidad en paisajes fragmentados, pero algunos consumidores podrían estar más atraídos a la seguridad de la inversión en plantas nativas robustas, la gran variedad de mariposas y pájaros bonitos atraídos por las plantas nativas, y la significación regional e histórica de jardinería con plantas nativas. La utilidad financiera, estética y cultural de las plantas nativas refleja el mercadeo o lado de la demanda de la utilidad ecológica. Los proveedores, como los viveros, pueden vender estas ventajas de las plantas nativas. Los programas federales, estatales y locales, demandan de manera creciente que se planten plantas nativas en tierras públicas proveyendo una plataforma educacional para viveros y consumidores. La promoción de alternativas nativas a viveros y consumidores llevará a una adopción más rápida de prácticas ecológicas apropiadas en paisajismo.

1 Presenter.

Introduction

Recognizing demand and supply considerations facilitates promotion of native plants over invasive alternatives. Like socially conscious investment in the stock market, adoption of ecologically beneficial landscaping strategies must show a positive return on investment. Socially conscious investment produces both a private, individual, financial return and a public, shared, ethical benefit. A demand perspective on native plants focuses on ways consumers derive private, individual satisfaction from planting native species and a public, shared, environmental benefit. In economic terms, these private or "internalized" benefits and the public "externalized" benefits describe the satisfaction obtained from adopting native alternatives. A supply perspective focuses on ways nurseries and other suppliers of plants can profit from promoting both public and private benefits of non-invasive plants. Toward developing a marketing strategy for promoting native alternatives to invasive plants, this paper compares public and private benefits from planting native species, describes the financial benefits from adoption of native plants to suppliers and consumers, and investigates the aesthetic and cultural appeal of native plants.

Promoting the planting of native alternatives to invasive plants involves several objectives: 1) Slowing the spread of invasive plants; 2) Providing the nursery industry with new and diverse plants to offer to the public; 3) Identifying consumer groups and developing marketing strategies for these groups; and, 4) Educating the public about the ecological usefulness of native plants. These objectives recognize the contributions of biologists, the nursery and landscape industries, consumers, and the general public to the ultimate success of promoting alternatives.

The Market for Plants

The market for invasive plants is driven by supply from the horticulture industry and by consumer demand. The horticulture industry continually seeks novel and diverse plants to introduce to the public. Horticulture is one of the fastest growing segments of United States agriculture and introduces new plants every year (Hall et al. 2005). It is also one of the major pathways for the introduction of invasive plants species (Reichard and White 2001). For example, Reichard (1997) estimated that 85% of non-native woody species that grow in natural areas in the United States came from the landscape trade. Because there is no incentive to suppliers to market ecological disadvantages of invasive plants, only change in consumer demand or regulation will diminish the supply of invasive plants.

Demand for plants comes from many categories of consumers, from government agencies landscaping roadsides and public buildings to landscape contractors working for businesses and residences to individual homeowners. Most consumers want plants that are easy to grow and that look nice most of the year. For instance a survey of visitors to home and garden shows in Michigan and Tennessee found that consumers' top reasons for selecting a particular plant were characteristics such as flowering season, sun/shade requirements and size/shape of a plant (Klingeman et al. 2001). Highway departments primarily choose plants based on appearance, quick growth, and soil stabilization ability (Harper-Lore and Wilson 2000).

Another cultural trend that should enhance the marketability of native plant alternatives to invasive plants is the current "green" movement (Fox 2008). Increasingly consumers want to make environmentally conscious choices in their purchases such as purchasing compact fluorescent light bulbs, locally and organically grown food, or fair trade products. Native plants fit very well as a "green" product because they are local, low input, and promote biodiversity. With these aesthetic, utilitarian and ethical goals in mind, supply and demand for native plants can be enhanced through appeal to the inherent climatic and habitat suitability of native plants, their ability to interact with native fauna, and their regional authenticity and novelty.

The Ecological Role of Native Plants

The ecological utility of native plants traditionally refers to external benefits of promoting sustainable and diverse environments. Externalized benefits are benefits to the larger community in which consumers share only if they are aware of environmental impacts beyond their own land, such as benefits from increased species diversity generally. Landscapers of public projects often have interests that may coincide with this larger community. Promoting ecological utility requires educating the general public, landscapers, and developers of public projects. Millions of people who are not homeowners or gardeners drive down highways, shop at local businesses and enter government buildings. Their favorable perception of native landscaping is critical to its success.

Native plantings in gardens and backyards produce external benefits by mimicking natural environments and thereby enhancing plant diversity, providing more complex habitat structure, and restoring the land's ability to absorb stormwater runoff and reduce pollution reaching water resources. Remaining native plant communities in urban and suburban areas are highly fragmented and ecological functions are often disrupted (Pickett et al 2008). By encouraging extensive use of native plants in landscaping, connections among these fragmented communities could be improved. Corridors are known to increase species diversity and for some species needing larger habitats corridors may be critical to their survival. The choice of plants selected for landscaping seldom takes into consideration the function that a plant may play in the ecosystem.

Homeowner's incentives are less naturally aligned with the larger community's concerns. Thus, it is helpful to promote internal ecological benefits associated with native plantings. Just as an educational approach increases environmental awareness, a marketing approach increases awareness of (for example) the direct benefits from improved ecological integration of flora and fauna resulting from native plantings compared to invasive plantings. One example is the increase in the population and diversity of animal species that homeowners could attract and enjoy (Figure 1).

Marketing can educate consumers about the ecological role of native plants in attracting wide varieties of the animals consumers enjoy. An increasing number of studies show the effects of the urban-rural gradient on animals (including insects, birds, and amphibians), generally showing a decrease in diversity or abundance of native species and an increase in abundance of invasive species in urban compared to rural environments (Tallamy 2007; but see Pickett et al. 2008).

Figure 1. Blazing star (*Liatris spicata* (L.) W illd.) with necturing Monarch butterfly (*Danus plexippus*).

For insects in particular, the type of plants used in landscaping may greatly influence their diversity and abundance. Introduced plant species seldom support native specialist insects, and even generalist insects are found in much lower abundance on introduced plant species (Tallamy 2007). Many gardeners enjoy attracting birds and butterflies to their garden — hence the popularity of plants like *Buddleja* species, butterfly bush. Insects provide much of the food for birds, amphibians, and other animals, and therefore maintaining their abundance and diversity may be critical to maintaining that of other species. Informing these gardeners that native plants are likely to attract a wider range of butterfly and bird species may be an effective marketing tool.

An example of this marketing approach is the American Beauties™ program (http://www.abnativeplants.com/). The American Beauties program is a cooperative partnership between the non-profit National Wildlife Federation (NWF) and two wholesale nurseries, North Creek Nurseries and Pride's Corner Farms. The wholesale nurseries market a selection of plants native to the Northeastern United Sates to retail nurseries in distinctive pots with colorful tags and informational brochures that include native garden landscape plans (Figure 2). The plants are grouped as plants for dry shade, moist sun, bird, or butterfly plants. A portion of the sale of each plant goes to the NWF.

The idea for the program was initiated by the NWF. NWF has a Certified Wildlife Habitat program for homeowners with more than 70,000 participants nationwide. The certification program promotes sustainable gardening and planting native plants for wildlife food and cover. Through the program they can direct participants to local nurseries that carry the American Beauties plants. For the garden centers, the program offers a new marketing tool. For growers it offers a way of promoting regional and other native plants that did not previously have a large enough market to make it worthwhile to grow them. The selection of plants is still limited to ones with a fairly broad geographic range and often cultivars of native plants are used because of their more uniform appearance (Dale Hendricks, pers. comm.). The NWF approach to marketing the ecological utility of native plants is being expanded into the Midwest and South.

Figure 2. Example of an American Beauty™ showing the distinctive packaging and information.

Bargain Hunters Beware – Financial Utility

Despite some recognition of the external ecological utility of replacing invasive plants with native plants, most consumers and even suppliers are unaware of the internal benefits. Except for trees, relatively few native species are among the top sellers in the nursery industry (USDA 1998). There are other marketable traits of native plants that could be advertised to consumers unaware or uninterested in ecological utility. These include the financial, aesthetic, and cultural utility of native plants.

In the long-term, selecting "the right plant for the right place" will reduce the use of costly inputs such as water and fertilizer. Although it is easy to find non-native plants suited to a range of environmental conditions, many native plants are equally easy to grow. Plants that have evolved in a region for thousands of years are generally well-adapted to the local climate and soil conditions and will thrive when sited correctly.

Immediate climactic suitability and durability result in less investment in maintenance, treatment and replacement. Ecological and aesthetic considerations aside, marketing these advantages should increase demand, particularly among those more interested in the final result of landscaping than the process of beautification. Financial utility though is perhaps the weakest argument that can be made for promoting native plant alternatives given the wide range of easy-to-grow ornamental plants available for consumers to choose from.

Aesthetic and Cultural Utility of Native Plants

Because appearance is a fundamental basis for plant selection, marketing of native species might proceed along two fronts that emphasize internal benefits. The first is visual appeal. This marketing may appear as development of appreciation for the "exotic" appearance of native plants not customarily seen in modern landscapes. Promoters of native plants have to work hard to overcome the perception that native plants are "weedy". This perception arises because native plants are most often viewed in natural rather than cultivated landscapes. When given space, most plants will assume a more regular shape and will often produce more flowers and fruits. The visual appeal of native plants can be improved by proper presentation (Figure 3).


Figure 3. Native sumac and goldenrod.

Marketing strategies could also develop a sentimental appeal to the cultural/regional authenticity of native plants. Government agencies have a natural interest in promoting the unique regional characteristics of their jurisdictions to promote a sense of community among their citizenry and to promote tourism. People who buy homes in historic neighborhoods, cabins in mountain settings or who move to new parts of the country have a natural interest in getting to know the ways of their communities and fitting in with identifying characteristics of those environments. Just as regionally identifiable types of residential structures are marketed in different parts of the country (e.g., salt box houses on Cape Cod, Massachusetts, or adobe houses in Santa Fe, New Mexico), native plants could be marketed both to public and private consumers based on their regional authenticity. Although traditionally landscaping has reflected the influence of formal European gardens, there have been influential landscape architects that have promoted more naturalistic landscape settings such as Jens Jensen, Frederick Law Olmsted and Ian McHarg, and using an ecological approach to landscape design is now practiced by many landscape architects (Thompson and Steiner 1997).

Delaware has designed a program called "Enhancing Delaware Highways" that promotes aesthetic and cultural utility as well as ecological utility. This program focuses on establishing a sense of place with highway maintenance and plantings that reflect the natural landscape of Delaware. Plantings primarily use native plants with a few non-native non-invasive plants such as crabapples and *Amsonia hubrichtii* Woodson (a North American native, but not native to Delaware). The program has also used native plantings that reduce establishment of invasive plants. For example, colonizing shrubs such as sumacs (*Rhus* species) and summersweet (*Clethra alnifolia* L.) are used to prevent re-invasion of *Ailanthus altissima* (Mill.) Swingle. Meadows are established through natural succession or planting of warm season grasses to reduce mowing of median strips and roadside edges. Often meadow edges are planted with more colorful native perennials or sweeps of native grasses to enhance the appearance of the un-mown area. A concept and planning manual provides detailed instructions for roadside designers and managers (Barton et al. 2005).

Information Dissemination and Education

The identity and characteristics of native plants compared to many invasive ornamental plants are largely unknown to consumers and suppliers. Many of the characteristics of hardy ornamental plants are similar to those of invasive plants — fast growth, hardiness, high seed production (usually because selected plants have many flowers or showy fruits). Most consumers are unaware that the plants they purchase are invasive and unaware of which plants are native or introduced. The first step is identifying those characteristics of native plants that will increase their demand and supply, and characteristics of invasive plants that will reduce their demand. The second is disseminating that information. Education is important both for promoting native plants but also for discouraging the use of invasive plants.

There are many possible sources of information for consumers. Many home gardeners rely on friends and family for information or on garden-center staff (Kelley and Wehry 2006). Millions of households rely on landscape designers and contractors to select their plants (National Gardening Association). Government agencies and businesses also contract out much of their landscaping work.

Professional organizations for landscape architects and contractors hold conferences and offer certification and licensing programs, but plant ecology and landscape use receives little emphasis (e.g., Association of Landscape Architects, Association of Landscape Contractors of America). Incorporating information about invasive plants and benefits of native plants into landscape contractor as well as landscape design and architecture programs is critical to reaching these professionals. In addition many states have certification programs for landscape contractors, arborists, and other grounds maintenance professions that could incorporate this information. Nurseries can be encouraged to acquire information by their own profit motivations or through professional conferences and certification requirements.

In addition to public education projects such as those offered through cooperative extension, the obvious places to start with information dissemination are nurseries and garden centers, places where many consumers go to get their plant information. Public gardens also reach a large number of visitors and many offer classes and lectures on sustainable landscaping.

The state of Delaware began a program in cooperation with the non-profit Center for Horticulture called "Plants for a Livable Delaware"**.** The purpose was to educate the public about invasive plants and non-invasive alternatives. For two years they cooperated with local nurseries providing signs for about ten ornamental plants considered invasive in Delaware. The signs had information on the environmental problems caused by that plant and a list of non-invasive alternatives. Nurseries could put the Livable Delaware logo on any plant possessing "adaptable characteristics to landscape situations", posing "no potential threat as an invasive plant", having "no serious disease or insect problems" and being "hardy to Delaware". They have published several booklets available free to the public on invasive plant identification and control, on non-invasive alternatives to native plants and on plants recommended for particular landscaping sites. The booklets are distributed by nurseries and landscaping companies and are available online (http://www.dehort.org/pubs/).

Other states have similar education programs aimed at gardeners such as California's "PlantRight" sponsored by the California Horticultural Invasives Prevention partnership (www.plantright.org). PlantRight educates both homeowners and professionals in the nursery and landscaping industries about non-invasive alternatives to invasive ornamental plants. The PlantRight web site provides lists of non-invasive alternatives to invasive plants based on gardening regions.

Conclusions

To promote the adoption of native alternatives to invasive ornamentals, this paper highlights the distinction between private and public motivations underlying landscaping decisions. The demand for various plant species depends on both the individual (internalized) and shared (externalized) benefits that buyers expect. This paper identifies private benefits that can be marketed to buyers to enhance the appeal of native alternatives.

This investigation increases the range of marketing tools available to promote native alternatives. Homeowners' landscaping decisions may be motivated by a shared, ethical concern for the ecological health of their environment or by the desire to attract insects, birds, amphibians, and other animals, or by their private satisfaction in having a robust, easy to maintain landscape. Climatically, edaphically, and geographically appropriate plants provide homeowners with financial utility by requiring fewer input costs, aesthetic utility by creating visual appeal, and cultural utility by reflecting local landscapes.

There are few examples of marketing programs exploiting these methods of making native plant alternatives more appealing. The American Beauties program is an excellent start for marketing native plants. It distinctively identifies native plants in the retail setting and, where appropriate, the plants ability to attract birds and butterflies. This program begins to provide information about the private utility of native plants. More education, about the cultivated appearance of native plants in a landscaped setting, the hardiness and suitability of native plants in the appropriate setting, and the regional significance of native plants would enhance the appeal of native plants.

Public agencies charged with landscaping their highways and other projects have interests more closely, though imperfectly, aligned with the public interest in the ecological health of their communities. The Delaware highways program illustrates awareness of ecological, financial, aesthetic, and regional appropriateness of plantings. The "Livable Delaware" program emphasizes non-invasive alternatives to invasive ornamental plants appealing to consumers' environmental awareness. In some ways, these provide models for marketing of native plants by government agencies, landscapers, nurseries, and others who inform consumers' decisions.

Increased information enhances adoption of ecologically sensible alternatives to invasive species. It is not enough simply to identify plants as native or non-invasive. Adoption of native alternatives can be enhanced by appealing to buyers' selfish interests as well as their ethical concerns. A greater focus on both public and private motivations of public and private consumers in the formal education of landscape contractors and landscape architects would increase nurseries' and consumers' awareness of private benefits of adoption of native alternatives to invasive plants.

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Biography

Sylvan Kaufman has a Ph.D. in Ecology and Evolution from Rutgers University. She has worked as the Curator at Adkins Arboretum in Maryland and is co-author with her father Wallace Kaufman of *Invasive Plants: Guide to Identification and the Impacts and Control of Common North American Species*.

David Barnes has a Ph.D. in Economics from Virginia Polytechnic Institute and a J.D. from the University of Pennsylvania Law School. He has written dozens of articles and books on statistical, economic, and legal topics.

Addressing the Threats of Invasive Plants Through Spatial Predictive Modeling and Early Detection and Rapid Response

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Abstract

Invasive plant management has typically been a form of reactive management initiated in retrospect after an incursion has caused significant ecological, economic and cultural impact. Prevention is widely recognized as the most effective and cost efficient strategy against invasive plants. Once established, invasive species are difficult and costly to eradicate. Ecological niche modeling integrated with geographic information systems (GIS) provide one tool to predict spatial invasions in one area based upon known occurrence points from region of the world. Predicting biogeographical distributions also contributes to early detection and response planning. In this paper, the predictive spatial distributions purple loosestrife and saltcedar will be discussed as well as how this information can be used in early detection and response planning.

Resumen

El manejo de las plantas invasivas típicamente ha sido una forma de manejo reactivo iniciado de manera retrospectiva a raíz de una incursión de impacto ecológico, económico y cultural importante. La prevención está ampliamente reconocida como estrategia de mayor eficacia y rentabilidad contra las plantas invasivas. Una vez establecidas, la erradicación de las especies invasivas es difícil y costosa. El modelo de nichos ecológicos integrado con sistemas de información geográfica es una herramienta que permite predecir invasiones espacialmente en una área basándose en puntos conocidos de ocurrencia de la invasora en otras regiones del planeta. La predicción de la distribución biogeográfica también contribuye a la planificación de la detección temprana y la respuesta rápida. En esta ponencia, se examinarán las distribuciones espaciales predictivas de *Lythrum salicaria y Tamarix* spp. al igual que la manera en que esa información puede utilizarse para planificar la detección temprana y la respuesta rápida.

Introduction

> *"Nowadays we live in a very explosive world, and while we may not know where or when the next outburst will be, we might hope to find ways of stopping it or at any rate damping down its force. Its not just nuclear bombs and wars that threaten us…..there are other types of explosions…. ecological explosions….like potato disease, a green plant like prickly pear, or an animal like the grey squirrel" (Elton 1958).*

In 1958, Charles Elton observed that over hundreds of millions of years plant and animal communities have become distinct from one another, however human trade and travel are rapidly obliterating these distinctions leading to ecological invasions, and these invasions have grave implications for the conservation of biological diversity (Elton 1958). His observations have been carried forward temporally and spatially, for example by Mullin et al. (2000), reporting that the number of new plant incursions and their impacts have increased rapidly over the past 30 years due to exponential increases in air travel, the increased speeds at which commodities and people traverse the globe, increased numbers of ports of entry, expanded exports and imports into new international markets, increased interest in the use of exotic plants in gardening and water gardening, and the increased access to foreign ecosystems.

Invasion ecology is much about where species are and where they are not. Researchers have been wondering about why species are where they are for almost 90 years and most likely much longer outside of the published literature. In 1917, Joeseph Grinnell wondered about why species are where they are, and why they are not where they are not, and arrived at conclusions by comparing environments inside and outside of a species distribution. Grinnell (1917b) found that the range of the California thrasher (*Toxostoma redivivum*) is delimited by temperature and faunal conditions, and these parameters comprise its niche which determines its distribution. Grinnell pioneered the concept of "Grinnellian Niche", describing the niche relationships of *T. redivivum* (Grinnell 1917a).

The Grinnellian Niche was later expanded upon by Charles Elton (1927), a British ecologist, who described the niche as a functional unit describing an organism's place in the biotic environment or ecological position within an ecosystem. Zoologist G. Evelyn Hutchinson (1957) further expanded upon the concept of niche, describing it as a set of biotic and abiotic conditions in which a species is able to survive and propagate. The niche then becomes a subset of environmental dimensions that limit or restrict an organism's survival. The concept of the niche, or ecological niche as referred to by many, has become central to some spatial predictive modelling approaches.

Efforts to predict species distributions, which are in some cases are species invasions, began as early as 1925 when Cook (1925) produced climatographs by superimposing responses of the alfalfa weevil (*Hypera postica*) to climate onto locational graphs of temperature and relative humidity. Cook (1925) used climatic data from northern Europe to predict invasions into the United States. Cook (1931) suggested that geographical distributions are limited by climatic conditions, and that climatic conditions are generally stable, hence it is possible to map future distributions. Cook (1931) postulated that climatic analysis of insect distributions was a new promising field and one in which advances were certain to be made in the near future. Cook (1931) realized that the predictive approach was limited by the accuracy of the data and distributional data is usually unsatisfactory. Climatic data for example, were available through a small number of stations which are widely separated hence local conditions are overlooked (Cook 1929). Cook (1931) suggested that climatographs, a form of spatial predictive modelling, would be the "basis for intelligent quarantines, which will not hinder commerce between the infested area and those regions where no damage is expected. There is no use in maintaining quarantine against an insect that would do very little damage if introduced". Many of Cook's theories and postulations are still relevant almost 80 years later. For example, we are still attempting to predict distributions from native ranges into novel areas, climatic conditions (or niches) limit distributions, and distributional data is still unsatisfactory for many species.

> *"One of the most interesting aspects of bioclimatic analysis is the forecasting of potential distribution of insect species into uninfested areas. Such forecasting attempts are particularly important in cases of foreign insect pests against which quarantine measures have been directed" (Messenger 1959).*

As visioned by Cook (1931), advances have been made in the climatic analysis of species distributions, mostly as a result of advances in computer technology. Geographic information systems (GIS) and general modelling procedures have advanced as a result of advances in computer technology and are being used to predict potential distributions of species including invasive species (see Daehler and Carino 2000, Madsen 1999, Peterson et al. 2003, Welk et al. 2002). Building on the contributions of Elton, Grinnell, and Hutchinson (and no doubt others), ecological niche modelling has emerged as one predictive tool over the past decade. Stockwell (1997) developed a modelling approach using the concepts of the ecological niche and machine algorithms. The Genetic Algorithm for Rule-set Production (GARP), is a modelling approach that allows the user to predict species distributions (Stockwell, 1997). GARP uses several algorithms to produce component rules in a broader rule-set, and portions of a species distribution may be determined as within or without its ecological niche, based on different rules from the algorithms (Crossman and Bass 2008, Peterson 2001). GARP approximates ecological niches by using binary machine language that looks for the high-fit binary solutions.

There are a number of examples in the literature on how ecological niche modeling has been used as a tool to predict species invasions. Peterson and Vieglais (2001) predicted the potential invasions by cattle egrets (*Bubulcus ibis*), house finches (*Carpodacus mexicanus*), Asian longhorn beetles (*Anoplophora glabripennis*), and the Japanese white-spotted citrus longhorn beetle (*Anoplophora malasiaca*). Peterson and Vieglais (2001) suggested that ecological niche models can be used develop strategies for avoiding species invasions. Welk et al. (2002) used Eurasian data to predict the invasion of garlic mustard (*Alliaria petiolata* (M. Bieb.) Cavara & Grande) across North America. Peterson et al. (2003) used ecological niche models to predict the invasion of garlic mustard (*Alliaria petiolata*), Russian olive (*Elaeagnus angustifolia* L.), hydrilla (*Hydrilla verticillata* (L.f.) Royle) and sericea lespedeza (*Lespedeza cuneata* (Dumont) G. Don) across North America using native range occurrence data. They concluded that ecological niche models can predict spatial invasions with high accuracy.

Other examples include Peterson and Scachetti-Pereira (2004) modelling of the Asian longhorned beetle (*Anoplophora galbripennis*) into North America, and Drake and Bossenbroek (2004) who forecasted the potential distribution of Eurasian zebra mussels (*Dreissena polymorpha*) in the United States. More recent examples of GARP modelling include work by Schussman et al. (2006) who modelled the potential distribution of the alien grass *Eragrostis lehmanniana* Nees in Arizona and New Mexico, Evangelista et al. (2008) who modelled *Tamarix chinensis* Lour. and *Bromus tectorum* L. in Utah, and Kelly et al. (2008) who modelled the potential distribution of an invasive forest pathogen *Phytophthora ramorum* Werres, De Cock & Man, a causal agent for sudden oak death (SOD) in the United States.

The objective of this paper was to predict areas of Prairie Canada that may be susceptible to invasions from purple loosestrife (*Lythrum salicaria* L.) and saltcedar (*Tamarix* spp.). Two invasive plants were selected for this study based upon their current distribution. Purple loosestrife is well established in Canada (Lindgren, 2003, Thompson et al. 1987, White et al. 1993), but it is hypothesized that it has yet to reach its full distribution range. Saltcedar was selected as it has yet to be found in Canada outside of cultivation, and it is hypothesized that habitats in Prairie Canada are susceptible to saltcedar invasion.

Methods

North American environmental coverages used as predictive variables were comprised of topographic and climate data layers available through the Intergovernmental Panel on Climate Change website (IPCC 2001). Topographic layers used were slope, elevation, flow accumulation, flow direction, and topographic index. Climate layers (1961–1990) included mean annual diurnal temperature range, mean annual number of frost free days, mean annual precipitation, mean annual solar radiation, mean annual maximum temperature, mean annual minimum annual temperature; mean annual temperature, mean annual water vapour pressure, and mean annual number of wet days. Data was generalized to 0.1 degree resolution grids or about 110 km × 110 km grids.

Georeferenced occurrence points for purple loosestrife in the province of Manitoba were collected between 1992 and 2004. Occurrence points for the province of Saskatchewan were obtained from the Saskatchewan Purple Loosestrife Project. Occurrence point data for the province of Alberta were obtained from annual reports produced by the Alberta Purple Loosestrife Project and through the Bow River Project. Saltcedar data were taken from Brookman (2004) and provided by the State of North Dakota.

Desktop GARP was used to model potential distributional as described by Stockwell (1997), Stockwell and Peters (1999), Peterson and Vieglais (2001), Scachetti-Pereira (2001), Ganeshaiha et al. (2003), Oberhauser and Peterson (2003) and Crossman and Bass (2008). For each species, 100 models were generated from which one composite model was created from the 10 best models. Selection of the 10 best models followed the procedure developed by Anderson et al. (2003). ArcView 9.0 was used to analysis GARP output. The 10 best GARP models were imported into ArcView 9.0, converted from ASCII files to raster grid files, and projected onto a rasterized relief map of Prairie Canada. Using spatial analyst, a composite map was created by combining all models. A risk map was produced by summing cell statistics. Projection of the composite risk map onto a map of Prairie Canada provided a final invasion risk map.

Results and Discussion

The ecological niche risk map produced for purple loosestrife indicated that purple loosestrife has not yet reached its invasion potential in western Canada (Figure 1). Moving from east to west, it is predicted that northern habitats remain which may support further purple loosestrife invasions. Of specific concern to waterfowl managers is the large extent of the prairie pothole region that is susceptible to invasion. Loss of wetland habitat in the prairie pothole region would be detrimental to North America's waterfowl production. Provincial governments weed supervisors, rural municipalities, urban areas, and conservation districts would be well advised to prepare early detection programs to prevent establishment of purple loosestrife in these regions, as well as response plans in advance of incursions.

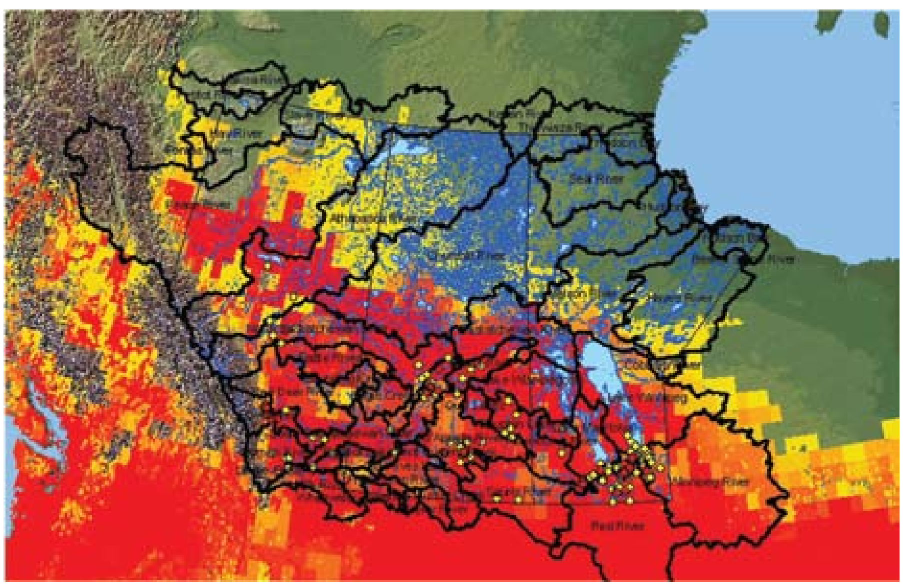

Figure 1. Purple Loosestrife risk map. Point occurrence data used to train ecological niche models are indicated by yellow circles while data used to independently test the model are indicated by red circles. The ten best subset models were summed to create one composite model producing a risk invasion map. Areas predicted to be at high risk of invasion are in dark orange while areas predicted to be at low risk of invasion are in yellow. Prairie Canada watershed sub-basin boundaries are outlined in black.

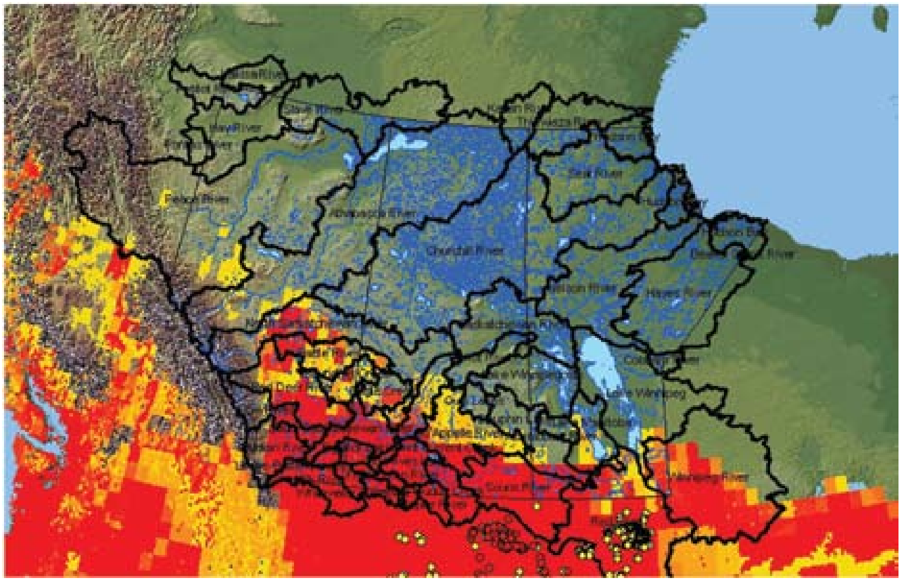

Figure 2. Saltcedar invasion risk map. Point occurrence data used to train ecological niche models are indicated by yellow circles while data used to independently test the model are indicated by red circles. The ten best subset models were summed to create one composite model producing a risk invasion map. Areas predicted to be at high risk of invasion are in dark orange while areas predicted to be at low risk of invasion are in yellow. Prairie Canada watershed sub-basin boundaries are outlined in black.

The composite risk map produced for saltcedar indicated that Prairie Canada is also highly susceptible to invasion (Figure 2). Saltcedar introduction will most likely occur through habitats in the Souris and Red River watershed sub-basins, either by seed or plant materials being transported along water courses. Initial introductions are predicted in habitats along the Red River and Souris River in Manitoba and into areas of southeastern Saskatchewan. Man-made water diversions will significantly increase the risk of potential invasions as they provide additional vectors of movement and dispersal of invasive species. Of particular concern to Manitoba is the North Dakota Devils Lake water diversion. Inter-basin water transfers between the Devils Lake sub-basin and Red River sub-basin will provide a vector for saltcedar introductions into Manitoba. Preventative programs, that include early detection and rapid response (EDRR) planning, need to be developed to address the risk of saltcedar to Prairie Canada.

Early detection and prevention are widely recognized as the most efficient strategies for the control of invasive species (Westbrooks et al. 2000, Worrall 2002). Predictive modelling can support components of an EDRR plan, in both the early detection and prevention of an invasive plant such as saltcedar. For example, predictive modeling can direct surveillance activities towards areas predicted to be at high risk to invasion. Peterson and Vieglais (2001) suggested that predictive modelling can be used to develop strategies to avoid species introductions and one effective strategic tool would be the development of an EDRR plan.

Worrall (2002) provided the following definition for early detection and rapid response.

> *Early detection is a comprehensive, integrated system of active or passive surveillance to find and verify the identity of new invasive species as early after entry as possible, when eradication and control are still feasible and less costly. It may be targeted at areas where introductions are likely, such as near pathways of introduction; or sensitive ecosystems where impacts are likely to be great or invasion is likely to be rapid.*
>
> *Rapid response is a systematic effort to eradicate, contain or control invasive species while the infestation is still localized. It may be implemented in response to new introductions or to isolated infestations of a previously established, non-native organism.*

Worrall (2002) described a successful EDRR effort that eradicated the black striped mussel (*Mytilopsis sallei*) in the Darwin Harbour (Australia), and an EDRR failure, where an invasive alga (*Caulerpa taxifolia* (Vahl) C. Agardh) was found in the Mediterranean Sea near Monaco in 1984. The alga was detected early, however no decision to respond was reached and as a result it spread rapidly severely impacting the coastal ecosystems of Croatia, France, Italy, Monaco and Spain.

An effective EDRR program for invasive plants would need to be comprised of several integrated components as described by Westbrooks et al. (2000). In an EDRR program, early detection includes the finding of an established population near its inception, reporting/submitting a voucher specimen, identification of specimens by reliable taxonomists, vouchering of confirmed specimens as a historical record, gathering of information about the target species through literature reviews, and rapid assessment planning. Rapid response generally includes on the ground action including early involvement of all impacted stakeholders to discuss the problem, development of a strategic plan of action (i.e., containment or eradication), identification of available technical methodologies, identification of funding sources, implementation of an action plan, quality control through periodic assessment of progress (i.e., adaptive management), and modification of an action plan per quality control findings. Westbrooks (2004) suggested that EDRR can be a cost effective approach to invasive plant management as it does not restrict trade and movement of species, only addresses species that have established free-living, self-perpetuating populations, causes minimal impacts on invaded habitats, and usually aims to restore invaded habitats. The modelling data presented in this paper indicate that large areas of Prairie Canada are susceptible to invasion from saltcedar and to further invasions by purple loosestrife. Invasive plant managers and regulators need to examine how EDRR models can be developed to optimize resources in preventing these incursions.

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Biography

Cory Lindgren is a Ph. D. candidate at the University of Manitoba in the Clayton H. Riddell Faculty of Environment, Earth and Resources. He is currently a Senior Program Specialist with the Invasive Alien Species section of the Canadian Food Inspection Agency leading the development of a Canadian Invasive Plants Framework.

Computer Aided Plant Identification

Richard Old

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Abstract

Students and practitioners in weed science often struggle with plant identification, which continues to foster an "I don't care what it is, how do you kill it" attitude. While this type of approach may meet with some limited success in agricultural situations where there is a single desired crop species, it is an abysmal failure in more complex systems such as rangeland, parks, or roadside vegetation management. Furthermore, the inability to identify weeds in the field has led to many of our problems with invasive species, which are not detected until eradication is no longer feasible.

In my three decades of teaching plant identification, it has become apparent to me that the difficulties students encounter in this subject are a result of the teaching methodology rather than the subject matter itself. These methods include plant memorization and dichotomous keys, which have been the impetus for what is now the most common method of plant recognition: "flipping the pages and looking at the pictures" attempting to match the plant with a picture in the book.

Resumen

Estudiosos y profesionales especializados en malezas suelen tener dificultad para identificarlas, lo que promueve una actitud de "No me importa lo que es sino cómo la matas". Mientras que esa actitud puede lograr ciertos resultados limitados en situaciones donde solo se desea una sola especie de cultivo, es un error garrafal en sistemas más complejos, tales como el manejo de tierras de pastoreo, parques o en el manejo de vegetación ruderal. Es más, la incapacidad de identificar las malezas en el campo ha anticipado a muchos de nuestros problemas actuales con especies invasivas que sólo son detectadas cuando ya no es posible erradicarlas.

En mis 30 años de enseñanza de identificación de plantas he descubierto que las dificultades para los estudiantes en esta materia son resultado más bien de la metodología de enseñanza y no del tema en sí. Estos métodos, que incluyen la memorización de plantas y claves dicotómicas, hoy en día son la base del método más común para reconocer plantas: "pasar rápidamente las páginas y mirando las fotografías" tratando de encontrar la que corresponde a la planta.

Improved methodology began to take shape in the computer programs of the late 1980s and is continuing to improve in its technology and acceptance. Today's computerized interactive identification systems are becoming more universally accepted as the proportion of the users that has grown up with computers has increased. Although the interactive technology can be applied to any field where identification of an unknown from a large number of possibilities is needed, the majority of the applications today have centered on plants.

La metodología comenzó a mejorar con los programas de computadora a fines de la década de 1980; su tecnología está mejorando y está aumentando su aceptación. Los actuales sistemas computarizados de identificación interactiva están siendo más aceptados, a medida que aumenta el número de usuarios acostumbrados desde niños a utilizar computadoras. Aunque la tecnología interactiva puede aplicarse a cualquier campo que requiera identificar un elemento desconocido a partir de un gran número de posibilidades, la mayoría de las aplicaciones de hoy se concentran en las plantas.

Plant Identification

Students and practitioners in weed science often struggle with plant identification, which continues to foster an "I don't care what it is, how do you kill it" attitude. While this type of approach may meet with some limited success in agricultural situations where there is a single desired crop species, it is an abysmal failure in more complex systems such as rangeland, parks, or roadside vegetation management. Furthermore, the inability to identify weeds in the field has led to many of our problems with invasive species, which are not detected or recognized until eradication is no longer feasible.

In my three decades of teaching plant identification, it has become apparent to me that the difficulties students encounter in this subject are a result of the teaching methodology rather than the subject matter itself. A brief overview of two common methods follows:

Plant Memorization

The students are given a set of specimens representative of weeds commonly found in the geographic area where the course is taught. They are then instructed to memorize the specimens for the test.

While students may be able to generate a good score on the test, they often have learned to recognize the specimen rather than the species and have no ability to identify the same plant species in the field. Since plants are highly diverse and notoriously variable under different conditions, this approach is severely limited by memorization capacity. With this technique, students gain no useful knowledge for identifying plants that are not "on the list".

Dichotomous Keys

The traditional tool for teaching plant identification in botany classes and identifying unknown specimens is the dichotomous key. Students reach an identification by answering a series of questions regarding the plant to be identified. The dependence upon availability of comprehensive plant material (various life stages) and knowledge of technical terminology (with the student forced to make choices such as whether their plant has syngynoecious anthers or not) makes this approach laborious and time consuming.

Dichotomous keys have been referred to as "tools created by people who don't use them, for people who can't use them". Many students in both botany and weed science develop such an aversion to this approach that they abandon the idea of developing any proficiency in plant identification. While many weed reference books continue to include a dichotomous key, the are largely unused.

Picture Matching

The above techniques have been the impetus for what has now become the most common method of plant "identification" (actually plant recognition) used in the field by the lay public and professionals as well. This technique consists of "flipping the pages and looking at the pictures" attempting to match the plant to be identified with a picture in the book. The drawbacks to this approach are numerous, but the most daunting is that fact that there are currently over 4,000 weed species in the United States! Even if a book existed with pictures of all the species, the logistics of flipping the pages to find the correct match would be overwhelming.

Interactive Synoptic Keys

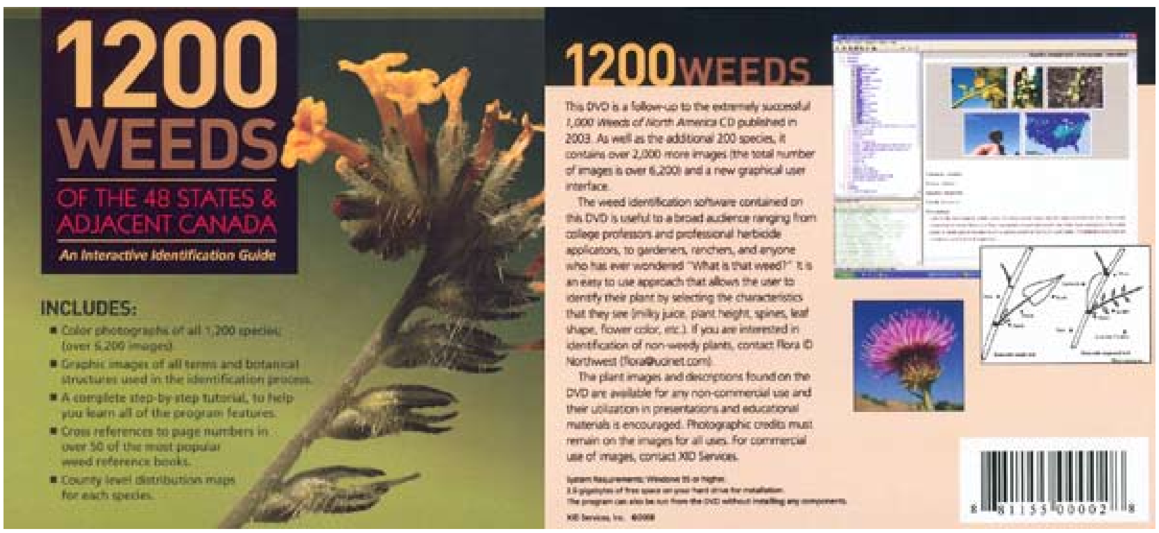
It has long been apparent, to those charged with teaching plant identification, that an improved methodology was needed, but only in the last few years has the technology existed to allow the student (and professional) to adequately master the subject. This improved methodology needed to incorporate the beneficial features of the three techniques discussed above, as well as some new abilities made possible by modern technology. Some of the requisites for success include:

- The ability to allow the person attempting to make the identification to follow a process of their own choosing, consistent with their own skill level and the condition/growth stage of the plant they are attempting to identify.
- The ability to parse large numbers of plants with a small number of steps.
- The ability to provide guidance in the identification process without limiting the user's choices.
- The ability to provide color photographs of all of the species.
- The ability to reference other sources of information (reference books, internet, etc.) to confirm tentative identifications.

This improved methodology began to take shape in the computer programs of the late 1980s and is continuing to improve in its technology and acceptance. Today's computerized interactive identification systems meet all of the criteria above and are becoming more universally accepted as the proportion of the users that has grown up with computers has increased. The tools are synoptic (including a large amount of information about each species), can provide interactive help and guidance, and can be used effectively with limited life stage material in hand. Although the interactive technology can be applied to any field where identification of an unknown from a large number of possibilities is needed, the majority of the applications today have centered on plants (and commonly weeds).

XID Services' Identification Software

XID Services has developed a PC or internet based system which includes all the features listed above for the interactive identification of any group of organisms or objects. The XID 1,200 Weeds database is the most comprehensive computer-based weed identification reference ever produced and the user-friendly nature of the "XID Authoring System" has caused it to be the system-of-choice for the creation of the largest interactive plant identification database ever produced. Created by Flora ID Northwest, this interactive database includes all native and naturalized vascular plants in sixteen states and four Canadian provinces, almost 11,000 species. The malleable nature of the technique allows authors a great range of individual expression as well as the ability to adapt the methodology to a diverse set of subject matter, including: pollen, fungi, butterflies, etc. If you are interested in producing your own interactive database, please contact: rold@xidservices.com



Biography

Ph. D.: Plant Science University of Idaho

1976 to present, Weed Identification Specialist for Washington State University Cooperative Extension Service.

1980 to present, Consultant on forensic botany to state and federal law enforcement

Owner and co-founder, XID Services, Inc.

Author, 1,000 Weeds of North America CD and 1,200 Weeds of the 48 States and Adjacent Canada, the most comprehensive Weed ID reference ever published.

Former Regional Reviewer, Flora of North America Project

Former Appointed Scientific Advisor, Washington State Noxious Weed Control Board

Former Chair, Education Committee, Washington State Noxious Weed Control Board

Former President, Eastern Washington Native Plant Society

Former Vice-Chair, Whitman County Noxious Weed Control Board

Former President, Eastern Washington Weed Board Association

Former Member, National Weed Alert Committee, Weed Science Society of America

1984 to 1992, Weed Diagnostician, University of Idaho

1991 – Idaho Weed Worker of the Year

1990 – Honorary lifetime member, Washington State Weed Association

1999 – Chair, International Botanical Congress, Session on Expert Identification Systems

2005 – Washington State Weed Warrior of the year, the highest award of the Washington State Weed Association

Weeds Across Borders
Field Tour Thursday, May 29, 2008

Hosts: Kim Nielsen and Karen Sundquist

08:30 Depart Banff Park Lodge (4 buses)

08:50 Parks Canada Sites: invasive plants issues in gravel pits and disturbed areas. Welcome by Parks Canada staff for first groups at each site

09:00 Concurrent sessions, splitting the group and rotating between sites
- a) Cadet Camp — site reclamation of disturbed ground. Perry Davis[1] and Ian Pengelly[2], Parks Canada.
- b) Cascade Gravel — weed issues pertaining to gravel crushing and gravel use. Ray Schmidt[3] and Hans Reisenleiter[4], Parks Canada, and Adrianne Peterson, Sublette County Weed and Pest, Pinedale, WY.

11:00 Arrive Canmore weed site Quarry Lake. Andrew Stiles, Nature Calgary, and Lisa Guest, Town of Canmore Parks and Recreation.

11:45 Depart for Canmore Nordic Centre

11:50 Lunch at the Calgary Olympic Development Association facility

13:00 Presentations
- a) Dawn Lafleur and Edwin Knox — Glacier/Waterton Lakes National Parks International Partnership
- b) Bob Parsons (Park County Weed and Pest Control, Powell, WY) — Cooperative Weed Management: The Key to Success

14:30 Canmore Weed Site, Canmore Creek/Mountain Shadows

15:15 Depart for Banff Park Lodge

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1 Environmental Surveillance Officer, Banff National Park
2 Fire and Vegetation Management Specialist, Banff National Park
3 Fire Information Officer, Banff National Park
4 Environmental Surveillance Officer, Banff National Park

Weeds Across Borders Site Tour
Town of Canmore, May 29, 2008

The site we are visiting today has a long history of ground disturbance. From the mining days of no respect of the environment, tent city's and planting plant species to support human life, to the current use of the area for recreation, enhanced fish habitat and an interpretive area.

Below we have a summarized history of the area for you to review and ask questions about.

Quarry Lake

- Originally it was a virgin mountain land then the Canmore Mines started coal mining in 1880s to produce coal for the Canadian Pacific Railway (CPR) locomotives and the building of the CPR rail line. Canmore's coal production escalated when the Banff National Park was designated and all coal mining in the national parks ceased such as Bank Head due to no mineral extraction in a national park.
- In the early 1960s the Canmore Mines Ltd. went from a total under ground mining operation to a partial open pit strip mine extending from the Quarry Lake site up to the TransAlta fore-bay canal and continued on the north side of the canal were the Nordic Centre is presently located up to the old George Town homestead. This type of mining was short lived about 10 years in total due to public discontent with the scaring of the natural landscape that can be seen from the Trans Canada Highway and being so close to Banff National Park so the strip mine operation ended and all open pits were reclaimed.
- The strip mine locations were originally leased from the province, when the mine closed in 1979 the leases reverted back to the province. The mine did a very good job of reclamation by back filling and introducing native grasses to the disturbed areas and left the Quarry Lake pit open due to natural water infiltration to create the lake. Kananaskis Country then modified and developed the site as a day use park. The province also maintained the area with K-country personnel. The lake is approximately 100ft/30m in depth at its deepest point.
- The large pile to the east of the lake is the over burden spoil pile left over from the strip mining operation, which was also top-soiled and seeded with a native reclamation grass seed.
- In the mid 1980's the Town Of Canmore entered into a recreational lease for the area with the province and assumed the maintenance of the area.
- In 2002 the area was then sub-leased to the Rocky Mountain Heritage Foundation. The Town of Canmore maintains the site through the tax base and provincial grants and any capital improvements are funded through the Rocky Mountain Heritage Foundation which are then included in the Town's 5-year capital and the Town oversees the projects on their behalf.

1 Mine / Canmore Creek

- The # 1 Mine opened in late 1800s and closed in the early 1900s. This mine's entrances were located at the top end of Canmore creek by the Three Falls (area is known to the locals as Three Falls) with one of the mine under ground entrances running in a northern direction under the housing estates that is now Rundle View and a second under ground entrance, which went in a southern direction under the Spray Lakes road towards Quarry Lake. This was the same seam of coal that they eventually strip mined. A lot of private lots in Rundle view could not be developed due to excavation equipment breaking through into the old mine shafts so some of the cul-de-sacs were deemed unusable.
- The lower flat section of Canmore Creek is where the under ground Chinese work force had their tent community. The area was once referred too as "Chinks" the slang name for the Chinese mine workers. When the # 1 Mine closed the "chinks" tent city was abandoned.
- The mounded bank on the north side of Canmore Creek was the debris spoil pile from processing the coal this area had a set of tracks on the top of the mound and as the spoil pile grew they extended the tracks. The spoil pile is mostly made up of rock and contaminated and unusable coal.
- In 1969 The Canmore Mines got involved with some provincial programs such as the Opportunities for Youth grants (OFY), which they utilized to hire local youths in the recessed community to clean up the "Chinks" site and did all of the reclamation work through that program and turned the site into a picnic area with numerous small bridges traversing the creeks to give access to the picnic table areas strewn through out the lower creek area.
- Canmore Creek was also always recognized as the emergency spill way for the Trans Alta power canals when they were built in the late 1920's. There is an emergency spill way built into the manmade southern canal banks with a manmade channel to direct the flow towards Canmore Creek.
- In mid 1980's Trans Alta wanted to do a test run with the emergency system, which was never done up to that point. They proceed with the test without any concept of what the end results would be and the whole creek area was completely devastated and they scoured all of the reclamation work out of the area. It was apparent that the spill way worked but it was also decided that they would never do another test again due to all the damages it created. Since that has happened the province (Fish & Wildlife) has spent many years repairing the damages and enhancing the fish spawning aspects of the creek.
- The existing emergency fire road that parallels the trail network was the original Spray Lakes Road and when the Mine shut done in 1979 the old strip mine haulage road was upgraded for the Spray Lakes Road and housing proceed in the Rundle View area and adjacent to the Creek.

Mountain Shadows

- From late 1800s to the late 1980s miners homes stood atop the small ridge between lower Canmore Creek and Three Sister Drive.
- The recessed miners planted most of their consumables that could be grown in the area such as Rhubarb, Tansy and Celery; this plant material can still be found at the site today and in some cases have become an invasive plant problem especially along the creek and river banks.
- The flat ground between lower Canmore creek and the Bow River was formed by the dredging of the Bow River. This area was a huge storage area for the river dredging (gravel) and operated as a gravel pit for many years until it was finally reclaimed and turned into a grassy field. This area currently has clusters of Tansy and Celery.

Invasive Plants found within the three areas

- Ox-eye Daisy, Toadflax, Canada Thistle, Common Tansy, Knapweed, Clematis, Scentless Chamomile, Celery, Rhubarb.

Control over the Years

2007 Hand pulling Toadflax by Town parks staff.

2007 Selective spraying of herbicides by our contractor.

2008 Town of Canmore will be facilitating an Education Session and weed pull day with residents and school groups hosted by Andrew Stiles.

Gravel Inspection: History and Standards

Adrianne Peterson

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Abstract

Noxious weeds are rapidly spreading throughout landscapes with multiple ownerships. The invasion is caused by several factors. Roads are being built, subdivisions are growing, oil and gas production is becoming more prevalent. Gravel, sand, top soil, and borrow material are being used in all areas of construction. Many of these gravel pits are contaminated with noxious weeds and are major distribution sources of invasive weeds to new areas.

The number one way to reduce the spread of noxious and invasive weeds is to prevent their distribution. Prevention is a strategy that appears in most National and Provincial programs. It seems gravel and equipment are late comers into these strategies. The North American Weed Management Association has recognized the potential spread of weeds through this method of distribution. We have developed and approved minimum standards to inspect gravel pits and areas surrounding them. NAWMA also created a standardized form to work in conjunction with these guidelines. This program is similar to weed free forage programs.

Resumen

Las malezas se están propagando con rapidez por terrenos con diferentes títulos de propiedad. La invasión es el resultado de varios factores. La construcción de carreteras, la expansión de complejos de viviendas y la producción de hidrocarburos se vuelven cada vez más predominantes. La gravilla, la arena, las capas superiores de suelo y otros materiales de segundo uso se están utilizando en todas las áreas de construcción. Muchas de esas graveras están contaminadas con malezas nocivas y por lo que son la fuente principal para que las malezas invasivas se propaguen a nuevas áreas.

La principal manera de reducir la propagación de malezas nocivas e invasivas es impedir su distribución. La prevención es una estrategia incluida en la mayoría de los programas nacionales y provinciales. Estrategias como el uso de la gravilla y equipo pesado fueron de las últimas integradas. Parece que las graveras y equipos están por fin adoptando estas estrategias. La Asociación para el Manejo de las Malezas en América del Norte (North American Weed Management Association, o NAWMA) ha reconocido el riesgo de la propagación de malezas por esas vías. Hemos preparado e implantado

As a result of this development, we are "spreading the word, not the weed" in an attempt to have others involved in the program accept the minimum standards and the form as part of their line of attack for weed control.

This is not a sure-fire program because not all borrow material will be noxious weed free because of the probable seed bank. However, the standards do consist of a preventative and educational program that enables future weed control of our gravel pits and surrounding areas.

normas mínimas para la inspección de las graveras y sus áreas circundantes. Asimismo, la NAWMA ha creado un formulario compulsorio para trabajar en cumpliendo con esas guías. Este programa es similar a los programas dirigidos a obtener forrajes libres de malezas.

Como resultado de esta evolución y adoptando el lema "propagar el mensaje, no a las malezas", estamos buscando que otros participen en el programa aceptando las normas mínimas y el formulario como parte de su línea de ataque para el control de las malezas.

Este programa no puede asegurar 100% de eficiencia porque no todos los materiales de segundo uso están libres de malezas debido a que pueden provenir de bancos de semillas. Sin embargo, las normas sí incluyen un programa preventivo y educativo que habilita el futuro control de malezas en nuestras graveras y en las áreas que las circundan.

Gravel, Roads, and Weeds

- Not really a good combination, especially if the weeds are noxious
- Throw equipment in and you could have a disaster

Prevention

- Early detection and rapid response
- Cleaning equipment
- Using certified weed-free gravel and materials
- Proper reclamation and monitoring

History

- Spotted knapweed found at a gravel pit in Sublette County Wyoming in 1990
- Potential to spread over large area into
  - Forest
  - County
  - Private
  - State

- Meeting with involved parties
- Quarantined (remedial agreement) the gravel pit in 1991
- Landowners upset!
- Educated many people
- Good prevention program established
- Initiation of a weed management program in a major subdivision
- Inspection of other gravel pits across the county
- County zoning regulation to inspect pits
- Sublette County started a trend that got Wyoming Department of Transportation to join in and require inspection of gravel on right-of-ways around 1995
- Other agencies have put weed-free materials into their best management practices (BMP) guidelines as a result of this

Yellowstone National Park

- Yellowstone National Park saw an opportunity for prevention
- Craig McClure from Yellowstone NP visited with the University of Wyoming, Sublette County and other people
- He started a pilot program to inspect gravel that could potentially come into the park
- From there it snowballed into the Greater Yellowstone area
  - Wyoming
  - Montana
  - Idaho
- A sub-committee was formed within the BMP committee to talk about inspection, etc.

Minimum Standards

- As a leader in the program, Wyoming used a similar standard to the weed-free forage program (WFF)
- There was really nothing drawn up formally until this last year when I drew up some standards
- The Greater Yellowstone Coordinating Committee (GYCC) reviewed the draft standards along with some of the Western Weed Coordinating Committee (WWCC) and this is what was accepted for the most part
- An inspection form was also reviewed

NAMWA involvement

- At the WWCC meeting, the North American Weed Management Association (NAWMA) was asked to look into similar standards for the gravel as for WFF
- This would help standardize the forms and inspection throughout the region
- I went to the NAWMA Board and they asked us to proceed with the standards and forms for gravel too This is the result of the committee's decision to take over the standards and form
- At the Las Vegas meeting the committee decided to take over the standards description and form design
- Any State will be welcome to come into the program, just like the WFF program

Minimum Standards

- Gravel/borrow pit area shall be free of those noxious weeds or undesirable plant species identified in the NAWMA WFF list and those weeds declared noxious within the State of origin
- Gravel shall be inspected in the State of origin by the proper authority
- Gravel shall be inspected in the area of origin (the area shall include, but not be limited to: surrounding ditches, top soil piles, gravel/sand piles, fence-rows, roads, easements, rights-of-way, working areas, storage areas, and buffer zones surrounding the entire area)
- Gravel shall be inspected prior to movement
- Area which contains any noxious weeds may be certified if the following requirements are met:
  - Area upon which the material was mined is treated to prevent seed formation or seed ripening to the degree that there is no danger of dissemination of the seed or any injurious portion from which such noxious weed(s) or parts of the weed(s) are capable of producing a new plant
    - Noxious weeds treated no later than rosette to bud stage, or boot stage for grass species
    - Treatment method can include, but is not limited to: burning, mowing, cutting or rouging, mechanical methods, or chemicals

- Requirements
  - Inspected by the proper authority
  - All areas of the pit will be inspected
  - Buffer zones
  - Inspection history (1 years, 2 years, etc.)

Transit

- There really has not been a transit certificate developed, but it might look similar to the weed-free forage one

Inspection Procedure

- Entire border shall be walked or driven
- All storage areas, gravel/sand piles shall be inspected and meet the standards
- Areas around all equipment, crushers, and working areas must be inspected and meet the standards
- Areas shall be inspected regularly, at least every 30 days during the growing season.
- An inspector may not inspect material of which said inspector has ownership or financial interest
- Weed list is the same as NAWMA and State's lists

Advantages

- Gravel will not likely travel as far as hay and straw
- Visual inspection will be easier than inspecting a field of tall hay or straw
- Time required to inspect should be less because one should be able to drive through most areas

Disadvantages

- On-going seed bank not a zero tolerance as the WFF program
- Still a potential of spreading noxious weeds
- Equipment may bring more weeds into the gravel pit area from outside
- Time consumed inspecting greater because several inspections a year are required
- End user does not always understand that there could still be seeds in the gravel

Conclusion

- This is not a sure-fire program as far as stopping the spread of noxious weeds
- It does bring awareness to the pit owners and end users
- Education is the greatest advantage of the program
- It is a start to working down the seed bank over the years of inspection
- If the program is used for several years some weed seeds will be exhausted

- This will help make the program be more easily accepted
- Gravel pits that have never had noxious weeds are more likely to stay weed-free
- You have to start somewhere or the weeds will continue to be spread everywhere!

Weed Free Update

- There is a new color of twine for the NAWMA weed-free program
- Phased in over the next couple of years (2010)
- Colorado runs the blue and orange twine. We thought when NAMWA took the standards over they would come into compliance but they never did leaving us with a double standard. Mostly the difference was the forms and they don't inspect storage areas. Colorado also would not approve the use of the twine to Crop Improvement Association. We have several of them in the program.
- We now have 20 States, 2 Counties, and 1 Province active in the program
- We are working with another State, County and Province at this time

Biography

Adrianne Peterson has worked for the county weed and pest district for 15 years and was appointed supervisor in 1990. Adrianne was born and raised in southeastern Wyoming on a 30,000-acre ranch. She is married to the Ag Extension Agent and they have two daughters. She is currently serving on the Wyoming Allocations Committee, NRCS State Technical Team, Wyoming Weed and Pest Council Audit Committees and Legislative Committees. Adrianne has been a member of NAWMA for 6 years and has served on the Board of Directors for the past two.

Adrianne has been successful in making Sublette County one of the most weed free counties in Wyoming. This is a result of vigilance, education of the public, and the training, supervision, and leadership that she provides to her crews. The experience of being on the NAWMA Board of Directors has been an enjoyable one for Adrianne. She has been a member of the Nominating Committee, the Mapping Committee, and the Weed Free Forage Committee during that period, and would welcome the opportunity to serve again.

Cooperation: The Key to Success – The History of the Southfork Weed Management Area in Park County, Wyoming

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Abstract

Weeds do not recognize political boundaries or private fences, but for years government agencies and private landowners have treated noxious weeds based on land ownership. After the 1988 Yellowstone fires, many land managers decided to look at the spread of noxious weeds in the same manner they had witnessed with the spread of fire. In the spring of 1989, representatives from federal agencies, states, local government and the private sector came together to establish a concept of weed control that was based on weed infestations and topography rather than land ownership.

Since the distribution of the *Guidelines For Coordinated Management of Noxious Weeds In the Greater Yellowstone Area* (1990) and the *Guidelines for Coordinated Management of Noxious Weeds: Development of Weed Management Areas* (2002), Park County Weed and Pest Control District in northwest Wyoming has formally implemented three

Resumen

Aunque las malezas no reconocen los límites geopolíticos ni los cercos privados, durante años las entidades gubernamentales y los propietarios privados han tratado el problema de las malezas nocivas basándose en los derechos de propiedad de tierras. Tras los incendios de Yellowstone en 1988, muchos manejadores de tierras decidieron responder a la propagación de malezas nocivas de la misma manera en que respondieron a la propagación del fuego. A principios de 1989, representantes de entidades federales, estados, municipios y del sector privado se unieron para establecer un concepto de control de malezas enfatizando en su propagación y la topografía en vez de en la propiedad de las tierras.

Desde la difusión de dos directivas para el control coordinador de las malezas (*Guidelines for Coordinated Management of Noxious Weeds In the Greater Yellowstone Area*, publicada en 1990; y *Guidelines for Coordinated Management of Noxious*

Cooperative Weed Management Areas (CWMA) and has laid the groundwork for two more. By using a true integrated weed management program of chemical, biological, and mechanical controls, along with education and restoration, many severe weed infestations have been reduced to a manageable level.

Weeds: Development of Weed Management Areas, publicada en 2002), las autoridades a cargo en el noroeste de Wyoming (*Park County Weed and Pest Control District*) han implantado formalmente tres áreas para la manejo cooperativa de malezas (*Cooperative Weed Management Areas*, o CWMA) y han iniciado dos adicionales. Utilizando un programa de control de malezas genuinamente integral – que incluye controles químicos, biológicos y mecánicos, junto con medidas de capacitación y restauración – muchas propagaciones graves de malezas se han reducido a un nivel controlable.

Introduction

Between July 15 and September 11 of 1988, there were 248 fires in the Greater Yellowstone Area and over 1.2 million acres (about 36%) were burned or scorched. More than 25,000 firefighters (as many as 9000 at one time) attacked Yellowstone fires in 1988, at a total cost of about $120 million. In the aftermath, about 665 miles of hand-cut firelines and 137 miles of bulldozer lines (including 32 miles in the park) needed some rehabilitation, along with the remnants of fire camps and helicopter-landing spots. Before all the fires were completely extinguished, requests for bids went out from federal agencies for native grass and forage seed to start the restoration of disturbed lands. In many cases, the specifications were very general in their descriptions of requested species and in most cases no reference was made to the "other weed seeds" that would not be allowed. The potential for a massive planting of noxious weeds was practically inevitable.

The History of Weed Management Areas

Recognizing the Potential Crisis

Local weed control agencies in the Greater Yellowstone Area (GYA) ecosystem recognized the possibility of new infestations of noxious weed being introduced by the use of poor quality seed. State weed coordinators from Wyoming, Montana and Idaho discussed what steps could be taken to reduce the chance of this happening. It was generally agreed that the problem centered on the fact that there were no guidelines which addressed noxious and exotic weeds on a multi-jurisdictional basis. In the winter of 1988, a meeting was held in Cody, Wyoming, to bring together federal land managers, state departments of agriculture, and local governmental agencies involved in weed control. From that meeting came the plans for an ad hoc committee to establish guidelines that would address the concerns of the group.

The committee consisted of Jim Free with the U.S. Forest Service; Barbra Mullin, Montana State Weed Coordinator; Hank McNeel, Weed Specialist with the Bureau of Land Management; Bob Parsons, Supervisor of the Park County Weed and Pest District; James Sweaney, Forestry Supervisor for Yellowstone National Park; and, Loal Vance, Idaho State Weed Coordinator. This committee met over the next year and in the spring of 1990 published the *Guidelines For Coordinated Management of Noxious Weeds In the Greater Yellowstone Area* (Free et al. 1990). The value of these guidelines is greatly enhanced by the fact that they had been approved with a Memorandum of Understanding (MOU) signed by the Governors of three states, three Regional Foresters, three State Directors of the Bureau of Land Management (BLM), and the Regional Director of the National Park Service.

The Cooperative Concept is Given Structure

The "*Guidelines...*" addressed most of the operations associated with noxious weed control as had been carried out for many years by county weed control districts and various governmental agencies. These operations included sections on awareness, education, prevention, inventory, integrated weed management, monitoring, evaluation, and reporting. All these sections were supported by extensive appendices of supporting material.

The primary benefit of the document seemed to center around the section, "Purpose and Organization of Weed Management Areas." As public land managers began to implement the guidelines, many saw the value of an organized committee of interested parties in providing on the ground application of noxious weed control. The basic concept of a weed management area (WMA) was "…replaces jurisdictional boundaries that are barriers to weed management programs in favor of natural or more logical boundaries that facilitate weed management and control."

Weed control projects in the past had been stymied by "the blame game" and "finger pointing" types of accusations. Because funding for weed control programs had often been centered on ownership boundaries, it seemed important to determine where the weed had originated and whose was at fault for the infestation. The concept of a WMA nullified the need to determine the culprit responsible for the initial introduction of the infestation since all agencies and individuals within the area would share in the cost of control. (It was still recognized as important to determine the method of introduction for educational purposes to prevent the likelihood of similar or ongoing incidences.)

The concept of a WMA was to establish the boundaries of the infestation and its potential spread, then use that information to determine the boundaries of the WMA. These natural barriers are usually associated with hydrographic divides or vegetational zones. Once the area has been defined, an inventory of land ownership is conducted to determine potential cooperators and land managers for the organizational structure of the WMA.

The "*Guidelines...*" also included suggestions on how to establish a steering committee, assessing the extent of the infestation, and writing a WMA plan. These suggestions were supported by examples included in the Appendices.

Guidelines are Expanded Beyond the Greater Yellowstone Area (GYA)

Because of the popularity of the WMA concept, and fueled by the reported successes, many requests were made for copies of the "*Guidelines*...". As this document was distributed over a continuing larger area, requests where made for a more generalized document that was not so specific to the GYA. In 2002 the ad hoc committee was reestablished to modify the document to include the majority of the western states. This document was entitled *Guidelines for Coordinated Management of Noxious Weeds: Development of Weed Management Areas* (Free et al. 2002) and for the most part, only minor changes were made. Two major changes were defining grazing as a biological control method and the addition of a section related to weed management for burned areas. The added sections addressed the subject of revegetation more completely than the previous document.

As the success of WMA's became more evident, other agencies and individuals began publishing documents tailored to their region or state. One of the more notable was the "*CWMA Cookbook*" from the Idaho Noxious Weed Coordinating Committee in 2003 (VanBebber 2003). This was one of the first documents to coin the phrase, *Coordinated* Weed Management Area (CWMA). Because this title emphasizes the idea of coordination, it seems to have become the more common terminology over the past few years.

Putting the Concept into Practice

Background

Prior to 1970, Wyoming's Park County Weed and Pest Control District had identified a small infestation of Dalmatian toadflax (*Linaria dalmatica* (L.) Mill.) about 47 miles west of Cody, Wyoming. The infestation was sparsely spread over about 180 acres of the Shoshone National Forest (United States Forest Service) land, near the junction of Cabin Creek and the Southfork of the Shoshone River. Because the infestations were insignificant compared to other weed problems, they were not prioritized in United States Forest Service (USFS) management plans. When the federal government reduced funding available for weed management programs, the USFS did not have the resources to keep Dalmatian toadflax control at the forefront of the Shoshone National Forest land management programs.

Within three years of this decision, Dalmatian toadflax spread to cover 2000 acres of national forestland and nearby private properties. The expansive infestation posed a growing threat to bighorn sheep grazing in the area. As it flourished, Dalmatian toadflax began to replace native plants, which provide important nutritional food sources for bighorn sheep and other grazing wildlife in the Shoshone River valley.

Topography and Demographics

The Southfork of the Shoshone River is one of the two major tributaries of the Shoshone River. It is located in Park County in the northwestern section of the State of Wyoming. Over 95% of the Southfork drainage is public land managed by the Shoshone National Forest. It has long been an important winter grazing range for bighorn sheep and elk in the Absaroka mountain range.

Because of its beauty and isolation from the general public, many of the large ranches in the valley have been purchased by non-resident landowners for summer vacation spots. Although there are still cattle ranches in the area, much of the land is used for private enjoyment and recreation. Many of the private landowners have little experience with the noxious weeds found in the mountain states of Wyoming. Very few recognized Dalmatian toadflax as an aggressive invasive species, but considered it a pretty mountain flower. The need for education was obviously paramount.

Selecting the Steering Committee

Both the "*Guidelines...*" and the "*CWMA Cookbook*" suggest a basic organizational structure that begins with the forming of a steering committee made up of interested and committed individuals. In the fall of 1992, the Park County Weed and Pest Control District (PCWP) and the Wapiti District of the Shoshone National Forest agreed to begin the process of forming a weed management area based on the GYA guidelines. The original committee consisted of representatives from PCWP, USFS, the Cody Conservation District (CCD), and the University of Wyoming Cooperative Extension Service (UWCES).

The committee discussed the need for a WMA and mutually agreed that it would be the best way to promote weed control in that area. It was decided that the management area would be called the "Southfork Weed Management Area" (SFWMA) and would encompass all lands within the drainage of the South Fork of the Shoshone River from its headwaters to the Buffalo Bill Reservoir west of Cody, Wyoming (Figure 1). The purpose would be primarily for the control of Dalmatian toadflax, but other weeds would be addressed when appropriate.

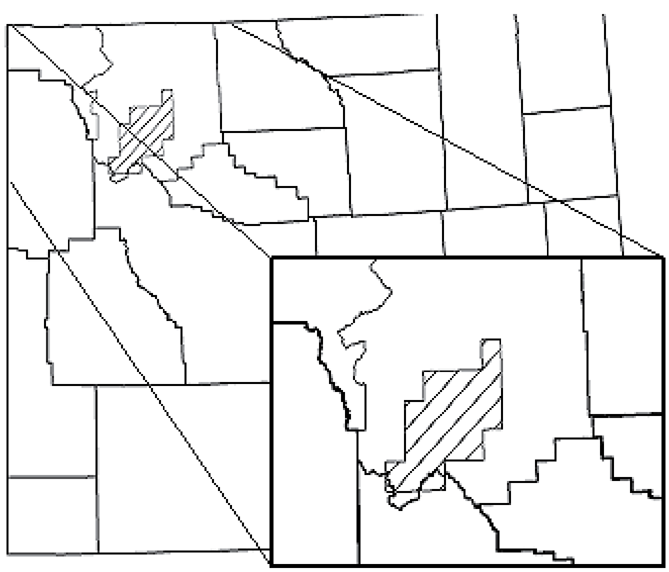

Figure 1. Location of the Southfork Weed Management Area, Wyoming.

Forming the Weed Management Area Coordinating Committee

In the Winter of 1992–1993, the steering committee contacted the local newspapers for an interview about the formation of a WMA. In addition, an advertisement was placed notifying interested persons of a meeting to address questions. The meeting was attended by the steering committee, the State Weed and Pest Coordinator from the Wyoming Department of Agriculture (WDA), and representatives from the Wyoming Game and Fish (WGF), the Bureau of Land Management (BLM) and the Bureau of Reclamation (BOR). There were also about fourteen private landowners or managers from within the WMA.

Major points of discussion and concern were:

- Why do we need to control Dalmatian toadflax when it is such a pretty flower?
- Are you going to use herbicides to control the weeds?
- What other vegetation is going to be killed with the use of herbicides?
- How are the herbicides going to affect wildlife and livestock?
- Are herbicides going to be used to control weeds along the river bank?
- Are there any biological control agents available?
- Will hand pulling the weeds get rid of them?
- Will all landowners be forced to control the toadflax even if they don't want to?
- Who is going to pay for the program?

At the conclusion of the meeting, a request for volunteers to form a coordinating committee was made. The general consensus was that each governmental land management agency would have a representative on the committee. Most of the private landowners felt that their concerns would be addressed by the PCWP and one or two private landowners could serve to ensure their private property rights were recognized.

By the conclusion of the public meeting, the general feeling of the crowd was positive. There were a few attendees that were totally opposed to the concept and vowed to contest not only the WMA but any efforts of the PCWP to try and force them to control noxious weeds on their lands or adjacent public lands. It was agreed that PCWP staff would approach these individuals on a personal basis to explain the Wyoming Weed and Pest Act and the Park County Weed and Pest District-wide Quarantine.

Activities of the Coordinating Committee

The SFWMA Coordinating Committee started meeting in the Spring of 1993 to establish goals and objectives for the organization (Appendix). The long term goal was simple —**Reduce the level of infestation within the Southfork Weed Management Area.**

The short term goals were:

- Contain Dalmatian toadflax within current boundaries
- Inventory and map the current boundaries of Dalmatian toadflax
- Determine effective Dalmatian toadflax control methods
- Develop awareness and educate the public about the Dalmatian toadflax problem

The committee agreed that one of the first activities had to be mapping and inventory of the infestation. Assignments were given to land management agencies to have the entire WMA mapped by the fall of 1994. This lofty goal was completed with the unexpected help of a grant from DOW AgroSciences to help fund the hiring of a private contractor to map the privately owned lands within the WMA.

Hiring a WMA Coordinator

In Park County, the PCWP staff is, by statute, responsible for coordinating an effective weed and pest management program within the county. It became very clear that the existing staff were not going to be able to devote the time necessary to ensure the success of the WMA. In an effort to address this problem, the SFWMA coordinating committee contracted with individuals to coordinate programs within the WMA. These individuals are financed through grants and other funding obtained by the SFWMA coordinating committee. They compliment the activities of the PCWP staff and are probably the single most important aspect of the success of the SFWMA.

Obtaining Financial Support

Although funding had been available for the ongoing noxious weed program within what was now the SFWMA, more financial support was needed to expand the work identified by the coordination committee. Both short term and long term monetary support methods were sought.

Short Term Support

- DOW AgroSciences provided funding to hire a commercial contractor to survey and map the private lands within the SFWMA. ($5000)
- The Cody Conservation District obtained a grant from the Wyoming Association of Conservation Districts to purchase bio-agents from USDA-APHIS/AR in Bozeman, MT. ($7500)
- Both the local chapter and the national chapter of the Foundation for North American Wild Sheep (FNAWS) supported the SFWMA with grants for biological control and revegetation for bighorn sheep winter range. ($10,000)
- The SFWMA applied for and received three Pulling Together Initiative (PTI) grants from the National Fish and Wildlife Foundation (NFWF). This was a precedent setting accomplishment since it was the first time that three PTI grants had been awarded to the same project. ($150,000)
- The WMA also received two grants from the Wyoming Wildlife and Natural Resources department and have currently applied for a third one. A large portion of this grant is designated to the SFWMA. ($150,000)
- The PCWP has directed a portion of their annual funding from the USFS State and Private Forestry grant to the SFWMA. (approximately $30,000 per year)
- The BLM provided funds for an educational information sign to be place along the highway which accesses the WMA. ($1200)

Long Term Support

- Because of the commitment of adjacent landowners and land managers of public lands to support the WMA, the Shoshone National Forest increased its USFS budget for weed control directed to the SFWMA. This had resulted in increased support of approximately $50,000 per year.
- The PCWP Board of Directors has agreed to provide a 100% cost share on all herbicides used on private lands for the control of Dalmatian toadflax within the SFWMA. The PCWP is also responsible for the cost of weed control along all county roads and state highways within the WMA. The total cost to the PCWP within the WMA is approximately $35,000 per year.
- Private landowners within the WMA have provided financial support either in the form of cash donations or in-kind services. Although this varies each year dependent upon the size of the donation or amount of work done on private lands, it is estimated that this results in over $20,000 per year in cash and services.
- The BLM has increased its budget for noxious weed control on public lands to help support programs within the WMA. In addition, they have provided extensive support in housing the mapping and inventory information on their geographic information system (GIS). We estimate a value of over $15,000 per year for this service.

Implementing the Integrated Weed Management Plan

It was agreed from the implementation of the SFWMA that weed control in the project area would include all methods of a true integrated pest management (IPM) program. Much of the success of this WMA is associated with the fact that allowing cooperators the option of various control methods has neutralized many of the concerns of herbicide control. Over the years, even the most determined chemical and biological control opponent has come to recognize that the proper use of herbicides and biological control is necessary for long term control of Dalmatian toadflax.

Awareness/Education

Because many of the private landowners within the WMA were not trying to make a living from agriculture or ranching on their lands, they did not recognize the negative effect of this invasive weed on the natural ecology of this ecosystem. Education became paramount in assuring the success of the WMA.

One of the most varied groups within the SFWMA was the Upper Southfork Landowners Association. This group meets annually in the early fall as this is the only time that many of the private landowners are in residence in Wyoming. Representatives from the PCWP and the CCD have been able to make presentations to this group over the years. This one-on-one contact has been invaluable in educating landowners of the threat that noxious weed infestations have on the financial value of their investment as well as the negative impacts to the ecosystem.

The SFWMA is home of one of the largest bighorn sheep winter ranges in Wyoming. Because of the threat of Dalmatian toadflax infestations to the survival of this big game species, the Foundation for North American Wild Sheep (FNAWS) asked for the WMA to provide an educational program for their members during their annual meeting in Cody, Wyoming. For three consecutive years, the SFWMA arranged a weed tour and hands-on educational program for FNAWS and local residents. The program included the presentation of information about toadflax and also provided attendees with the experience of hand pulling Dalmatian toadflax infestations.

The USFS and the BLM provided funds to sponsor interns from the Student Conservation Association (SCA) to develop a public relations and education publication to be used by future SCA interns in the Rocky Mountain area. These individuals worked very closely with the SFWMA to educate individuals and promote noxious weed control programs.

The SFWMA arranged to have a sign posted at the head of the South Fork Valley with information about Dalmatian toadflax and the potential of it spreading to other areas. The sign was provided by the Worland District BLM office. The Park County Commissioners agreed to use the county road and bridge department to install the sign along the highway.

Chemical Control

Chemical control of Dalmatian toadflax has been a major part of the weed control program in Park County for many years. Application has always been hand spraying of products such as picloram, 2,4-D, dicamba, metsulfuron, and imazapic. Although this is the most efficient method of controlling toadflax, it is still just one tool in the IPM control program.

Biological Control

Extensive work has been done by the University of Wyoming and the USDA-APHIS-ARS to establish biological control agents to control Dalmatian toadflax within the SFWMA. Agents that have been introduced into the area include: *Brachypterolus pulicarius*, *Calophasia lunula*, *Gymnetron linariae*, *Gymnetron antirrhini*, and *Mecinus janthinus*. Of these insects the two most affective have been the *B. pulicarius* and the *M. janthinus.* However, the *M. janthinus* has been difficult to establish in some areas because browsing bighorn sheep continue to eat the stems where the over-wintering agents are found. It is still the belief of the SFWMA that over the long term, biological control will be the tool that reduces Dalmatian toadflax to an acceptable level of infestation.

Mechanical Control

Dalmatian toadflax is one of the few noxious weeds that can be effectively controlled with hand pulling. Many local landowners within the WMA have developed extensive control programs centered on the mechanical removal of Dalmatian toadflax. Landowners are encouraged to use hand pulling of isolated plants or new infestations as an effective control method. However, it has not proven to be effective on a large scale because of the cost of labor and the inability to continually eliminate new growth during the entire growing season.

The shallow volcanic soils found within the WMA prevent the use of mechanical farm equipment such as discing or plowing. Most of the lands are rangeland and therefore the use of mechanical equipment is not a viable alternative. Mowing in mountain meadows has been used to reduce seed production, but because of the short growing season, the loss of forage makes mowing impractical.

The use of fire for control is also a very limited alternative. Areas where wildfire or even prescribed burns have removed the desirable vegetation, the density of the infestation of Dalmatian toadflax has increased dramatically. Even if fire did give some level of control, most areas do not have enough understory to carry the fire.

Revegetation

The use of competitive grasses and forage has long been a preferred method of control of Dalmatian toadflax. Extensive experiments have been conducted within the SFWMA to establish both native and non-native vegetation to reduce the density of Dalmatian toadflax. Some of the plots within the WMA have been successfully seeded using broadcasting and working the seed in with light harrowing. Heli-seeding has also resulted in the establishment of competitive grasses and forbs in some of the burn areas. However, because the SFWMA is normally has a relatively dry climate and has been in a drought cycle for at least eight of the last ten years, some revegetation projects have met with very limited success.

Prevention and Early Detection

It is the general belief that prevention and early detection has been the most successful tool in controlling the spread of Dalmatian toadflax both inside and outside the SFWMA boundaries. The contention that the effectiveness of prevention cannot be measured does not change the fact that common sense tells us that the lack of introduction will reduce the overall level of infestation.

Many of the control efforts within the SFWMA are dependent upon the concept of prevention and early detection. All the educational programs of the SFWMA contain components that emphasize the importance of purchasing weed-free forage products for use on private lands. In addition, the USFS and the BLM require that all forage brought onto public lands be certified weed-free forage or grain. PCWP has a district-wide quarantine which requires that all farm products be inspected and released prior to movement within the county. This program has been strongly promoted within the SFWMA as well as around the rest of the county.

All the SFWMA coordinators, PCWP staff, and UWCES agents include weed identification in their educational classes. This helps ensure that local residents not only recognize noxious weeds when they encounter them, but also recognize the importance of controlling small infestations before they have a chance to spread. Many small infestations of Dalmatian toadflax have been reported by individuals using public lands within the WMA for recreational purposes.

Acquiring Partners

As stated in the title, cooperation is truly the key to the success of the SFWMA. The diversity of individuals and governmental agencies who have contributed in various ways has served as an example for other WMA's in both Park County and neighbouring counties and states. Here is a partial list of cooperators.

- Park County Weed and Pest Control District, Park County, WY
- Shoshone National Forest, U.S. Forest Service, Cody, WY
- Cody Conservation District, Cody, WY
- University of Wyoming, Laramie, WY
- Private Landowners within the Southfork Weed Management Area, Cody, WY
- Upper Southfork Homeowners Association, Southfork of Shoshone River, WY
- Wyoming Game and Fish, Cody, WY
- Bureau of Land Management, Worland and Cody, WY
- Natural Resources and Conservation Service, Cody, WY
- USDA-APHIS-PPQ, Bozeman Biocontrol Station, Bozeman, MT
- Wyoming Department of Agriculture, Cheyenne, WY
- BASF, Laramie, WY
- DOW AgroSciences, Billings, MT
- Center for Invasive Plant Management, Bozeman, MT
- Foundation for North American Wild Sheep, Cody, WY
- Rocky Mountain Elk Foundation, Missoula, MT

The list could be much more extensive if we were to list each individual landowner that provided in-kind services both in labor and use of their land for research. Also the organizations and foundations that provided financial support in the form of grants and technical services are not listed. Without these people and many others, the SFWMA would not have been as successful as it has.

Evaluating the Results

The success of the SFWMA can be measured in many ways. The most obvious benchmark is whether or not the infestation of Dalmatian toadflax has been reduced over the last thirteen years. This has been documented quantitatively by continued monitoring and inventorying. Although isolated plants are still found in the proximity of the original infestations, the density is reported to be 20% of what it was in 1996. Many of the local residents have also commented about the reduction of Dalmatian toadflax within the WMA. Education programs, signs posted at trailheads and weed control at access points to the backcountry have reduced the potential of infestations in wilderness areas and adjacent public lands.

Another measure of success is the fact that no other infestations of Dalmatian toadflax have been established since the formation of the SFWMA. Although isolated plants and new small patches have been reported, rapid response from the PCWP and other governmental agencies has prevented establishment of permanent infestations.

The success of forming a weed management area has been duplicated many times over since the introduction of the concept in the *Guidelines For Coordinated Management of Noxious Weeds In the Greater Yellowstone Area* and the *Guidelines for Coordinated Management of Noxious Weeds: Development of Weed Management Areas*. In Park County there have been two more equally successful WMA's started over the past thirteen years, and two more areas have been designated as future areas for organization. The favourable reaction to the WMA concept has resulted in formal recognition of the term in many state and federal legislative acts and policies. Today, few people involved in weed management are unaware of the WMA concept and the importance it plays in successful control of large infestations of noxious weeds.

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Yellowstone National Park Website. 2007. Numerous articles are located that provide information on the 1988 wildfires and other related information. Various authors.

Appendix: Southfork Weed Management Area Goals and Management Plan

Introduction

The Southfork drainage in Park County is currently experiencing a serious infestation of Dalmatian toadflax. Due to the extent of the infestation and the diverse land ownerships, it was decided that a cooperative effort is needed to address this problem. The following groups have agreed to form the Southfork Weed Management Area, to allow personnel and resources to be pooled.

- Park County Weed and Pest, P.O. Box 626, Powell, WY 82435; phone: 307-754-4521
- Cody Conservation Districts, 808 Meadow Lane, Suite A, Cody, WY 82414; phone: 307-587-3251
- University of Wyoming Cooperative Extension Service-Park County, P.O. Box 3099, Cody, WY 82414; phone: 307-587-2204, ext. 248
- Wyoming Game and Fish Department, 2820 State Hwy 120, Cody, WY 82414; phone: 307-527-7125
- Soil Conservation Service, 808 Meadow Lane, Suite A, Cody, WY 82414; phone: 307-587-3251
- Bureau of Land Management, P.O. Box 119, Worland, WY 82401; phone: 307-347-9871
- United States Forest Service, P.O. Box 2140, Cody, WY 82414; phone: 307-527-6241

Weed Management Area boundaries

The drainage of the Southfork of the Shoshone River from its headwaters to Buffalo Bill Reservoir.

Land Ownership and Use

The Weed Management Area is made up of land owned by private citizens, the Bureau of Land Management, the U.S. Forest Service, the Bureau of Reclamation and the State of Wyoming.

The land is used for grazing, crop production, recreation, mining and wildlife. It includes wildlife winter range, irrigated agriculture and upland rangeland. Certain land entities, such as wilderness areas and selected landowners, provide special restrictions which need to be addressed.

Weed Management Area Goals

Long-term Goal

Reduce the level of infestation of Dalmatian toadflax within Southfork Weed Management Area.

Short-term Goals

- Contain Dalmatian toadflax within current boundaries.
- Inventory and map the current boundaries of Dalmatian toadflax occurrence.
- Determine effective Dalmatian toadflax control methods.
- Develop awareness and educate the public about the Dalmatian toadflax problem.

Background Information

The river and its tributaries are a major limiting factor. The water and rocky soils provide physical barriers to control. They also limit the chemical options which are available for use in Dalmatian toadflax control programs. Another factor which needs to be taken into account is that the area provides important winter range for a variety of big game animals. The inventory process will identify additional areas with special restrictions. Those restrictions will be addressed when the program actions are planned.

To our knowledge the only threatened or endangered species which may be in the area are the grizzly bear, peregrine falcon and the bald eagle. There are no plants in the area which have been proposed for listing.

Range site descriptions and soil types will be considered on a site by site basis as needed for proposed control actions. Archaeological sites and other cultural sites will also be addressed individually when necessary. Surveys for cultural and archaeological sites and endangered and threatened species, as well as other factors which may be required, prior to all major treatment projects.

There are abundant resources available to address weed problems. The University of Wyoming, Soil Conservation Service, Weed and Pest Control District, Bureau of Land Management, U.S. Forest Service, Wyoming Game and Fish Department, as well as other groups and individuals, have expertise and personnel. Many of these same groups have funds which may be made available. Park County Weed and Pest has the mechanism in place to handle funding coordination and accounting.

Planned activities

Inventory and Mapping

The Southfork Weed Management Area will have a mapped inventory of Dalmatian toadflax by fall of 1994. The area and those responsible are:

Areas	Responsible Persons/Agencies
Wilderness Areas	U.S. Forest Service
Private and State Lands	Cody Conservation District and Soil Conservation Service
National Forest Land (other than Wilderness)	Game and Fish, U.S. Forest Service and Weed and Pest

Park County Weed and Pest will fill in the gaps. They will map Dalmatian toadflax in their normal area of operations. Inventory and mapping progress will be evaluated at the end of 1993. A plan will then be made to ensure all areas are mapped by the fall of 1994. The mapping will be consolidated by the Bureau of Land Management. All inventories and mapping will follow BLM guidelines.

Education

The general public, including permittees, outfitters and surrounding landowners need to be educated about Dalmatian toadflax. Signs, posters and brochures are three ways to accomplish the education. Weed and Pest will coordinate the signs, posters and brochures.

Control Research

- *Herbicide Trials*: The Extension Service will put out herbicide test plots during the summer and fall of 1993.
- *Biological Control Agent Release*: The Extension Service will work with Bob Lavigne on a biological control agents.

Biography

Bob Parsons has been employed as the supervisor of the Park County Weed and Pest Control District in northwestern Wyoming for 30 years. He has served on the board of directors for various professional organizations including the North American Weed Management Association (NAWMA) and the Wyoming Weed and Pest Council and is actively involved with several national committees such as the National Invasive Weed Awareness Week and the Intermountain Noxious Weed Advisory Council. He has attended most of the previous Weeds Across Borders conferences and has participated in Canadian hosted conferences of the Eastern Slopes Invasive Plants Council, the Alberta Invasive Plants Council, and the North American Weed Management Association. Bob and his wife live in Powell, Wyoming, and his hobbies include travel and computers.

Glacier/Waterton Lakes National Parks International Partnership

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Abstract

A major threat to native plant communities is the invasion, establishment, and spread of invasive non-native plants. Invasive plants do not recognize political boundaries and combating them in an international transboundary region is complicated. Glacier (United States) and Waterton Lakes (Canada) National Parks have developed an international partnership to address this issue. This partnership is extremely important for facilitating communication concerning non-native invasive plants, sharing knowledge of management practices, monitoring techniques, educational tools, and coordinating projects. This continued cooperation across traditional boundaries encourages prevention, control of invasive non-native plant species, and subsequent restoration with native plants.

Resumen

Una de las principales amenazas para las comunidades vegetales autóctonas es la invasión, establecimiento y diseminación de plantas invasivas alóctonas. Las plantas invasivas no respetan los límites políticos y combatirlas en una región internacional transfronteriza es complicado. Los parques nacionales Glacier (Estados Unidos) y Waterton Lakes (Canadá) han forjado una alianza internacional para enfrentar ese problema. Esta alianza es crucial para facilitar la comunicación relativa a las plantas invasivas alóctonas e intercambiar conocimientos sobre prácticas de ordenamiento, técnicas de vigilancia, herramientas pedagógicas y la coordinación de proyectos. Esta cooperación permanente a través de fronteras tradicionales, fomenta la prevención, el control de las especies de plantas invasivas alóctonas y la subsiguiente restauración con plantas autóctonas.

1 Presenters.

Introduction and Background

Figure 1. Waterton-Glacier International Peace Park.

The Crown of the Continent Ecosystem (CCE) is one North America's largest ecologically intact regions (16,158 sq mi; 42,000 sq km). Waterton-Glacier International Peace Park is at its core and encompasses a richly diverse, forested, mountain terrain (Figure 1). The entire region is bisected by the Continental Divide, which forms a tri-oceanic watershed system that feeds into three continental drainage systems: west into the Columbia; east into the Missouri; and, north into the Saskatchewan. Ranging from the Highwood River in Alberta and Elk Valley in British Columbia south to the Bob Marshall Wilderness Complex in Montana, the CCE has internationally significant biodiversity. The high diversity results from geographic location, steep terrain, and subsequent contrast in climate with significant influence of both continental and maritime air masses.

Native plant and animal diversity is unusually high. Two major continental biomes and 4 major floristic provinces, ranging from mesic boreal forest to semi-arid grassland, inhabit the region with numerous plant communities and over 1,000 plant species, many of which exist at the limits of their biogeographic ranges. Further, the Waterton-Glacier area offers a *de facto* international sanctuary and a corridor for wildlife interaction, migration, and a genetic exchange between the two countries. A number of threatened and endangered species inhabit this ecosystem, and, although they don't recognize the international boundary, the different legal listing processes in the two countries sometimes mean they are listed in one country only. For example, Glacier has at least 5 important species (grizzly bear, gray wolf, bald eagle, lynx, and bull trout) none of which are legally listed in Canada, while Waterton has some that are not listed in the U.S. (half-moon hairstreak butterfly and Bolander's quillwort).

The spread of exotic (non-native) species represents a profound threat to global biodiversity (Mack et al. 2000, Parker et al. 1999) and threatens the values of wildland ecosystems in particular (D'Antonio et al. 2004). Especially in pristine areas of the CCE, the invasion, establishment, and spread of invasive, non-native plants is perhaps the single greatest threat facing managers today. For example, more than 126 species of invasive, non-native plants have been intentionally or inadvertently introduced by humans in Glacier National Park (Lesica 2002). Many of these species, such as spotted knapweed (*Centaurea stoebe* L. (= *C. maculosa*)), orange hawkweed (*Hieracium aurantiacum* L.), St. Johnswort (*Hypericum perforatum* L.), and oxeye daisy (*Chrysanthemum leucanthemum* L.), are of significant concern to park management due to their ability to spread rapidly and listing as state noxious weeds. While occurrences of invasive, noxious plants have historically been located along roadsides and within developed areas, wind, people, wildlife, and livestock all serve as vectors for carrying noxious weed seeds beyond these initial infestations into wilderness and backcountry areas (Tyser 1992, Tyser and Key 1988, Tyser and Worley 1992). Disturbance mechanisms such as wildfire can help to provide a fertile environment for the non-native plants to develop and spread to adjacent areas.

Disturbingly, the numbers of invasive plant species listed in Canada and the United States are increasing in quantity, area, and density. For managers in the CCE, there is increased concern that invasive plants will spread even more rapidly in the near future, due to numerous, large wildfires that occurred in 2003 (i.e., 18% of Glacier's vegetation burned in 2003).

Glacier National Park Weed Program

Glacier National Park (Glacier) initiated an Integrated Weed Management program in 1991 and has a completed and approved Exotic Vegetation Management Plan. This program has been based on National Park Service policy, which states that exotic species should be controlled if they displace native flora, interrupt ecological processes, or interfere with interpretation of natural scenes**.** The weed management program focuses specifically on management strategies that target the early detection, prevention, and control of invasive plant species that threaten the natural landscape in Glacier National Park. Control techniques include the use of herbicides, manual, mechanical, biological, cultural, and restoration.

In 1999 an Access/GIS database was created to map and monitor exotic vegetation in the Park as part of this program. The Montana Noxious Weed Survey and Mapping System provided the base format for the database which includes: acreage infested; weed cover; density; and, distribution. The exotic database is maintained in Microsoft Access™ and is updated annually to address regional and national inventory and monitoring standards. Weeds targeted for inventory are those on Montana's State Noxious Weed list. Exotic vegetation data is recorded directly on maps and/or by GPS. Maps are digitized and updated in an Arcview™ GIS program in order to monitor spread and status of management activities.

Glacier's current weed management program recognizes 4 categories of noxious weeds based on Montana's Noxious Weed List. These include watch-out species (Category 4), non-established new invaders (Category 3), established new invaders (Category 2), and those that are widespread in the state (Category 1). Similarly, the park's weed management priorities are based on the State's four noxious weed categories as well as on the abundance of a particular weed species within the park and the resource values at risk. Priority species for control are the category 3 non-established new invaders.

Glacier has chosen to use an integrated approach to manage noxious weeds. Integrated Weed Management (IWM) is used to avoid harming Glacier's native plant communities or interfering too much with the ecosystem. It is a multidisciplinary approach using a variety of methods and treatments that are best suited for specific species and locations. The methods used can be manual, mechanical, cultural, biological, or chemical, dependent on the situation. This approach targets a weed then selects the methods of treatment best suited for the location. Control of weeds within the park is undertaken cautiously to prevent damage to native plants, animals, and aquatic resources. Actions are based on research and consultation with field experts.

Glacier currently has a 10-person seasonal weed crew that surveys and treats weeds parkwide. Glacier is also host to a 3-person satellite crew of the Northern Rocky Mountain Exotic Plant Management Team (EPMT). This crew works at smaller park service units located throughout the state of Montana. Their work focuses solely on noxious weed control.

Weeds cross borders as easily as the wind, so it is important to tackle weed problems regionally. Glacier staff are working closely with neighbours to keep these "undesirables" in check. The park is coordinating its invasive weed control efforts with neighbouring counties, the United States Forest Service, the Blackfeet Indian Reservation, the adjacent Canadian provinces, as well as Waterton Lakes National Park.

Waterton Lakes National Park Weed Program

Waterton Lakes National Park (Waterton) is into its 4th decade of non-native plant management. Efforts in the early years focused on control of spotted knapweed using mostly hand-pulling and minimal use of herbicide. The program today is much enhanced and is very similar in its structure to that in Glacier. It is directed through the Non-Native Plants Management Strategy prepared in 2000. This strategy, like Glacier's, follows an integrated pest management approach. The strategy is in the process of being updated and the intent is to create a working document with elements of it reviewed yearly as new knowledge is gained and priorities evaluated.

In 2007 the program received enhanced federal Ecological Integrity funding for building science capacity, which allowed the creation of two monitoring technician positions. The intent of these seasonal 6-month positions is that they function as crew lead hands and monitoring/inventory technicians for the program. The program lead is a Park Warden who works under the direction of the park's Fire and Vegetation Resource Conservation Specialist and an Ecosystem Scientist. Four permanent 4-month seasonal positions and 2 students complete the summer weed crew. Staff in these positions rotate every few weeks with the park's Trail Crew. It helps to reduce the monotony of weed control work and to ensure more weed-aware eyes are also covering backcountry areas of the park. This allows for the "early detection" principle to be more easily implemented.

In 2002 Waterton adopted Glacier's Access/GIS database for use in its program. In 2004, with some modification, the database was also adopted by the other Canadian mountain national parks. New staff in Waterton's program are working to bring this important element of the program "up to speed" and have Glacier's staff to use as a resource base, given their familiarity with the program.

Three-day crew exchanges between the two parks have been successful. This will be continued in the future as it allows for the beneficial sharing of ideas. This is just one way in which a dynamic program can be assured. Other weed control work exchanges take place with the nearby Nature Conservancy of Canada, the neighbouring municipal districts of Cardston and Pincher Creek, and the Castle-Crown Wilderness Coalition to the north of Waterton …more "weeds across borders" joint management efforts.

Waterton-Glacier International Peace Park Partnership

Waterton Lakes National Park was established in 1895 and Glacier National Park was designated in 1910. To celebrate peace and goodwill along the border, Waterton – Glacier International Peace Park was chartered in 1932 through the diligence of far-sighted Rotary Clubs in Alberta and Montana. It was a unique idea — the first International Peace Park of either nation, or for that matter, anywhere in the world.

In this larger context, the existence of the "Peace Park" is a statement about human stewardship and cooperation within the relatively intact ecosystem we call the Crown of the Continent. To most everyone, it is *one place*. In fact, the two parks were functioning as a unit, long before the political designations. Current joint projects between the two national parks include: population studies using grizzly bear DNA from hair samples; bull trout genetic variability; archeological indexing, monitoring and restoration of whitebark and limber pine; and, the impact of invasive non-native plants. Park employees work with the implicit assumption that no project is done in isolation.

Waterton and Glacier have worked closely together to improve each of their integrated weed management programs. Glacier has shared its Exotic Plant Management database with Waterton and the other Canadian mountain parks. This allows Waterton and Glacier to compare management strategies and share inventory data. Glacier and Waterton both have held workshops to evaluate and update each park's existing weed management programs. Crews from both parks have been trained together in inventory and monitoring methods and have worked together on important projects (Figure 2).

Another cooperative project has been the development of an invasive plant field guide. Currently there exists no single reference or common strategy for containing and managing invasive plants in the Crown of the Continent Ecosystem (CCE). For these reasons, a user-friendly, ecosystem-specific field guide on invasive plants with potential for ecological impact in protected areas is being created. The Crown of the Continent Research Learning Center and Glacier's Invasive Plant Species Biologist are designing and developing the field guide in concert with members of the Crown Invasive Plant Network (CIPN), a committee of the Crown of the Continent Managers Partnership (CMP). The guide will serve as a tool for educating staff, volunteers, and the general public. It will also provide the CIPN a foundation from which to build a common strategy for communication, education, and technical assistance. The guide will

Figure 2. Joint field tour at Waterton Lakes town site (photo by Kelly Cooley).

contain detailed descriptions for approximately 40 species, including the highest priority species occurring in the CCE and those with potential to invade the CCE. The invasive plant field guide will be printed in 2008.

Glacier and Waterton have also worked cooperatively on important restoration projects. In 2004 The Peace Park Native Plant Garden was created in the Waterton Park townsite with assistance from Glacier's Native Plant Restoration Program. Glacier staff helped to collect the seeds in Waterton, grew the plants in their nursery, and helped with installation. Glacier's revegetation and nursery staff and volunteer Senior Rangers continue to assist Waterton with the maintenance of this garden.

Glacier has also helped Waterton with a large project restoring their decommisioned Trade Waste Pit (TWP) site. The TWP restoration project was developed by staff at the two parks in cooperation with Dr. Anne Naeth from the University of Alberta. The long-term goal is to restore this 4-ha site to native grassland, and in doing so compare various planting treatments and amendments that will be useful in future restoration projects. To date nearly 3600 plants have been grown out from locally-collected seed and planted on site, with more seeding and planting to be undertaken in future years. Control of invasive non-native species at the site is an important aspect of the project.

This international partnership between Waterton and Glacier is extremely important for facilitating communication concerning non-native invasive plants, sharing knowledge of management practices, monitoring techniques, educational tools, and coordinating projects. This continued cooperation across traditional boundaries encourages prevention, control of invasive non-native plant species, and subsequent restoration with native plants.

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Biography

Dawn LaFleur started working for the National Park Service in 1992 as the field supervisor for the Glacier National Park's native plant restoration crew. She is currently Glacier's Integrated Pest Management Biologist, managing the integrated weed, pest and hazard tree programs. Dawn has a Master of Science degree in land resources from the University of Wisconsin-Madison. Dawn focuses on invasive non-native plant management through prevention, monitoring, education and control strategies. She collaborates with numerous local and state entities to provide a coordinated effort to prevent the spread of invasive plants.

Cyndi Smith started working for Parks Canada in 1980 and has worked in one national historic site and five national parks in western and northern Canada, in roles as diverse as interpretation, law enforcement, backcountry patrol and resource management. Cyndi has a Biological Sciences Diploma from the Northern Alberta Institute of Technology in Edmonton, AB; a Bachelor of Environmental Studies from University of Waterloo in Waterloo, ON; and a Master of Science from Simon Fraser University in Burnaby, BC. In Waterton Lakes National Park Cyndi is responsible for ecosystem research and monitoring activities, species at risk, and data management. She has coordinated invasive species monitoring and restoration of native ecosystems in the park.

Edwin Knox started working for Parks Canada in 1985 in Yoho National Park. Since 1991 Edwin has worked in Waterton Lakes National Park with one 7-month secondment to Ivvavik National Park in Canada's high arctic. As a Park Warden in Waterton Lakes NP, Edwin has been involved in law enforcement, public safety, and resource management work and since 2007 has been the program lead in the non-native plants and restoration program. This program has recently seen enhanced funding and with a crew of 10 staff and in collaboration with neighbouring jurisdictions there is reason for optimism in the work to control non-native plants. Edwin has a diploma from the Environmental Science Program of Lethbridge Community College in Lethbridge, Alberta.

Keynote Presentation – Presentación principal
13 Ways to Juggle Our Conception of Invasive Species.

Brendon Larson

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Abstract

Humans have recently been transporting species around the planet at a faster rate than they previously dispersed on their own. A fraction of these species spread in their new place and have tremendous ecological and economic impacts. We thus call them "invasive species," yet in so doing we frame the process in a way that emphasizes its negative dimensions and makes it difficult to step back and look at it anew. Since these species will not go away—and will probably become more abundant—it is essential that we continually revisit how we conceptualize them in order to develop a flexible and mature relationship with them. In this presentation, I offer thirteen ways of looking at these species to help draw attention to some of the shortcomings with the entrenched way of conceptualizing them. Rather than denying that there is a problem, I wish to encourage a richer appreciation for the complexities involved and a concomitant sense of humility.

Resumen

Los seres humanos recientemente han estado transportando especies por el planeta a un ritmo más rápido que la diseminación previa de éstas por sí mismas. Algunas de esas especies se extendieron en sus nuevos sitios y tienen un impacto ecológico y económico tremendo. Por eso las llamamos "especies invasoras"; sin embargo, al hacer eso enmarcamos el proceso de tal manera que se recalcan sus dimensiones negativas y se hace difícil dar un paso atrás y mirarlas con nuevos ojos. Dado que esas especies no se irán-y probablemente serán más abundantes -es esencial que volvamos a plantearnos continuamente cómo conceptualizarlas a fin de desarrollar una relación flexible y madura con ellas. En esta ponencia, presento trece formas de ver esas especies con el fin de señalar algunas de las deficiencias de la forma corriente de conceptualizarlas. En vez de negar la existencia del problema, quiero promover una apreciación más rica de las complejidades presentes y un sentido concomitante de humildad.

Suggested Reading – Lecturas Sugeridas

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Biography

Brendon Larson is an Assistant Professor in the Department of Environment and Resource Studies at the University of Waterloo. He has completed an MSc in evolutionary ecology at the University of Toronto (1997) and an Interdisciplinary PhD in Science and Society at the University of California, Santa Barbara (2004). In 2005-2006, before accepting his current position, he held a post-doctoral fellowship as a social scientist helping biologists in the Center for Population Biology, University of California, Davis to understand communicative and social dimensions of their research. His current research concerns ethical and linguistic dimensions of the relationship between biological science (ecology, evolutionary biology and invasion biology) and society, particularly in terms of how metaphoric communication forms a link between them (for further details, see http://www.fes.uwaterloo.ca/ers/faculty/blarson.html). He has published widely on such issues in journals including Biological Invasions, BioScience, Frontiers in Ecology and the Environment, and /Science Communication, in addition to his scientific articles.

Innovative Tools for the Transfer of Invasive Plant Management Technology

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1 Presenter.

Abstract

Invasive plants are an ever growing problem worldwide. Rapid and efficient access to information on the identification and management of invasive species is, at times, difficult to obtain. To offset these problems, the U.S. Army Engineer Research and Development Center has produced two information/expert systems that allow efficient access to information on available technologies to manage invasive plant species.

Resumen

La problemática de las plantas invasivas ha ido en aumento a escala mundial. Muchas veces resulta difícil el acceso rápido y eficaz a información sobre la identificación y manejo de especies invasivas. Por tal razón, el Centro de Investigación y Desarrollo del Cuerpo de Ingenieros de los Estados Unidos (USAERDC) ha producido dos sistemas expertos o de información que permiten el acceso eficaz a información acerca de tecnología disponible para el manejo de plantas invasivas.

Introduction

The capability of plant managers to successfully control noxious and nuisance plant infestations is highly dependent on their ability to obtain pertinent and up-to-date information on a plethora of topics concerning ecology, biology, and identification of invasive plants as well as information on available management techniques including chemical, mechanical, and biological control. To meet these needs, researchers at the U.S. Army Engineer Research and Development Center (ERDC) have developed two plant management information/expert systems, the Noxious and Nuisance Plant Management Information System (PMIS™) and the Aquatic Plant Information System (APIS™) that allow for rapid and easy access to these topics (Cofrancesco et al. 2000). The following sections provide a history of the development of these systems and brief descriptions of the PMIS™ and APIS™.

History

The creation of the ERDC information/expert systems began in the late 1990's with the development of an aquatic plant identification system with funding provided by the U.S. Army Corps of Engineers, Jacksonville District, FL. The first aquatic plant system was developed using the object-oriented programming language C++. After the creation of the plant identification module, information on individual plant species was incorporated. This system became version 1.0 of the APIS™ (Grodowitz et al. 1998). Initially the system was disk-based and utilized 256 color graphics. Because of the growing capabilities of personal computers (i.e., more efficient programming languages, ability to use full color graphics, etc.), this system has undergone three major revisions, the current release being version 3.0. Once the initial system was created, funding from various sources, especially the Aquatic Plant Control Research Program (APCRP), allowed the addition of plant species and their associated control technologies.

Because of the need for information on nuisance terrestrial plants as well as the aquatic species, the PMIS™ system was developed by the Department of Defence (DoD Legacy Program

2006). Initially the funding for the creation of this system came from the Strategic Environmental Research and Development Program (SERDP). Since the original system, five more major revisions have been completed. The current available version is 6.0. Funding for revisions was received primarily from the DoD Legacy Program, but other government entities, including the Department of Transportation, the Federal Highway Administration and the Bureau of Reclamation, provided funds to add additional plant species. The plants added were identified by the various funding agencies as problematic species specific to their agency operations.

To date, over 15,000 copies of APIS™ and 25,000 copies of PMIS™ have been distributed and are being used by researchers, educators, federal agencies, and land managers throughout the world. One important accomplishment of the PMIS™ is the Armed Forces Pest Management Board recognizes it as the official Technical Information Manual for invasive plant species management.

Systems Overview

The PMIS™ and APIS™ are highly interactive systems that allow for rapid and easy access to information in a variety of formats, such as text, photos, hyper-linked text, and videos. Each also contains a plant and herbicide identification system, plant specific information, and information on available control options for each plant species.

Currently each system operates on Windows XP™ based PCs with a minimum of 3.26 megabytes of free hard drive space. Also required are a CD-ROM, a Pentium processor of 100 MHz or higher, and the capability of displaying a screen resolution of at least 800 × 600 pixels.

A web-based version of each system has been developed. The web-based versions include all the information contained in the PC versions minus the identification modules. Updates to each system can be downloaded directly from the web site. The web-based version of APIS™ can be found at http://el.erdc.usace.army.mil/aqua/apis/apishelp.htm while the web version of PMIS™ is located at http://el.erdc.usace.army.mil/pmis/pmishelp.htm.

In order to broaden the accessibility of the information contained in the APIS™ system, a mobile version of the APIS™ has recently been developed for use on Windows Mobile™ 5.0 (or newer) based touch screen PDAs. The mobile version allows users access to pertinent and relevant plant information at remote locations. The information in the mobile version is identical to that currently available within the PC versions. It contains both plant and herbivore identification modules, species specific information, and information on each of the available control options. This mobile version is currently released on CD but will soon be available for download.

Detailed information on each plant species is contained within each information system. Plant-specific information includes scientific name, common name, native range, descriptions, growth characteristics, and problems associated with invasion (Figure 1). Numerous high quality photographs of each plant are available (Figure 2) as well as detailed maps that illustrate the US distribution. The photographs used are collected by researchers and experts in the field of invasive plant species. Distribution information is obtained from the United States Department of Agriculture's PLANTS Database found at http://plants.usda.gov.

APIS

File Edit Bookmark Options Help

Help Topics | Back | Print | << | >> | Close Help

Eichhornia crassipes (Mart.) Solms (Waterhyacinth)

Synonym(s): *Eichhornia speciosa* Kunth
Piaropus crassipes (Mart.) Raf.

Family: Pontederiaceae

Home Range/U.S. Distribution:

Eichhornia crassipes (Mart.) Solms. is native to South America, probably Brazil. Plants are thought to have been first introduced into the United States at the 1884 Cotton States Exposition in New Orleans, Louisiana (Sculthorpe 1967). Because of its showy flowers, waterhyacinth is sold as an ornamental for small fish ponds and sometimes escapes or is intentionally introduced into larger water bodies such as lakes and reservoirs. The distribution of *E. crassipes* shown on the map in this system depicts where populations are expected to "overwinter" and regrow during most years.

Another species of waterhyacinth, *Eichhornia azurea* (Sw.) Kunth, has been introduced into south Texas from Latin America (Correll and Johnson 1970, Tarver *et al.* 1986). It can be distinguished from *E. crassipes* by a lack of inflated petioles and the presence of an obvious stem with leaves along its entire length that are separated by distinct internodes.

U.S. Range Map:

Species Description:

Water-hyacinth floats on the surface of the water or is sometimes stranded on mud and appears rooted. The individual plants consist of several leaves in rosettes and are connected by stolons. Prominent, black roots hang from each rosette. The leaf petiole is usually inflated, spongy, and up to 20 cm long. The leaf blades are thickened, leathery, 2 to 15 cm long and 2 to 10 cm wide, suborbicular, ovate or broadly elliptic with parallel veins. The leaf bases are heart-shaped, square or rounded, the leaf apices rounded to flattened. The inflorescence is a spike with several light-blue to bluish-purple flowers that have a yellow blotch. The fruit is a many seeded capsule.

Figure 1. Information on each plant species is provided via hyperlinked text files.

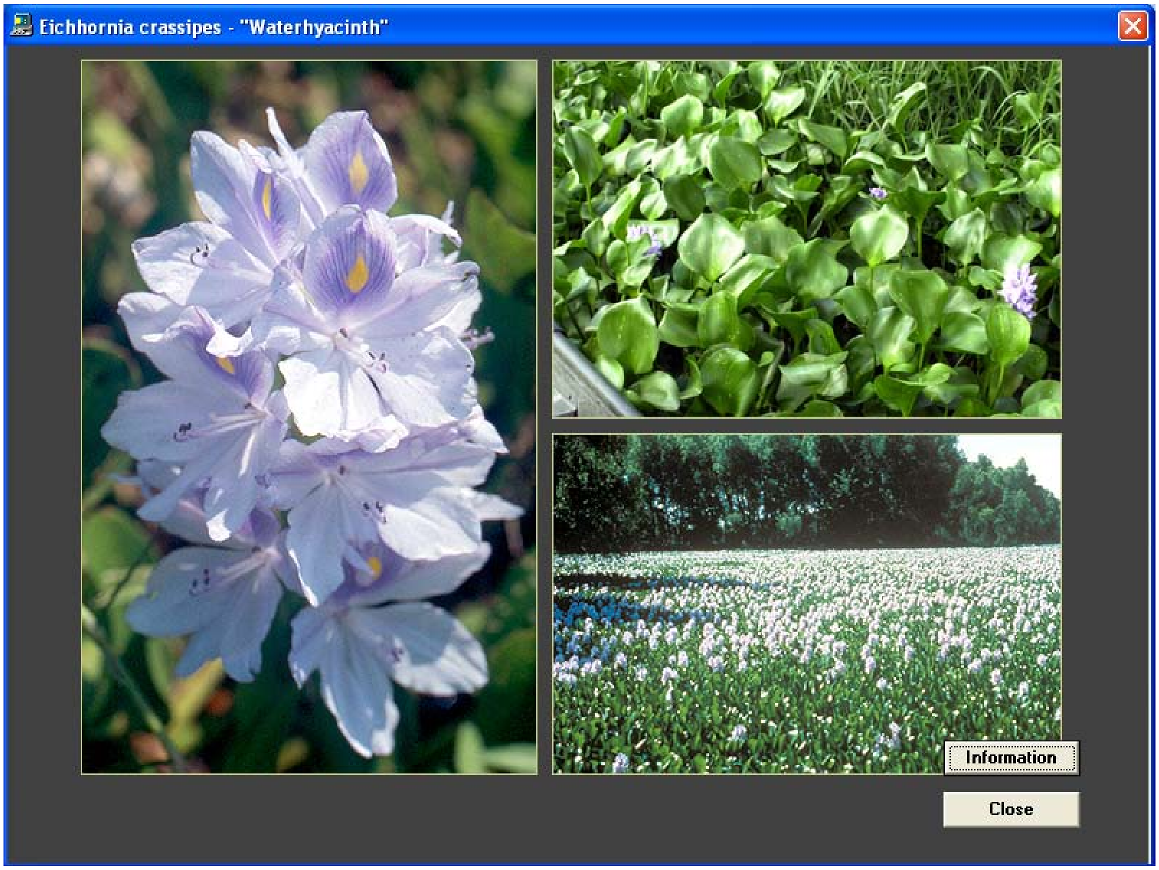

Figure 2. An example of the full-color photographs that are available in APIS™ and PMIS™. For most plant species, the photographs illustrate flowers, entire plants and plant populations.

If the species of interest is unknown, the plant identification modules allow users to rapidly and efficiently identify nuisance plant species contained in the system. The identification system utilizes expert system-type programming, which closely simulates the interaction between technical and non-technical personnel. As questions are answered, the system continually narrows down the remaining possible species and asks only relevant questions (i.e., questions that aid in eliminating species from the list in an effort to save valuable time). Each question is based on taxonomic characteristics that are relatively easy for non-technical users to locate and assess. If a user is unclear about the meaning of a particular question or doesn't know the definition of certain terms, there are links to help files that contain descriptions and illustrations for reference. Possible answers are provided pictorially to ensure accuracy and avoid confusion over botanical terms and species characteristics (Figure 3). Once a plant has been identified using the identification module, the user is given an opportunity to verify that the plant identified is the actual plant in question. Verification is performed by asking more specific questions based on the given plants unique characteristics to ensure the initial identification was correct.

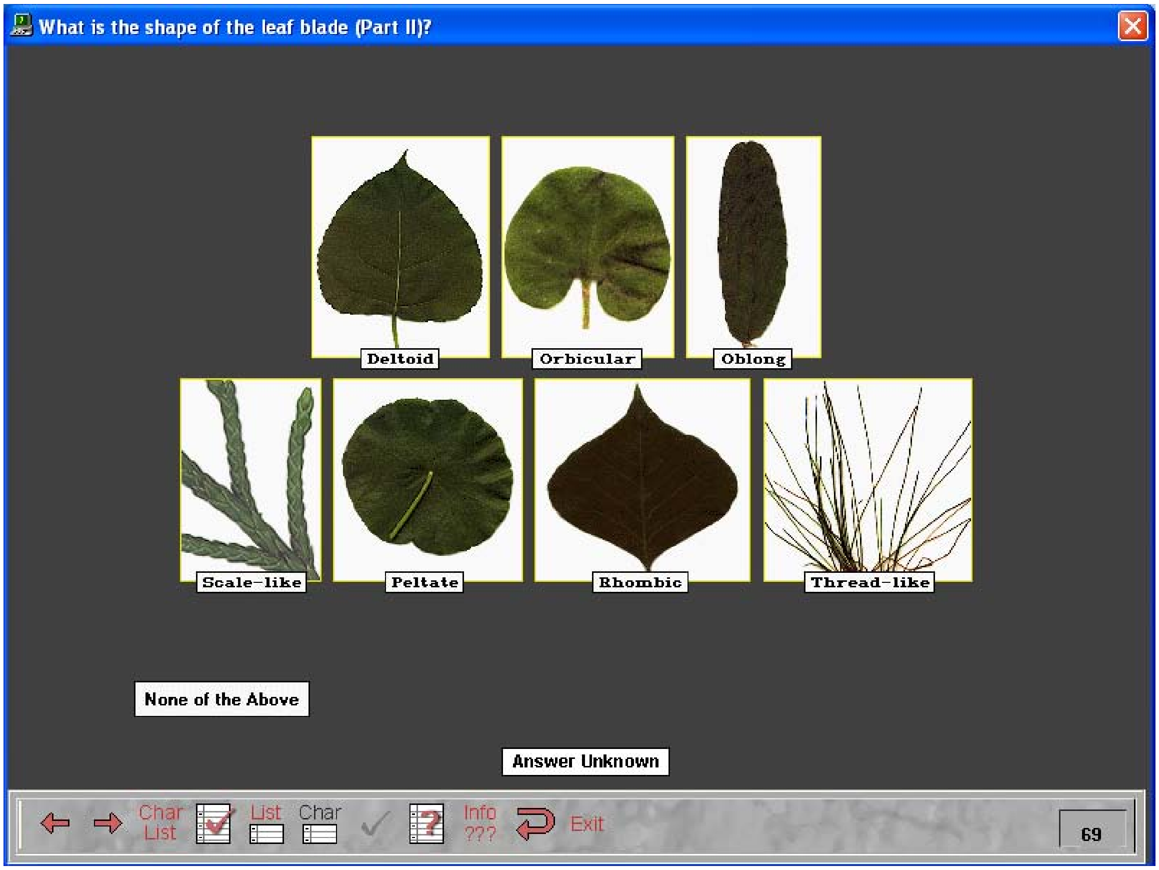

Figure 3. Question screen from the plant identification portion of APIS™. Note how each character for the question listed on the title bar is clearly displayed through high-quality photographic images. By selecting the appropriate icon located along the bottom of the screen, the user gains access to more detailed textual or illustrative information for the displayed question.

For those invasive plants that have biological control agents, information is available on each operational agent. For each agent, the information provided includes scientific and common names, descriptions, damage the agent may cause, collection techniques, and strategies for implementing their use. Embedded within the descriptive information are links to videos that depict agent activity. Also provided are photographs of the life stages of the agent and plant damage that might be observed once an agent becomes established.

Information on mechanical controls is available for each plant species. Photographs of many of the mechanical options are provided allowing a visual concept of the control function. There is also detailed text-based information available describing the equipment and its use.

Significant information on chemical control options is available for each plant species. Chemical control information includes available formulations (and associated manufacturers), application rates, toxicological data, and use restrictions. This information is derived directly from the manufacturer's Environmental Protection Agency approved label. In addition, there is an identification system for selecting the best herbicide based on site-specific characteristics of water condition, water use, restrictions on irrigation, individual State law requirements, etc.

Although APIS™ and PMIS™ are similar in format, there are some significant differences. The APIS™ contains information on 69 native and invasive aquatic and wetland species Also present in the system are several identification modules that are not in PMIS™ including keys to native plant herbivores, damage identification, commonly encountered leaf-mining flies in the genus *Hydrellia*, and a physiological age-grading for *Neochetina eichhorniae*, a biocontrol agent for waterhyacinth. In addition, there are models incorporated into the APIS™ including the AMUR Stock and the HARVEST models. AMUR assists users in evaluating proposed grass carp stocking rates and subsequent impact to aquatic plant growth. HARVEST aids in determining mechanical harvesting cost and production rates with different mixes of equipment and site conditions.

In contrast the PMIS™ targets invasive species that occur in both terrestrial and aquatic habitats. Included in the 150 terrestrial and aquatic invasive plants in the system are the aquatic invasive species found in APIS™ minus the native species. In addition, PMIS™ provides summary information on noxious plant and pesticide application laws through its State Noxious Plant and Pesticide Laws Information System (SNPPLIS) with information for all 50 states.

Future Directions

Information content in each of these systems is updated on a frequent basis. This includes adding information on new plant species as well as information on plant specific control options. Along with the new content the existing information is reviewed and updated as necessary.

In addition to adding new content, the operations of the systems are continually updated as new technologies become available. For example, in the newest versions, the entire core programming is being revised to utilize a relational database structure allowing easier and more rapid updating to the systems and more efficient information access with more robust display options. The reprogramming into a database structure will also extend to the web-based versions allowing for enhanced web interactivity and the addition of the identification modules. Constant synchronization of the CD and Web versions is another added benefit of this type of reprogramming. The database structure will allow for more efficient access to the information. The next version of APIS™ is scheduled for release in fall 2008.

Along with the upgrades identified, the next version of PMIS™ will also contain short videos of most of the included plant species. The videos showcase specific plant problems, important identifying characteristics, and introduction history. The new version of PMIS™ is scheduled for release in fall 2009. Once this new version is complete, a hand-held mobile version of PMIS™ will be developed to run on PDAs.

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Forewarned is Forearmed!
Progress in Development of the U.S. National Early Detection and Rapid Response System for Invasive Plants – Proposal for a North American Early Warning System for Invasive Plants

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Abstract

Currently, a National Early Detection and Rapid Response System (EDRR) for Invasive Plants is being developed in the United States. Conceptually, the system is a coordinated framework of local, state, and national interagency groups that is designed to prevent the establishment and spread of new invasive plants through early detection and reporting of suspected new invaders, identification and vouchering of specimens by cooperating botanists, archiving of confirmed new records in regional and national plant databases, rapid assessment of confirmed new exotic species by federal and state scientists, and rapid control response to new incursions that can be eradicated. A National EDRR Framework is also being developed in Canada, through the work of the federal ministries, as well as provincial invasive species councils. With a functional EDRR communications structure in place in Canada

Resumen

Actualmente se está desarrollando en los Estados Unidos un sistema nacional de Detección Precoz y Respuesta Rápida (DPRR) para las plantas invasoras. El sistema se concibe como un marco coordinado de agencias locales, estatales y nacionales con el propósito de impedir el establecimiento y la dispersión de nuevas plantas invasoras. Esto se logrará por medio de la detección precoz y la denunciación de las nuevas invasoras sospechadas; la identificación y el depósito de ejemplares por los botánicos cooperativos; la integración de los nuevos registros confirmados en los bases de dados botánicos regionales y nacionales; la evaluación pronta, por investigadores a nivel federal y estatal, de las especies exóticas nuevas confirmadas; y una respuesta rápida para controlar aquellas especies que sean susceptibles de ser erradicadas. Un marco nacional para la DPRR también está en preparación en el Canadá a través

and the U.S., a North American Early Warning System for Invasive Plants can be developed to help publicize information about new and emerging invasive plants across the continent.

de los ministerios federales competentes además de los consejos provinciales sobre especies invasoras. Con la implementación de un sistema operacional de comunicación DPRR para Canadá y los EE.UU., se podrá desarrollar un sistema norteamericana de alerta temprana sobre las plantas invasoras que contribuirá a divulgar ampliamente la información acerca de las nuevas plantas invasoras que emergen a través del continente.

Introduction

To help minimize the establishment and spread of invasive plants in the United States, efforts are being made to develop a **National Early Detection and Rapid Response System (EDRR) for Invasive Plants**. Conceptually, the system is a coordinated framework of local, state, and national interagency groups that is being established to promote EDRR as the preferred management strategy for preventing the establishment and spread of new invasive plants by individual land owners, as well as other political and administrative land units. Operationally, EDRR is accomplished through: **early detection and reporting** of suspected new plants to appropriate officials (by trained volunteers and agency field personnel); **ID and vouchering** of submitted specimens (by cooperating botanists); **archiving** of new invasive plant records in designated regional and national plant databases (e.g., the Invasive Plant Atlas of New England (IPANE)); **rapid assessment** of confirmed new records (by federal and state weed scientists); and, **rapid response** to confirmed new invaders (by invasive plant task forces, e.g., the Carolinas Beach Vitex Task Force) (Westbrooks 2001, Westbrooks 2002, Westbrooks 2004a, Westbrooks 2004b, Westbrooks and Eplee 1997).

Development of an EDRR Tool Box – an Online Resource for EDRR Partner Groups

To more effectively assist partner groups in developing the state and local elements of the system, the United States Geological Survey (USGS) is cooperating with IPANE and the Center for Earth Science Information (CESIN) at Columbia University to develop an online EDRR Tool Box. Ultimately, the EDRR tool box will serve as a online technical resource in the effort to develop new EDRR capacity across the country. The tool box will include basic support documents such as an EDRR Partnership Directory, State EDRR Coordinating Committee Work Plan Template, Guidelines for Volunteer Training, Guidelines for Rapid Assessment, Eradication Principles and Practices, and etc.

Develop of State and Provincial EDRR Coordinating Committees across the U.S. and Canada

Currently, a number of state and provincial EDRR committees are being established by cooperating partner groups to lead in the development of new capacity for EDRR across the United States and Canada. The South Carolina EDRR Committee, which was established by the South Carolina Exotic Pest Plant Council (SC–EPPC), is a good example.

In 2007, SC–EPPC established its **State EDRR Committee** to help develop new capacity for preventing the establishment and spread of new and emerging invasive plants in South Carolina. Strategically, the purpose of the committee is to lead the development of state and local elements of the **National EDRR System for Invasive Plants** within South Carolina. Such a national system is only as effective as the sum of its parts.

From an strategic standpoint, the main purpose of the SC–EPPC EDRR Committee is to assist agencies and organizations in meeting their EDRR goals, i.e., in *carrying out* their *official roles and responsibilities* that are related to invasive species prevention. However, an important focus area will be to help address new species are that not already regulated, and/or primarily pose a threat to native ecosystems.

Six steps are generally recognized for development of new EDRR capacity within a state or province. These are to:

- Establish a State/Provincial EDRR Coordinating Committee
- Develop a Committee Work Plan
  - Identify Committee Members; Develop a State EDRR Target List
  - Develop a Clear Communications Structure with Protocols for Reporting, Rapid Assessments, and Rapid Response Initiatives
- Develop and Train a State Early Detection and Reporting Network (EDRN)
  - Agency Field Personnel (Department of Natural Resource Biologists, Nature Conservancy Land Stewards, County Extension Agents, County Weed Supervisors, County Ag Fieldmen, etc.)
  - EDRN Volunteers (Native Plant Society Members, Friends Groups, Civics Club Members, Master Gardeners, Fishermen, Scouts, etc.)

- Identify and Monitor High Priority Resources at Risk – Identify, Survey, and Monitor Important Natural and Managed Resources that are at Risk from Biological Invasion.
  - Conduct Weekend BioBlitzes at selected Parks, Forests, Refuges, etc.
  - Monitor High Hazard Sites Where New Invasive Species May Become First Established (e.g., Maritime Ports of Entry, International Airports, Bonded Warehouses, Free Trade Zones, Inland Intermodal Shipping Terminals)
- Rapid Assessment – Conduct Rapid Assessments of Newly Reported Species that are not already regulated within a state (regulated species generally don't require a new assessment).
  - Identify an appropriate lead agency to address a particular new invasive plant problem, or
  - Recommend the establishment of an invasive plant task force to address a new invasive plant problem that cannot be address by a single agency.
- Rapid Response – Develop a Rapid Response Plan to Address the Problem.
  - Assist the designated lead agency in addressing a new invasive plant problem, or
  - establish an invasive plant task force to address the problem – as appropriate. The Carolinas Beach Vitex is a good example of a successful interagency partnership.

Overview and History of the Carolinas Beach Vitex Task Force – An Interagency Partnership in Action

Beach Vitex (*Vitex rotundifolia* L. f.) is a woody vine that is native to the Pacific Rim (Figure 1). In the mid–1980s, Beach Vitex was imported by the North Carolina State University Arboretum from the beaches of Korea for use as a beach stabilization plant in the southeastern United States. It was planted for erosion control on South Carolina beaches in the early 1990s in response to the devastation caused by Hurricane Hugo (Brabson and Westbrooks 2004).

Figure 2. Exposed roots of Beach Vitex.

In the late 1990s, Tommy Socha, a dune restoration specialist with the U.S. Army Corps of Engineers in Charleston, South Carolina, began to notice Beach Vitex spreading from landscape plantings on beaches along the South Carolina coast, crowding out native species like Sea Oats (*Uniola paniculata* L.) and Sea Beach Amaranth (*Amaranthus pumilus* Raf.). Socha became very concerned about the ultimate impact of Beach Vitex on multi–million dollar Corps Dune Restoration Projects along the Carolina coast.

Why is Beach Vitex a Problem?

Unlike native Sea Oats which has fibrous roots that help anchor sand dunes against storm waves, Beach Vitex has long tap roots (Figure 2) that anchor the plant itself during major storm events, but do little to help protect the dunes against erosion. In addition, Beach Vitex is a low profile plant with a tight canopy of leaves. For this reason, Beach Vitex does not trap wind–blown sand (and thus continually build up sand dunes) as efficiently as tall native grasses like Sea Oats. Without constant replenishment from wind–blown sand, infested sand dunes are much more susceptible to erosion than dunes populated with native dune species.

Figure 2. Exposed roots of Beach Vitex.

Citizen Scientists Speak Out About Beach Vitex

By 2001–2002, volunteers with the South Carolina United Turtle Enthusiasts (SCUTE) began to notice the spread of large Beach Vitex plantings (Figure 3), as well as the appearance of Beach Vitex seedlings on the beaches of Horry, Georgetown, and Charleston Counties, South Carolina. Soon after that, Betsy Brabson and other sea turtle volunteers began expressing concern about the possible impacts of the plant on native dune plants, as well as Loggerhead Sea Turtle nesting habitat and behavior.

Figure 3. Beach Vitex spreading in South Carolina.

Establishment of the South Carolina Beach Vitex Task Force

In November 2003, after contacting a number of state and local agencies, SCUTE volunteers collaborated with the U.S. Geological Survey to host the first **U.S. Beach Vitex Symposium** at the Belle W. Baruch Institute near Georgetown, South Carolina. At that meeting, which was attended by a number of concerned citizens, the local press, as well as representatives from federal, state, and local agencies and organizations, several topics were discussed. These included the potential impact of the plant on dune ecosystems, on multi–million dollar beach restoration projects along the Carolina coast, and ultimately the impact on property values in affected communities. Following the symposium, the **South Carolina Beach Vitex Task Force** was organized to address the problem. In 2004, the task force received a grant of $47,000 from the National Fish and Wildlife Foundation and the Federal Interagency Committee for the Management of Noxious and Exotic Weeds (FICMNEW) to assist in the effort.

Establishment of the Carolinas Beach Vitex Task Force

In the spring of 2005, a meeting was held in Wilmington, North Carolina, to discuss the impact of Beach Vitex on coastal communities in the Tarheel State. At that point, it was clear that a bi–state effort would be needed to address the problem. As a result, the **Carolinas Beach Vitex Task Force** was established to help coordinate efforts to address the plant in both states. The initial objectives of the Task Force (Anonymous 2008) were to:

- Detect and map Beach Vitex populations in coastal South Carolina and North Carolina.
- Remove seedlings from public areas to prevent further spread.
- Conduct an ecological assessment to determine the impact of Beach Vitex on native plants and animals.
- Develop environmentally sound methods for removal.
- Restore affected areas with native plants.
- Educate homeowners, landscapers, and the general public about the problem.

Since 2003, the South Carolina Task Force has been coordinated by Betsy Brabson, a sea turtle volunteer from Georgetown. Efforts in North Carolina were initially coordinated by David Nash, a dune restoration specialist with the New Hanover County Cooperative Extension Service, with assistance from Dale Suiter, an Endangered Species Biologist with the U.S. Fish and Wildlife Service in Raleigh. The effort in North Carolina is now being coordinated by Melanie Doyle, a horticulturalist with the North Carolina Aquarium at Fort Fisher in Carolina Beach, with assistance from Dale Suiter.

Principal partners (lead agencies and organizations) in the Carolinas Beach Vitex Task Force include SC Sea Turtle Network Volunteers, NC Sea Turtle Network Volunteers, Clemson University, University of South Carolina, NC State University, SC Department of Natural Resources, NC Department of Environment and Natural Resources, SC State Parks System, NC

State Parks System, North Carolina Department of Agriculture, Fort Fisher Aquarium, South Carolina Nursery and Landscape Association, SC Native Plant Society, NC Native Plant Society, SC Exotic Pest Plant Council, NC Exotic Pest Plant Council, BASF Corporation, Belle W. Baruch Foundation, Gaylord and Dorothy Donnelley Foundation, Town of Pawleys Island, SC, U.S. Fish and Wildlife Service, U.S. Geological Survey, Winyah Bay National Estuarine Research Reserve (National Oceanic and Atmospheric Administration), U.S. Army Corps of Engineers, United States Department of Agriculture (USDA) – Animal and Plant Health Inspection Service (APHIS), and the USDA Natural Resources Conservation Service. The project also includes numerous cooperators (home owners, municipalities, counties) that own or manage properties in coastal communities that are infested with Beach Vitex (i.e., impacted and potential stakeholders) (Carolinas Beach Vitex Task Force 2008).

The Beach Vitex Project in South Carolina

Since the establishment of the Beach Vitex Task Force in 2003, work to address the problem has been organized in three primary phases. This includes Task Force Establishment and Organization (Phase 1), a Large Scale Eradication Demonstration (Phase 2), and a Final Beach Vitex Eradication Program (Phase 3).

Phase 1 – Task Force Establishment and Organization

Focus Areas include:

- *Interagency Coordination – Task Force Organization and Planning*
  - Annual Work Plan, Annual Symposium, Summer and Winter Planning Meetings
- *Early Detection and Reporting*
  - Volunteer Recruitment and Training, Seedling Detection and Removal on Public Beaches, Documentation and Reporting of Landscape Plantings of Beach Vitex along the Carolina Coast
- *Data Archiving*
  - Creation of a Beach Vitex Distribution Database
- *Information and Public Outreach*
  - Numerous Seminars, Lectures, Articles Interviews, a Task Force Website www.beachvitex.org
- *Small Control and Restoration Demonstrations*
  - Four infested sites in Georgetown County, South Carolina
- *Regulatory Framework*
  - Local Ordinances Against Further Planting
    Pawleys Island, Georgetown County, Isle of Palms, Folly Beach, Kiawah Island, Dewees Island, Town of Edisto Beach

  - Listing as a Federal Noxious Weed in the U.S.
    A Beach Vitex Weed Risk Assessment was completed by the U.S. Geological Survey in 2005–2006.
    APHIS has not proceeded with the federal listing process because Beach Vitex is listed as being native to Hawaii in some text books.
  - Listing as a State Noxious Weed in South Carolina
    The WRA was submitted to the Clemson University Plant Industry Department (DPI) for consideration in listing Beach Vitex as a State Noxious Weed in South Carolina in 2007. Clemson DPI has not acted on the listing request.
- *Phase 1 Funding*
  - Pulling Together Initiative (PTI) Grants – National Fish & Wildlife Foundation (NFWF): 2004–2005 ($47,000); 2005–2006 ($40,000); 2006–2007 ($40,000); 2007–2008 ($40,000); 2008–2009 ($40,000).

Phase 2 – Large Scale Eradication and Restoration Demonstration

Phase 2 of the South Carolina Beach Vitex Project has been led by scientists Dr. Chuck Gresham and Dr. Jack Whetstone with Clemson University, at the Bell W. Baruch Institute in Georgetown, South Carolina. In this phase, the eradication and restoration research that was initiated at four infested sites under Phase 1, was expanded to 75 infested sites in Georgetown and Horry Counties, South Carolina. While a number of chemical and manual control methods have been evaluated in the project, the most effective method of control includes a directed application of the herbicide imazapyr (Trade Name – Habitat™), which is produced by BASF, Inc.

In the first summer or fall of the treatment effort, imazapyr is applied to hacked stems of Beach Vitex to ensure effective penetration of the active ingredient. After this, treated plants are left in place over the winter to help anchor the dune against winter storms, and to permit complete translocation of the chemical throughout the plant. In the spring of the second year, the treated (now completely dead) Beach Vitex plants are cut back to the dune surface, and native dune plants, primarily Sea Oats and Bitter Panicum (*Panicum amarum* Elliott), are planted and fertilized.

While this is a very labor intensive method (a 1.6 acre infestation required 200 man hours to treat), it is 99% effective in eradicating Beach Vitex from a site and restoring it with native dune plants, however, it is also essential that treated areas be monitored for regrowth and promptly treated again to ensure total eradication. As of April, 2008, most infestations from Winyah Bay northward to the North Carolina state line had been eradicated.

The activities of Phase 2 of the South Carolina project has been supported by the following grants:

- **2006–2007:** $133,005 Grant – National Fish and Wildlife Foundation (U.S. Fish and Wildlife Service – Savannah–Santee–Pee Dee Ecosystem Team).
- **2007–2008:** $135,000 Private Stewardship Grant – U.S. Fish and Wildlife Service
- **2007:** $50,000 Grant – USDA Natural Resources Conservation Service, Columbia, S.C.
- **2007:** $25,000 Grant – Gaylord and Dorothy Donnelley Foundation, Chicago, IL
- **2008:** $15,000 Grant – Town of Pawleys Island, SC

Phase 3 – Complete Eradication of Beach Vitex from the South Carolina Coast

Under Phase 3, pending the availability of funding from federal, state, and local sources, remaining Beach Vitex infestations along the South Carolina Coast will be eradicated. If federal funding is secured, the U.S. Fish and Wildlife Service is expected to take a leading role in completing the South Carolina project under its Coastal Partnership Program.

Also, under Phase 3, efforts will be made to expand local ordinances against planting of Beach Vitex in communities along the South Carolina Coast. Finally, additional efforts will be made to encourage the listing of Beach Vitex as a State Noxious Weed (by DPI), and as a Federal Noxious Weed (by USDA APHIS).

The Beach Vitex Project in North Carolina

Since the Carolinas Beach Vitex Task Force was established in 2005, principal partners have made substantial progress in addressing the problem in North Carolina.

- Task Force Partners have worked with project cooperators to document landscape plantings of Beach Vitex in all coastal communities (now included in the Task Force Database). Task Force partners and cooperators continue to survey and document all infestations of the plant along the North Carolina coast.
- Task Force Coordinators have developed a work plan to guide partner and cooperator activities.
- There has been steady progress in developing a regulatory framework to prevent further sale and planting of Beach Vitex in coastal communities in North Carolina.
- A number of municipalities have passed ordinances against further sale and planting of Beach Vitex along the North Carolina coast. To date, these include Baldhead Island, Ocean Isle Beach, Caswell Beach, Pine Knoll Shores, North Topsail Beach, and Topsail Island.
- In the spring of 2007, the Weed Risk Assessment that was completed by the U.S. Geological Survey, and submitted to the North Carolina Department of Agriculture (NCDA) for consideration in listing Beach Vitex as a State Noxious Weed in North Carolina. NCDA is moving forward with the listing process.
- In the fall of 2007, the Raleigh office of the U.S. Fish and Wildlife Service, received a $128,500 Keystone Grant from the National Fish and Wildlife Foundation to eradicate Beach Vitex from North Carolina beaches. Project coordinators began control and restoration efforts in cooperation with affected communities (cooperators) in the fall of 2008.

The Carolinas Beach Vitex Task Force – A Model Interagency Partnership

The Carolinas Beach Vitex Task Force is widely recognized as a model interagency partnership. In February, 2008, the Task Force was given the National Community Spirit Award by the National Fish and Wildlife Foundation at the 9th annual National Invasive Weed Awareness Week in Washington, D.C. In March, 2008, the South Carolina project which was approved for a fifth and final year of funding, received the highest score of all 94 grant proposals submitted for consideration under the NFWF Pulling Together Initiative Grant Program. In May, 2008, Betsy Brabson received the 2007 U.S. Fish and Wildlife_s Southeast Region Conservation Award in Atlanta, Georgia.

The Carolinas Beach Vitex Task Force is a good example of the new trend in invasive species management through *interagency partnering*. This type of collaborative, consensus building process that brings *principal partners* (lead agencies and organizations) and *cooperators* (affected and potential stakeholders) together around a common cause, is an effective approach for addressing new invasive species that threaten the biological and natural resources of the United States and Canada. Lessons learned in the Beach Vitex project will provide valuable guidance in forming similar partnerships to address other new invasive species problems around the country and elsewhere in the world.

Establishment of a North American Early Warning System for Invasive Species

Since political land boundaries alone will not stop the spread of new invasive plants across North America, the U.S. EDRR effort must ultimately be combined with similar efforts in Canada and Mexico. Once clear protocols are established for reporting and responding to new invasive plants in each country, a continental early warning system can be established to help publicize information about new and emerging invasive plants across North America. Ultimately, the North America Early Warning System for Invasive Plants (EWS) will provide standardized weed alerts on confirmed new invaders, including distribution, life history, pathways of introduction and spread, as well as ecological and economic impacts. Having such knowledge about new invasions across the continent will also permit agencies and organizations to take steps to manage pathways of introduction and thus protect vulnerable managed and natural resources at risk through prevention. Discussions about the need for a North American EWS began at the 2004 Weeds Across Borders Conference (WAB) in Minneapolis, MN, and have continued at subsequent WAB conference in 2006 (Hermosillo, Mexico), and 2008 (Banff, Canada). A report on progress in developing the U.S. EDRR System and the North American EWS will be made at the next WAB conference in 2010.

Summary

Over the past 100 years, a Federal/State crop protection system has been developed to protect and enhance food and fiber production in the United States. In this system, new invasive species (e.g., foot and mouth disease (*Aphtae epizooticae*), karnal bunt (*Tilletia indica* Mitra), and gypsy moth (*Lymantria dispar*)) that have a direct and measurable impact on economically important food and fiber industries (e.g., cattle, grain, forestry), can often be effectively addressed by a very small number of partners (e.g., the USDA, cooperating State Departments of Agriculture, and the affected industry). However, based on our work on federal/state weed eradication projects across the United States over the past 30 years, it is clear that, typically, no single agency has the resources, expertise, or authority to address most multi–jurisdictional invasive species problems on a unilateral basis. The work of the California Department of Food and Agriculture, which has successfully eradicated a number of new and emerging weeds over the past 100 years, is a notable exception. However, in most cases, the establishment of an interagency task force of affected and potential stakeholders is the most effective approach for addressing a new problem. This is especially true in dealing with new species are not already regulated, and/or primarily pose a threat to natural ecosystems. Beach Vitex, a woody vine from Korea that was first planted along the Carolina coast in the mid–1980s, is a good example. The creation of state and provincial EDRR Coordinating Committees is the first step in developing EDRR capacity to address new problems like Beach Vitex. At the continental level, Weeds Across Borders Conference partners are taking a lead in development of a North American Early Warning System for alerting public officials and land managers about new invasive plants and their pathways of dispersal. With regulatory exclusion (at ports of entry), EDRR, and early warning systems in place, the U.S., Canada, and Mexico will be better able to mount an effective defence against future economic and environmental losses associated costs due to "plants out of place in North America".

Forewarned is forearmed!

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USDA APHIS Weed Programs. Early Detection and Rapid Response and the Federal Incident Command System

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Abstract

The Federal Interagency Committee for the Management of Noxious and Exotic Weeds (FICMNEW), a US Federal interagency weed group, issued in 2003 a conceptual design for an Early Detection and Rapid Response system for invasive plants. USDA APHIS, a member agency of FICMNEW, was involved the development of this plan and the describing document. This culminated a stakeholder process initiated in 1998. The need identified was to identify gaps in existing response programs and propose a template for a US national system to detect, assess, and respond to invasive species infestations in their early stages of establishment. Following this, as an out-growth of the tragic events of 9-11-2001, U.S. Homeland Security Presidential Directive – 5 (HSPD-5) was issued on February 28, 2003. HSPD-5 requires all U.S. federal departments and agencies to adopt a National Incident Management System (NIMS) in their domestic emergency program management. NIMS is designed to provide a consistent nationwide approach for federal, state, tribal, and local

Resumen

La Comisión Interministerial Federal para el control de malezas nocivas y no autóctonas (*Federal Interagency Committee for the Management of Noxious and Exotic Weeds*, o FICMNEW) presentó en el 2003 un diseño conceptual de un sistema de detección temprana y respuesta rápida para plantas invasivas. La Dirección de Inspección Fitosanitaria (*Animal and Plant Health Inspection Services*, o APHIS), adscrita a la Secretaría de Agricultura de Estados Unidos (USDA), participó en el desarrollo del plan y la redacción del documento. Esto finalizó el proceso entre los grupos interesados en el 1998. Se identificó la necesidad de determinar las deficiencias de los programas de respuesta existentes, y el proponer un modelo de sistema nacional estadounidense para la detección, el análisis y la capacidad de respuesta ante la propagación de especies invasivas en sus comienzos. Un resultado como consecuencia de los trágicos acontecimientos del 11 de septiembre de 2001 fue el decreto presidencial (*Homeland Security Presidential Directive-5*, o HSPD-5), emitido el 28 de febrero del 2003. Este decreto

governments to work effectively and efficiently together to prepare for, respond to, and recover from domestic incidents, regardless of cause, size, or complexity. At the center of NIMS is the Incident Command System (ICS), a unified command system supporting efforts by the US federal government, where requested, to assist these governments in pre-identifying and evaluating sites where a multi-jurisdictional unified command system can be quickly established when needed. The Animal and Plant Health Inspection Service (APHIS) is the lead US agency for pest-related regulatory matters. As such, for pest related agricultural or natural ecosystem emergencies APHIS leads the ICS, or in the case of another type of emergency, APHIS provides direction for the pest-related elements under another emergency responder agency's lead. The ICS framework places equal emphasis on the response, the preparation, and the recovery processes. Activities are grouped into domains that define the life cycle of a domestic incident. These five domains are: Awareness, Prevention, Preparedness, Response, and Recovery. APHIS regulates federal noxious weeds under the authority of the Plant Protection Act and Federal Seed Act. This presentation will explore how these systems interlink, and how they relate to federal, state, and local decision making regarding invasive plant detections, and program design, initiation, and management.

requiere que todos los departamentos y agencias federales de Estados Unidos implanten un Sistema Nacional de Manejo de Incidentes (*National Incident Management System*, o NIMS) como parte de su manejo del programa nacional para emergencias. El sistema NIMS está diseñado para establecer un enfoque uniforme en todo el país con el propósito de que los gobiernos a nivel federal, estatal, municipal y en áreas indígenas puedan actuar conjuntamente de manera eficiente y efectiva en la preparación, respuesta y recuperación relacionadas con incidentes nacionales, independientemente de la causa, alcance o complejidad de estos últimos. Un elemento fundamental del sistema NIMS es el Sistema de Comando Centralizado para Incidentes (*Incident Command System*, o ICS), que apoya las iniciativas del gobierno federal estadounidense, cuando es solicitado, para ayudar a los estados del país a identificar de manera anticipada y a evaluar los lugares en los que un sistema centralizado multi-jurisdiccional y unificado puede ser implantado rápidamente en caso de necesidad. APHIS es la entidad responsable en Estados Unidos de asuntos relacionados a la reglamentación del control de plagas. Por lo que dirige el sistema ICS en situaciones de emergencias agrícolas o de ecosistemas naturales relacionadas con plagas. En otros tipos de emergencias, ofrece orientación para los elementos relacionados con plagas según el plan de respuesta que haya establecido otra agencia federal encargada del caso. El plan de trabajo del sistema ICS ofrece igual importancia a los procesos de respuesta, preparación y recuperación. Las actividades se agrupan en categorías que definen el ciclo de vida de un incidente nacional. Esas cinco categorías son: sensibilidad, prevención, preparación, respuesta y recuperación. APHIS reglamenta las malezas en virtud de la Ley de protección fitosanitaria (*Plant Protection Act*) y de la Ley federal sobre semillas (*Federal Seed Act*). La ponencia analizará la interrelación entre estos sistemas y la manera en que se vinculan con la toma de decisiones a nivel federal, estatal y municipal en lo relativo a la detección de plantas invasivas y al diseño, el comienzo y el manejo de los programas para combatirlas.

Introduction

The United State Department of Agriculture (USDA) is, with the exception of Department of Defense (DOD), the largest and oldest Department in the U.S. federal government. USDA additionally has the largest budget in the U.S. government, again with the exception of DOD. In 1862 the agency which became the USDA was set up as a bureau without Presidential Cabinet status, and in 1889 was raised to Cabinet department status. USDA currently is organized with seven Under Secretaries presiding over various program areas. The Animal and Plant Health Inspection Service (APHIS), which houses most of the plant and animal regulatory programs, reports to the Under Secretary of Marketing and Regulatory Programs. APHIS "action" programs consist of six domestic sections: 1) Animal Care; 2) Biotechnology Regulatory Services; 3) International Services; 4) Veterinary Services; 5) Wildlife Services; and, 6) Plant Protection and Quarantine; as well as one international section, International Services. The Plant Protection and Quarantine (PPQ) strategic plan summarizes the PPQ mission to safeguard agriculture and natural resources from risks associated with the entry, establishment, or spread of animal and plant pests and noxious weeds to ensure an abundant, high-quality, and varied food supply. PPQ is divided into three main sections: Plant Health Programs which handles port inspection and permit related issues; Emergency and Domestic Programs (EDP) which handles field program management; and the Center for Plant Health Science and Technology (CPHST) which develops program methods development and handles risk assessment. The Federal Noxious Weed program reports to the Assistant Deputy Administrator of EDP through the Director of the Plant Pathology and Weed program staff.

The national leadership teams, such as the federal noxious weed program, are responsible to develop, communicate, and implement strategic and operational plans for their respective program areas. This occurs in cooperation with the regional program staffs, which are responsible for program implementation mainly in cooperation with state staffs for both APHIS and the state government. The national and regional staffs both are involved in application of program methods and risk assessments developed by the third member of this management triad, CPHST.

What is a "Noxious Weed"?

The term "noxious weed" is defined in the Plant Protection Act (PPA), the APHIS plant pest legislative authority, as "any plant or plant product that can directly or indirectly injure or cause damage to crops (including nursery stock or plant products), livestock, poultry, or other interests of agriculture, irrigation, navigation, the natural resources of the United States, the public health, or the environment." (7 United States Code (USC) 7702 - Plant Protection Act -- SEC. 403. Definitions). This broad language authorizes APHIS to require general or specific permits allowing movement of regulated pests or infested materials, and to establish regulations to prevent the introduction of plant pests into the United States. These regulations are printed in Chapter 7 sections 300-399 of the Code of Federal Regulations. The weed section is commonly cited as 7 CFR 360, while the Seed Regulations are in 7 CFR 361.

Authority to Hold, Treat, or Destroy Items

APHIS authority beyond the above cited permit authority is limited by a later section of the PPA. This section states "If the Secretary considers it necessary in order to prevent the dissemination of a plant pest or noxious weed that *is new to or not known to be widely prevalent or distributed within and throughout the United States* [emphasis added], the Secretary may hold, seize, quarantine, treat, apply other remedial measures to, destroy, or otherwise dispose of any plant, plant pest, noxious weed, biological control organism, plant product, article, or means of conveyance that … has reason to believe is a plant pest or noxious weed or is infested with …" (7714 USC SEC. 414. General Remedial Measures for New Plant Pests).

Quarantine Pest

In comparison, the definition of a "Quarantine pest" in the relevant international treaty to which the U.S. is signatory, is "a pest of potential economic importance to the area endangered thereby and not yet present there, or present but not widely distributed and being officially controlled…" (International Plant Protection Convention – text approved by the FAO Conference at its 29th Session, Nov. 1997). The U.S. PPA authorities, and our regulations implementing the PPA authority, are consistent with this international definition.

Invasive Species

It is often asked, what is the difference between a noxious weed and an invasive species? Invasive species means "an alien species … whose introduction does or is likely to cause economic or environmental harm or harm to human health" (Executive Order 13112 of February 3, 1999 – Invasive Species). Weeds provide good examples to clarify what is meant by an invasive species because most people have a concept of what constitutes a "weed", most commonly simply defined in general terms as a plant out of place. Invasion (or invasiveness) is defined in ecological terms as a process. In the weed example, there are various ecological processes a plant must go through to become a successful and harmful invader. Several barriers must be overcome for a plant to be considered an invasive weed, the plant case of an invasive species. Examples of such barriers are: large-scale geographical barriers; survival barriers; establishment barriers; and, dispersal and spread barriers. But in order to be defined as either a noxious weed or an invasive species the common element is harm and impact, not simply being "out of place". A noxious weed means the special case of a regulated invasive plant species, thus is a subset of the class "invasive species".

Federal Versus State Laws/Regulations

State laws and regulations vary, so such regulation may occur at various levels. There are at least 50 different state laws, with "state" usually defined to include territories and recognized tribes. I will assume this broad definition of a state in this discussion (see: http://nationalplantboard.org/laws/index.html). Due to the doctrine of States rights, these local regulations (also called rules) apply in the U.S. within state boundaries in the absence of a federal quarantine. This includes authority over internal movement or sales within a state. For the U.S., interstate commerce in most cases falls under federal authority. A quarantine is a federal or state regulation. Weeds listed as federal noxious weeds are defined as quarantine pests for import, interstate movement, or eradication, but not in the specific sense of overriding state authority, unless a specific regulation is published in the Federal Register which defines quarantine boundaries and rules. An example is the federal quarantine for witchweed (7 CFR §301.80).

Thus, there are weed laws (authorities) and weed regulations (implementation of the authority) occurring at both state and federal levels. But the reasons for these regulations differ. Federal noxious weeds are regulated primarily for interdiction (prevention) or for eradication, but not usually for management alone. Exceptions to this rule of thumb are federal biological control targets, but many of these targets are not federal noxious weeds. State noxious weeds may also be regulated for interdiction or eradication, or may in fact also be federal noxious weeds, but many state weeds are regulated primarily as management targets, and do not meet the requirements in the APHIS authority for regulation as federal noxious weeds.

Early Detection and Rapid Response

The Federal Interagency Committee for the management of Noxious and Exotic Weeds (FICMNEW), a U.S. Federal interagency weed group, issued in 2003 a conceptual design for an Early Detection and Rapid Response (EDRR) system for invasive plants. USDA APHIS as a member agency was involved the development of this document, as the culmination of a stakeholder process initiated in 1998. The perceived need was to identify gaps in existing response programs and propose a template for a U.S. national system to detect, assess, and respond to invasive species infestations in their early stages of establishment.

How do the regulatory concepts described previously fit together within an EDRR framework? Hopefully, in such a way that it can prevent Erratic Detection and Reluctant Response. So, then, what is EDRR, and what does EDRR mean to you? Currently, there are numerous local, state, and regional interagency groups involved with invasive plant management throughout the United States. These groups may be under state or federal authority and funding, or may be independent, for example Cooperative Weed Management Areas (CWMAs), or other non-governmental organizations. One of the main EDRR objectives is to encourage each of these groups to promote an EDRR approach as a preferred management option for new and emerging invasive species, and to assist in the development of a National EDRR System for Invasive Plants. This will allow new detections to be identified and quickly entered into regulatory or program design decision-making at the appropriate level. This level may be local, state, or federal, depending upon the known distribution of the species.

Federal Incident Command System

In response to the events of September 11, 2001, Homeland Security Presidential Directive–5 (HSPD-5) was issued on February 28, 2003. HSPD-5 requires all federal departments and agencies to adopt the National Incident Management System (NIMS) in their domestic emergency program management. NIMS is designed to provide a consistent nationwide approach for federal, state, and local governments to work together to prepare for, respond to, and recover from domestic incidents. At the center of NIMS is the Incident Command System (ICS). ICS is a flexible, scalable response organizational platform. It provides a common framework within which people can work together effectively across multiple agencies that do not routinely work together (with varying organizational structures). ICS is designed to provide standard response and operation procedures http://en.wikipedia.org/wiki/Incident_Command_System.

Incident Command System History

ICS was originally developed in the 1970s during massive wildfire-fighting efforts in California and following a series of catastrophic fires in the California urban/rural interface. Property damage ran into the millions, and many people died or were injured. Follow-up studies determined that response problems often related to communication and management deficiencies rather than lack of resources or failure of tactics.

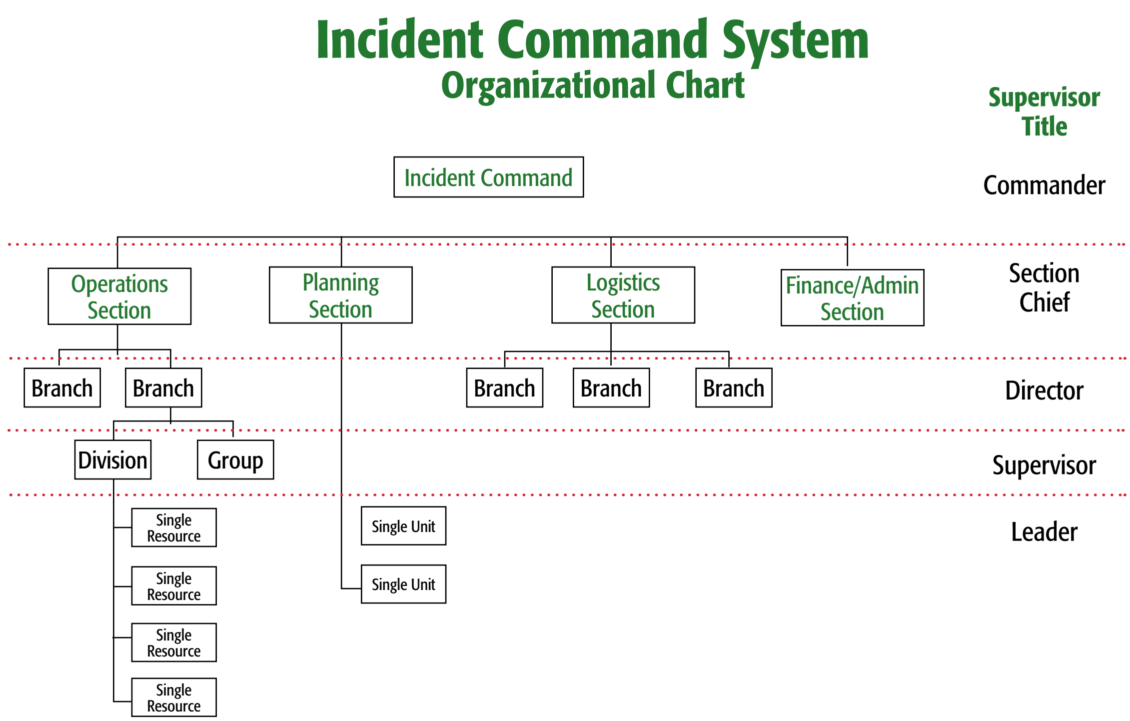

Figure 1. Incident Command System organizational chart.

Weaknesses in incident management were often due to:

- Lack of accountability, including unclear chains of command and supervision
- Poor communication due to both inefficient uses of available communications systems and conflicting codes and terminology
- Lack of an orderly, systematic planning process
- No predefined methods to effectively integrate inter-agency requirements into the management structure and planning process

Federal managers are now mandated to undergo ICS training, and we are often included in mock exercises, often with our state partners.

When a program is triggered, the ICS structure provides a consistent process and consistent job titles, somewhat similar to a military staff structure. An incident commander, or in the case of APHIS often a joint command including commanders from both APHIS and the state regulatory program, preside over Section Chiefs for the standard units of Operations, Planning, Logistics, and Finances. Level names and consistent command titles are defined to allow rapid clearly defined expanding or retracting of the program structure as needed.

The ICS framework flows along a response continuum. Activities are grouped into domains that define the life cycle of a domestic incident. These five domains are:

- Awareness
- Prevention
- Preparedness
- Response
- Recovery

Early Detection and Rapid Response Decision Process

The APHIS decision-making process for EDRR may be described within these five ICS domains. Within the Awareness, Prevention, or Preparedness domains may fall EDRR activities related to: Pre-Planning; Detection and Reporting; and, Identification and Vouchering. Drafting response plans prior to detection of a new pest is an example of pre-planning within this area.

The Response domain usually is considered as starting with Rapid Assessment. Various possible decisions may be made. If the detection is determined to be a common weed, the decision would be to either stop further planning, or refer for a local response. This is what we might commonly call “dandelion reports”. It should be noted, that an exception might be a dandelion report in the state of Alaska or the Yukon Territory of Canada, where the pest plant is not yet common. If the plant is determined to be already Federally regulated a decision would be made as to whether a program already existed, or if planning for such a program is needed. If the plant is not federally regulated, a next step is to check for state regulations in the detection site. If the plant is already state regulated similar program decision making would likely be shifted to the state program planning level.

New Pest Advisory Group

If the plant is not common, and is not currently regulated at state or local levels, a group many be assembled within APHIS PPQ called the New Pest Advisory Group. This is an ad hoc group assembled (after a brief need assessment within PPQ CPHST) to determine whether the detected plant is appropriate for listing as a federal noxious weed and what are appropriate program or planning steps. Possible outcomes include deciding to develop a federal regulation, in which case a regulatory planning process is triggered, and program planning for eradication of the plant will likely begin in parallel (e.g., a decision to do further survey). Additional alternative outcomes are to do further risk assessment or decide that the plant is not an appropriate federal target, and thus should be referred back to the state for regulatory assessment or state planning. If the state determines no state response is warranted, the plant could still be referred for a possible local response.

Regulatory and Program Planning

Once it is determined that a state or federal response is warranted, the plant will enter either regulatory planning and/or program planning. This will then provide a Rapid Response at the appropriate federal, state, or local level, or often a combination of these. It is noteworthy that Rapid Response may be preceded by a number of steps, which may consume considerable time. So "rapid" may be in relative terms, however, many of the above steps occur concurrently, and so not always require considerable time.

Current Program Approach

Program umbrella groups currently are most often centered upon individual taxa. Examples are the Regional Tropical Soda Apple Task Force (RTSATF). PPQ in cooperation with stakeholder coalitions established a regional Memoranda of Understanding (MOU) for cooperative work on the federal noxious weed Tropical Soda Apple (TSA) in southeastern states. The TSA MOU includes cooperation between state and Federal agriculture and veterinary agencies to deal with movement of the weed's seed in and with cattle. The TSA program is designed around concepts of Integrated Vegetation Management (IVM) and includes conventional survey and control efforts as well as biological control. A recent similar approach has been established by a northeastern U.S. MOU for Giant hogweed. A Mississippi Cogongrass taskforce is a further example centered around a regional or state approach for a single taxa. Alabama recently signed such a Cogongrass MOU for their state partners.

Developing Program Approach

EDRR focus may be more appropriately centered upon regional invasive species umbrella groups. This could avoid a piecemeal approach requiring individual groups for each species with little coordination. Examples of this broader approach are the Invasive Plant Atlas of New England (IPANE), which initially centered primarily on invasive plant survey, but is exploring expansion to include control work. Additional regional groups are the Mid-south Invasives group, centered on Mississippi and surrounding states, and the recently forming MidWest Invasives group. Another example is a steering committee formed under the Southern Regional Plant Board for Benghal Dayflower/Tropical Spiderwort in the southeastern U.S. Such efforts may also be extended to non-traditional or non-agriculture stakeholder groups; for example, wildlife management groups such as the Association of Fish and Wildlife Agencies (AFWA), where there are cross-cutting issues such as fire issues associated with Cogongrass infestations.

Recovery

An important part of the ICS is the inclusion of Recovery as a program domain. In previous program approaches, inclusion of such elements as post-treatment monitoring or revegetation efforts were often ignored. Ecologically sound programs, based on the concepts of Integrated Vegetation Management, however, require a more broad-based view of program design, including measurement of outcomes and program success or failure. Such program monitoring, to be effective, requires incorporation of procedures and funding into the program during the initial planning process.

APHIS Weed Categories

APHIS separates the federal noxious weeds into three categories. Taxa in the A1 category are exclusion targets, not currently known to be present in the U.S. This category currently includes 42 taxa. The term taxa is used, because in several cases entire genera are regulated, and in one case, a clone or sub-taxon. In the A2 category there are 62 taxa. Thus, at the time of this talk, 104 taxa are regulated at the federal level in the U.S. as Federal Noxious Weeds. A third category, B weeds, are defined as regulatory non-quarantine pests. An example is seeds from species regulated under the federal seed act, which have a tolerance in trade. This includes 9 species which are not federal noxious weeds. All federal noxious weeds are cross- listed under the Federal Seed act in 7 CFR 361.

Regulations in Progress

Currently in progress are two regulatory workplans which include regulation of additional Federal Noxious Weeds, including seven new species with completed pest risk assessments (Docket No. APHIS-20070146):

- *Onopordum acaulon* L.
- *Onopordum illyricum* L.
- *Euphorbia terracina* L.
- *Ageratina riparia* (Regel) R.M. King and H. Robinson
- *Arctotheca calendula* (L.) Levyns
- *Acacia nilotica* (L.) Willdenow ex Delile
- *Inula britannica* L.

In addition, a federal order titled "Federal Import Quarantine Order for Climbing Ferns" was promulgated in May 2008 to prevent entry into U.S. of *Lygodium microphyllum* (Cav.) R. Br. (Old World climbing fern) and *L. flexuosum* (L.) Sw. (Maidenhair creeper). This was in response to a petition to APHIS by the Florida Department of Environmental Protection to regulate *Lygodium* species. This is being followed-up by a regulatory workplan for an interim rule to formally add these two species to the Federal Noxious Weed list. Further consideration in the risk assessment was made of additional *Lygodium* species, which were determined to require further information before their regulation could be supported.

Current APHIS weed field program

At present the following species have state programs funded in part by APHIS PPQ:

- Benghal Dayflower (a.k.a., Tropical Spiderwort)
- Broomrape, Small (*Orobanche minor*)*
- Broomrape, Branched (*Orobanche ramosa*)*
- Cogongrass
- Caulerpa - Med. clone
- Giant Hogweed
- Giant Salvinia
- Goatsrue
- Hydrilla
- Japanese Dodder*
- Onionweed
- Tropical Soda Apple
- Wormleaf salsola
- Witchweed*

* Parasitic plants also regulated under 7 CFR 330.

Design of regional, state, or local approaches to umbrella groups vary widely. Functional groups may cover all invasive taxa or be limited to weeds only. Such groups may be informal or regulatory. They may have a natural area major emphasis or an agricultural pest major emphasis. There is no need to dictate a top-down approach. Each state should use the organizational model adapted to their situation. More taxon-specific projects or task forces may include interested parties, which may be somewhat self selecting. Groups may vary in organization from area to area. A charter or similar mandate from a regulatory authority is nice but is not absolutely essential. The consistent need is for people dedicated to solving the problems. Various organizational approaches and needs are discussed in the CWMA cookbook (see: http://www.fs.fed.us/invasivespecies/documents/cookbook.pdf). APHIS PPQ is interested in helping to encourage use of volunteers for pest detection or management (see CAPS site: http://www.aphis.usda.gov/plant_health/plant_pest_info/pest_detection/downloads/volunteer_guidebook14-5.pdf). PPQ is interested in the development of an interagency roster of scientific expertise and may use it to enlist help, particularly in eradication programs. Such experts could help prepare informational material on pests of concern and work on maintaining a priority list of pests. They could also be a pool of experts to staff NPAG ad hoc groups helping to assess or develop program plans for newly detected pests.

One of the problems in finding and sustaining an approach to the invasive species problem is defined in a quote from "An Inconvenient Truth" by Upton Sinclair: "It is difficult to get a man to understand something when his salary depends upon his not understanding it." This summarizes the need for us as people concerned about the invasive species problem to determine to be a part of the solution, not a part of the problem.

Biography

Dr. Alan Tasker joined the APHIS Plant Protection and Quarantine (PPQ) Invasive Species and Pest Management staff in Nov 1999 as National Noxious Weed Program Manager after 8 previous years with APHIS. His job includes planning and coordination of APHIS Domestic Weed Programs. He currently serves as co-chair of the interagency weed group FICMNEW (Federal Interagency Committee for the Management of Noxious and Exotic Weeds). In addition to a Ph. D. in agronomy from the University of Missouri-Columbia, Dr. Tasker received a B.S. in agriculture from Kansas State University, and a M. S. in agronomy from Montana State University. He (as Sheriff Al) together with Randy Westbrooks (Randy the Weed Wrangler) have been singing weed songs at Kid's Fun Day at National Invasive Weed Awareness Week for the past three years. We finished NIWAW9 in February, and are already planning NIWAW10.

IPANE: Could New England's Early Detection Network Benefit Eastern Canada?

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Abstract

The Invasive Plant Atlas of New England (IPANE; ipane.org) is a multifaceted approach to regional early detection of invasive plants. IPANE, was founded in 2001 to create a comprehensive six state New England regional partnership to: minimize the ecological damage caused by invasive plants; provide reliable and accessible educational material; maintain a network of professional and trained volunteers to gather information and to locate new incursions; provide a web-accessible database and maps of invasive and potentially invasive plants; conduct and encourage research on the biology and ecology of invasive plants; and, use program-generated data to develop predictive distribution models for the region. This program uses the synergy of all the components to create a regional early detection and rapid assessment network to curtail new invasions before

Resumen

El atlas de plantas invasivas de Nueva Inglaterra (*Invasive Plant Atlas of New England*, IPANE; ipane.org) es un enfoque multipartito para la detección temprana regional de plantas invasivas. El IPANE se instauró en 2001 para crear una alianza regional integral entre seis estados de Nueva Inglaterra con los fines siguientes: reducir al mínimo los daños ecológicos causados por las plantas invasivas; proporcionar materiales pedagógicos fiables y accesibles; mantener una red de profesionales y voluntarios capacitados para recabar información y detectar nuevas incursiones; ofrecer una base de datos y mapas en línea sobre plantas invasivas y potencialmente invasivas; realizar y fomentar investigación sobre la biología y ecología de las plantas invasivas; y utilizar información generada por el programa para elaborar modelos de distribución predictivos para la región. Este

1 Presenter.

they become widespread on the regional landscape. IPANE is a model for the United States Geological Survey National Early Detection Network currently being developed and its website hosts the National Early Detection Network Toolbox, a compendium of information developed for use by Network partners and potential partners. In addition, an Early Detection Alert system has been developed to inform key federal and state agency staff, conservation organizations, and those with vegetation management responsibilities about new or potential invaders to the region. These include current and anticipated distribution, diagnostic characters, images, pertinent biological and control information, and key contacts.

Most of the non-native species currently considered invasive by IPANE appear to be spreading into New England from the south or west. IPANE is strategically placed to act as an advanced warning system for the 5 provinces of Eastern and Maritime Canada. At a meeting held in Nova Scotia in September 2007, this idea was suggested to attendees from 4 of these 5 provinces and the Canadian government. By expanding its alert system, IPANE could serve as a focal point for Early Detection information moving in any direction and tie Eastern Canada into the National Early Detection Network of the United States.

programa utiliza la sinergia de todos sus componentes para crear una red regional de detección temprana y evaluación rápida que está dirigida a frenar nuevas invasiones antes de que se propaguen en las tierras de la región. El IPANE está siendo utilizado por la red nacional de detección temprana (*National Early Detection Network*) adscrita a la oficina de estudios geológicos (*United States Geological Survey*) para el modelo que está actualmente desarrollando y su sitio web publica la ***caja de herramientas de la red nacional de detección temprana y respuesta rápida*** (*National Early Detection Network Toolbox*), un compendio de información elaborada para los socios de la Red y otros socios potenciales. Asimismo, se ha creado un sistema de alertas de detección temprana (*Early Detection Alert system*) para informar a personal clave del gobierno federal y de las entidades de los estados, organizaciones de conservación y responsables de manejo fitosanitaria sobre nuevas o potenciales especies invasivas en la región. Esas alertas incluyen la distribución actual y prevista, elementos de diagnóstico, imágenes y la correspondiente información biológica y de control, al igual que el nombre de contactos clave.

La mayoría de las especies no autóctonas que actualmente son consideradas invasivas por el IPANE parecen estar propagándose en Nueva Inglaterra desde el sur o el oeste. El IPANE está estratégicamente situado para intervenir como sistema de alerta temprana para las 5 provincias de la zona orienta y marítima de Canadá. En una reunión celebrada en Nueva Escocia en septiembre de 2007 se sugirió esta idea a los delegados de 4 de esas 5 provincias y al Gobierno de Canadá. Expandiendo su sistema de alerta, el IPANE podría servir como nodo central para información de detección temprana proveniente de cualquier dirección y vincular la zona oriental de Canadá con la red nacional de detección temprana de Estados Unidos.

The Invasive Plant Atlas of New England

The Invasive Plant Atlas of New England (IPANE) is a multifaceted approach to early detection that covers the six New England States (Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, and Connecticut). It was started in 2001 by a partnership including scientists or conservationists from the Ecology and Evolutionary Biology Department at the University of Connecticut, the Silvio O. Conte National Fish and Wildlife Refuge, and the New England Wild Flower Society with funding from a United States Department of Agriculture (USDA) Cooperative State Research, Education, and Extension Service (CSREES) competitive grant program. Although the overarching goal of IPANE was to establish a regional early detection network, other components of the comprehensive program include: the IPANE website (nbii-nin.ciesin.columbia.edu/ipane/) which features a catalogue of species information, interactive databases of historic and current distributional data on invasive and potentially invasive plants in New England; a corps of trained volunteers; outreach; and, biological and ecological research. The program was started to: gather basic data on existing invasive and potentially invasive plants in the region; to make these data available in web-accessible databases and maps of incursions; and, to minimize the ecological damage caused by invasive plants by providing reliable and accessible education material. IPANE maintains a network of professionals and trained volunteers who gather information and who attempt to locate new incursions before they become well established and widespread. A major component of the IPANE program is to both encourage and conduct research on the biology and ecology of invasive plants. Data gathered by the network of volunteers are being used to develop predictive distribution models for the region. The program uses the synergy of all the components to create a regional early detection and rapid assessment network to curtail new invasions before they become widespread on the regional landscape.

The National Invasive Species Council's Management Plan (NISC 2001) includes Early Detection and Rapid Response (EDRR) as one of its 8 key components. In June 2000, a meeting, orchestrated by United States Geological Survey (USGS) and the Federal Interagency Committee on the Management of Noxious and Exotic Weeds (FICMNEW), was held in Fort Collins, CO, that lead to the publication of FICMNEW's "A National Early Detection and Rapid Response System for Invasive Plants in the United States" (FICMNEW 2003). These documents point to the need for an integrated program to discover new incursions before they are well established that involves research, technical assistance, rapid assessment of the potential for spread and a strategic response to the new incursion. IPANE was created to fill this need in the northeast. Further, the program also addresses other components of the national management plan, including information management, education and public awareness.

New England is an invaded landscape. Given the size of some of the New England states, biologically it is much more reasonable to look at the region as a whole rather than from an individual State perspective. The States in New England range in size from the very small Rhode Island (the smallest state in the United States) with only 1,545 square miles, to Maine, the largest of the 6 states, with 35,385 square miles. The entire region covers 71,992 square miles, making it slightly larger than the states of North Dakota or Washington (Wikipedia 2008a). To put its size in perspective, New England is comprised of the 50th, 48th, 46th, 45th, 44th, and 39th largest states in the U. S.! Conversely, New England has a reasonably high rate of urban and suburban development, having areas like Boston at the northern end of the infamous "BosNYWash Corridor" or "Northeast Megalopolis". This includes cities like Manchester (NH), Worcester (MA), Providence (RI), Hartford and New Haven (CT) (Wikipedia 2008b). In contrast there are areas such as the almost 800,000 acre White Mountain National Forest (www.fs.fed.us/r9/forests/white_mountain/about/wmnf_flyer.pdf) or northern Maine that are still undeveloped and contain many large wilderness areas. This is especially amazing in light of the fact that the White Mountain National Forest gets over 6 million visitors a year and is within a day's drive for 70 million people. Not surprisingly, these northern areas are not highly invaded at this point in time (see IPANE data), but the fact that so many people visit these less invaded areas provides a clear and potential pathway and system of vectors that should not be overlooked.

One of the primary thrusts of the IPANE program has been to develop a network of program-trained volunteers who can both locate incursions of invasive and potentially invasive plants and gather some basic ecological data on the occurrence that can be used in rapid assessment, scientific research, and strategic management. The original goal was to train 25 volunteers per state per year with an overall 3-year goal of having 450 trained volunteers on the landscape looking for new incursions and gathering data. Presently there are over 600 trained IPANE volunteers from the 6 New England States and adjacent New York State. IPANE training consists of a day-long session that covers the IPANE program, species identification, how to choose sites and submit data, and other useful field information. Although other kinds of training programs are offered by IPANE, a potential volunteer must attend at least one of these introductory training sessions to be considered an IPANE volunteer. Each volunteer chooses a USGS Topographic Quadrangle for which they are responsible for surveying, although they can submit data from anywhere in New England. As of 2007, these volunteers have submitted over 4800 field forms (each representing a single plot which may have anywhere from zero to a dozen invasive plants per plot). The forms, which can be for terrestrial or aquatic sites and can be submitted on-line, have yielded reports for over 10,000 occurrences.

IPANE currently tracks 120 vascular plant species as invasive or potentially invasive in New England, but does not classify these species as the status of each taxon may be different from State to State. Now that every State has some sort of legal designations and concomitant category names, it would be misleading to do so. Many of the well-know invasive plant species such as *Berberis thunbergii* DC. (Japanese barberry), *Celastrus orbiculatus* Thunb. (Oriental bittersweet), *Rosa multiflora* Murr. (Multiflora rose), *Elaeagnus umbellata* Thunb. (Autumn olive), and *Frangula alnus* Mill. (Glossy buckthorn) are widespread throughout most of the region, especially in the southern region of Connecticut, Rhode Island, Massachusetts and southern parts of Vermont, New Hampshire, and coastal Maine. Other species are widespread and common in some parts of New England and appear to be expanding into other regions of New England. Some of these may not be equally well known across the region but commonplace problems where they occur locally. Consequently, these may be overlooked in some areas after they initially arrive and do not show up on the "radar screens" until they have become thoroughly established. Examples of these include *Alliaria petiolata* (M. Bieb.) Cavara & Grande (Garlic mustard), *Cardamine impatiens* L. (Narrowleaf bittercress), *Euonymus alatus* (Thunb.) Siebold (Burning bush or Winged euonymus), *Rubus phoenicolasius* Maxim. (Wineberry), *Valeriana officinalis* L. (Garden heliotrope), *Trapa natans* L. (Water chestnut), and *Microstegium vimineum* (Trin.) A. Camus (Japanese stiltgrass). A third group of species are not widely distributed or only occur in a very few locations in the New England region at this point. These taxa are often unknown or not familiar to most people and for that reason easily overlooked, yet if they become established have the potential of rapid unnoticed dispersion. Examples of this group include *Pueraria montana* var. *lobata* (Willd.) Maesen & S. Almeida (Kudzu), *Polygonum perfoliatum* L. (Mile-a-minute vine), *Lonicera maackii* (Rupr.) Herder (Amur honeysuckle), *Hydrocharis morsus-ranae* L. (Northern frog-bit), *Hydrilla verticillata* (L. f.) Royle (Hydrilla), *Butomus umbellata* L. (Flowering rush), and *Carex kobomugi* Ohwi (Japanese sand sedge). This last group includes some of the species on the IPANE early detection web page (nbii-nin.ciesin.columbia.edu/ipane/earlydetection/early.htm).

After the Fort Collins meeting in 2000, the partners setting up IPANE chose, for a number of reasons, to focus on Early Detection as the central theme of the program. First was that it seemed a logical place for us to start. Prevention is often cited as the first, best way to avoid problems from non-native species which could potentially become established and widespread in a region. Given the scope of our intended endeavour, we are not capable of effectively preventing an invasive species from arriving in New England. Detecting "it" early in its establishment and before it became widespread seemed the best that we could accomplish. IPANE is based on the synergism of its component parts and the training volunteers to look for certain species that, based on their biology and ecology, would likely become invasive if undetected and uncontrolled, seemed a good way to integrate science and the public. All three partner groups had experience in education and training and so we saw from the outset that this was a viable approach. Lastly, and perhaps most importantly, in New England we have a large number of people who are reasonably good field naturalists and who have a strong commitment to conservation and the preservation of biological diversity. This, we felt, was a recipe for being able to locate new incursions and help facilitate their removal before they continued their inexorable spread.

IPANE uses all of its components to create a regional early detection and rapid assessment network for New England in order to curtail new invasions before they become widespread on the regional landscape. A key to success of any effort such as this is to make as much information as possible widely available. Special, regionally focussed workshops are now offered to our volunteers to familiarize them with "early detection species" for their region. There is a conundrum that we are trying to address by offering these early detection workshops; that is, the well-know taxa that the volunteers are likely to discover are not usually "early detection species". The species considered "early detection species" are, thankfully, not often encountered by the volunteers. The volunteers, we felt, could run the risk of either losing interest in looking for them (no rewards for their search) or forgetting what they look like because they are seen so infrequently. We have started repeating these workshops every year in the hopes that more people will become familiar with the "early detection species" for which we hope they are searching. At the same time, it is hoped, that we will attract new IPANE volunteers through these workshops. As the predictive models are developed, the volunteers will be used to field-check them, adding more data. At the same time, we can use the models to help us fine-tune the "early detection species" lists for individual states or parts of New England.

IPANE is a model for the USGS National Early Detection Network currently being developed (Westbrooks 2008). The IPANE website will be used to host a "National Early Detection Network Toolbox" that is currently being developed. This tool box will be a compendium of information developed for use by the National Network Partners and will be available to others interesting in accessing either Early Detection protocols or other information on all aspects of Early Detection.

IPANE has developed 2 other mechanisms for early detection. The IPANE website has a page where anyone can send in a report of a plant population that they have seen with which they are not familiar or that the person reporting thinks might be invasive (nbii-nin.ciesin.columbia.edu/ipane/earlydetection/sightings.jsp). This page includes a place for a name, email address, telephone number, a "your note to our staff," and the ability to attach up to 3 digital images. Anyone, regardless of whether they are an IPANE volunteer or not, can send us a query about the unknown plant or known invasive. Reports obtained this way are read by IPANE staff and responded to accordingly. Thankfully, most reports have not been of invasive species. No taxa previously unknown in New England have come to IPANE's attention through this mechanism. If we do receive something that we feel needs further clarification or action we can either contact the person who reported the incursion or ask a nearby IPANE volunteer to follow up on the report and to gather more information or to collect a specimen. We make a point of getting back to each and every person who sends IPANE a sighting by this mechanism. Reports of taxa obtained in this manner are not entered into the IPANE database until verified.

The other early detection program that IPANE is currently developing is a network of what we call Localized Early Detection Sites (LEDS). A LEDS is a smaller, more manageable site than a State, with a smaller list of anticipated "early detection species." A LEDS could be a National Forest, a US Fish and Wildlife Service Refuge, a National Park, a State Park, botanical garden or arboretum, or even a land trust preserve or set of preserves. Almost any parcel of land could fit this concept if there is an agency, organization, or group of people in charge with a vested interest in slowing the spread of invasive plants on to the land they oversee. We are working to establish a LEDS in and around the White Mountain National Forest and others at smaller venues around New England are in progress. Once the site is determined, IPANE staff, working with people associated with the potential LEDS (staff, overseers, resource managers, or even knowledgeable amateurs) will help formulate a listed of "early detection species" for that site. These lists will have a reduced and more manageable number of species, from 6 to a dozen, and be specific to that site. They will include either anticipated species, because of known vectors or pathways of introduction, or those already present but in very low numbers. IPANE will help train staff, who in turn can educate visitors to the site, so that they all become the site's own early detection network. A local person will be designated as the contact and IPANE stands ready to help with the verification. Eventually, we hope to have a network of these LEDSs in place around New England.

This all works! There have been a number of success stories around New England. One of the earliest involved a report from a very knowledgeable botanist of *Senecio jacobaea* L. (Tansy Ragwort or Stinking Willie) in central Massachusetts. Because of both the abundance of this invasive species in eastern Canada and the historic records for its occurrence in both Maine and Massachusetts, Les Mehrhoff had been using this species in public presentations as a good example of an "early detection species" for New England. After a talk he gave to the staff of the Massachusetts Audubon Society, a botanist who then worked for them, Tom Rawinski, handed him a note on hotel stationery saying that there were "3–5 acres" of Tansy Ragwort in Massachusetts (this note is still on file). Following Tom's directions, Mehrhoff visited the site shortly after that, confirmed the report, and located the landowner. With the landowner's permission, IPANE orchestrated a site visit with people from the University of Massachusetts Extension Service, the Massachusetts Department of Agriculture (which has the statutory responsibility for invasive species and noxious weeds control in the Commonwealth of Massachusetts), and someone from the local Natural Resources Conservation Service office. We met with the landowner and discussed control options with the state Department of Agriculture representative. IPANE is not a control entity, so our involvement at this site ended except that we surveyed nearby areas to look for additional incursions.

Two other cases point to the utility of this kind of early detection network. An IPANE volunteer reported a roadside incursion of Mile-a-minute vine from a roadside in a county in Connecticut where we did not know it existed. In fact, at the time, this new occurrence represented the northeastern-most known incursion of this species in New England. The volunteer, Betsy Corrigan, not only reported the discovery, but she approached the landowner to inform him of the infestation and then took it upon herself to contact the Connecticut Department of Transportation and asked for their help. As if that was not enough, she convened a group of volunteers from IPANE and the Connecticut Invasive Plant Working Group to help pull and bag plants. After learning of other nearby incursions, she started a local program to locate additional incursions and helped raise money to support further control efforts. Not bad for a volunteer, working with volunteers.

Lastly, IPANE received a report of Kudzu in southwestern Connecticut through its "Report a Sighting" webpage. The site, on which there was an extensive stand of this well-known invasive plant, was visited to verify the report which was, unfortunately, correct. It appeared as if the property belonged to the Connecticut Department of Transportation (CT-DOT) because of its proximity to an abandoned toll plaza on a major interstate highway. IPANE contacted the CT-DOT and as soon as they ascertained that they did have responsibility for the site, they sent their roadside vegetation control staff to spray the infestation. CT-DOT continue to monitor the plants and have re-sprayed individual branches that appear to have survived the initial treatment. In 2007, The Canadian Food Inspection Agency and Environment Canada convened a meeting in Truro, Nova Scotia, to discuss invasive species initiatives in the 4 Atlantic Canada provinces; New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland. The meeting, "Atlantic Environment and Invasive Plants: Who, What, When, Where, Why, and Weeds," was to look into collaborative possibilities for managing invasive plants. Representative of National and

Provincial government agencies, conservation organizations, academia, and concerned individuals attended the 2 day meeting. Les Mehrhoff was invited by Bruno Gallant, of the Canadian Food Inspection Agency to make a presentation about IPANE as "the neighbour to the south and west of the region" representative at the meeting. At that time he discussed IPANE's role relative to Early Detection and how a volunteer-based collaborative like IPANE could work in Atlantic Canada.

After the meeting, Mehrhoff discussed with some IPANE staff, the idea of a regional network of Early Detection "Alerts" that would include New England and ultimately New York State, the 4 Atlantic Canada provinces, and hopefully Quebec. Alerts were to focus only on completely novel occurrences of non-native taxa known to be invasive in other areas but as yet unknown in the region or of known invasive species, already here in some parts of the network's coverage that are beginning to show marked expansion throughout parts of the area. People included in this system would be responsible for early detection and rapid response or for programs that were directly involved with invasive plant control in the region. The proposal that we envisaged had 3 phases. Phase I of this plan was to develop a system of regional alerts for New England. This would consist primarily of a moderated list-serve that would be by invitation only and get limited use. Phase II was to expand into New York State and Canada. Phase III was the local dissemination of information travelling over this network to people on the ground who could both watch for the species and help with management and control if it was discovered. The intention was to build the system through Phases I and II and then those involved in Phase II would develop the lists of contacts and mechanisms for contact of the Phase III partners. A feed-back loop mechanism was also envisaged as part of the network.

The Fig buttercup (*Ranunculus ficaria* L.) provides a useful example of how this kind of international network could benefit Atlantic Canada. This plant has been known in New England since the last decade of the Nineteenth Century although it is unclear if the specimen came from a garden or was taken in the wild. It is now increasingly common in Connecticut, Rhode Island, and Massachusetts. It does not appear to exist in Vermont but there is a 1962 record, apparently collected in the wild, of its occurrence in southern New Hampshire. It was recently reported as growing wild (garden escape?) in a botanical garden in Maine. It also has been planted in a botanical garden in St. John, Newfoundland (C. Kasimos, pers. comm.). Fig buttercup appears to be rapidly spreading in the southern New England states and adjacent New York State as an increasing number of reports of new incursions are obtained every year. Notifying list-serve members of the apparent increase and spread of this species would alert members to be on the lookout for this species in non-cultivated situations. Alerts would also warn people working in botanical gardens in both Maine and Newfoundland to take special care with this species, hopefully removing it before it begins to disperse away from where it was found or intentionally planted. If it is completely removed from these 2 sites, its ultimate arrival and spread into northern areas might be dramatically delayed or even stopped. This might help avoid the control nightmare that currently exists where Fig buttercup is now a serious problem.

Unanticipated funding limitations have not permitted the implementation of this project beyond the discussion stage. It is hoped that recent budgetary plans for 2009 will again include this worthwhile project. This proposal clearly advances the goals of the National Early Detection Network to an international level. Data flowing through a network of programs similar in content and scope to IPANE, could provide a very strong and effective tool to be used against the spread of invasive species. It is clear how a network as outlined could provide a very effective EDRR network for northeastern North America and should be put in place as soon as financially feasible. It remains IPANE's intention to do this.

Acknowledgements

We would like to thank the numerous people who have supplied information or comments on the network of Early Detection Alerts proposed here, the distribution of taxa discussed, and who have supported the entire concept of a volunteer-based National Early Detection Network. We would also like to thank the IPANE volunteers for so generously giving of their time and knowledge.

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Building an Early Detection and Rapid Response Framework for British Columbia: Successes and Challenges

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Abstract

The British Columbia Early Detection and Rapid Response (EDRR) Framework was developed in collaboration with all levels of government and the Invasive Plant Council of British Columbia stakeholders. The Framework provides a potential model to formalize the EDRR to new and emerging invasive plants in British Columbia. It outlines the potential roles and responsibilities of "key players" and information on the crucial processes and steps required to successfully implement an EDRR system, including surveillance, incursion communications, invasive plant risk assessment, incursion management, monitoring, reporting and preventative action. The Framework will be discussed with respect to successes, challenges, and lessons learned during its development.

Resumen

El Marco de detección temprana y respuesta rápida (*Early Detection and Rapid Response Framework*, o EDRR) para Colombia Británica fue elaborado en colaboración con todas las partes interesadas de los diversos niveles de gobierno y del Consejo para Plantas Invasivas de Colombia Británica (*Invasive Plant Council of British Columbia*). Ese marco establece un modelo que formaliza la detección temprana y la respuesta rápida para las plantas invasivas nuevas y emergentes en la provincia de Colombia Británica. Describe las funciones y responsabilidades de los actores principales e incluye información sobre los procesos cruciales y los pasos necesarios para implementar con éxito un sistema de detección temprana y respuesta rápida, tales como vigilancia, manejo de incursiones, evaluación de riesgos de las plantas invasivas, manejo de incursiones, vigilancia, notificación y medidas preventivas. El marco será examinado en términos de los éxitos que ha logrado y la experiencia acumulada durante su elaboración..

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About the Invasive Plant Council of British Columbia

The Invasive Plant Strategy for British Columbia (and subsequently, the Council) stemmed from a call to action by the Fraser Basin Council in response to the growing threat of invasive plants in British Columbia (BC). The goal of the Strategy is to build cooperation and coordination to protect BC's environment and minimize negative social and economic impacts caused by the introduction, establishment, and spread of invasive alien plants.

The Invasive Plant Council of British Columbia (IPCBC) is guided by a Board of Directors, which is comprised of 17 individuals representing a variety of perspectives. Directors are selected by perspective at the Annual General Meeting. Perspectives on the Board of Directors include federal government, First Nations, provincial government, local government, forest industry, mining, agriculture, utilities, transportation, regional committees, conservation and wildlife, recreation and tourism, and horticulture. Five committees provide direction to the Board of Directors on key IPCBC actions: Research and Development; Technical and Operations Support; Communications and Awareness; Finance and Fund Development; and, Regulation, Compliance and Enforcement. All of these committees are open and inclusive.

Regional Districts and Regional Weed Committees form a collaborative network across BC. These organizations complete localized invasive plant management and/or outreach programs in their respective regions.

Building an EDRR Framework for BC

The Early Detection and Rapid Response (EDRR) Framework for BC is consistent with the objectives of the Invasive Plant Strategy for BC, the Invasive Alien Species Strategy for Canada, and Invasive Plants in BC's Protected Lands: A Strategic Plan. Additionally, the development of this framework strongly drew on existing models including regional EDRR plans across BC; Weed Alert Rapid Response Plan Victoria 2004/2005 (Australia); Tasmanian Weed Alert Network (Australia); State Response Plan to New Weed Incursions (Australia); National Weed Detection Project (Australia); and Weed Spotter Network (Australia). The Framework was originally drafted by Amanda Moncrieff (Department of Environment and Conservation, Western Australia) and revised by both Jodi Romyn (IPCBC) and Jane Perry (J. Perry Resource Communications).

The development of the Framework was initiated by a joint meeting with representatives from federal, provincial, and local governments and was identified as a key task for the IPCBC. A committee was formed to draft the Framework, which was then circulated to all levels of government as well as to Regional Committees and others for feedback. All of the input received was incorporated into the current version (Version 7).

The intent of the Framework is to provide a collaborative, pro-active action plan to address the introduction and establishment of new and emerging invasive plants in BC. This draft Framework recognizes existing EDRR systems, attempts to build on lessons learned from regional EDRR initiatives, and aims to complement existing structures. The draft Framework describes processes, steps, and responsibilities of "key players" needed to implement a strengthened EDRR system for BC. Overall, the Framework identifies the two most effective strategies to protect BC's environment and economy against the threat of invasive plants: 1) prevention; and, 2) early detection.

Processes involved in an effective EDRR program include: surveillance; incursion reporting, identification, and collection; incursion distribution; risk analysis; decision making; response (incursion management); communication and information; monitoring and outcome reporting; and, ongoing prevention.

Surveillance includes an Invasive Plant Alert Network, which is a formalized province-wide network of 'spotters and specialists'. This network assists in structured reporting (early detection) as well as training and ongoing information sharing. Some Regional Committees have such volunteer programs already in place around the province. Reporting incursions involves several initial steps including species identification, voucher collection and notifying to the EDRR regional contact (e.g., Regional Committee). From there a summary is provided to the EDRR Program Coordinator, who is tasked with the overall coordination of the EDRR program for BC, and a dialogue is initiated with key stakeholders. IPCBC, Inter-Ministry Invasive Plant Working Group (IMIPWG), and Regional Committees are then notified of the incursion and field data related to the incursion is entered into the provincial Invasive Alien Plant Program (IAPP). If required, a specimen of the suspected invasive plant species is sent to an institutional herbarium for identification.

Once the species is identified the Invasive Plant Assessment Panel conducts a risk and impact assessment and the extent and distribution of the incursion is confirmed. The Invasive Plant Assessment Panel will provide recommendations for the new incursion based on both the assessed risk and the extent of distribution within the province. An appropriate level of response—high, medium or low—will be assigned to the incursion and forwarded to the Rapid Response Management Team. Similar processes are currently functioning in some regions of BC and include staff from the Ministry of Agriculture and Lands, the Ministry of Forests and Range, the Royal British Columbia Museum, and many invasive plant specialists. The final decision on the response and allocation of resources required to address the new incursion will be made by key stakeholders, which form the Rapid Response Management Team. This team finalizes and implements a collaborative, multi-jurisdictional incursion management plan for high or medium responses. All land agencies must be involved.

To ensure communication and information sharing, regular updates on the status of the new incursion will be provided to the IPCBC, IMIPWG, Regional Committees, Regional Districts, target industries, and community groups.

Monitoring and outcome reporting for new incursions is essential in determining treatment successes and costs as well as to assess response measures against EDRR program objectives. If necessary, amendments can then be made to the process and outcomes can be communicated to key stakeholders.

Prevention is an ongoing, source-specific process that is needed to prevent future incursions of invasive plants in BC and can be achieved through initiatives like an alert list and ongoing education and awareness.

Successes

The EDRR Framework for BC is a joint goal of the IPCBC as well as federal and provincial government. The Framework was developed in collaboration with all levels of government, the IPCBC, key stakeholders, and Regional Committees and recognizes and builds on existing regional programs.

Challenges and Lessons Learned

Although some processes are in place, a strong collaborative, multi-jurisdictional approach is crucial to an effective EDRR program. A risk assessment needs to be developed that is clear, quick, useable, and action oriented. Additionally, an action plan needs to be drawn that identifies available resources, roles and responsibilities, and lead agencies.

Overall, EDRR requires time, collaboration, and resources. Above all else, we must remember that weeds know no boundaries…

Next Steps

Currently, the Framework is in draft version seven (as of November 2007) and several steps are required to move the process forward over the next year including the development of an invasive plant list as well as the identification of agency roles and responsibilities. The Framework is expected to roll out in 2009 with the goal of being a province-wide plan that incorporates and is supported by all land agencies is BC.

Contact Us

For information on the IPCBC, the draft EDRR Framework for BC or any other Council initiatives, please contact us by email at info@invasiveplantcouncilbc.ca, by phone at 250-392-1400, or by visiting www.invasiveplantcouncilbc.ca.

Invasive Plant Council of BC

Biography

Crystal Klym recently joined the IPCBC as the Assistant Coordinator in November 2007. Since 2000, Crystal has worked for a variety of organizations primarily in invasive plant management, but also in the areas of community outreach and education, outdoor recreation, national park feasibility study communications, and mine land reclamation. Crystal grew up in the Similkameen Valley of British Columbia, has a diploma in Integrated Environmental Planning Technology from Selkirk College, and is currently working towards her Bachelors degree in Environmental Management Degree from Royal Roads University. Crystal serves on the Okanagan Similkameen Conservation Alliance's Board of Directors and is an active member of the South Okanagan Similkameen Bike Club.

Gail Wallin currently serves as Executive Director for the IPCBC along with her senior role with the Fraser Basin Council, which has provided ongoing support since inception. Gail has been involved in all facets of the development of the Council from the beginning days from facilitating workshops, drafting plans to recruiting funds. With a formal background in biology, management and conflict resolution along with extensive experience in natural resource management, Gail has got to know communities (and plants) in all corners of BC. Williams Lake is home to Gail and her daughter Kyla and a base for their canoeing, skiing, and camping adventures across the Cariboo and BC.

Addressing the Threat of Invasive Alien Species in Alberta: A Tool for Assessing Risk and Prioritizing Response

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Abstract

In order to appropriately respond to an invasive species, it is critical to understand the risk posed by the species to the environment, the economy and society. Of equal importance, is the ability to quickly assess the risk of a species so that immediate action can be considered. Alberta's invasive alien species risk assessment tool is intended to allow a rapid, predictive, and quantitative assessment of the likelihood of adverse impacts from an invasive alien species that can differentiate risks related to varying landscape uses.

Using the tool, assessments can be completed relatively rapidly so species can be periodically reexamined. Rapid assessments also provide an opportunity for a rapid response that could prevent the establishment and spread of an invasive species.

Resumen

Para hacer frente adecuadamente a las especies invasivas, es crucial comprender el riesgo que representan para el medio ambiente, la economía y la sociedad. Es igualmente importante contar con la capacidad de evaluar rápidamente el riesgo representado por una especie, que permita tomar medidas inmediatas si fuera necesario. La herramienta de evaluación rápida del riesgo de plantas exóticas invasivas de Alberta está concebida para permitir una evaluación rápida, predictora y cuantitativa sobre la posibilidad de impactos adversos causados por una especie exótica invasiva, que puede distinguir los riesgos relacionados con los diversos usos del paisaje.

La herramienta de evaluación también es flexible, puesto que está concebida para diferenciar los riesgos según los diversos usos del paisaje (por ejemplo, áreas agrícolas con respecto a área naturales, o lagos destinados a la recreación con respecto a humedales). La diferencia en la utilización de los paisajes hace que su nivel de exposición a las especies invasoras o los impactos potenciales de las mismas sean distintos y

la herramienta de evaluación rápida (RAT) se está desarrollando para ilustrar dichas diferencias.

La herramienta permite también hacer una evaluación de la certidumbre para cada pregunta formulada. Esta información permite al asesor identificar en qué lugares se requiere información adicional para mejorar la evaluación o comprender mejor las especies invasoras.

Gracias a esta herramienta, las evaluaciones pueden completarse con relativa rapidez, de tal manera que las especies pueden reexaminarse periódicamente. Además, la evaluación rápida brinda la oportunidad de responder rápidamente, lo que podría prevenir el establecimiento y la diseminación de una especie invasiva.

Introduction

Invasive Alien Species (IAS) are increasingly recognized for their global and local impacts to our economy, our social values, and our natural environment. IAS are defined as organisms introduced or spread outside their natural past or present distribution, and threaten the environment, the economy, or society, including human health.

In the United States, approximately half of the species listed as threatened or endangered under the Endangered Species Act are considered to be at risk primarily because of competition with or predation by non-indigenous species (Wilcove et al. 1998). In other regions of the world, as many as 80% of the endangered species are threatened and at risk due to the pressures of non-native species (Armstrong 1995).

Currently there are gaps in our knowledge of IAS and their impacts to Alberta's economy. Information on IAS is too fragmentary to permit an assessment of total cost to the province. Extrapolating from the United States, it is conservatively estimated that IAS costs Alberta approximately $1 billion per year over all sectors of the economy (McClay et al. 2004). Worldwide, IAS are generally considered to be the second greatest threat to biodiversity after habitat destruction (Wilson 1992).

Historically, the process for identifying and managing IAS in Alberta has primarily been reactive. The focus has often been on the control of established species and the prevention of further spread. Management priorities are primarily determined by considering production losses alone, and are not always allocated in relation to the level of risk. Lesser-known species, for which the impacts are not well understood, are often overlooked (e.g., invasive aquatic species such as *Didymosphenia* alga).

Objectives

The purpose of the IAS Risk Assessment Tool (RAT) is to provide a systematic and quantitative decision-making tool that can be used by governments, companies and individuals. The tool can assist in the prioritization of alien species for management by estimating their likelihood to establish, spread and adversely impact Alberta's economic base, social values, natural resource productivity and biodiversity. As most resource management decisions incorporate environmental, economic, and social considerations, the integration of these elements into the tool was a key objective in its development.

The RAT allows for a consistent approach to assess the impacts of IAS threatening to enter or currently established in Alberta. The tool outputs can provide a focus for containing, controlling or eradicating IAS across jurisdictions. In addition, information from the RAT can be used to inform and support communication strategies, and early detection/rapid response initiatives to prevent the establishment and spread of IAS. The ranking ability of the tool will also support and rationalize the legislative listing of restricted species.

Resource management in Alberta is conducted on a variety of scales, from the individual landowner, to the county and municipality, to regions, to the province. For best utility, the RAT was intended to be scalable to the needs of the various managers. This ability would ensure the tool was more broadly applied across the province.

The RAT was intended to be able to complete risk assessments relatively rapidly, especially in comparison to more detailed, quantitative risk assessments, some of which require years to complete. This rapid assessment approach supports the re-examination of a species over time with the addition of new information.

While conceptually, the RAT could be used to assess any species, the intended scope of the tool has been focused on assessing the potential risk associated with terrestrial plants and unintentionally introduced aquatic species. In part, this focus is to make the development of the tool more manageable, but it also recognizes that other assessment processes exist for cases such as intentional transfer of species (National Code for Introductions and Transfers).

The tool also fulfills an educational purpose by providing users with information on those factors affecting exposure to potentially invasive species and the effects of such species on the environment, the economy, and society.

Risk Management Framework

The RAT is a foundational component of Alberta's IAS Risk Management Framework. The Framework is a systematic process that allows a proactive, cost-effective, and consistent approach to assess and respond to identified impacts from invasive species. It consists of four key incremental stages (Figure 1):

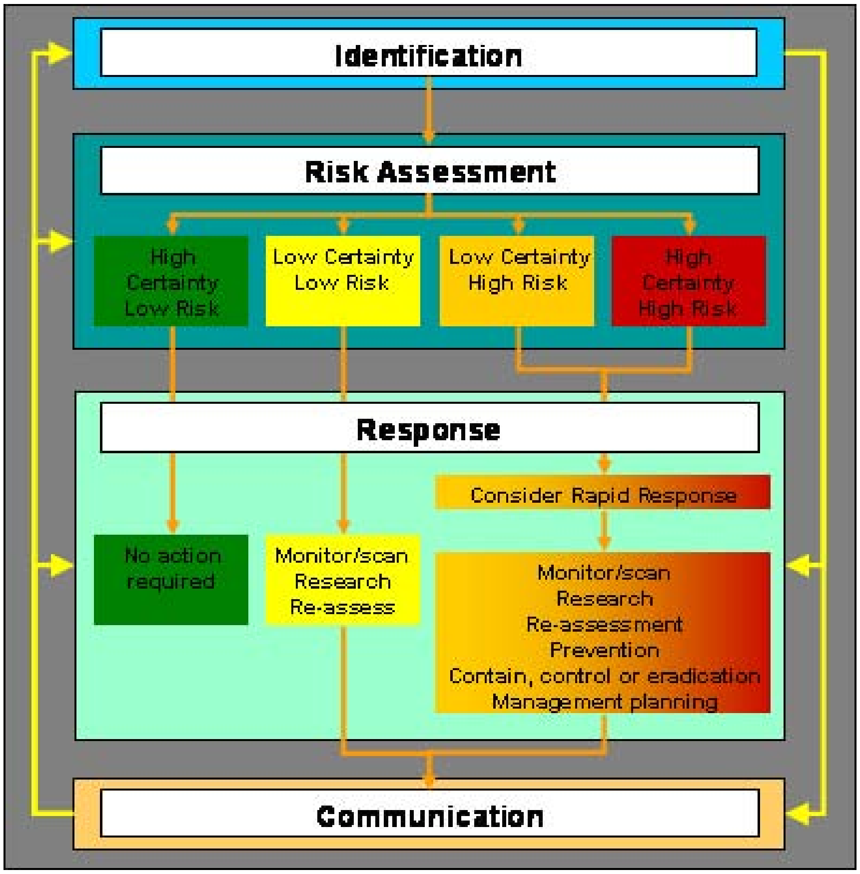

Figure 1. Risk Management Framework.

Identification

The identification of IAS threats is accomplished in the first step through scanning and monitoring for IAS. Scanning is a means of identifying IAS that are likely to invade through existing pathways or from adjacent jurisdictions. Monitoring is used to detect new occurrences of IAS and to assess the status and distribution of IAS already established in Alberta.

Risk Assessment

Second is a rapid assessment of IAS risk using the RAT. The tool allows a predictive, quantitative, rapid assessment of the likelihood of adverse impacts from potential and established IAS in environmental, social and economic terms.

Response

The third stage of the framework is to develop and implement a response appropriate to the risk posed by the IAS. The overarching goal of IAS management is to reduce the risk of environmental, economic, and social harm through efficacious management responses, such as prevention, direct control actions, and policy or legislation.

Communication

The last stage of the framework utilizes a suite of communication actions to enhance awareness, establish best management practices, and promote cooperative actions. While positioned within the framework as a discrete stage, communication activities are intended to support all stages of the framework.

Tool Development

The initiative to develop Alberta's invasive alien species risk assessment tool was spearheaded by the Inter-departmental Invasive Alien Species Working Group (IASWG) late in 2006. Staff from several Alberta government ministries participate in the project.

AMEC Earth & Environmental (AMEC) was retained by the IASWG in January 2007 to develop the groundwork for the RAT. AMEC's work involved a literature review of existing risk assessment systems and risk indicators used in these systems. This was a critical stage to determine the initial functionality of the risk assessment system, select appropriate risk indicators, and complete the first version of the tool. Several unique features were incorporated into the RAT version 1, including the assessment of user confidence in the scores provided.

The RAT version 1 was widely distributed to invasive species managers in Alberta and across Canada. Feedback from this review was collected via an online survey and incorporated where appropriate.

On March of 2007, an expert panel consisting of national and international risk assessment and invasive species specialists was assembled to further review and suggest improvements to RAT version 1. The panel strongly supported the tools approach in integrating environmental, economic, and social elements. Of the numerous comments from the expert panel, many focused on the over-simplification of the social and economic effects sections, the use of "unknown" answers, and the validity of the risk calculation.

This led to the development of the RAT version 2. The revision of the tool was intended to address many of the expert panel concerns. Gardner Pinfold Consulting was contracted to propose modifications and extensions to the economic and social sections of the tool. The working group itself tackled the reorganization of the tool and addressed the calculation of risk. Through 2007 and the early part of 2008 IASWG further reviewed and refined the RAT version 2.

Risk Assessment Tool, version 2

The RAT is based on a simple, four step procedure (Figure 2). Users provide information or address specific questions within the first three steps with the final step consisting of a summary and analysis of the information provided to calculate risk numbers.

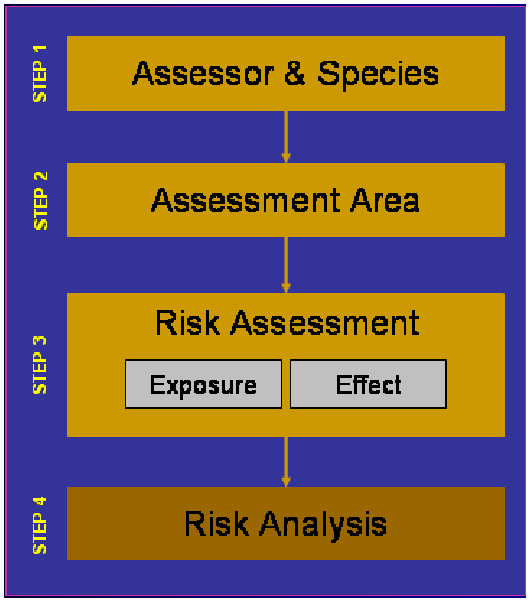

Figure 2. RAT four step procedure.

Step 1: Assessor and Species Details

In Step 1 (Assessor and Species Details), the user provides the relevant information about themselves and the species they are assessing. The species information includes descriptions of restrictive and protective rankings, and quarantine or importation information. As this information may vary by jurisdiction, the tool distinguishes between the varieties of jurisdictions neighboring Alberta. The information provided by the user within this section is not used in the calculation of risk, but is used to capture useful information about the species so that it can be provided along with risk scores calculated from other sections of the RAT.

Step 2: Assessment Area

Step 2 (Assessment Area) is where users describe their assessment area. Given the scalable nature of the RAT, a clear description of the assessment area is required so that the users of the tool can understand the boundaries of the area assessed, as well as other factors that may affect the assessment of risk, such as location and topography. The user is also asked to provide an estimate of the percentage of their assessment area in each of the provinces natural sub-regions and watersheds. For the assessment of aquatic species, the tool asks for the percent area of specific aquatic features such as lakes, rivers, wetlands, etc.

Within Step 2, the user is asked to provide an estimate of the differing land and aquatic uses. For example, an assessment area may be 80% agriculture, 10% forestry, 5% parks, and 5% urban.

Alternately, aquatic uses such as irrigation, recreational fishing, aquatic habitat and others may be described. These estimates are intended for use in adjusting the overall calculated risk by the uses within an assessment area; however, this adjustment has not yet been integrated into the RAT version 2.

Step 3: Assessment Questions

The most significant and substantial step in the RAT version 2 is Step 3 (Assessment Questions). In this section, users are asked to answer a series of questions that will ultimately be used to calculate environmental, economic, social, and overall risk associated with the assessment species.

Questions are accompanied by a rationale section that is intended to provide key information on why the questions or grouping of questions is important to the assessment of species. To some degree, the rationale is an educational and information background for why the tool poses the question.

In addition, the user's ability to consistently answer the questions is supported by the provision of guidance. These sections are specifically intended to provide instruction on how to translate the user's assessment of the species into one of the answers and scores provided. In many cases, the guidance sections use examples to illustrate the potential answers to the assessment questions.

Questions

In total, there are 59 questions in Step 3 of the RAT and these are subdivided in Exposure, Environmental Effects, Economic Effects, and Social Effects sections. The Exposure questions are further subdivided into five main groupings, and these are:

Present status	questions on presence, abundance and distribution intended to answer *Is it here?*
Introduction	assessment of the potential pathways of introduction, both natural and anthropogenic, and the species transit abilities, such as number in transit, survival, and detection, to determine *Can it get here?*
Survival	evaluations of potential habitat, climate, and the species tolerance for varying environmental conditions to establish *Can it survive?*
Establishment	consideration of the species reproductive abilities, number of offspring, survival, and other factors to assess *Can it establish?*
Dispersal	review of the natural and anthropogenic dispersal mechanisms for the species to establish *Will it spread?*

The remaining sections pose questions that focus on the potential effects of a non-native species on the environment, the economy and society.

Environmental effects questions of the RAT investigate the potential effects of competition, predation/parasitism, host/vector, and hybridization on other species. In particular, the questions aim to differentiate between the potential effects on desired non-native species, secure or abundant native species, and vulnerable or "at-risk" species. By differentiating based on these groupings, the user can begin to separate potential effects by land use. For example, in a park or natural area setting, the effects on vulnerable species is of particular importance, while in an agricultural or an urban setting it is the desired non-native species that may be of particular concern. In addition to the species level questions, the environmental effects section also poses a question relating to abiotic or ecosystem processes. This question refers to potential effects on non-biological ecosystem components such as water or nutrient availability, soil structure, and others.

The questions in the Economic Effects section focus mainly on those activities producing goods and services for profit and were based on the sectors described in the North American Industry Classification System (NAICS). One question, concerning health, is an exception to this approach. The health question is included in the economic section because of the possibility that an assessed species could lead to substantial health care costs.

Potential effects of an assessed species are either Direct (imposes costs directly on production activities or directly reduces productivity) or Indirect (imposes costs by affecting other species or natural processes which in turn affect a production activity). These potential effects span the range of market activities (goods and services that have a market price) and non-market activities (goods and services that do not have a market price, often natural features of the environment).

The Social Effects section encompasses a number of possible direct and indirect effects on human activities, on natural processes that provide some human enjoyment, or on human's perception of the environment.

Answers

For each of the 59 questions, the user can select from up to five categorical answers provided. Each categorical answer corresponds to a numerical score; this score is used in the calculation of risk.

In all cases, the user can answer "Unknown" if information is not available to answer the question. These unknowns are of importance within the tool, as they point to the potential data gaps for the species being assessed. These gaps may in turn provide a focus for research.

Where the question posed is of particular importance in assessing the potential for exposure to a species (e.g., available habitat), the numerical scores have been doubled or tripled to reflect the relative importance of the question.

The RAT is intended to rank species by their risk and not quantify the risk (as in a detailed quantitative risk assessment. As such, the score weighting simply reflects the relative importance of the question in relation to the other questions. The weighting is not intended to quantify the difference in importance between questions, but simply reflect that one question is relatively more important than another.

Confidence

In addition to the categorical answers, the user can assign a confidence rating to each answer they provide. For example, an assessment of a well understood species where the user drew information from documented sources, confidence ratings would be high. In cases where the user was unsure of an appropriate answer, the confidence in the answer would be low. Confidence ratings are integrated into the calculation of risk, such that low confidence would increase final score for a question.

Low confidence ratings are assigned a score of three, medium ratings are scored as two, and high confidence ratings are scored as one.

Rationale

This field is intended to allow a user to document why they answered the way they did and provide additional information and considerations for assessing the species. This area is also intended to capture citations of source information, such as published information, web based resources and others.

Step 4: Risk Analysis

The analysis and calculation of risk in the RAT version 2 is relatively simple. The stepwise description of the calculation of risk is as follows:

Integration of Confidence

- For each question, the answer score and the confidence score are multiplied together.
- Example: Answer score = 2, Confidence score = 3 (high), Overall score = 6

Summation of Sections

- Each section (Exposure, Environmental effects, Economic effects, and Social effects) is summed.
- These totals are subsequently used to calculate risk.

Calculating Risk by Effect

- For each type of effect, risk is calculated individually using the standard equation for risk.

$$\text{Environmental risk} = \text{Exposure} \times \text{Environmental effect}$$

$$\text{Economic risk} = \text{Exposure} \times \text{Economic effect}$$

$$\text{Social risk} = \text{Exposure} \times \text{Social effect}$$

Calculating Overall Risk

Overall Risk = Exposure ((Environmental + Economic + Social effects)

The stepwise progression allows the user to track backward through the tool, its questions, and calculations, to understand how the final answer was achieved.

Next Steps

A number of "next steps" are envisioned for the RAT to improve its function and test its assessments. The intended focus for the RAT is terrestrial plant species and unintentionally introduced aquatic species. While the majority of questions and their answers are suitable for both terrestrial and aquatic species, there is still a requirement to adjust some questions and answers to more fully address aquatic species.

The RAT is also intended to differentiate between the risks to different land or aquatic uses. In this case, risk would be calculated based on the answers to only those questions relevant to a particular land use.

The RAT is expected to undergo testing, where a suite of species are assessed in order to determine if the tool can differentiate between species and also provide relatively consistent results.

The tool is likely to be developed into an online calculator that will enable a broad spectrum of users to access and use the tool.

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Biography

Scott Millar is a professional biologist with Alberta Sustainable Resource Development. He joined the Government of Alberta in 2005, after 13 years in fisheries consulting industry. Scott presently chairs the Alberta Interdepartmental Invasive Alien Species Working Group and represents the province on the National Aquatic Invasive Species Committee.

Weed Management in Alberta's Oil and Gas Industry

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Abstract

Penn West Energy Trust, with assistance of AMEC Earth & Environmental, developed an on-line database application to manage weed data for their oil and gas developments in west-central Alberta. Penn West has adopted a pro-active approach of gathering and tracking of weed (control) information, by developing a systematic weed management plan. The database is an integral tool in their weed management process, and was developed to provide the following key information and functions:

- Species specific weed infestation reviews
- Weed control information and status reports
- Visual display of infestation problems (mapping capabilities),
- Evaluation of management techniques
- Cost analysis reports
- Progress monitoring and reporting
- Quality assurance capabilities
- Historical data storage and review

Resumen

Penn West Energy Trust, con el apoyo de AMEC Earth & Environmental, desarrolló una aplicación de base de datos en línea para manejar la información sobre las malezas detectadas en sus terrenos de explotación de hidrocarburos localizados en la zona centro-occidental de Alberta. Penn West ha tomado la iniciativa, recabando y dando seguimiento a la información sobre el control de malezas, mediante la elaboración de un plan de manejo de malezas sistemático. La base de datos es una herramienta integral de su proceso de manejo de malezas y fue desarrollada para proporcionar la siguiente información y funciones clave:

- Revisiones sobre la infestación de malezas de especies específicas.
- Información sobre el control y estatus de malezas.
- Ilustración visual de problemas de infestación (capacidades cartográficas).
- Evaluación de técnicas de manejo.

- Standardized field inspection reporting
- Supplemental information storage

Reports can be conducted both on a site specific basis and on regional or province wide basis. This user-friendly database set up for field staff, field foreman or managerial personnel, retrieves information by on-screen data display or reporting functions. Periodic data can be retrieved ranging from daily progress reports to annual review reports.

Weed management plans are most effective when they are considered "living" documents: incorporating lessons learned, and continuously evolving to improve control techniques or anticipate and plan for future problems. The need for cooperative weed management planning and data sharing are imperative for this expanding industry and expanding threat of invasions.

- Informes de análisis de costos.
- Supervisión de avances y notificación.
- Capacidades de aseguramiento de la calidad.
- Almacenamiento y análisis de datos históricos.
- Estandarización de la elaboración de informes sobre inspecciones de campo.
- Almacenamiento de información complementaria.

Los informes pueden realizarse tanto para un sitio específico como para una región o provincia. Esta base de datos de uso sencillo, desarrollada para personal de campo, capataces de campo y personal de manejo, obtiene información presentada en pantalla o en informes definidos mediante funciones. Se pueden obtener datos periódicos, que van desde informes sobre avances diarios hasta informes de análisis anuales.

Los planes de manejo de malezas son más eficaces cuando son considerados documentos "vivos", es decir cuando incorporan la experiencia acumulada y evolucionan continuamente para mejorar las técnicas de control o anticipar y planificar respuestas en caso de problemas futuros. Se necesita con urgencia instaurar una planificación cooperativa para el control de malezas y el intercambio de información para esta industria en expansión y la creciente amenaza de invasiones de especies nocivas.

AMEC Weed Management Plan

AMEC Earth & Environmental (AMEC) has been working with Penn West Energy Trust (Penn West) to design an integrated weed management system using an on-line database application. AMEC has developed a systematic weed management plan for Penn West that enables the company to organize and prioritize weed information in a manner that will assist them with their annual weed management activities.

Weed Management Problems in Oil and Gas Industry

In the last 5 years, the oil and gas industry worldwide has been under increased pressure to expand production. With the oil prices being at an all-time high, companies are continually challenged to develop new sites and pipelines in order to keep up with the global demands. As an example of this growth, in 2007 Alberta alone saw a total of 11,000 new well sites built (not including pipelines and processing plants) in both natural forested and agriculture areas.

With the booming industry, the constant change in the number of sites under management is also a challenge. Common acquisitions of oil and gas companies or purchase of existing properties is a frequent occurrence. With each property transaction knowledge of the various levels of weed maintenance becomes lost, which further expands the array of challenges regarding weed management. Some sites have extensive weed control programs, while others are merely lacking, or only driven by legal enforcements from the local municipalities (which are often triggered by the local land owners). Expansions have the potential to produce an array of infestation and public image problems.

Every human activity that affects the landcape becomes a potential pathway for weed infestation. Some pathways are manageable, however, in many remote areas the risk of weed invasion is almost inevitable. There is some control on a regional level, where oil and gas companies can attempt to control their own activities. Common local weeds are no longer the only concern, as new weeds are introduced and forming new challenge for oil and gas operators. Consequently, it is going to be difficult to choose the right weed control solutions.

Hidden Costs

Once weed infestation is documented on a site, the consequences can be quite costly. These costs are commonly associated with the direct cost of weed control, but also the indirect cost associated with failure to receive reclamation certificates. The top three reasons for a reclaimed site not to receive a reclamation certificate are: 1) site compaction; 2) presence of industrial debris; and, 3) presence of noxious weeds on the site. Failure to receive a reclamation certificate commonly triggers additional assessments and a delay of site closure, resulting in additional operation and lease costs. For each well site delayed by a failed reclamation certificate, a conservative estimation of the additional annual cost is approximately $10,000/year.

As well, the cost associated with weed control is often under-estimated or, in some extreme cases, completely unknown. Cost-tracking is a major concern as the direct costs associated with weed management is often not analyzed as a separate cost. Frequently, weed control is considered part of site development or site maintenance cost. It is commonly accepted that this cost cannot be avoided or reduced. Compounding these costs, is the lack of quality control systems that determine if the correct weed control techniques are being implemented. As a result, weed control invoices are processed and paid, often, without question. If left unchecked, the hidden cost associated with weed management can easily accumulate into the hundred thousands or even million(s) of dollars.

Current Assessments

Often reclamation assessors for initial on-site reclamation assessments (Phase 1) are not experienced biologist and weeds are often overlooked until the final stages of the assessment. Reclamation failure for the presence of weeds is a consequence of lack of weed management. Effective weed control programs cannot function without proper analysis of critical data. The magnitude of the data associated with weed control can be overwhelming, and, with time become a costly endeavor to manage.

Consider the Following Scenario

"After attendance of all these great sessions of the conference, you have now all become experts in weeds and weed management. Congratulations, you have been hired as the new weed management coordinator for an Alberta oil and gas company! You are responsible for 10,000 sites across Alberta, but consider that continuous acquisitions as well as expansions in number of facilities are currently underway. You have no support staff, other than one office manager that is willing to help on the odd lunch hour with some minor data entry. You have a 4.5-month growing season in which you need to control and address any weed infestations, and all the information that we have on weeds in located in your office." All you need to do now is implement the plan.

The main issues that we need you to address immediately include the following:

- Cost – Find out what our total costs are, and reduce costs where possible.
- Data Management System – We currently don't have one, but perhaps it is a good idea to figure out how to deal with all these subcontractor invoices, and weed inspection notices, and a few weed inventories which are all found within these boxes of files.
- Education and Staff Involvement – Nobody knows much about weeds and weed control, what our obligations are, or who is responsible.
- Environmental Responsibility – We want to limit the amount of herbicides used, but when used, make sure we use them appropriately.
- Public Perception – We want to get rid of all these landowner complaints and lawsuits that we are currently dealing with, significantly reduce the number of municipal weed notices, and show the public and governing organizations that we have a good weed management plan in place. We also want to be on the nomination list for various environmental stewardship awards to improve our public image.

- Weed Management Plan – We need to figure out a weed management plan and how it should be implemented, in an effective and cost efficient manner. You will also need to provide us with interim progress report, since we need to be able to justify your position (salary) to upper management.

Thank you for taking on this challenge, and good luck!

With internal expertise on weed management often lacking, cooperation with experts and a data management systems is essential. To make informed decisions that are effective in the long-term, consistent and complete data collection requires management and logical presentation. A weed database can produce invoices, track effective weed management systems, identify problematic sites, identify trends and improvements, as well as track of progress and success.

Figure 1. Your new office.

Who is Penn West Energy Trust?

Penn West is an industry leader in the area of environmental awareness and is committed to minimizing the environmental impact of its oil and gas operations. Based in Calgary and currently operating in the three Prairie Provinces, Penn West has developed an Environmental Policy and Plan aimed to meet or exceed all provincial and federal laws, regulations and standards pertaining to the environment.

Since 2005, Penn West has been involved with the development of a pro-active weed management program and database. In that same year, Penn West achieved the Gold Level status in the Canadian Greenhouse Gas Challenge Registry and currently is also an active Platinum Level Participant in the Canadian Association of Petroleum Producers Stewardship Program. This Platinum level is the highest level attainable in this program, which aims to "foster continuous improvement in the industry's environment, health and safety performance."

The Weed Management Database

The Weed Management Database is designed to be accessible by all Penn West employees from various office and remote locations. The database is web enabled (via the Windows Internet Explorer™ web browser), with access secured by assignment of individual usernames and passwords. Access status is segregated based on the authority to view only or modify data. Through, various reports and screens, it provides easy access to general or site specific information. The database is designed to be a live database.

Reports

Standardized reports are designed to provide common searches, with built-in adaptability for additional customized data reports. This will allow for database flexibility in weed management strategies. These summary reports can be site specific (single site) or can be specified for a range of sites in a particular (production) area. Data can be sorted on a specified time frame (daily, monthly, yearly), which further aids in the progress tracking and status updates for internal reporting. In addition, specified cost reports can be generated. The database can also be employed as an educational tool, by generating general reports of information, including weed classifications (according to the Alberta Weed Act, and municipal bylaws), contact information, and weed photographs can be uploaded to assist in weed identification (although not currently available).

Data Consistency

The functionality of any database is limited by the quality of the information incorporated into the database. Standardized data has to be uniform in quality so that the data is comparable. To achieve this, standardized forms have been created and copies made available through the database. Some of these forms include the weed inventory, mowing reports, and weed control reports, just to name a few. Data consistency is also required from outside parties, including subcontractors who provide services. Subcontractor must agree to provide a minimum standard of information in order to receive payment for invoices issued, including: weather information during application, itemization of product and equipment used, and target weeds and physiological status of weeds. In addition some subcontractors provide site sketches to illustrate infestation locations; however, this is not currently a mandatory practice.

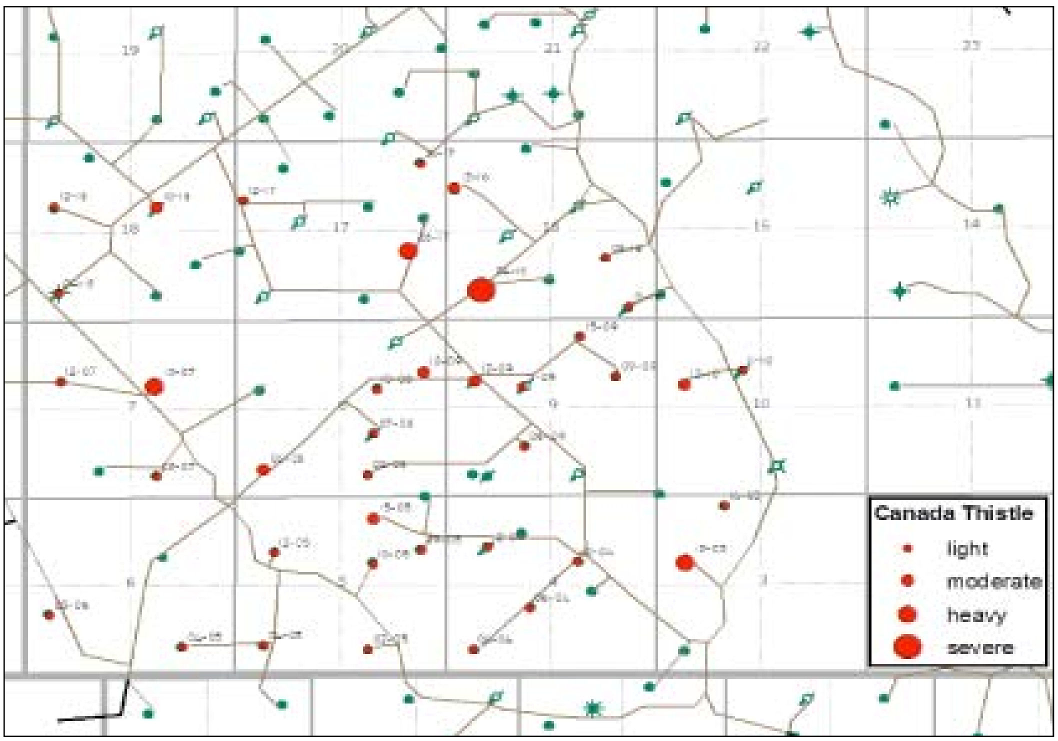

Figure 2. Weed inventory function example.

Inventory

A weed inventory function is built in the database to identify infestation problems. The infestation can be defined for a specific species or a group of species (i.e., all restricted weeds), or it can be selected based on infestation levels of any species (i.e., selection of all 'high' infestations of any weed). Furthermore, with incorporation of the database into a spatial Geographic Information System (GIS), infestation maps can be produced for a specified area or site (Figure 2).

Sub-Contractor Performance Evaluation

The database can also be used for quality assurance and eligibility for warrantee work, as many companies work with private contractors to manage their weeds. The quality of the applicators can be quite variable, with some applicators being very efficient and using the proper timing and control techniques, while others just respond to the request for weed control, without consideration of planning for long-term effectiveness. The database allows for subcontractor performance assessment, evaluation of the long-term effectiveness, cost analysis of the application, environmental impact analysis, methods used, and is there any warrantee work to be claimed.

Cost Analysis

Cost analysis is an important component of weed management. Justification of cost is sometimes hard to determine on such a large scale of sites (e.g., is the mowing program effective or should the mowing intensity increase or decrease). Each site is unique in its infestation and history of weed control as well as certain sites are more prone to infestation of specific species than others and may require more efforts for control. Area specific reports can be created to determine the average costs associated with that particular operation area. This may assist with expansion or acquisition decisions if problematic infestations are associated with high maintenance costs in that particular production area. Cost analysis can also assist in comparison of weed control methods (e.g., if a particular herbicide treatment does not control the weeds, then possibly a herbicide resistant weed is present, and therefore a different [sometimes cheaper] control method, such as tillage, may need to be considered as an alternative). A cost comparison of subcontractors can be made to determine what rates are being used for labour, equipment and products. Subsequently leverage for increased contracts may allow this sub-contractor to award discounted rates.

Historical Data

Historical and current data are incorporated to create or update a weed management plan or identify problematic sites. Review or a search can be completed on historical infestation levels, control treatments, timing and costs associated with treatments. This is especially helpful in times of disagreements with nearby property owners or in cases of potential herbicide damage disputes or new infestation responsibility.

Weed Management Planning

The ability to sort data based on specified sites and time, is a highly useful tool for weed management. Weeds are time sensitive in their susceptibility to specific weed control methods, which in turn are each associated with different treatment costs. In order to ensure effective weed control using the most efficient budget, consideration of site specific limitations must be included. The sorting capability of this database will assist in identifying trends, thus aiding in prioritization of tasks. It further allows for tracking of progress and identification of the level of internal cooperation. The database can assist in evaluation of specific weed control programs, such as mowing, tillage, or handpicking, not only for cost analysis, but also for evaluation of the reduction in weed infestation.

In order to evaluate the functionality of the weed management program, as with every (pro-active) system, it requires planning and implementation, but also review and revision on a yearly basis. The database also requires a skilled weed manager that can identify problems and solutions to address the evolving dynamic science of weeds. Certain activities may seem to work one year, but not the following year (herbicide resistance, change in landowner and surrounding infestation, or lack of summer staff availability to assist with mowing, weather, etc.). An annual review of the functionality and contents of the database is conducted and modifications are incorporated where possible.

Future Database Developments

The database is under continuous monitoring for effectiveness. The database can be tailored for modifications or expansions on an annual basis (potential incorporation of other pest monitoring such as clubroot [*Plasmodiophora brassicae* Wor.], is currently under review). Currently a calendar of weed management "events" may assist the weed coordinators in their weekly planning. By setting checkpoint items or milestones in the calendar, the database can assist the manager in directing their efforts. Time sensitive activities can be prioritized and using an automated weed control plan possibly connected with email reminders – e.g., mow weeds before flowering which is prior to June 1st. Even though some efforts are already being implement, cooperative weed control programs can be incorporated to work with regional stakeholders in addressing target weeds or general weed infestations.

As the database develops, GIS is becoming a more demanded component for the functionality of the weed control program (Figure 2). Visualization of results can help identify trends and problems. Incorporation of other GIS related data (roads, railways, utility corridors, pipelines, etc.) can provide further detail to assess potential future trends. Predictions of new infestations can be incorporated in the planning of weed management "events". The potential for some advanced modelling capabilities also exists. These are just a few examples that are currently being considered, but there are endless possibilities associated with this weed management database.

Summary

The main issues, such as cost control, data management, education, environmental responsibility, public perception and weed management planning, can be addressed with a weed management program that incorporates a data management system. Along with internal awareness and in house expertise, there is a willingness to take on environmental responsibility among most oil and gas companies. Weed management initiatives have been developed in order to address not only weed infestations, but also public perception and cooperation among adjacent land managers. In the long-run, weed management systems can add up to cost-savings and a cleaner and weed-free environment. But, it should always remain a dynamic process that requires timely review and modification in order to stay up-front in the race against new invasions of weeds.

Biography

Atty Bressler is an Environmental Agrologist for AMEC Earth & Environmental in Edmonton, Alberta. Born and raised on a dairy farm in the Netherlands, she obtained a B. Sc. in Agriculture from the University of Alberta and is now a Professional Agrologist with over ten years of experience in agriculture, environmental assessments and land reclamation.

Atty has developed a diverse background conducting and managing projects in Alberta, British Columbia, and Northwest Territories involving soil assessments, vegetation inventories, rare plant studies, agricultural land assessments and weed management programs. She has worked closely with public and private resource industry, the road building industry, as well as the oil and gas industry.

Prior to her employment with AMEC, Atty gained extensive experience in agricultural research, working with a number of rural agriculture producer groups and municipalities including weed management systems. She was the project manager for the initial development of the Alberta Invasive Species Risk Management Tool as presented herein by Scott Millar. Atty has recently been involved with the City of Calgary in development of the weed implementation plan and resource management plan, and was the project manager for the development of the weed management database presented here.

She loves to play soccer with her kids when she's not clearing her neighbourhood of noxious weeds.

British Columbia Invasive Alien Plant Program (IAPP) Application

Val Miller

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Abstract

Developed by the British Columbia Ministry of Forests and Range, the centralized web-based Invasive Alien Plant Program (IAPP) application is a complete invasive plant management tool. With its user-friendly interface and interactive mapping abilities, it was the first of its kind in Canada. Built on the robust Oracle 10g platform it allows for long-term growth and expansion, enabling natural resource managers in provincial and local governments, First Nations, industry, and regional weed committees to coordinate their field season activities, create professional reports and maps, optimize the use of their resources and avoid duplication of efforts by other agencies.

The many practical features of the IAPP application include not only the recording and visual map display of invasive plant inventories, treatments and monitoring records, but also boasts sophisticated querying, batch planning, and reporting capabilities using a number of Crystal Reports. Recently a brand

Resumen

Creado por el Ministerio de Bosques y Pastizales de Colombia Británica, la herramienta en línea del Programa de Plantas Alóctonas Invasivas (*Invasive Alien Plant Program*, o IAPP) es una herramienta completa para el manejo de plantas alóctonas invasivas. Con su interfaz de sencilla utilización y capacidades de cartografía interactiva, fue el primer programa de este tipo en Canadá. Construido sobre la robusta plataforma Oracle 10g, permite un crecimiento y expansión a largo plazo. Habilita a los manejadores de recursos naturales de gobiernos provinciales y municipales, de las Primeras Naciones, la industria y los comités regionales de malezas, para coordinar sus actividades en la temporada de campo, elaborar informes y mapas de calidad profesional, optimizar el uso de sus recursos y evitar la duplicación de esfuerzos entre instituciones.

Entre las numerosas y prácticas características de la herramienta IAPP están no sólo el registro y despliegue de mapas de inventarios de plantas

new “Report-A-Weed” feature was introduced which provides a simple, one-stop portal for anyone to submit weed sightings via the interactive IAPP Map Display site.

Training seminars are conducted around the province, free of charge, on an ongoing basis to introduce prospective agency users to the power of IAPP. Since its launch in 2005, IAPP has continued to introduce new features and upgrades based on feedback from its continually growing user community.

invasivas, tratamientos aplicados y registros de supervisión, sino que también ofrece sofisticadas funciones de interrogación, planificación de lotes y capacidades de elaboración de informes que utilizan una serie de informes *Crystal Reports*. En fecha reciente se introdujo una nueva función “Reporte una Maleza”(*Report-A-Weed*) que ofrece un portal sencillo y de un paso para que cualquiera pueda notificar la detección de malezas utilizando el sitio de visualización cartográfica (*IAPP Map Display*).

Se están impartiendo seminarios de capacitación gratuitos en la provincia, de manera permanente, para promover entre los potenciales usuarios de entidades gubernamentales las potentes funciones del IAPP. Desde su implantación en 2005, el IAPP ha continuado agregando nuevas funciones y actualizaciones basadas en la retroalimentación de la creciente comunidad de usuarios..

British Columbia (BC) is an extremely diverse province encompassing 94.7 million hectares. It is bordered by Alaska, the Yukon and Northwest Territories to the north, Alberta to the east, and the states of Washington, Idaho and Montana to the south. Seventy-five percent of the landscape is mountainous terrain with ranges separated by numerous lakes, rivers and plateaus. The north-west extension of the Canadian prairie is found in the north-east corner, and along the 27,000 kilometres of rugged coastline, 40,000 islands of varied size complete the British Columbia landscape. This diverse geography is reflected in the province’s wide range of climatic and ecological conditions. British Columbia has been classified into 14 biogeoclimatic zones, including the Bunchgrass, Ponderosa Pine, Coastal and Interior Douglas Fir, Coastal Western Hemlock, Montane and Sub-Boreal Spruce, and Interior Cedar-Hemlock zones, and covers 8 Canadian plant-hardiness zones. The variety and abundance of habitats suitable for invading alien species provides additional challenges for invasive plant managers.

One solution to assist in communication, collaboration, and effective planning of invasive plant programs, is the centralized web-based Invasive Alien Plant Program (IAPP) application. Developed by the BC Ministry of Forests and Range, IAPP is composed of two modules: 1) a database that houses inventory, treatment, monitoring, biocontrol agent dispersal, and planning information; and, 2) an interactive mapping component that displays the information. All land management agencies and stakeholders involved in invasive plant management in the province are encouraged to use IAPP and participation is expanding over time. Currently, four provincial

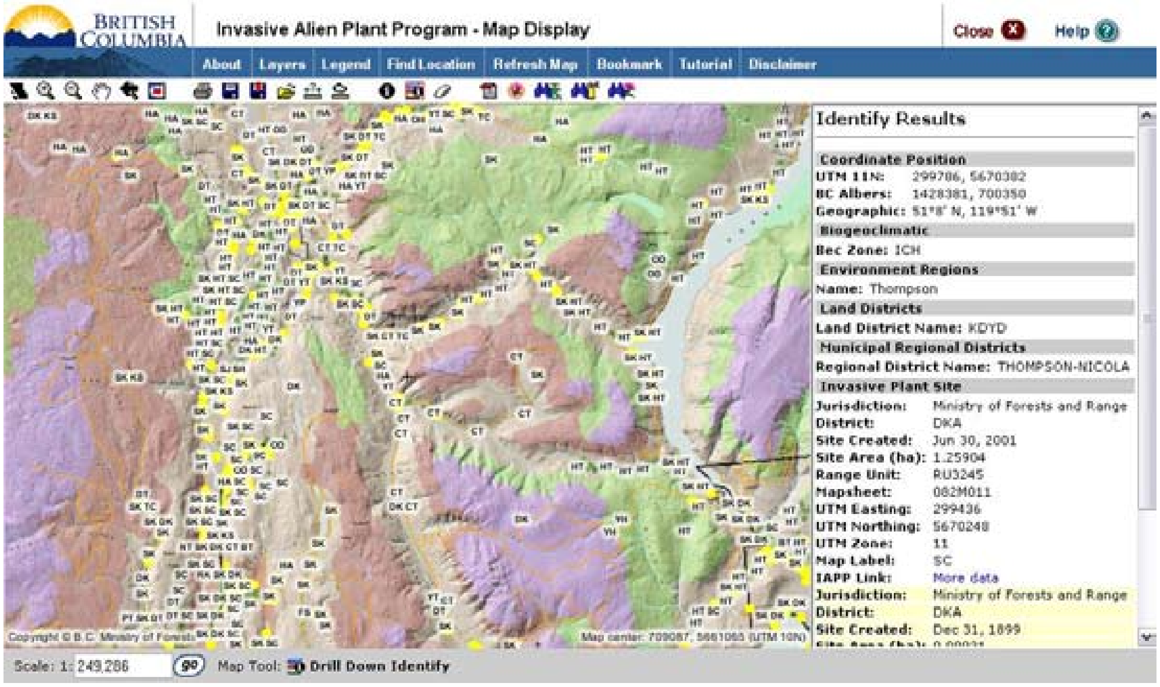

Figure 1. IAPP Map Display example with highlight query for sites with sulphur cinquefoil (*Potentilla recta* L.) selected, and detailed results on a selected location displayed.

ministries, most regional districts, several municipalities, regional weed committees, the Invasive Plant Council of BC, several utility companies, forest licencees and researchers are using the application to coordinate their field season activities, create professional reports and maps, optimize the use of their resources and avoid duplication of efforts with other agencies.

The IAPP Database and Map Display modules are fully integrated and the map display information is refreshed every 24 hours. IAPP Map Display is accessible by anyone with internet access. This module displays all the spatial invasive plant data in British Columbia, specifically the sites where invasive species have been found and any associated treatment activities. The invasive plant information can be displayed on one or many different layers, including administrative boundaries, topographic information, ortho photos, ecological habitat types, and maps can be printed for use in the field (Figure 1).

The on-line Data Entry Module is used for entering, editing, extracting and examining invasive plant data. To ensure integrity of the data that are displayed and shared with various invasive plant managers and land management agencies, access to this module is limited to authorized users of recognized agencies. Recognized agencies are those that have direct land management responsibility or are a local/regional invasive plant committee. Each agency is responsible for the integrity of the data they enter into IAPP. The Ministry of Forests and Range provides regular IAPP training courses throughout the province to ensure users are familiar with the program and can accurately enter their data. There are also on-line help and robo-demos available to enhance user knowledge.

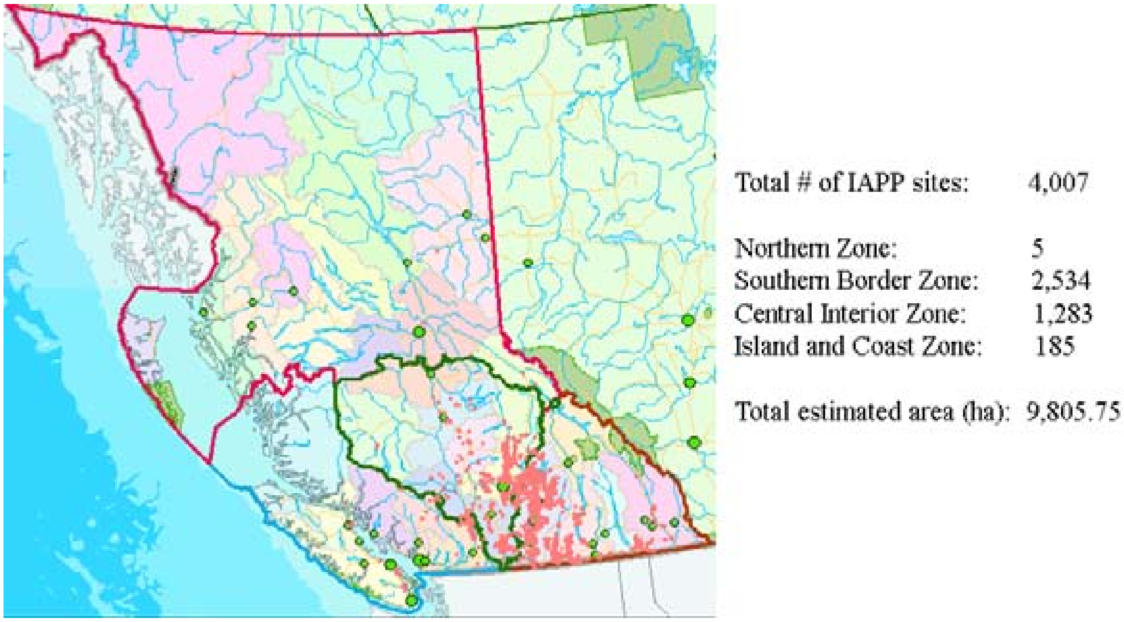

Figure 2. Total number of sulphur cinquefoil sites (pink dots) in British Columbia within Ministry of Forest and Range Invasive Plant Management Zones. Green dots indicate cities. Source: Ministry of Forests and Range, IAPP, May 5, 2008.

IAPP also provides the ability to search, extract information, produce Crystal Reports™ and upload photographs. Searches for sites, treatment or monitoring records delivers on-line results. Many extracts are available and can be viewed or downloaded as a Microsoft Excel™ spreadsheet, and used for analysis, planning or other purposes. Crystal Reports is a new functionality that will be available in January 2009. This utility will produce professional tables by selected agency for a specified date/year range of the following: Survey Report; Inventory Summary Report; Treatment Summary Report; Treatment Detail Report; and, Biological Control Monitoring Report. Uploading photographs to invasive plant site records or specific treatment activities is an easy function within the application. The only restrictions are that photos must be less than 200 kilobytes in size, and, due to privacy legislation, must not show people's faces, house numbers, or other identifiable private entities.

IAPP is an unprecedented management tool for invasive plant managers in BC. Data gathered in the field are entered into the IAPP Data Entry module where it is converted to spatial layers and loaded into the Integrated Land Management Bureau's Land and Resource Data Warehouse (LRDW). This centralized corporate repository of integrated land, resource and geographic information in British Columbia supports a large number of government applications, and provides spatial information to clients. Individuals or agencies can download the IAPP inventory site layer from the LRDW for their own mapping and Geographic Information System (GIS) needs. A simple example of this is depicted in Figure 2, which displays the total number of sulphur cinquefoil (*Potentilla recta* L.) sites in the province.

IAPP is built on the robust Oracle™ 10g platform to meet predicted long-term growth and expansion needs, and it is completely web-based and centralized. The provincial government covers the cost of maintenance and enhancement of features which leads to data management cost savings for participating agencies. Originally developed for Ministry specific requirements, an expanded version is under way that will address multi-stakeholder needs, improving ease of data entry and reporting capabilities. This new IAPP version 1.6 is set for release in January 2009.

An exciting component of IAPP 1.6 will be the establishment of a "Report-A-Weed" feature which will provide a simple, one-stop portal for anyone to submit weed sightings via the interactive IAPP Map Display site. In a simple three step process, the person reporting a new sighting either enters the coordinates of the site or selects the location by clicking on the enlarged Map Display, selects the plant species, enters the date of observation and size of infestation, and completes the report by entering their contact information for potential follow-up. Once submitted, the report goes through a site verification process with the IAPP data to determine if it is already a known location or within an area that is heavily infested by the reported invasive plant species. If it is a new location, the report is forwarded to the Invasive Plant Specialist for that area for further action and communication to the local Invasive Plant Committee. This new feature will help augment established and developing early detection and rapid response protocols in the province.

The use of the IAPP application by those involved in invasive plant management minimizes duplication of efforts, facilitates efficiencies and improved development of local, regional and province-wide management plans, and improves coordination of activities between jurisdictions. The IAPP application is one tool that is improving invasive plant management in British Columbia. The application can be found at http://www.for.gov.bc.ca/hra/Plants/application.htm.

Biography

Val Miller is the provincial Invasive Plant Officer with the British Columbia Ministry of Forests and Range. She is located at the Kootenay Lake Forestry Centre in Nelson, BC, where she manages a team of invasive plant specialists and seasonal staff that are strategically located across the province. A registered professional agrologist with a B. Sc. in Range Management from the University of Idaho, Val has been actively working on invasive plant species management and biological control projects in the province for over 20 years. She has collaborated with federal, provincial and non-government agencies, providing invasive plant species ecology and management advice as well as on-the-ground delivery of biocontrol, treatment, and inventory projects through partnership arrangements. Since re-joining the Ministry in 2006, Val has been heading up the maintenance and ongoing development of the provincial web-based Invasive Alien Plant Program (IAPP) application.

The *Weeds of Mexico* Website, Two Years after its First Publication
El Sitio Web *Malezas de México* a Dos Años de su Primera Publicación

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Abstract

The Spanish-language Weeds of Mexico website project was initiated in 2000. The first version was published in April 2006 at www.malezasdemexico.net with photographs and factsheets for 450 species; another 400 species had followed by October 2007. Today, the site receives about 200 pageviews/species/month (the large and multilingual site Fishbase has about 800 pageviews/species/month). The distribution of the pageviews shows that content (number of species in website/per family/level of coverage) drives use, together with placement in Google, and time. A cost-benefit analysis under Mexican conditions, considering only time saved for information procurement, shows an amortization in terms of public benefit within 1–2 years.

Resumen

El proyecto sitio web Malezas de México en español inició en el año 2000. La primera versión se publicó en Abril de 2006 en www.malezasdemexico.net con fotografías y fichas informativas de 450 especies; otras 400 especies se añadieron hasta octubre de 2007. Actualmente, el sitio registra aproximadamente 200 accesos/mes/especie (el sitio Fishbase, muy grande y multilingüe recibe aproximadamente 800 accesos/mes/especie). Los accesos muestran que el contenido (número de especies/especies por familia/nivel de cobertura) promueve el uso, junto con la ubicación en Google, y el tiempo. Un cálculo de costo-beneficio del sitio web bajo las condiciones de México, considerando solamente el tiempo ahorrado para obtener información, muestra una amortización en términos de beneficios públicos en 1–2 años.

1 Presenter.

Introduction

Mexico has a highly diverse weed flora, most of it native. It has the lowest proportion of exotic species of any of the North American Free Trade Agreement (NAFTA) countries (2.8 %) and the lowest proportion of exotic weeds among weedy species (22 %) (Espinosa et al. 2004, Villaseñor and Espinosa 2004). The absolute number of exotic vascular plant species (638 reported; Villaseñor and Espinosa 2004 and some unpublished data) is much lower than for the state of California (1025; Rejmanek and Randall, 1994). It is the area of origin for a high proportion of tropical weeds that are invasive world-wide (e.g., *Prosopis* spp., *Parthenium hysterophorus* L., *Bidens pilosa* L., *Amaranthus hybridus* L., *Cosmos sulphureus* Cav., *Argemone mexicana* L., *Lantana camara* L., *Mikania micrantha* Kunth, *Chromolaena odorata* (L.) King & H. Rob.).

Despite these conditions, there are some serious invasive species problems (March-Mifsut and Martínez-Jiménez 2008, Vibrans 2008). Examples are *Eichhornia crassipes* (Mart.) Solms or various tropical forage grasses, which were and are being introduced systematically and bred for better productivity and resistance. There are some advances in prevention and controlling the entrance of new species; a national strategy for invasive organisms is in a discussion stage and Mexico is participating in the drafting of the North American Plant Protection Organization (NAPPO) standards. Various other regulations are being discussed at government levels. Awareness and infrastructure challenges exist, as Francisco Espinosa describes in his contribution (Espinosa 2008).

However, the second step of an invasive species management program, rapid detection and response, is much less developed. There is little awareness of the problem in the general and professional public, and very few specialists exist who would note a new weed or invasive species when it appears **and** have the tools or the connections to identify and publicize the discovery — probably not much more that about a dozen individuals in the whole country. This contrasts with the network of weed scientists that exist in both Canada and U.S.A.

The response infrastructure is not yet functional, though the legal foundation does exist. The recent discovery and publication of two known and serious invasive species with limited distributions and large potential impact, *Senecio inaequidens* DC. (Rzedowski et al. 2003) and *Polygonum nepalense* Meisn. (Vibrans and Hanan-Alipi 2008), has yet to elicit an official response.

Until recently, new invasive species were found occasionally by specialists reviewing herbarium material. In general, herbarium revisions and the description of new species continue at an even pace in Mexico, so the taxonomists at the institutions are continuing their work. However, recently I revised the subtribe Brassicinae of the Brassicaceae (in Mexico, this subtribe contains the exotic genera *Brassica*, *Raphanus*, *Eruca*, *Hirschfeldia*, *Diplotaxis*, *Erucastrum* and *Sinapis*). This group is a relatively good indicator of the intensity of general plant collection activity that does not involve specialists. The species grow exclusively in disturbed places, which more specific biodiversity projects do not include. About 1600 specimens were consulted, which corresponded to about 1300 individual records. Figure 1 shows the numbers of collections per decade.

Figure 1. Number of collections of Brassicinae by decade. Brassicinae is a subtribe of Brassicaceae (= Cruciferae) and contains only species that are exotic for Mexico, e.g., *Brassica, Raphanus, Eruca.*

Some of the collections from 2000 to present probably have not yet been incorporated into the herbarium collections. But, the data seem to indicate that this venue of discovery is closing; general collection has practically collapsed in the last 15 years and is now below the level of the 1960's. This may be a reflection of: the phylogenetics boom that has students working on specific groups and known species, not on general floristics; biodiversity inventories are not as popular anymore; there are no large collection initiatives; and, collection permits are now required. Perhaps some areas are considered to be sufficiently collected. All of these factors probably play a role in the drop of the collection activity.

The purpose of the Weeds of Mexico website was to encourage taxonomic literacy in the interested public, raise consciousness particularly for the problem of exotic introductions, and to ameliorate the early detection problems. The web format was chosen because the internet is much more accessible today to the target population (rural inhabitants, students as well as professionals) than any written matter (Figure 2).

The first public version of the website was launched in April of 2006. At the last meeting of Weeds across Borders in Hermosillo in May of 2006 I spoke about it; this time, I would like to report on the lessons of the two years since, and on the perspectives.

Figure 2. An internet café in Santa Catarina Ecatlán, a Totonac Indian community with a population of 800 in the Sierra Norte de Puebla, one of the poorest regions of Mexico (March 2008).

Origin of the Data

The data shown below are based on the visitor and pageview (hit) data of the website provided monthly by CONABIO (Comisión Nacional para el Conocimiento y Uso de la Biodiversidad; www.conabio.gob.mx); these data show number of hits per family, and proportion of visits (more than 3 minutes) for a whole month. It does not provide data on individual users (number, geographical origin). Data on variation among days of the week and on the geographic origin of the users is taken from a proxy, a blog (jehuite.blogspot.com) that accompanies the website and presumably is visited by the same type of users as the website. Also, some data stem from a workshop on the website at the Mexican Botanical Congress in Zacatecas, 2007, which was combined with interviews of the participants, mainly students.

Results

Evolution of the Website

The time-line of the website evolution has been the following:

- 2000: First project (images and collections)
- July 2005: Prototype
- April 2006: First public version with 450 species at www.malezasdemexico.net
- Versions: September 2006 (660 species), March 2007 (760 species) and June 2007 (850 species); October 2007 (only with corrections)

So, at present, the site has images and extensive factsheets on 851 species; the images are vouchered. The images, the morphological descriptions and the distribution data for Mexico and the world have been a priority. For identification, the site includes comparative tables by flower color; interactive keys had been a goal, but are difficult to make because baseline data for many species are lacking. We also have an introduction in the Yucatecan Maya language; eventually we hope to include other important native languages of Mexico.

Coverage of the Website

The site now includes the most common weeds of the center and north of the country; it generally covers 70–90% of the species in surveys and weed lists (Table 1). The least represented biome is the humid tropics.

Pageview Data

The number of hits per month (Figure 3) has increased more or less steadily. Relative use falls: 1) during vacations (particularly Christmas and Easter); and, 2) after about four or five months without updates, because apparently Google lowers the priority of the search results. The drops of March and April, 2008, are probably caused by Easter. The fact that the site is used primarily for work (and school) related issues is apparent from these drops; this is confirmed by data from the blog, which show sharp decreases on weekends.

A graph (Figure 4) relating the average number of species in the site to the number of daily pageviews shows that there is a close relationship between use and number of species included in the site.

There is also a close relationship between number of hits and number of species of a family represented in the website (Figure 5). Poaceae are consulted slightly more frequently than Asteraceae, probably because of their utility, but the difference is not large (there is one useful family with one species that reliably has 2000 hits per month — Cannabaceae). The degree of coverage of a treatment appears to have a certain influence; Brassicaceae (more than half of the weedy members of the family and all of the common ones are covered) is consulted more than the Solanaceae where a similar number of species are treated, but for which the proportion of species covered is lower.

Table 1. How complete is the Weeds of Mexico site? (Version June/October 2007)

Source	Number of species	Proportion
Common weeds of Mexico (De Ita Gómez 1992)	21 of 22	95%
Weeds of the valley of México (Espinosa and Sarukhan 1997)	142 of 159	89%
Urban weeds of Mexico City (Vibrans 1998)	207 of 256	81%
Agrestal weeds of maize, Puebla-Tlaxcala (Vibrans 1998)	219 of 317	69%
Weeds in cotton, Comarca Lagunera (Agundis and Rodriguez 1978)	30 of 39	77%
Weeds of Buenavista, Coahuila (Villareal, 1983)	101 of 135	75%
Weeds of Salvatierra, Guanajuato (Calderón and Rzedowski 2004)	190 of 260	73%
Agrestal weeds of Aguascalientes (De la Cerda Lemus 2002)	107 of 149	72%
Prevalent weeds, Central America (García et al. 1975)	101 of 277	36%

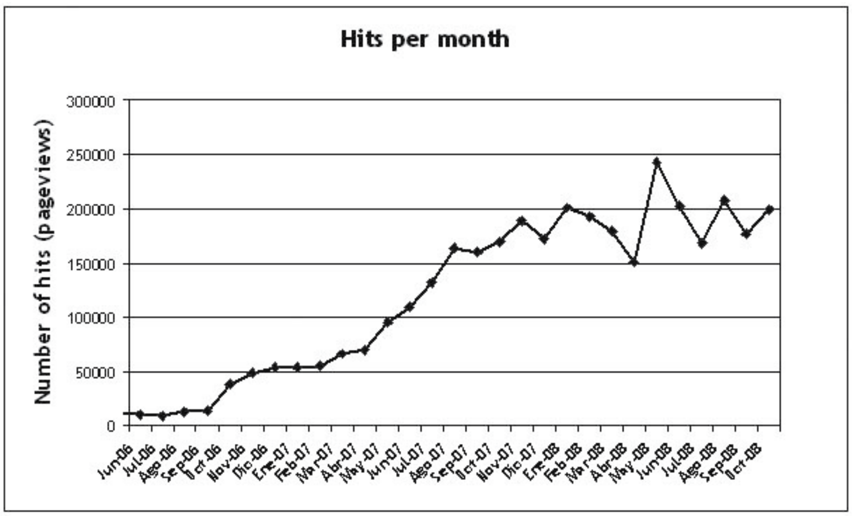

Figure 3. Hits per month at the Weeds of Mexico website.

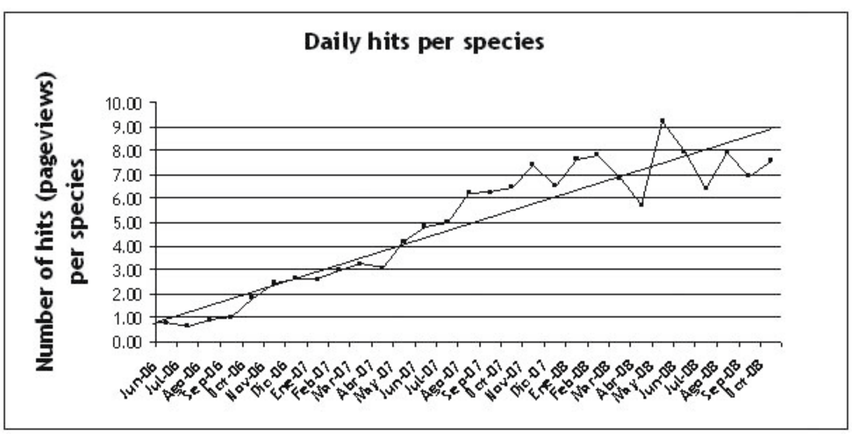

Figure 4. Monthly averages of hits per species included in the website.

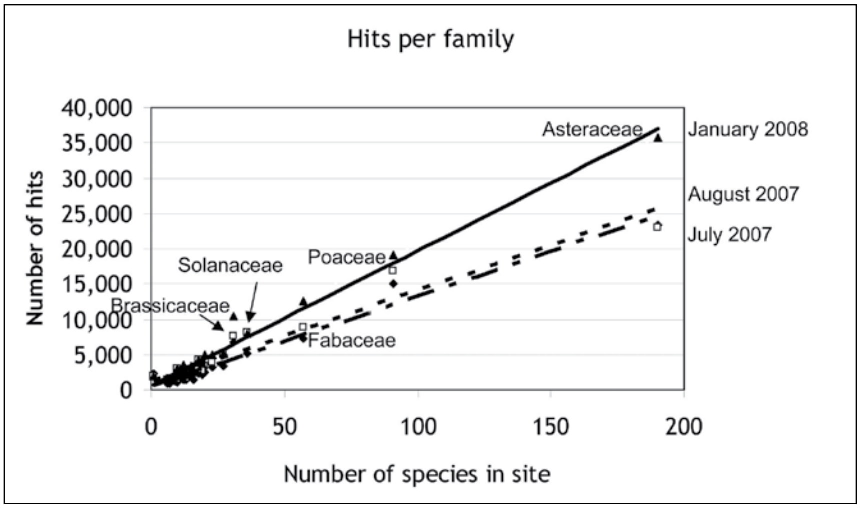

Figure 5. Averages of hits per family in three different monthly periods.

The average number of hits per species is about 200 per month. The much larger, and multilingual, website Fishbase (www.fishbase.org), which has comparable purposes and users as Weeds of Mexico, has about 800 hits per species per month. Considering that Weeds of Mexico is mainly in Spanish, the level of use appears to be quite good.

Approximately half of the users of the blog have Mexican IP-addresses; most of the rest are from the USA and Canada (mainly Spanish-language), from Latin America and from Spain. This is probably similar for the website. Few visitors use the translation functions of Google and other search machines.

User Feedback

User feedback is by e-mail (an e-mail address is prominently displayed on the site), as well as personal comments received during scientific events and during workshops that I organize occasionally. At first I thought e-mail correspondence might prove time-consuming, however, it has been rather limited (about one mail per week on the average) and is often on topics not covered by the site, for example on the identification of ornamental plants. General comments frequently remark on the lack of maps at the site.

At a workshop during the Mexican Botanical Congress in Zacatecas in fall of 2007, I carried out a survey of the 23 participating students. The questions were on the features they considered priorities for the further work. The results are the following (ordered from most desired to less important):

1. Include more species with photographs **and** factsheets
2. Add information on diagnostic characters for all species
3. Include keys
4. Include more species with photographs (without factsheets)

5. Include distribution maps
6. Include a glossary

Therefore, maps are not really the highest priority for many users and adding to the coverage appears to be more important. Moreover, the rather extensive factsheets are appreciated, particularly the information on practical aspects, such as control and use. Users clearly want more content than just pictures and id information.

Labor Investment and Costs

Each species treatment requires approximately the following labor investment:

- 1.5 h by the photographer (this includes traveling time)
- 2 days by a technician (plant processing, image processing, building pages, adapting morphological descriptions, inserting standard information into fact sheet)
- 1 day by a qualified botanist (field work, selection of images, editing of fact sheet, general supervision).

Additionally each species treatment requires about $20 of travelling money, and some equipment (computers, digital camara).

Under Mexican conditions this translates to grant requirements of about $200 per treated species if the qualified botanist draws a wage elsewhere; if this cost is included, it comes to about $300. On the average, I have dedicated about half of my paid time to this project in the last eight years. The web page is hosted by CONABIO, a government institution with a very extensive web infrastructure, so the hosting costs are marginal.

Costs and Benefits

From these data a cost-benefit analysis can be attempted, based on the following:

- The calculations are on the basis of 160,000 hits per month
- About 25% of the hits (40,000) are visits of more than 3 minutes, with the assumption that the user found information of interest
- A second (conservative) assumption supposes that every 3 minutes of useful information represents 6 minutes of bibliographic research, which would be the main alternative, at least for a Spanish-speaking population. It thus saves 3 min; 40,000 (3 min = 200,000 min = 3333 h
- An hour is priced at 40 pesos (about $3.80), which is about the starting salary of a professional.

Then, the general economic benefit would be 80,000 pesos ($7,600) per month or 960,000 ($91,500) per year. The project amortizes in less than 2 years, if only the time saved in obtaining information is considered. This is of course an underestimation, since it does not consider the fact that often the site would be the only information available to many users, or the savings that result from the actions taken upon identification, both of which are difficult to quantify.

Future Work

We plan to focus on increasing the number of species pages, especially for weed species of the humid tropics. Other short-term plans include:

- a useful links page;
- an interactive glossary
- a tutorial for creating species pages for beginners
- a tutorial on plant collection

Longer-term aims are the inclusion of:

- images of seeds and seedlings;
- professional editing
- interactive keys
- distribution maps
- texts in languages other than Spanish (English, Nahuatl, Yucatec Maya, Zapotec, Mixteco)

Conclusions

The Weeds of Mexico website has developed a satisfying acceptance in the Spanish-speaking world. Content is a strong driver of usage. The site can be shown to recoup the public investment in a very short time, even if only time-saving for information retrieval (not prevention) is estimated under very conservative assumptions. We hope it will raise public awareness for preventive measures and fast reaction to cross-border migrations of weeds and invasive plants.

Acknowledgements

We thank Francisco Espinosa-Garcia for his comments on this contribution, and the organizers of the Weeds across Borders conference for the invitation to participate. The Secretaría del Medio Ambiente/CONACyT (Consejo Nacional para Ciencia y Tecnología), CONABIO and the Colegio de Postgraduados have financed the project.

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Invasive Weeds and Climate Change: Threats and Consequences

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Abstract

Human induced increases in atmospheric carbon dioxide are likely to result in climatic forcing climatic change in the environment, including warmer winters and changes in precipitation and in the frequency of extreme weather events. However, carbon dioxide, in addition to being a "greenhouse" gas, also serves as one of four principal environmental resources (along with light, nutrients and water), needed by plants to complete their life cycle. Both the indirect effects of rising carbon dioxide concentration, [CO_2], through climatic change, and the direct effect of [CO_2] on plant function, are likely to alter the establishment and success of invasive weed species in ways that are as yet poorly understood. In the current discussion, I will provide two distinct examples of how rising [CO_2] can influence invasive weeds, first by showing the potential role warming winters could play in the northward migration of kudzu (*Pueraria lobata*); and secondly, the direct effect of recent small (50 ppm) changes in atmospheric [CO_2] on cheatgrass (*Bromus tectorum*) and fire ecology.

Resumen

El aumento del nivel atmosférico de dióxido de carbón debido a las actividades humanas conllevará probablemente a cambios climáticos, que podrían incluir inviernos más templados y cambios en la precipitación y en la frecuencia de eventos meteorológicos extremos. Sin embargo el dióxido de carbón, además de ser un gas de efecto invernadero, sirve también como uno de los cuatro principales recursos ambientales (junto con la luz, los nutrientes y el agua) indispensables para el ciclo de vida de las plantas. Tanto los efectos indirectos del incremento de la concentración [CO_2] del dióxido de carbón, a través del cambio climático, como sus efectos directos sobre la función de las plantas, probablemente influirán sobre el establecimiento y el éxito de las malezas invasoras, aunque aún no se entiende mucho sobre los detalles de estos efectos. En la presente discusión, se citarán dos ejemplos de la influencia del aumento de la [CO_2] sobre las malezas invasoras. El primero de estos indica el rol posible de la moderación de los inviernos en la migración hacia el norte del kudzu (*Pueraria lobata*), mientras el segundo es el efecto directo de los recientes cambios pequeños (50 ppm) en la [CO_2] atmosférica sobre la espiguilla colgante (*Bromus tectorum*) y la ecología de los incendios.

The Consequences of Rising Carbon Dioxide

The global background concentration of atmospheric carbon dioxide has increased by approximately 21% since 1960, from a concentration of approximately 315 ppm, to 386 ppm today (IPCC 2007). There are two strong lines of evidence that suggest that this increase is related to human activity. First, records of power plants and the fossil fuel industry indicate the amount of fossil fuels consumed in the United States and elsewhere during this period are associated with a rapid increase in carbon dioxide, a by-product of combustion (Figure 1), Secondly, fossil fuels have less of the heavier carbon isotope (C_{13}), consequently, adding [CO_2] from fossil fuel combustion will result in a dilution of this isotope in the atmosphere (i.e., the "Seuss" effect). Overall, the observed increase in anthropogenic [CO_2] emissions particularly during the later half of the 20th century, corresponds well with the observed increase in atmospheric [CO_2], as reflected in the Keeling curve (Figure 1).

As [CO_2] increases, what are the consequences? The first is related to the physical properties of the CO_2 molecule itself. That is, the CO_2 molecule resonates (or absorbs energy) in the infra-red portion of the electro-magnetic spectrum (Weast 1984). By doing so, it prevents long-wave (infra-red) radiation from escaping back into space, with a subsequent increase in surface

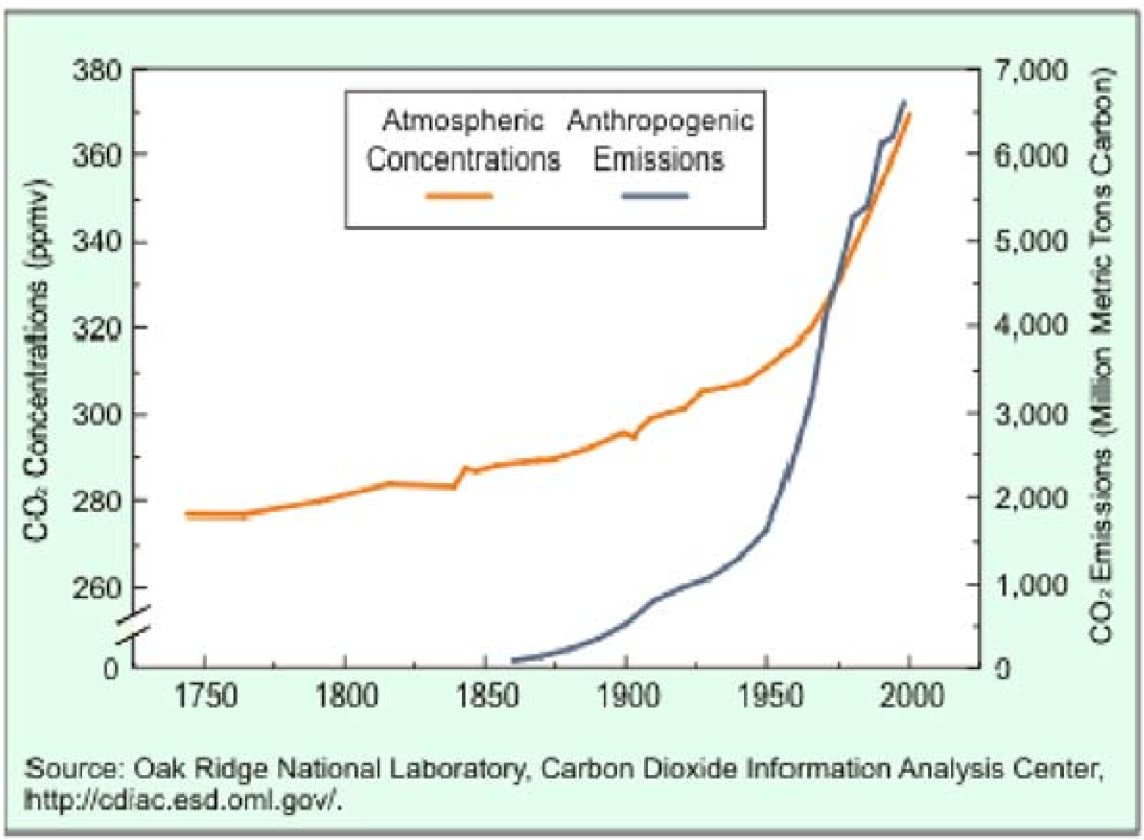

Figure 1. Change in global atmospheric carbon dioxide concentrations, and anthropogenic emissions of carbon dioxide since 1750.

temperature. This characteristic of the CO_2 molecule, is also shared by water vapor (H_2O) and other atmospheric gases (N_2O, CH_4, CFCs). The presence of these gases in the atmosphere contributes to a natural greenhouse effect, one that keeps the earth about 15°C warmer than would otherwise occur based on solar radiation alone.

Although water vapor is the dominant greenhouse gas, it can vary by more than an order of magnitude in the atmosphere. Consequently, the degree to which rising [CO_2] will alter surface temperatures is a function of spatial and temporal variability in the amount of water vapor present. In simplistic terms, if water vapor is high, then adding CO_2 will have little effect on surface temperature (e.g., tropical equatorial regions with high humidity); conversely, if water vapor in the air is low, then adding CO_2 will increase surface temperatures either regionally (e.g., polar regions and deserts), or temporally (e.g., warmer winters). Rising surface temperatures for the later are confirmed by the most recent IPCC assessment (IPCC 2007).

Such differential changes in temperature and associated climate impacts are of obvious interest in understanding related effects on weed biology. However, there is another additional effect of rising carbon dioxide. Carbon dioxide, along with sunlight, nutrients (e.g., nitrogen and phosphorous) and water are the four essential resources needed for plants to complete their life cycle. Any change in their availability will alter plant growth directly. Consequently, the recent increase in atmospheric carbon dioxide should stimulate the growth and reproduction of plants of and by itself. This has been observed by some to be a "wonderful and unexpected gift of the industrial revolution" (Robinson and Robinson 1997).

The later statement, assumes that "green is good", that any stimulation in plant growth will be uniformly beneficial. And yet, as weed scientists know, many plants are detrimental to human society, not only in agriculture, but from a medical, environmental and aesthetic point of view. Among such plants, invasive weeds, (i.e., exotic or alien species) are those plant species, non-native to a given geographical area, whose geographic introduction within a community results in extensive economic or environmental damage. Millions of acres of productive rangelands, forests and riparian areas have been overrun by such invaders, with a subsequent loss of native flora. E. O. Wilson, the noted ecologist, has observed that, "On a global basis, the two great destroyers of biodiversity are, first habitat destruction and, second, invasion by exotic species." (1999). It has been estimated that more than 81 million ha of natural habitats (primarily in the western U.S.) have already been lost to invasive, noxious weeds, with an ongoing loss of 809 ha a day (Westbrooks 1998). The invasive plant species that are most harmful to native biodiversity are those that significantly change ecosystem processes, to the detriment of native species.

How then will rising [CO_2], either indirectly (i.e., rising temperatures) or directly (i.e., stimulation of photosynthesis and growth), alter the biology and/or spread of invasive weeds? Here I present two preliminary examples. The first is related to the indirect effect of rising [CO_2], and involves the spread of kudzu [*Pueraria lobata* (Willd.) Ohwi] with warming winter temperatures; the second is related to the direct effect of recent increases in atmospheric [CO_2] on the growth of cheatgrass (*Bromus tectorum* L.) and associated changes in fire ecology.

Kudzu and Warmer Winters

Background

In North America, one of the worst plant invaders is kudzu, a leguminous vine introduced from Asia in the early 1900s for forage and erosion control. The aggressive growth of kudzu, associated with rapid leaf development and low biomass allocation to woody stems, has allowed it to spread quickly into disturbed areas and adjoining forest (Forseth and Innis 2004). The ability of this vine to dominate landscapes has led to some highly suggestive nicknames, including "the plant that ate the south" and a "vegetal form of cancer" (Forseth and Innis 2004). In addition, kudzu is a recognized host of soybean rust, a major threat to soybean production in North America (Lynch et al. 2006).

Northern Migration

At present kudzu occupies over 3 million ha and is migrating northward at the rate of approximately 50,000 ha per year (Pappert et al. 2000). A comparison of northern limits for kudzu from 1971 to 2006 indicates a considerable increase in the northern boundary of kudzu during this period (Figure 2). Since kudzu has been within the U.S. for over 100 years (introduced as a "wonder" plant at the Philadelphia Centennial Exposition of 1876), it seems unlikely that a new strain of kudzu appeared with a greater degree of cold tolerance in the 1970s.

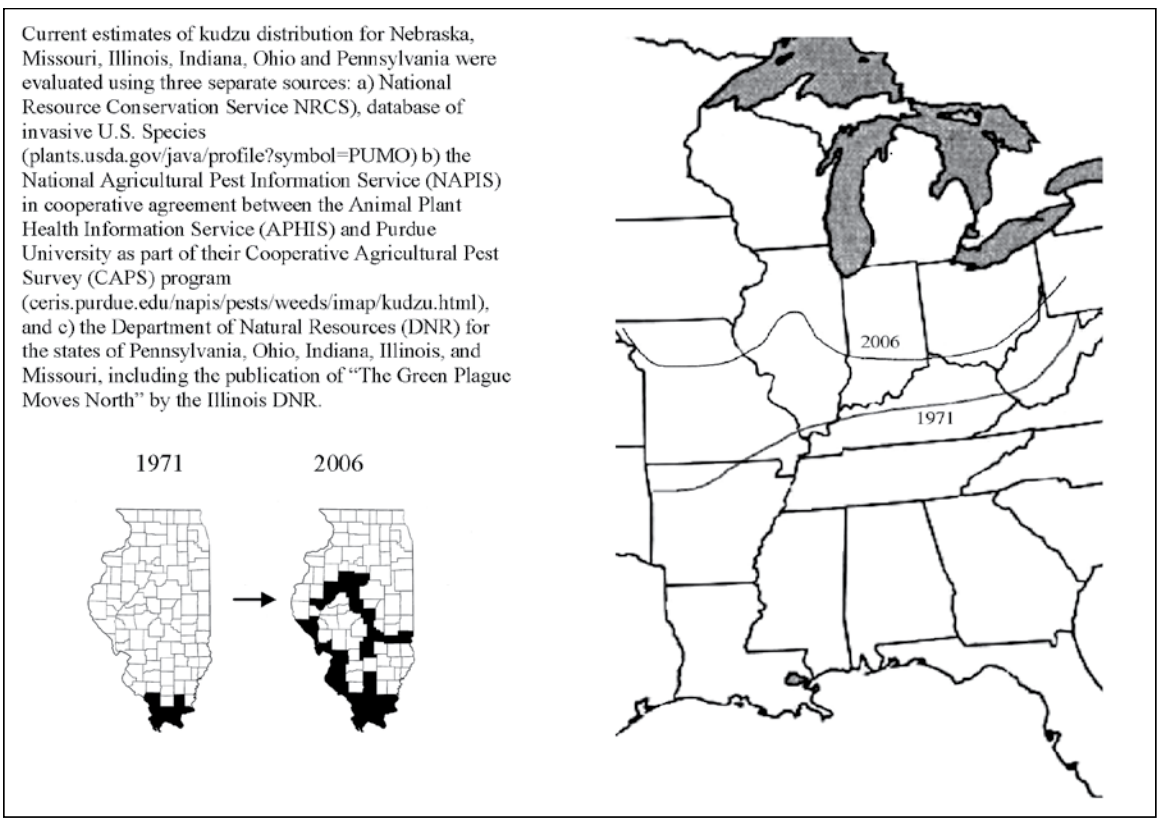

Figure 2. Change in northward distribution of kudzu since 1971. Inset shows counties reporting kudzu populations for the state of Illinois in 1971 and 2006.

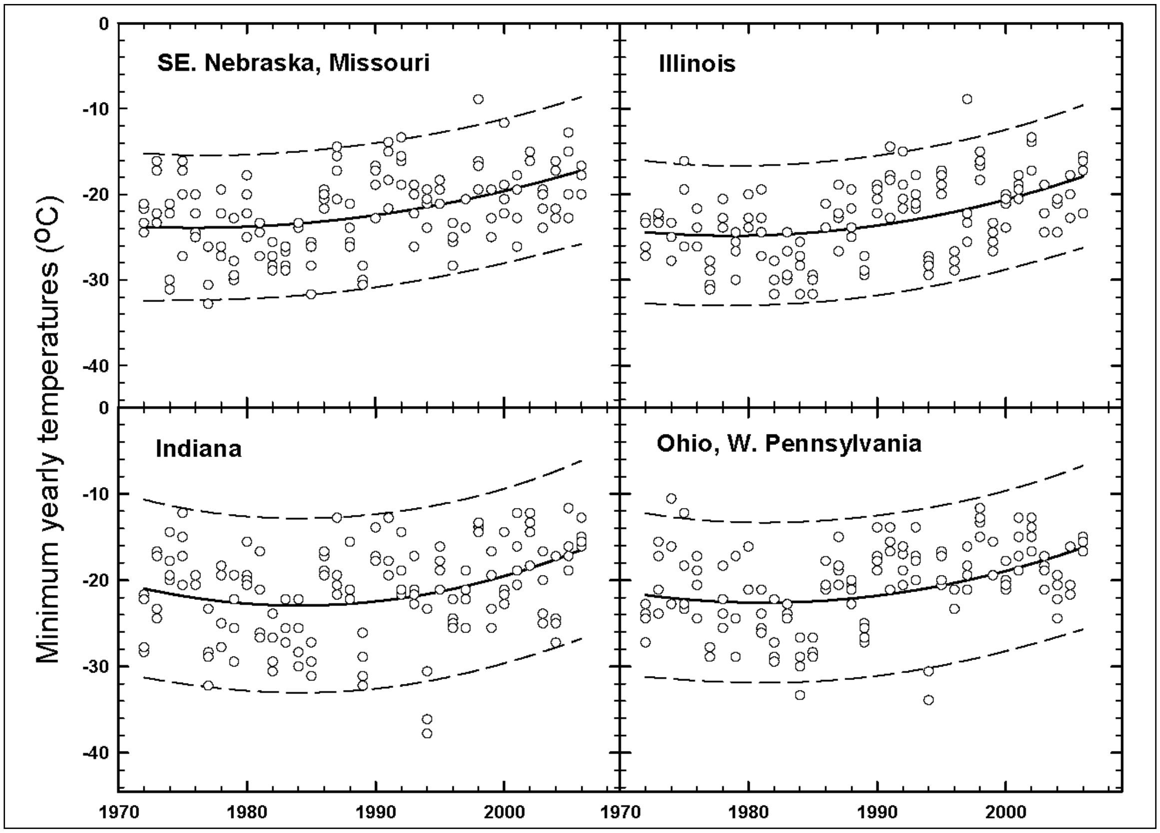

Figure 3. Lowest recorded winter temperature (1971–2006) for selected counties in Midwestern states now reporting populations of kudzu.

Alternatively, Sasek and Strain (1990) suggested that cold winters and water scarcity limited the expansion of kudzu to the north and west, respectively. These initial data provided preliminary evidence that kudzu could not survive average minimal temperatures of –20°C. More recent data from Heather Coiner at the University of Toronto has suggested that complete cellular disruption occurs in the young kudzu seedling at –28°C with as little as 4 hours exposure (H. Coiner, pers. com.).

Warmer Winters

Interestingly, data from counties throughout states in the Midwest, suggest that winters are, in fact warming considerably, and many of these counties are now reporting stands of kudzu (Figure 3). Although there is uncertainty regarding an absolute minimal thermal temperature, it is clear that if such trends continue, further expansion of kudzu, and potentially a number of other invasive weeds (or pests, or diseases), can be expected with warmer winter temperatures (e.g., pine bark beetle in Canada).

Cheatgrass, CO_2 and Fires

Background

One example of environmental damage related to invasive weeds is the introduction of natural or anthropogenic fires within native communities not well adapted to either occurrence, frequency and/or intensity of fire cycles. Originally introduced from central Asia, cheatgrass is an annual grass which grows quickly in dry environments, colonizing open spaces between perennial, native shrubs and producing large quantities of fine flammable material that increases the frequency and intensity of fire events (Billings 1990, 1994). As fire events increase, native species diminish, while cheatgrass, a fire adapted species, spreads into large monocultures, with a subsequent decline in species diversity. At present, cheatgrass is found in almost 7 million ha, primarily in western grazing lands, with an additional 25 million ha at high risk (Jayne Belnap, pers. com.).

Cheatgrass and Rising Carbon Dioxide

To determine the sensitivity of cheatgrass to rising carbon dioxide, and potential changes in fuel load, we quantified biomass accumulation and digestibility of three cheatgrass populations from different elevations in the Sierra Nevada range (California) to small (50 ppm) changes in [CO_2] that have occurred since the pre-industrial [CO_2] baseline. The experimental CO_2 values (270, 320, 370, 420 ppm) correspond approximately to the CO_2 concentrations that existed at the beginning of the 19th century, that during the 1960s, the current [CO_2], and the near-term [CO_2] projection for 2020, respectively. From 25 until 87 days after sowing (DAS), above-ground biomass for these different populations increased 1.5–2.7 g per plant for every 10 ppm increase above the 270 [CO_2] pre-industrial baseline (Figure 4). Among all populations, the indigestible portion of above-ground plant material [acid detergent fiber (ADF), mostly cellulose and lignin] increased with increasing [CO_2] (Ziska et al. 2005). In addition, the ratio of C:N increased with age and [CO_2] concentration, and was highest for the lower elevational population (Ziska et al. 2005). These CO_2-induced qualitative changes could, in turn, result in potential decreases in herbivory (less palatability to herbivores) and decomposition with subsequent effects on the above ground retention of cheatgrass biomass. Greater above-ground retention, in turn, would contribute to greater fuel loads, and increased fire incidence. These data suggest that increasing atmospheric [CO_2] above pre-ambient levels may have contributed significantly to cheatgrass productivity and fuel load with subsequent effects on fire frequency and intensity.

The cheatgrass observations are consistent with other invasive weed data (Ziska 2003), suggesting that, on average, invasive species may show a stronger response to recent changes in atmospheric carbon dioxide than other plant species (Ziska and George 2004). Indeed, a handful of studies suggest that [CO_2] *per se*, may favor invasive species within assemblages of plant communities (Ziska and George 2004). It can be argued that such a strong response of invasive plants will be dependent on other resources, such as water and nutrients, and may not mimic experimental evaluations *in situ*. This is a fair criticism. Yet, it is also worthwhile to note

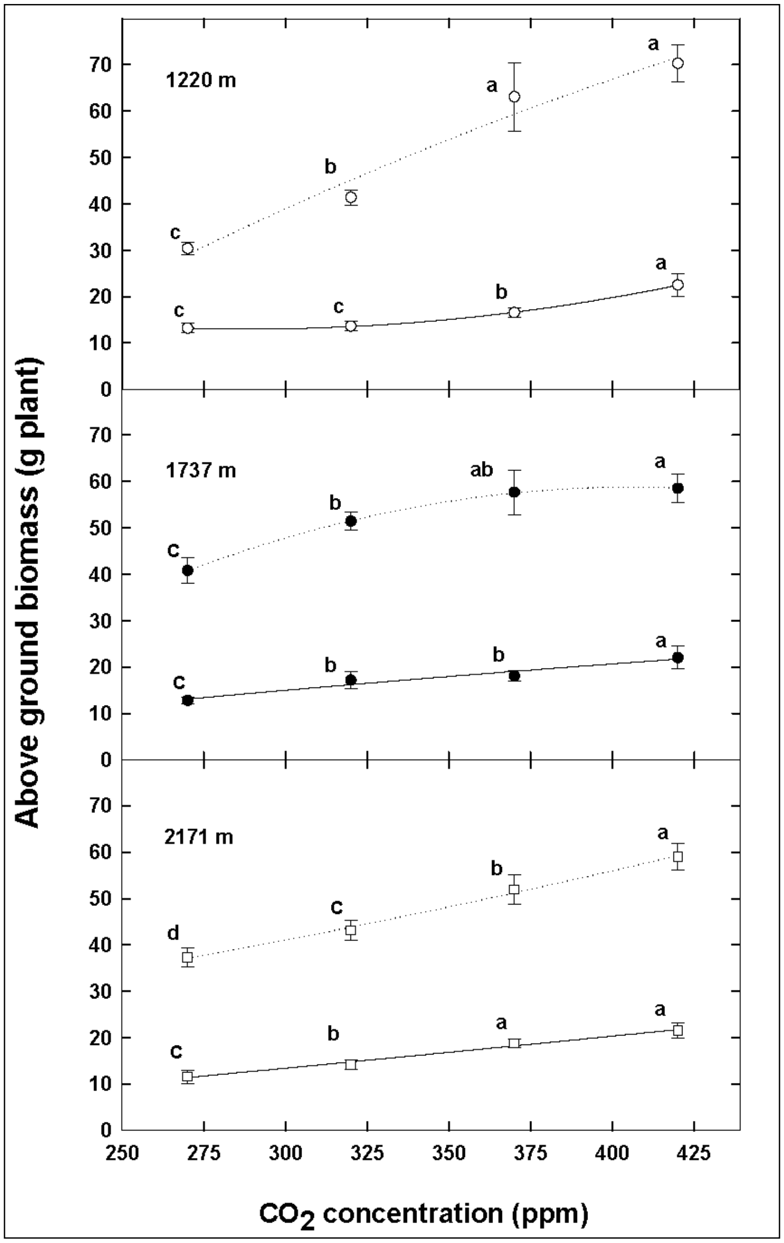

Figure 4. Changes in above-ground biomass of cheatgrass collected at three elevations in the Sierra Nevada Mountains (1220, 1586 and 2171 m) as a function of recent changes in atmospheric carbon dioxide concentration. See Ziska et al. (2005) for additional details.

that for invasives in managed, agricultural systems, water and nutrients may be optimal. Even in native systems such as for cheatgrass, optimal water and nutrients may be periodically available depending on fluctuations in weather (Young et al. 1987).

Some Tentative Conclusions

The environmental and economic impact of invasive weeds on agronomic and native plant systems has been unprecedented. Yet, surprisingly, very little research has been directed to understanding the direct or indirect consequences of rising [CO_2] on invasive weed biology.

The two examples given here are not meant to be inclusive, but rather, illustrative of the types of significant impacts projected with [CO_2] and climate change. Overall, these data, while preliminary, suggest that rising [CO_2] will alter the thermal limits that constrain the range of a given invasive species; alternatively, rising [CO_2] will result in direct stimulation of these invasives with subsequent effects on plant communities and ecological processes.

However, it is also evident that the issue of [CO_2] / climate, is not, by and large, being addressed by weed scientists. Given the impacts that are occurring, or are likely to occur in the future, this seems unfortunate. Information is crucial in order to assess how rising carbon dioxide may exacerbate invasive species impact, and to provide the tools needed by policy makers, farmers, scientists and environmentalists to manage and control invasive weeds in the future.

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Biography

Dr. Lewis Ziska is a plant physiologist with the USDA's Agricultural Research Service in Beltsville, Maryland. He is the senior author on more than 50 peer-reviewed publications documenting the impact of rising carbon dioxide and global climate change on weed biology in managed and natural eco-systems. After graduating from the University of California, Davis, he began his career as a Smithsonian fellow, then took up residence as the Project Leader for global climate change at the International Rice Research Institute in the Philippines before joining USDA. At present he is investigating the role of rising carbon dioxide and changing climate on weed-crop competition, invasive/noxious weeds, weed management, and weeds and public health.

Dr. Ziska's research has appeared in: The Wall Street Journal, National Geographic, The New York Times, USA Today, The Washington Post, Newsweek, U.S. News and World Report and CNN Headline News. He was recently featured in the HBO documentary, "Too Hot Not to Handle".

Natives Gone Wild: Climate Change and a History of a Yukon Invasion

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Abstract

Herbarium collections and published works were reviewed to determine the date, source and distribution of introduced plants in the Yukon Territory, Canada. Examples of plants with changing distribution and survival rates are given. Mechanisms for these changes are linked to global climate change. The proliferation of new plant species is linked to increasing use of agronomic seed mixes for reclamation and horticultural products combined with a more favourable climate for survival of contaminant weeds and seed.

Resumen

Mediante una revisión de colecciones de herbario y de trabajos publicados, determinamos las fechas, las fuentes de introducción y la distribución de las plantas introducidas en el Territorio Yukón de Canadá. Se citan ejemplos de especies de plantas que han cambiado sus distribuciones y sus tasas de supervivencia. Los mecanismos de estos cambios están ligados con el cambio climático global. La proliferación de nuevas especies de plantas está ligada con el aumento del uso de mezclas de semilla agronómicas para la reclamación y la horticultura, juntamente con un clima más favorable para la supervivencia de malezas y semillas contaminantes.

1 Presenter.

Herbarium collections from the Canadian Museum of Nature (CAN[1]), Agriculture and Agri-Food Canada (DAO), University of British Columbia (UBC), Royal British Columbia Museum (V), University of Alaska, Fairbanks, Museum of the North (ALA), the Smithsonian Institution (US), were reviewed and used with published works (including Cody 1996, Hultén 1941–1950, Porsild 1951, 1974) to determine the historical distribution and source of introduced plant collections in the Yukon Territory, Canada. The first collections in Yukon began with the Franklin expedition in 1825–1827 (Franklin 1828). More extensive collections were made by Reverend Stringer in 1891–1904 and F. Funston in 1894–1895 (Funston 1896). The first introduced plants were reported in 1899 by J. B. Tarleton with the Smithsonian Institution (Britton and Rydberg 1901). John Macoun made extensive forays into the agricultural areas of the Klondike in 1902 followed by many more collectors with E. Schoff (1904), D. D. Cairnes (1912) (Cairnes 1914), A. Eastwood (1914) and M. O. Malte (1916) being the most prolific.

During the period 1899–1941 year-round ground transportation into Yukon was by rail between Whitehorse and Skagway, Alaska (Minter 1987). During the summer watercraft were the primary mode of transportation, commercial transport being mainly by sternwheeler. During the winter, dog-team and horse-drawn sleighs served the populace. In the 1930s air travel was added with a series of airstrips in the communities of Dawson, Whitehorse and Mayo (Keith 1972). The distribution of introduced plants during this time was associated with agricultural operations, mainly in the Klondike Valley in the vicinity of Dawson City and to a lesser extent on farms along the Yukon River. Forty-one introduced species were known by 1941, one of which, White Sweet-clover (*Melilotus albus* Medik.), is now considered invasive (Figure 1).

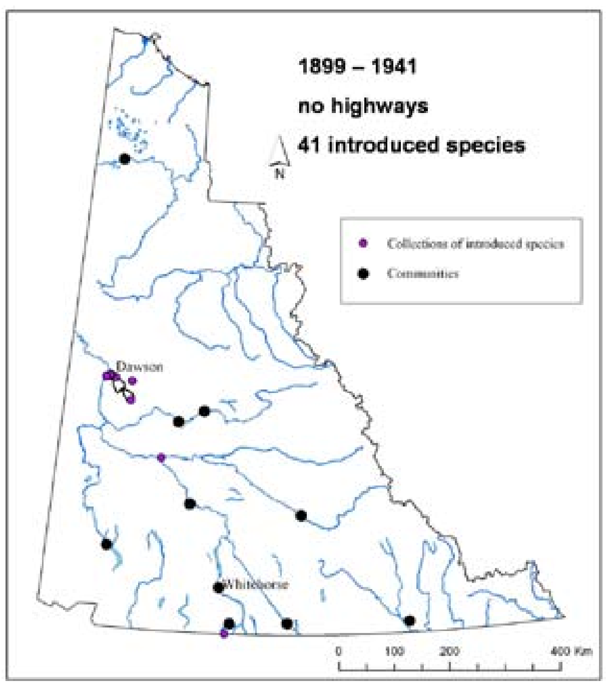

Figure 1. Distribution of known introduced plants 1899–1941.

1 Herbarium codes follow Holmgren et al. 1990.

With the impetus of the Second World War followed by a demand to access Yukon's rich mineral resources, a highway system was built throughout much of the southern Yukon. The Canol Road (1942, Highway 6), the Alaska Highway (1942, Highway 1) and the Haines Road (1943, Highway 3) were constructed during the war period. In the 1950s the Klondike Highway (Highway 2) connected Whitehorse with Dawson City and the Silver Mines (the Silver Trail, Highway 11) of Keno and Elsa. By 1953, the Top of the World Highway (Highway 9) was constructed to connect Dawson City with Chicken, Alaska and the 40 Mile and 60 Mile goldfields. In 1963 the Cantung Road, now known as the Nahanni Range Road (Highway 10), was constructed to access the Cantung Mine at Tungsten, Northwest Territories, and finally the Robert Campbell Highway (Highway 3) was completed in 1971.

The highways were unpaved, and road maintenance consisted of grading the road surface and then the ditches to control encroaching vegetation, primarily willows. Little highway seeding was done during this time though many projects studied the situation, recommending seed mixes. V. C. Brink (1943) was hired to look at appropriate native grasses for re-seeding and G. W. Douglas (1973) worked on a similar project.

The roads provided new access to many regions, and collections were made along roads, in communities and throughout the back-country. Significant collections of introduced plants were made by V. C. Brink (1943), H. M. Raup and D. S. Correll (1943), A. E., R. T., M. P., E. and B. Porsild (1944–), J. P. Anderson (1944), J. D. Campbell (1948–1950), J. A. Calder and L. G. Billard (1949), J. M. Gillett and D. A. Mitchell (1949), W. B. Schofield (1957), J. A. Calder and I. Kukkonen (1960), K. A. Beamish (1968), S. E. Welsh and G. Moore (1968), V. L. Harms (1970), V. C. Brink (1970), R. Rosie (1973–) and G. W. Douglas (1973–1977), amongst others during the period of 1942–1975. Introduced plants continued to average one new species per year and by 1975 eighty-three species were known including six of the species now considered invasive (Figure 2).

Dempster Highway (1979, Highway 5) was the only contemporary highway constructed during the period of 1976–1994. However, many highway improvements and realignments were being done and reseeding projects began using agronomic species. Seeding practices increased for revegetation of disturbed mineral, oil and gas exploration and production sites. Inventories of vascular plants continued with R. Rosie, W. J. Cody, J. H. Ginns, V. Hodgson, G. Brunner, S. Withers and C. E. Kennedy making collections and depositing the specimens into herbaria. The Flora of Yukon (Cody 1996) was published based on all known collections up to this time. By 1994, 113 introduced species were known, representing 10% of the flora; five additional invasive plant species were added during this period (Figure 3).

From 1994 to the present, revegetation was practised on an increasing scale, often using inexpensive and readily available agronomic seed. The use of agronomic seed led to the attraction of wildlife, primarily ungulates including bison, elk, moose and mule deer, along highways, resulting in safety and wildlife concerns for highway and wildlife managers. Non- native species were also introduced as contaminants of the seed. As Sweet-clover spread, replacing lower-growing native plants, dangers to motorists also increased. Sweet-clover can grow to over two meters, obscuring road signs, site distances and wildlife species. From these hazards the concept

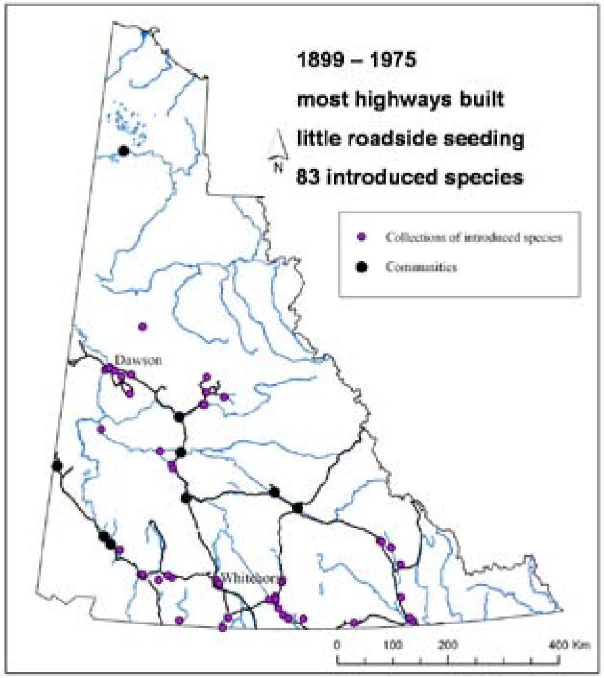

Figure 2. Distribution of known introduced plants 1899–1975.

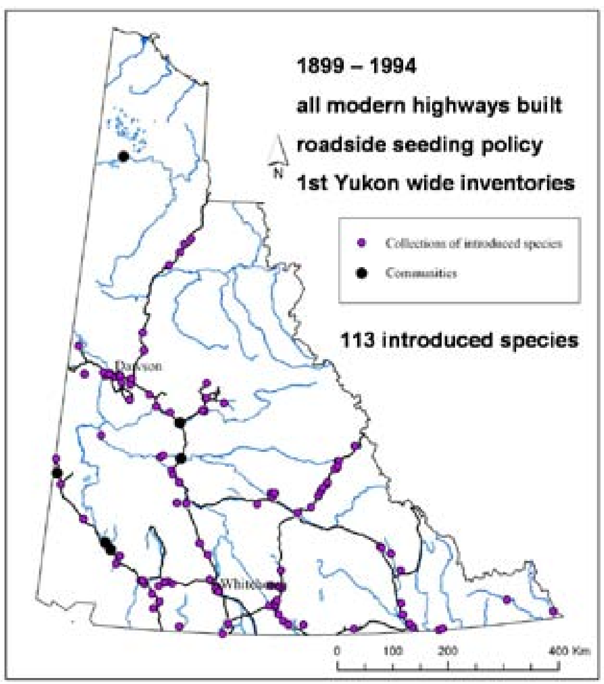

Figure 3. Distribution of known introduced plants 1899–1994.

of invasive species began to be considered and recognized as an issue. Realizing the costs of revegetation through seeding, the Yukon Department of Highways and Public Works has in recent years been taking a lead in reducing the use of agronomic seed in the numbers of sites seeded, quantities of seed per site and amount of fertilizer applied. This reduces the palatability of roadside vegetation to ungulates. Studies are underway to look into ways to reduce the spread and density of Sweet-clover on roadsides.

Since the publication of the Flora of Yukon in 1996 to the present, collections and inventories have continued (Bennett et al. *in press*, Cody et al. 1998, 2000, 2001, 2002, 2003, 2004, 2005). R. Rosie, S. Wither, G. Brunner, W. J. Cody, B. A. Bennett, C. E. Kennedy, L. Freese, L. Schroeder, P. Caswell, P. Peterson, J. Saarela, V. Loewen and others have added to the flora. Many inventories targeted areas not previously surveyed, adding 128 species for a total of 1240 (1352 taxa) now known from Yukon. During this time 33 introduced species were added, including invasive species such as Canada Thistle, Spotted Knapweed, Common Tansy, Altai Lyme Grass and Dalmatian Toadflax. Few introduced species have yet escaped the town sites and roadsides to invade undisturbed native systems (Figure 4). There are currently 145 introduced plant species including 16 that are considered invasive (Table 1).

Inventories of Yukon's arctic coast (2005–2006) specifically targeting areas of potential introduced plants, such as areas of long term human habitation, commerce or disturbance, and Distant Early Warning (DEW) stations, found no introduced plants. The communities of Inuvik and Aklavik in the neighbouring Mackenzie Delta did have some introduced and potentially invasive plants (Figure 5).

Eight of the warmest ten years on record in Yukon have occurred since 1994 (Environment Canada 2008). Besides increasing mean temperatures, the climate has become more variable. Extended periods below –40°C are becoming rare and killing frosts, once expected in August, are now regularly occurring later into September or, in some years, early October. Also during this time, changes have been observed in the distribution and reproductive success both in the native and introduced flora.

Examples of plants changing their established patterns include white Sweet-clover which, though widely reported to be biennial, functions primarily as an annual in Yukon. Historically plants in southern Yukon would be in full flower in late August and would be killed by frost. In recent years, as the killing frost date has come later, Sweet-clover has been able to successfully complete its lifecycle, spreading along roadways and colonizing river banks and bars. Even though Sweet-clover has been present since 1935 and escaped from cultivation in the Whitehorse since 1943, it occurred in low numbers and densities and only in recent times has expressed invasive properties.

Alfalfa (*Medicago sativa* L.) was commonly used in roadway seed mixes. Previously the plant was able to persist as a perennial, but was slow to spread and remained where planted. Since 2000, patches have begun to coalesce and colonize surrounding areas along the roadways. Lucerne (*Medicago falcata* L.) was originally planted at the federal agricultural experimental station in Haines Junction where it remained until the mid 1990s, but has since spread into surrounding undisturbed meadows.

Table 1. List of Introduced Yukon Plant Species

Invasive-ness Ranka	Family	**Genus**	**Species**	Common Name	Abun-danceb	Persis-tencec	Source	Date of first collection
3	Caryophyllaceae	*Cerastium*	*fontanum*	Common Mouse-ear Chickweed	U	1	unknown	1899
4	Poaceae	*Alopecurus*	*geniculatus*	Marsh Meadow-foxtail	R	2	agriculture	1899
2	Poaceae	*Lolium*	*perenne ssp. multiflorum*	Perennial Rye Grass	R	1	revegetation	1902
2	Fabaceae	*Trifolium*	*hybridum*	Alsike Clover	C	1	agriculture, revegetation	1902
2	Fabaceae	*Trifolium*	*pratense*	Red Clover	C	1	agriculture, revegetation	1902
2	Asteraceae	*Matricaria*	*matricarioides*	Pineapple weed	C	1	unknown	1902
3	Poaceae	*Poa*	*trivialis*	Rough-stalk Blue Grass	U	1	revegetation	1902
3	Asteraceae	*Senecio*	*vulgaris*	Common Ragwort	R	2	horticulture, agriculture	1902
4	Poaceae	*Phleum*	*pratense*	Timothy	C	1	agriculture	1902
4	Polygonaceae	*Rumex*	*acetosella*	Sheep Sorrel	X	3	agriculture	1902
5	Poaceae	*Bromus*	*racemosus*	Bald Brome	X	3	agriculture	1902
5	Poaceae	*Bromus*	*secalinus*	Rye Brome	X	3	agriculture	1902
5	Poaceae	*Deschampsia*	*danthonioides*	Annual Hairgrass	X	3	unknown	1902
5	Poaceae	*Deschampsia*	*elongata*	Slender Hairgrass	X	3	transportation (railway)	1902
5	Poaceae	*Lolium*	*temulentum*	Poison Darnel	X	3	unknown	1902
5	Poaceae	*Polypogon*	*monospeliensis*	Annual Rabbit's-Foot Grass	X	3	unknown	1902
5	Poaceae	*Vulpia*	*myuros*	Rat-tail Six-weeks Grass	X	3	agriculture	1902
5	Caryophyllaceae	*Spergula*	*arvensis*	Corn Spurry	X	3	unknown	1902
5	Caryophyllaceae	*Vaccaria*	*hispanica*	Cowcockle	R	3	agriculture (birdseed)	1902
5	Brassicaceae	*Lepidium*	*sativum*	Garden Pepperwort	X	3	horticulture	1902
5	Brassicaceae	*Sinapis*	*alba*	White Mustard	X	3	unknown	1902
5	Rosaceae	*Potentilla*	*biennis*	Biennial Cinquefoil	X	3	unknown	1902
5	Fabaceae	*Trifolium*	*cyanthiferum*	Bowl Clover	X	3	agriculture	1902
5	Polemoniaceae	*Gilia*	*capitata*	Blue-headed Gily Flower	X	3	unknown	1902
5	Plantaginaceae	*Plantago*	*aristata*	Large-bract Plantain	X	3	unknown	1902
5	Asteraceae	*Madia*	*glomerata*	Mountain Tarplant	X	3	unknown	1902
2	Asteraceae	*Sonchus*	*asper*	Spiny-leaf Sow-thsitle	R	2	horticulture	1904
5	Urticaceae	*Urtica*	*urens*	Burning Nettle	X	3	unknown	1904
5	Brassicaceae	*Neslia*	*paniculata*	Yellow Ball-mustard	X	3	agriculture	1904
5	Asteraceae	*Helianthus*	*subrhomboideus*	Stiff Sunflower	X	3	unknown	1904
2	Chenopodiaceae	*Chenopodium*	*album*	Lamb's-Quarter	C	1	unknown	1916
2	Fabaceae	*Trifolium*	*repens*	White Clover	C	1	agriculture, revegetation	1916
3	Poaceae	*Agrostis*	*gigantea*	Giant Bent	R	2	revegetation	1916
3	Polygonaceae	*Polygonum*	*convolvulus*	Black-bindweed	C	1	agriculture	1916
3	Brassicaceae	*Capsella*	*bursa-pastoris*	Shepherd's Purse	C	1	agriculture	1916
5	Poaceae	*Bromus*	*tectorum*	Cheat Grass	X	3	agriculture	1916
5	Brassicaceae	*Sisymbrium*	*altissimum*	Tall Hedge Mustard	R	3	unknown	1916

Invasive-ness Ranka	Family	Genus	Species	Common Name	Abun-danceb	Persis-tencec	Source	Date of first collection
5	Fabaceae	*Vicia*	*villosa*	Wolly Vetch	X	3	unknown	1916
1	Fabaceae	*Melilotus*	*alba*	White Sweet-clover	C	1	agriculture	1935
5	Poaceae	*Phalaris*	*canariensis*	Common Canary Grass	X	3	agriculture	1941
1	Poaceae	*Bromus*	*inermis*	Smooth Brome	C	1	agriculture, revegetation	1943
2	Caryophyllaceae	*Stellaria*	*media*	Common Chickweed	C	1	agriculture, horticulture	1943
2	Fabaceae	*Vicia*	*cracca*	Tufted Vetch	C	2	agriculture, transportation, horticulture	1943
2	Asteraceae	*Taraxacum*	*officinale*	Common Dandelion	C	1	unknown	1943
3	Poaceae	*Avena*	*fatua*	Wild Oasts	R	3	agriculture	1943
3	Boraginaceae	*Amsinckia*	*menziesii*	Small-flowered Fiddleneck	R	2	unknown	1943
4	Brassicaceae	*Camelina*	*microcarpa*	Little-pod False Flax	R	2	unknown	1943
4	Brassicaceae	*Descurainia*	*sophia*	Herb-Sophia	U	2	unknown	1943
5	Poaceae	*Triticum*	*aestivum*	Wheat	X	3	agriculture, transportation	1943
5	Polygonaceae	*Polygonum*	*fowleri*	Fowler's Knotweed	X	3	unknown	1943
2	Polygonaceae	*Polygonum*	*achoreum*	Leathery Knotweed	U	1	transportation	1944
3	Poaceae	*Poa*	*annua*	Annual Blue Grass	C	1	transportation	1944
3	Polygonaceae	*Rumex*	*crispus*	Curled Dock	R	2	unknown	1944
5	Poaceae	*Avena*	*sativa*	Oats	X	2	agriculture, transportation	1944
5	Poaceae	*Hordeum*	*vulgare*	Barley	R	2	agriculture	1944
7	Geraniaceae	*Geranium*	*bicknellii*	Northern Crane's-bill	R	2	unknown	1944
5	Poaceae	*Aira*	*caryophyllea*	Hair Grass	X	3	transportation	1946
1	Poaceae	*Agropyron*	*pectiniforme*	Crested Wheat Grass	C	1	revegetation	1947
3	Poaceae	*Alopecurus*	*pratensis*	Field Meadow-foxtail	C	1	agriculture	1947
1	Poaceae	*Elytrigia*	*repens*	Creeping Wild Rye	U	2	revegetation	1949
2	Fabaceae	*Caragana*	*arborescens*	Siberian Peashrub	R	2	horticulture	1949
3	Poaceae	*Agropyron*	*sibiricum*	Siberian Wheat Grass	U	2	revegetation	1949
3	Brassicaceae	*Thlaspi*	*arvense*	Field Pennycress	C	1	agriculture	1949
4	Poaceae	*Festuca*	*trachyphyllla*	Hard Fescue	R	2	agriculture	1949
4	Ranunculaceae	*Thalictrum*	*venulosum*	Veiny-leaf Meadow Rue	?R	2	unknown	1949
4	Papaveraceae	*Papaver*	*croceum*	Poppy	U	2	horticulture	1949
4	Apiaceae	*Pastinaca*	*sativa*	Wild parsnip	R	2	agriculture	1949
4	Asteraceae	*Taraxacum*	*erythrospermum*	Red-seeded Dandelion	X	2	unknown	1949
5	Poaceae	*Secale*	*cereale*	Rye	R	2	agriculture, transportation	1949
5	Boraginaceae	*Asperugo*	*procumbens*	German Mad-wort	X	3	horticulture	1949
5	Lamiaceae	*Dracocephalum*	*thymiflorum*	Thyme-leaf Dragonhead	R	3	agriculture	1949
5	Asteraceae	*Chrysanthemum*	*ircutianum*	Early Daisy	X	3	unknown	1949
2	Asteraceae	*Crepis*	*tectorum*	Hawkweed	C	1	transportation	1957
2	Ranunculaceae	*Clematis*	*tangutica*	Golden Clematis	R	1	horticulture	1958
3	Poaceae	*Psathyrostachys*	*juncea*	Russian Wild-Rye	R	2	agriculture	1960
1	Fabaceae	*Medicago*	*falcata*	Lucerne	C	1	argiculture	1967
5	Asteraceae	*Senecio*	*eremophilus*	Desert Ragwort	R	3	transportation	1968

Invasiveness Rank[a]	Family	**Genus**	**Species**	Common Name	Abundance[b]	Persistencec	Source	Date of first collection
1	Scrophulariaceae	*Linaria*	*vulgaris*	Greater Butter-and-Eggs	C	1	horticulture	1970
5	Scrophulariaceae	*Veronica*	*arvensis*	Corn Speedwell	R	3	unknown	1970
5	Scrophulariaceae	*Veronica*	*serpyllifolia*	Thyme-leaf Dragonhead	R	3	unknown	1970
2	Boraginaceae	*Lappula*	*squarrosa*	Stickseed, Bristly Sheepburr	U	2	unknown	1973
4	Asteraceae	*Gaillardia*	*aristata*	Gailardia	R	2	agriculture	1973
3	Ranunculaceae	*Ranunculus*	*repens*	Creeping Buttercup	X	3	transportation	1977
4	Brassicaceae	*Arabis*	*glabra*	Tower-mustard	?R	2	transportation	1977
1	Poaceae	*Phalaris*	*arundinacea*	Reed Canary Grass	?	1	agriculture, revegetation	1979
3	Brassicaceae	*Lepidium*	*ramosissimum*	Branched Pepperwort	C	1	unknown	1979
1	Asteraceae	*Leucanthemum*	*vulgare*	Oxeye daisy	R	1	horticulture, transportation	1980
1	Asteraceae	*Sonchus*	*arvensis ssp. uliginosus*	Perennial Sow-thistle	C	1	unknown	1980
2	Poaceae	*Elymus*	*sibiricus*	Siberian Wild Rye	C	1	revegetation	1980
2	Poaceae	*Poa*	*compressa*	Flat-stem Blue Grass	U	1	revegetation	1980
2	Fabaceae	*Medicago*	*sativa*	Alfalfa	C	1	agriculture, revegetation	1980
2	Fabaceae	*Onobrychis*	*viciifolia*	Sainfoin	R	2	revegetation	1980
2	Lamiaceae	*Galeopsis*	*tetrahit var.bifida*	Hemp-nettle	R	1	revegetation, horticulture	1980
2	Asteraceae	*Matricaria*	*perforata*	Scentless False Mayweed	R	1	unknown	1980
3	Poaceae	*Festuca*	*arundinacea*	Tall Rye Grass	R	2	revegetation	1980
3	Polygonaceae	*Rumex*	*longifolius*	Door-yard Dock	R	2	transportation	1980
3	Brassicaceae	*Brassica*	*rapa*	Canola	R	1	agriculture, revegetation	1980
4	Chenopodiaceae	*Spinacia*	*oleracea*	Spinach	R	2	agriculture	1980
4	Scrophulariaceae	*Veronica*	*longifolia*	Long-leaf Speedwell	R	2	agriculture, horticulture	1980
5	Caryophyllaceae	*Gypsophila*	*elegans*	Baby's Breath	R	3	unknown	1980
5	Brassicaceae	*Rorippa*	*curvipes var.truncata*	Blunt-leaved Yellowcress	R	3	unknown	1982
4	Ranunculaceae	*Thalictrum*	*dasycarpum*	Purple Meadow-Rue	R	2	agriculture	1991
1	Euphorbiaceae	*Euphorbia*	*esula*	Common Spurge	R	2	argiculture	1992
2	Rosaceae	*Sorbaria*	*sorbifolia*	Sorbaria	R	2	horticulture	1992
3	Fabaceae	*Vicia*	*angustifolia*	Garden Vetch	R	2	unknown	1992
4	Poaceae	*Agrostis*	*capillaris*	Colonial Bent	R	2	agriculture, revegetation	1993
2	Poaceae	*Lolium*	*perenne ssp. perenne*	Perennial Rye Grass	R	1	revegetation	1994
3	Poaceae	*Agrostis*	*scabra var. geminata*	Rough Bent	R	2	revegetation	1994
5	Caryophyllaceae	*Dianthus*	*plumarius*	Carnation	R	3	horticulture	1994
1	Asteraceae	*Centaurea*	*stoebe*	Spotted Knapweed	X	3	unknown	1995
1	Asteraceae	*Cirsium*	*arvense*	Canada thistle	R	2	transportation	1995
1	Asteraceae	*Tanacetum*	*vulgare*	Common Tansy	U	2	horticulture, transportation	1995
2	Poaceae	*Bromus*	*carinatus*	California Brome	R	2	revegetation	1995
2	Fabaceae	*Astragalus*	*cicer*	Chick-pea Milk-vetch	R	2	revegetation	1995
2	Asteraceae	*Tragopogon*	*dubius*	Goat's Beard	R	2	transportation	1995
3	Caryophyllaceae	*Silene*	*noctiflora*	Night-flowering Catchfly	R	2	revegetation	1996
5	Polygonaceae	*Fagopyrum*	*esculentum*	Buckwheat	X	3	agriculture (birdseed)	1997
1	Poaceae	*Leymus*	*angustus*	Altai Lyme Grass	R	2	revegetation	1998
3	Aceraceae	*Acer*	*negundo*	Manitoba or Ash-leaf Maple	R	2	horticulture	1998

Invasiveness Rank[a]	Family	**Genus**	**Species**	Common Name	Abundance[b]	Persistence[c]	Source	Date of first collection
5	Poaceae	*Setaria*	*viridis*	Green Bristle Grass	X	3	transportation	1998
5	Asteraceae	*Centaurea*	*cyanus*	Cornflower	X	3	horticulture	1998
5	Asteraceae	*Crepis*	*capillaris*	Smooth Hawk's-beard	X	3	transportation	1998
2	Poaceae	*Elymus*	*hispidus*	Intermediate Quack Grass	R	2	revegetation	1999
2	Polygonaceae	*Rheum*	*rhaponticum*	Rhubarb	C	1	agriculture	1999
2	Poaceae	*Dactylis*	*glomerata*	Orchard Grass	R	3	revegetation	2000
2	Poaceae	*Thinopyron*	*ponticus*	Eurasian Quack Grass	R	1	agriculture	2000
3	Fabaceae	*Lotus*	*corniculatus*	Garden Bird's-foot Trefoil	R	3	revegetation	2000
5	Boraginaceae	*Myosotis*	*scorpiodes*	True Forget-me-not	R	3	horticulture	2000
4	Brassicaceae	*Arabis*	*caucasica*	Gray Rockcress	R	2	horticulture	2001
5	Brassicaceae	*Erysimum*	*cheiri*	Wallflower	X	3	horticulture	2001
5	Brassicaceae	*Sinapis*	*arvensis*	Corn Mustard	R	3	unknown	2002
2	Rosaceae	*Prunus*	*padus*	Maytree or European Bird Cherry	C	2	horticulture	2003
5	Poaceae	*Bromus*	*japonicus*	Japanese Brome	X	3	revegetation	2003
1	Scrophulariaceae	*Linaria*	*dalmatica*	Dalmatian Toadflax	X	3	unknown	2004
3	Polygonaceae	*Rumex*	*pseudonatronatus*	Field Dock	R	2	transportation	2004
3	Caryophyllaceae	*Cerastium*	*glomeratum*	Sticky Mouse-ear Chickweed	R	2	horticulture	2004
3	Fabaceae	*Medicago*	*lupulina*	Black Medic	R	2	transportation	2007
3	Valerianaceae	*Valeriana*	*officinalis*	Garden Valerian or Allheal	R	2	horticulture	2007
5	Brassicaceae	*Camelina*	*sativa*	Gold-of-Pleasure	R	2	agriculture	2007
5	Lamiaceae	*Lamium*	*amplexicaule*	Giraffehead	R	3	horticulture	2007
5	Rubiaceae	*Galium*	*aparine*	Sticky-willy	X	3	agriculture (birdseed)	2007
6	Poaceae	*Puccinellia*	*distans*	Spreading Alkali Grass	P	4		
6	Polygonaceae	*Polygonum*	*persicaria*	Lady's-Thumb	F	4		
6	Brassicaceae	*Armoracia*	*rusticana*	Horse-radish	F	4		
6	Verbenaceae	*Verbena*	*hastata var. scabra*	Simpler's-Joy	F	4		
6	Rubiaceae	*Galium*	*palustre*	Common Marsh Bedstraw	F	4		
6	Asteraceae	*Sonchus*	*oleraceus*	Common Sow-thistle	F	4		
7	Poaceae	*Festuca*	*rubra*	Red Fescue	?C	1	revegetation	
7	Poaceae	*Poa*	*nemoralis*	Forest Blue Grass	?	2	revegetation	
7	Poaceae	*Poa*	*pratensis ssp.pratensis*	Kentucky Blue Grass	?	1	unknown	
7	Polygonaceae	*Polygonum*	*buxiforme*	Prairie Knotweed	?C	1	transportation	
7	Fabaceae	*Vicia*	*americana*	American Vetch	?R	1	unknown	
7	Boraginaceae	*Hackelia*	*deflexa*	Nodding Stickseed	?X	3	unknown	
7	Boraginaceae	*Plagiobothrys*	*scouleri*	Meadow Popcorn Flower	?R	3	unknown	
7	Lamiaceae	*Stachys*	*pilosa*	Hedge-nettle	?R	2	unknown	
7	Plantaginaceae	*Plantago*	*major*	Great Plantain	?C	1	unknown	
7	Asteraceae	*Gnaphalium*	*uliginosum*	Marsh Cudweed	?R	2	unknown	

See notes on next page.

[a] Invasiveness Rank
1 - highly invasive - may displace or replace native ecosystems
2 - aggressive - widespread, persistent, but may not replace native species or change ecosystem function
3 - taxa present in the territory that are not known to be invasive here but have been found to be invasive in other jurisdictions
4 - has been reported in the territory but has not been shown to be problematic and may not persist
5 - species that likely don't persist
6 - false reports
7 - native and introduced populations exist

[b] General Abundance
C - common (widespread established)
F - falsely reported
P - possible but not yet documented
R - rare (known from only 1 or two localities)
U - unknown
X - possibly not persistent
? - possibly native

[c] Persistence
1 - widespread
2 - local
3 - not persistent
4 - falsely reported

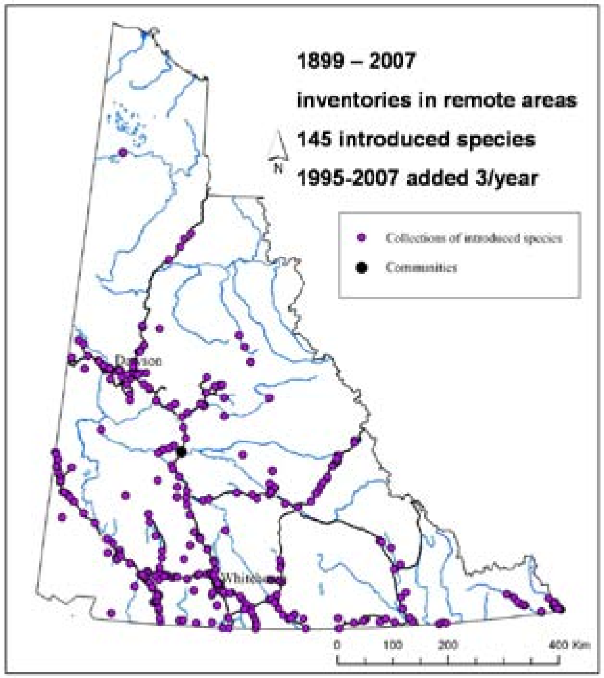

Figure 4. Distribution of known introduced plants 1899–2007.

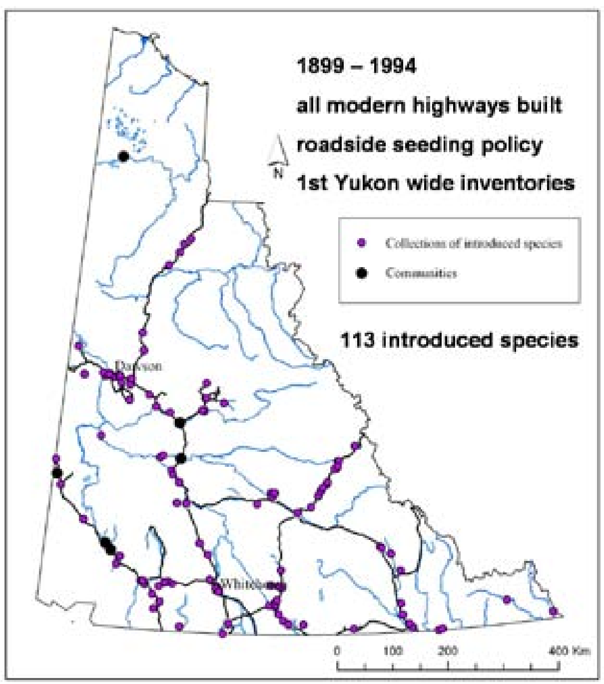

Figure 5. Yukon coastal plant survey 2005–2006.

The European bird cherry (*Prunus padus* L.) has been a popular horticultural tree in the territory since at least the early 1940s. It is widely planted in most Yukon communities. The first naturalized seedlings were observed in 2003 (Bennett et al. *in press*). In 2006 the first naturalized flowering trees were found on islands in the Yukon River. In the summer of 2007 several hundred seedlings were discovered in the communities of Whitehorse, Carmacks, Watson Lake and Dawson. Though most of the seedlings were in their first year, plants of up to three years old were found in Whitehorse neighbourhoods.

Perhaps the most dramatic example of a plant changing it distribution patterns is the spread of the native narrow-leaf hawkweed (*Hieracium umbellatum* L.). The species was known in Yukon only from the southeast region of the territory where it inhabited relatively mild habitats such as hot springs, riverbanks and lake-shores. In 2007 narrow-leaf hawkweed was found to be colonizing roadsides along the Alaska Highway as far west as Whitehorse. In some cases the plants demonstrated invasive properties, spreading rapidly and forming large stands throughout the roadsides, resembling those of sow-thistle.

The results of this study indicate that the rates and number of sources of plant introductions are increasing in the Yukon Territory. It is hypothesized that the invasive nature of plants is changing and that these changes may be linked to global climate change with warmer winters, longer frost-free periods and increased summer precipitation. It is expected that the distributional boundaries set by temperature and moisture are changing and plants so problematic in the south may soon advance northward. Studies will continue to monitor *Prunus padus* to see if it becomes invasive. Projects will also take place this summer to attempt to eradicate some of the more recent invaders.

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Biography

Bruce Bennett has been a plant taxonomist for over 20 years and currently works for the Yukon Department of Environment as the Wildlife Viewing Biologist. He moved to the Yukon Territory in 1995 when he began to research invasive plants. He became a founding member of the Yukon Invasive Species Council (YISC) in 2004. His botanical work and interests have taken him throughout Yukon, Alaska, Northwest Territories and British Columbia. He has worked as a collection manager for the Royal British Columbia Museum, a plant community technician with the Canadian Wildlife Service, a senior botanist with the University of Alaska and the US Parks Service and as a botanist for the Yukon's Conservation Data Centre, NatureServe Yukon. He has been writing a revision of the Rare Plants of the Yukon since 1996 and has coauthored 8 papers on additions to the Yukon flora. He is a member of the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), Plants and Lichens Species Specialist Subcommittee, and a regional reviewer for the Flora of North America. His interests include ecosystem dynamics, biological diversity conservation and protected areas management in relation to ecological and socio-economic drivers, such as invasive species, climate change, human population and consumption issues.

Randi Mulder has specialized in GIS and data management. She has assisted Bruce Bennett with his botanical research since 1995 and is currently working for NatureServe Yukon as a data manager, dealing with species of conservation concern. Previously she spent 10 years coordinating research and providing all mapping support for the Yukon Chapter of the Canadian Parks and Wilderness Society.

Managing Invasive Plants in the National Wildlife Refuge System, U.S. Fish and Wildlife Service

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Abstract

The National Wildlife Refuge System is actively engaged in controlling and managing invasive plants on refuges across the country. Invasive species have been identified as the single most important threat to the Refuge System. At present, refuge lands host over two million acres of invasive plants extending from the Mexican border to the Canadian border. The current and potential future costs to the Refuge System are significant both financially and ecologically. We estimate that financial expenditures for invasive species projects in FY 2007 alone totalled $11.3 million from base funding. To confront this threat, a number of new and innovative programs are being implemented. In addition to developing invasive species strike teams, we have built a strong volunteer program. Tools such as online training programs, developed in collaboration with the Center for Invasive Plant Management, are being used to engage both volunteers and staff in invasive plant management.

Resumen

El Sistema Nacional de Refugios de Vida Silvestre esta comprometido a combatir las especies de plantas invasoras en los diferentes refugios por toda la nación. Las especies invasoras han sido identificadas como la principal amenaza al Sistema de Refugios. En este momento, las especies de plantas invasoras cubren alrededor de dos millones de cuerdas desde el borde de México hasta el borde de Canadá. Los costos actuales y futuros para el Sistema de Refugios, en términos financieros y ecológicos, son significativos. Los gastos financieros en proyectos de especies invasivas fueron estimados en $11.3 millones de dólares en el año fiscal 2007. Para enfrentar el reto, varios programas han sido implementados. Un programa fuerte de voluntarios ha sido creado, además se han desarrollado equipos de respuesta a las especies invasivas. Herramientas como el programa de entrenamiento electrónico, el cual fue creado en colaboración con El Centro de Manejo de Plantas Invasivas, han sido utilizadas para involucrar tanto a voluntarios como personal en el manejo de plantas invasoras.

1 Presenter.

Introduction

The National Wildlife Refuge System (NWRS) spans 96 million acres from the frozen tundra of Alaska to the tropics of the Florida Everglades. Managed by the United States Fish and Wildlife Service (USFWS), the NWRS includes 548 wildlife refuges, thousands of waterfowl protection areas, and many special management areas such as federally designated wilderness areas and wild and scenic rivers. It provides habitat for wildlife, as well as recreational opportunities for the American public.

Controlling invasive plants on refuge lands has become a key management priority for the NWRS. According to a recent study conducted by the Government Accountability Office, in which refuge managers were polled on how a variety of management issues affected funding between 2002 and 2007, invasive plants were identified as the number one problem influencing habitat trends on refuges. The same study showed that time spent addressing invasive plant issues saw the greatest increase among a variety of habitat management activities during that same five year period (GAO 2008).

The NWRS derives its management authority for controlling invasive species from its Biological Integrity Policy. This policy specifically directs refuge staff to prevent, detect and control populations of invasive species present on its lands, as well as to restore native species and their habitats (USFWS 2001). In coordination with other Federal agencies operating under Executive Order 13112, the USFWS defines invasive species as non-native species likely to cause harm, be it economic or environmental harm, or harm to human health (E.O. 13112, 1999 Feb. 3).

Impacts on the National Wildlife Refuge System

The invasive plants found on refuges are non-native species that were either intentionally or accidentally introduced to the United States at some time in the near or distant past. Without the naturally occurring constraints placed on them in their countries of origin, such as predators and parasites, many of these species are able to out-compete, and sometimes totally replace, native plants.

As of 2008, 2.33 million acres, or about 2.4 percent, of refuge lands were known to be infested with invasive plants (USFWS 2008). While the NWRS is committed to controlling and eradicating invasive plants, the total number of infested acres that we are able to treat on an annual basis is relatively low, at about 13 percent (Figure 1).

Although the percentage of acres treated annually appears to have remained relatively constant in recent years, the cost of control has greatly increased. The USFWS tracks the cost of various activities and purchases related to invasive species management in the NWRS. The cost of these activities has risen every year from $6 million in 2004, to $11.3 million in 2007. The NWRS also keeps track of special projects that need to be completed on refuges through its Refuge Operation Needs System (RONS). Projects specifically targeted for invasive species control and management have increased from $107 million in 2004 to $166 million in 2007.

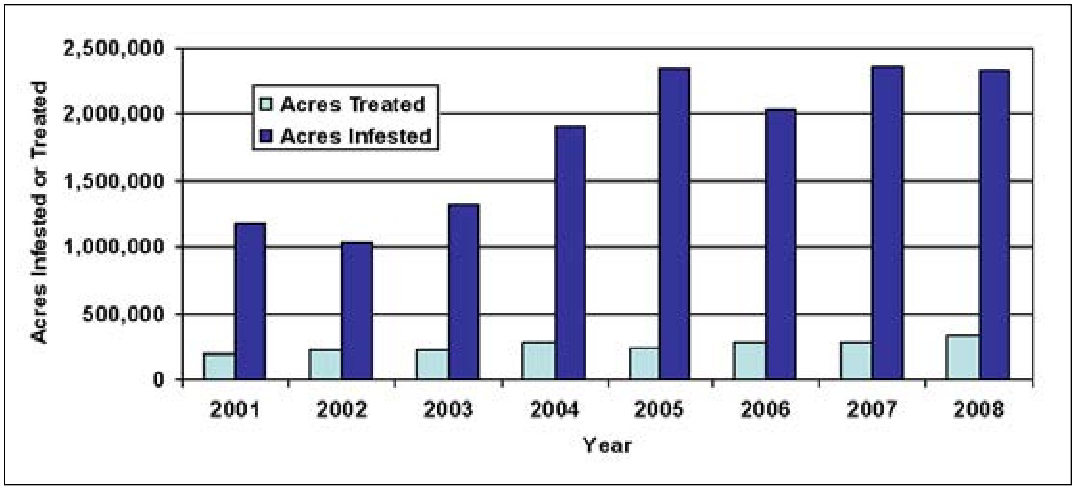

Figure 1. Acres infested with invasive plants and acres treated for invasive plant infestations from 2001 through 2008 in the National Wildlife Refuge System.

Strategic Initiatives to Combat Invasive Plants in the NWRS

In order to confront the challenge of managing invasive plants on refuges, the USFWS is implementing a variety of strategic initiatives at national, regional and local refuge levels. These initiatives fall neatly into the categories of prevention, early detection, rapid response, control and management, monitoring, outreach and capacity building.

Prevention

Preventing invasive plant infestations from occurring or spreading to non-infested areas requires an understanding of how invasive species move, especially the pathways and vectors they utilize. Examples of pathways for invasion on refuges may be birdwatchers and biologists who unknowingly carry the seeds of invasive plants stuck in their boots; anglers who transport pieces of aquatic weeds on their boats and other equipment; and maintenance, law enforcement, and fire fighting staff who move seeds or plant parts in the tires of their vehicles.

At the regional level, Hazard Analysis and Critical Control Point Planning (HACCP) for invasive species was developed by USFWS staff to assist land and resource managers nationwide to better incorporate prevention measures into daily management operations. Using a decision tree framework, HACCP enables managers to map out key pathways and identify critical control points where implementation of prevention measures can reduce or eliminate the threat of infestation by invasive species. HACCP courses are available at the National Conservation Training Center in Shepherdstown, West Virginia. A Spanish language version of the HACCP system has been developed and is available on the Mexican federal agency website: www.conabio.gob.mx/invasoras.

At the local level, the Charles M. Russell National Wildlife Refuge, in partnership the South Phillips County Ranchers Stewardship Alliance, developed a program to wash off-road vehicles during the 2007 hunting season. A portable wash system was rented and manned by volunteers who hand-washed the vehicles of hunters entering and leaving the refuge. Over 40 vehicles were washed in two days by volunteers contributing more than 100 hours of their time. In addition, 100 free car wash certificates were given away to hunters in the nearby town of Malta. Recreational vehicles can be one of the most significant vectors for spreading invasive plants on public lands. This project deserves special recognition because it emphasizes prevention; stopping the problem before it starts.

Early Detection of New Infestations

When prevention strategies are unsuccessful, the most cost effective place to focus management efforts is in the early detection phase before an infestation can spread and become established. Taking management action to control an infestation at this stage, when it is still relatively small in size, can be much less expensive, both financially and ecologically, than taking action after the infestation has already become established.

In the NWRS, volunteers have played a vital role in early detection efforts on refuge lands. The Volunteers and Invasives Program (VIP), coordinated by the NWRS at the national level, provides funding to refuges through a special Congressional appropriation to engage volunteers in invasive species management activities. Partners working with the NWRS on this program include the National Wildlife Refuge Association (NWRA), The Nature Conservancy (TNC), and the United States Geological Survey (USGS) National Institute of Invasive Species Science (NIISS).

In Alaska, where early detection efforts are critical due to the relatively pristine environment, volunteers have been involved in initial inventories of disturbed areas. At Innoko NWR, a small grant from the VIP program in 2006 supported transportation and basic necessities for a team of volunteers to survey historic gold rush sites and long-utilized hunting camps for specific invasive plants that refuge staff suspected may have been brought in by miners and hunters. That same year, along the Beaver Creek Wild and Scenic River that runs through Yukon Flats NWR, volunteers surveyed gravel bars and downstream areas for invasive plants that could have been brought in by kayakers, canoeists, dogsled mushers, hunters and fishermen. Although non-native plant species were discovered at both sites, no invasive plants were found during these survey efforts.

The Ottawa NWR, which preserves some of the last remaining remnants of the Great Black Swamp in the heart of the Lake Erie marshes in Ohio, has a dynamic invasive species program with a strong early detection component. In the spring of 2007, refuge staff and volunteers discovered poison hemlock (*Conium maculatum* L.) and the small-flowered hairy willow herb (*Epilobium parviflorum* Schreb.) starting to appear in the marshlands. Because these infestations were discovered early, and small in size, they were easy to eradicate. Early detection efforts at this refuge also brought about the discovery of a rare occurrence of the federally threatened eastern prairie fringed orchid (*Platanthera leucophaea* (Nutt.) Lindl.).

Rapid Response, Control, and Management

The NWRS Invasive Species Strike Teams (ISST) are mobile response units designed for rapid response and eradication of newly discovered invasive plant infestations on refuges. Modelled after the National Park Service's Exotic Plant Management Teams, the ISST's utilize a similar strategy to the "hot shot" fire fighting crews that focus on wildfire management. If not controlled quickly, invasive plant infestations can spread much like wildfires, beginning small and expanding to cover huge areas. There are currently five ISSTs in the NWRS which are strategically placed in the following geographic locations: 1) Hawai'i and the Pacific Islands; 2) the lower Colorado River basin; 3) Florida Everglades; 4) the upper Missouri/Yellowstone/ upper Columbia River basins; 5) and, the North Dakota prairie pothole region.

With support from the NWRS's VIP program, volunteers and refuge Friends groups also play an active role in invasive plant rapid response, control and management activities on many refuges. During the summer of 2007, Horicon NWR in Wisconsin used a small grant of $5,000 from the VIP program to engage 48 volunteers who invested 400 hours to control infestations of invasive plants such as common buckthorn (*Rhamnus cathartica* L.), bush honeysuckle (*Lonicera* spp.) and black locust (*Robinia pseudoacacia* L.). Girl scouts from Camp Silverbrook surveyed the project area using a GPS device and set up 44 photo points to mark the location of buckthorn trees over 82 acres (Figure 2). Using these data a GIS map was created to prioritize the removal of the buckthorn. Fellow volunteers from local school groups cut and piled the plants. Later, members of the Friends group crafted pens and walking sticks from the refuse to sell as educational items in the visitor center's bookstore.

Figure 2. Girl scouts with Erin Railsback, Visitor Services Specialist, at Horicon NWR recording information from a photo location on a data sheet prepared for them. Source: USFWS

In 2006, Parker River NWR in Massachusetts established a partnership with the Massachusetts Audubon Society to fight perennial pepperweed (*Lepidium latifolium* L.). They combined funding from the Pulling Together Initiative, administered by the National Fish and Wildlife Foundation, with a small grant from the VIP program, and engaged 70 volunteers who succeeded in hand pulling 3,000 lbs (about 1400 kg) of pepperweed. They also established a "fire lane" north of the refuge to act as a barrier to existing stands of pepperweed that can provide a source of seed for re-colonizing the refuge's marshlands.

Also in 2006, a VIP program grant provided to the Litchfield Wetland Management District at Weber Waterfowl Production Area in Minnesota enabled staff to engage 32 volunteers, primarily Boy Scouts, in the control of invasive woody vegetation. The scouts logged 239 hours using loppers and hand saws to cut back invasives such as buckthorn and Russian olive (*Elaeagnus angustifolia* L.) on 92 acres of land. A refuge staff member worked closely with the Scouts painting the stumps of the fallen vegetation with herbicide to prevent regrowth.

In summary, over a three year period between 2005 and 2008, the VIP program enabled 2,750 volunteers to contribute more than 49,000 hours to the treatment, inventory, and restoration of over 211,000 acres of refuge land through its small grants program. The NWRA has designed a user-friendly website that enables easy access to reports and maps produced by refuges participating in the VIP program (www.refugeassociation.org/New-invasives). A map of the United States provided on the website has hyperlinks that lead the viewer to a list of refuge volunteer projects in each state. Each project on the list has an attached report, map, or article to provide further information.

Monitoring, Mapping, and Modeling

Another component of the VIP program includes mapping and monitoring invasive plants. The primary objective of this component is to collect quantitative data on the location and extent of existing infestations. Volunteers and refuge staff are trained to use handheld computers with attached GPS devices to collect baseline inventory data. These data assist managers in prioritizing areas for treatment. It also helps managers track the spread of infestations and the efficiency of treatment methods over time. Refuge-based training is coordinated at the national level for volunteers and staff who want to be actively involved in mapping invasive plant infestations on refuges. Since its inception in 2003, the mapping component of the VIP program has trained over 198 volunteers and refuge staff on 30 refuges/complexes across the country. So far, trained individuals have surveyed and mapped 24,862 acres of refuge lands.

For large landscape scale refuges we are testing predictive modelling approaches with help from the NIISS. On Hart Mountain National Antelope Refuge in Oregon, as well as Kenai NWR in Alaska, National Elk Refuge in Wyoming and Hakalau NWR in Hawai‘i, the NIISS team has worked with vegetation maps and field data to create models of invasive species spread. Field data are collected by sampling plots in understory and priority areas, such as burned areas, to document species richness at various scales. The data are analysed using regression trees and multiple linear regression techniques. Maps are prepared from the data which reveal areas that are susceptible to invasion by non-native plants.

Capacity Building

In collaboration with the Center for Invasive Plant Management (CIPM) at Montana State University, the VIP Program recently developed an online training program for Refuge System volunteers and Friends groups (www.fws.gov/invasives/volunteersTrainingModule). The web-based program provides basic introductory information that is suitable for anyone interested in learning about invasive plants (Figure 3). The five self-study modules include a variety of topics, such as the organization and history of the NWRS, the role of volunteers in managing invasive species in the NWRS, invasive plant biology and control, and tips for community outreach and education. Each module includes a learning quiz and hyperlinks to other web-based resources for more in depth review.

Figure 3. Home page of the invasive plant online training program for volunteers.

In order to provide refuge staff with the proper training for managing invasive plants on refuges the USFWS's National Conservation Training Center (NCTC) in Shepherdstown, West Virginia, offers a course entitled "Field Techniques for Managing Invasive Plants". This course offers practical information about invasion ecology, management strategies, and calibration methods for working with chemical treatments.

As a supplement to the course offered by NCTC, and to better accommodate refuges that are unable to send staff to off-site trainings, a series of online training modules has been developed to assist NWRS staff members in their efforts to manage invasive plants on refuge lands (www.fws.gov/invasives/staffTrainingModule). Like the online training program developed for volunteers, these modules were created in collaboration with the Center for Invasive Plant Management. They are designed to provide a general overview of planning and policy, as well as integrated pest management control methods, such as prescribed fire, grazing, mechanical removal, chemical control, and biological control.

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Ecological Stewardship in the Urban Prairie: Grassroots Weed Awareness Initiatives in Northwest Calgary, Alberta

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Abstract

Invasive alien species, prairie conservation, and environmental stewardship are but a few of the natural and cultural history concepts and issues touched upon by a recent grassroots public environmental education initiative in northwest Calgary, Alberta. A curriculum-connected, site-specific ecological pedagogy was used in the creation of a unique set of interpretive signage panels in a suburban grassland and aspen parkland setting. Students, teachers, parents, and community members worked together over several years to produce the original art, poetry, and text for 34 amazingly beautiful and provocative signs for both school-based and public education. In particular, two of the major panels speak directly to the threat of IAS to local grassland parks: "Aliens Amongst Us!" and "Owls and Oxeyes." Close collaboration with The City of Calgary Natural Area Parks department and Dr. E. W. Coffin School, and an open inquiry process informed the development of the panels. Detailed GPS data situates each sign, and a future website

Resumen

Las especies invasivas alóctonas, la conservación de praderas y el cuidado ambiental son apenas unos cuantos conceptos de historia natural y cultural y de asuntos abordados en una reciente iniciativa comunitaria de concientización pública realizada en el noroeste de la ciudad de Calgary, provincia de Alberta. Se utilizó una pedagogía ecológica conectada con los programas de enseñanza y relacionada con sitios específicos para crear un conjunto único de paneles de señalización interpretativa en un ambiente de praderas suburbanas y tierras de parque público con álamos. Estudiantes, profesores, padres y miembros de la comunidad trabajaron conjuntamente a lo largo de varios años para crear 34 paneles de señalización de gran belleza y cargados de arte, poesía y textos originales que invitan a la reflexión, para la educación tanto de escolares como el público en general. Dos de los principales paneles abordan directamente la amenaza que plantean las especies invasivas alóctonas para las praderas de los parques locales: "Aliens Amongst

will support this generative project. As a set, the resulting signs speak closely to the complexities of our ecological context and our place in the web of existence, especially at the precious and precarious intersections of our natural and built environments where weeds abound.

Us!" (Alóctonas Entre Nosotros) y "Owls and Oxeyes (Búhos y Ojos de buey)". Una estrecha cooperación con la dirección de parques naturales de la ciudad de Calgary (*City of Calgary Natural Area Parks Department*) y la escuela Dr. E. W. Coffin School, al igual que un proceso abierto de consulta, alimentaron la elaboración de los paneles. Datos detallados de cartografía espacial ubican a cada panel y un futuro sitio web apoyará a este proyecto generativo. En conjunto, los paneles de señalización creados reflejan las complejidades de nuestro contexto ecológico y nuestro lugar en el entramado de la vida, especialmente en las delicadas y precarias intersecciones de nuestros entornos naturales y construidos donde abundan las malezas.

Grassroots Weed Awareness Through Interpretive Signage

Invasive alien species, prairie conservation, and environmental stewardship are but a few of the natural and cultural history concepts and issues touched upon by a recent grassroots public environmental education initiative in northwest Calgary, Alberta. A curriculum-connected, site-specific ecological pedagogy was used in the creation of a unique set of interpretive signage panels in a suburban grassland and aspen parkland setting in a residential area near the southwest corner of Nose Hill Park (Figure 1).

The signs are in two sizes: small ovals represent each letter of the alphabet and feature student art; the rest are larger panels featuring paintings, stories, and poems by local residents. The project committee collaboratively developed the main text, and consulted a wide array of inputs from the greater community. As a result, many stakeholder voices are represented on the signs in deeply meaningful formats, thus directly facilitating the development of both community and individual ecological identity and a sense of place for all viewers.

Thomashow (1995) discusses the fabric of community in his ecological identity explorations. He suggests that "one's perception of community is crucial in traveling the path of ecological citizenship." Sobel (2004), in his book about connecting classrooms and communities with place-based education, includes both the natural and built environments in looking "at how landscape, community infrastructure, watersheds, and cultural traditions all interact and shape each other." Hart (1997) argues for emphasizing local environmental research by children because "genuine ecological understanding involves an understanding of environmental phenomena 'in place' — that is, their complex spatial relatedness to one another." Orr (1994), in looking at recovering a sense of place as a route to a desired biophilia or love of planet, suggests that "means rediscovering and restoring the natural history of our places." A main purpose of the community environmental education projects I have been involved in is precisely to "rediscover and restore" natural and cultural heritage "in place."

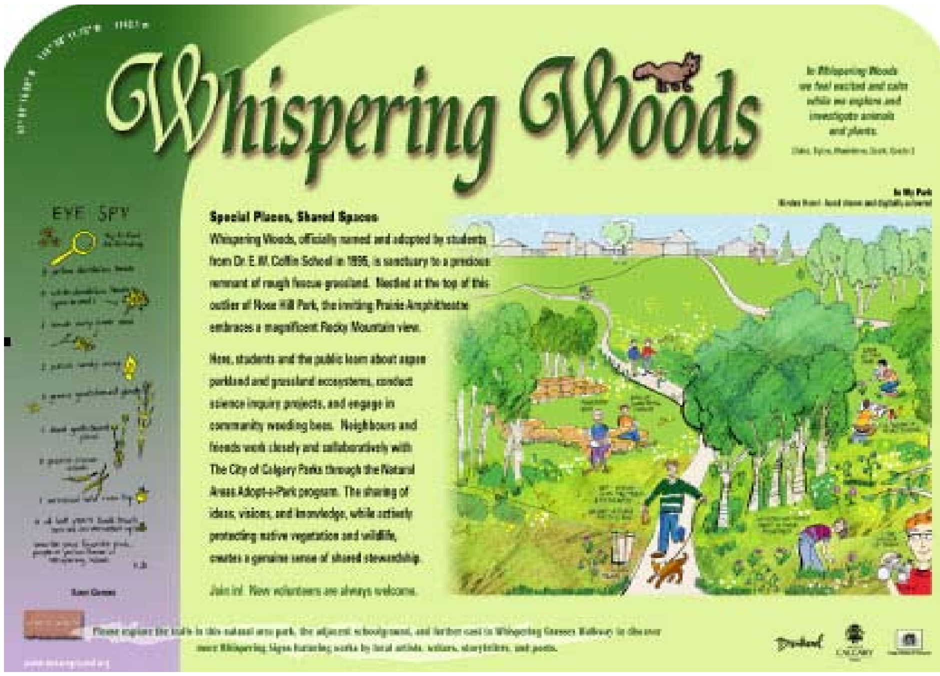

Figure 1. Whispering Woods Interpretive Panel: Collaborative Community Stewardship.

The cumulative sign content addresses an extensive cross section of interrelated concepts from the biosphere, hydrosphere, atmosphere, lithosphere, and sociosphere, thus presenting an ecocentric perspective of our ecological context. Community members, parents, teachers, and students worked together over several years to produce the original art, poetry, and text for thirty-four amazingly beautiful and provocative signs for both school-based and public education. The initial philosophical framework was enhanced via a process of open inquiry during the development of the panels, and through close collaboration with The City of Calgary Natural Area Parks department and Dr. E. W. Coffin School. Collaboration and stewardship have been key to the development of the interpretive panels, and to enhancing a sense of attachment for the small natural spaces within the local community.

Nabhan and Trimble (1994) state there are "common ways in which wildness – even in its simplest forms – can nourish a lasting attachment to the earth, and, in turn, nurture self-esteem." Herrero (2000) writes about "Wild Love" as a form of attachment, "Love of nature is the integration of our emotional, intuitive dimension, with our rational-logical dimension into feelings, thoughts and actions reflecting deep connection, wonder, respect, concern and caring for nature. Love leads to long term commitment. I doubt if divorce is possible." This back and forth between people and the environment nurturing each other is key to sustainability within a shared context.

The notion of caring for something that we love and respect is a cornerstone of environmental education, even if a causal link remains intuitive. Perhaps this is best represented by Aldo Leopold's oft quoted, "We abuse land because we regard it as a commodity belonging to us. When we see land as a community to which we belong, we may begin to use it with love and respect" (1949). A sense of belonging to a land community is related to a sense of place. Mueller Worster and Abrams (2005) examined conceptual understanding of sense of place amongst farmers and fishermen by interviewing them to look at three characteristics: 1) ecological context; 2) social context; and, 3) place attachment. They found that increased ecological and social knowledge of a place contributed to strong ecological and social identities, and together with attachment to a place, the farmers and fishermen had a well-developed sense of place and, whether linked or not, also exhibited environmentally responsible behavior.

My premise in my environmental stewardship work assumes that the more we understand our ecological and social context, the more we become attached to place, and thus the more likely we will be to participate in sustainable behaviors, and *vice versa*. Thus, both a) developing a sense of place in others and ourselves, and b) fostering opportunities for students and the public to engage in meaningful stewardship activities, should be a fundamental *modus operandi* for all educators and leaders in any field of endeavor related to our ecological and social contexts.

Two of the major panels speak directly to the threat of invasive alien species (IAS) to local grassland parks: "Aliens Amongst Us!" and "Owls and Oxeyes." Local artist Pat Oezefe painted the Oxeye daisies, though to "lovingly" depict something she truly dislikes was a challenge for someone whose livelihood is growing native seeds and plants! Pat is also known through her business, ALCLA Native Plants, which she and her husband, Al Fedkenheuer, run from their home in Brentwood, near where all the signs are located. Nancy Hansen, another local resident, painted and sketched the main art works on the *Aliens Amongst Us!* sign. Nancy also illustrated Kirker and Kary's (1996) book entitled *Exploring Nose Hill*, which includes sections on invasive species. This popular field guide has just been reprinted and is available from local authors Jill Kirker and Diana Kary, by calling Grassroots NW Environmental Awareness Society at 403-284-1316.

Also featured on the *Aliens Amongst Us!* sign is text by local youth, Rowan Cockett, based on his Grade 12 science fair project on invasive species (Cockett 2006), as well as a poem by his sister, Audrey Lane Cockett, entitled *Rough vs. Smooth*, which also speaks to the threat of alien brome grass in our native fescue grasslands.

Two poems about invasive alien species are featured on the signs. "Leucanthemum Lament" goes with the "Oxeye Daisy" painting on the "Owls and Oxeyes" sign. *Leucanthemum vulgare* Lam. is the botanical name for oxeye daisy, sometimes called Marguerite, or Love-me, Love-me-not. "Rough vs. Smooth" goes with the "Aliens Amongst Us! sign."

Leucanthemum Lament
Oh, Marguerite, I know thy smile,
With ox-eyed stare you would beguile.
Thy prolific seed and prostrate root
Spreads far and wide from single shoot.Love
thy beauty? Love thee nowt.
Oh, daisy, we must bear thee out!

by Polly Knowlton Cockett
and Robin Cockett

Rough vs. Smooth
I'm just a happy little fescue,
But I think I need a rescue.
Alien grasses like smooth brome
Are moving in upon my home.
Invasive species are taking over,
Despite their pretty fields of clover.
We must keep these foes at bay,
Even though they're good for hay.
How shall we now control this pest,
And let me thrive and grow my best?

by Audrey Lane Cockett, Grade 6, 2004

Close collaboration with The City of Calgary Natural Area Parks department and Dr. E. W. Coffin School, and an open inquiry process informed the development of the panels. Detailed Global Positioning System coordinates situate each sign with latitude, longitude, and elevation, and a website, www.natureground.org, supports this generative project. As a set, the resulting signs speak closely to the complexities of our ecological context and our place in the web of existence, especially at the precious and precarious intersections of our natural and built environments where weeds abound.

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Biography

Polly Knowlton Cockett is a doctoral student in Environmental Education at the University of Calgary, a teacher with the Calgary Board Education, and she holds Master's degrees in both Science Education and Geology. For over a decade, Polly has voluntarily managed the award winning outdoor environmental projects at Dr. E. W. Coffin School in collaboration with The City of Calgary Parks and her local community of Brentwood in northwest Calgary.

Aquatic Weeds 101: What Terrestrial Managers Should Know

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Abstract

Invasive aquatic plant species impact our waterways by impeding commercial navigation, obstructing flood control structures, interrupting hydropower production, degrading water quality, interfere with recreational use, and alter native plant communities significantly, contributing to the reductions and elimination of endangered plant and animal species. These plant species are not just problematic to the warmer climates; currently they are prevalent in Canada, infest every state in the US, and are found throughout Mexico. Pathways for their introduction have been documented to occur through both commercial and non-commercial activities. The true magnitude of their monitory and ecological impact on water resource activities is unknown. In the U.S. it is estimated that these plants cost $3–5 billion in economic losses every year and organizations spend $100–275 million annually managing infestations. The cost of dealing

Resumen

Las especies vegetales invasoras acuáticas afectan a nuestras vías fluviales, impidiendo la navegación comercial, obstruyendo estructuras para control de inundaciones, interrumpiendo la generación de energía eléctrica, degradando la calidad del agua, interfiriendo con los usos recreativos y alterando significativamente las comunidades vegetales nativas al contribuir a la reducción y desaparición de especies de flora y fauna en peligro de extinción. Estas especies de plantas no son un problema únicamente en los climas cálidos. Actualmente prosperan en Canadá, han infestado cada uno de los estados de Estados Unidos y pueden encontrarse por todo el territorio de México. Se ha documentado que las vías por sonde se introducen son de naturaleza comercial como no-comercial. Se desconoce la verdadera magnitud de su impacto monetario y ecológico sobre las actividades relacionadas con los recursos acuíferos. En Estados Unidos, se estima que estas plantas

with invasive aquatic plant species continues to rise annually and this trend will continue unless significant resources are devoted to addressing all the areas contributing to this problem.

causan daño estimado entre 3 y 5 mil millones de dólares cada año y que las organizaciones invierten entre 100 y 275 millones de dólares anualmente en el control de infestaciones. El costo de controlar especies de plantas acuáticas invasoras continúa aumentado cada año y esta tendencia continuará si no se dedican importantes recursos para abarcar a todas las áreas que contribuyen a este problema.

Introduction

Invasive aquatic weeds produce significant problems throughout the aquatic habitat and limit or restrict vital water resources. Floating and submersed problem vegetation populates areas in extensive numbers and fouls propellers or entirely blocks channels, making the passage of boats impossible. Large floating or submersed mats of vegetation clog water intakes at flood control structures, water supply facilities, and hydropower plants. Weed infestations can require that significant resources are expended to allow these facilities to remain operational. Recreational facilities at lakes can become obstructed with vegetation, thus reducing or eliminating the ability of visitors to utilize these facilities for boating, swimming, or fishing. The invasion of aquatic weeds also has a significant impact on the native habitat. In many situations invasive plants disrupt the ecological balance. Native plant communities are displaced and replaced with a monoculture of exotic plants. This disruption has significant implications throughout the community. Primary and secondary consumers have key components of their food source removed or displaced. These types of alterations can have significant impacts on the plant and animal communities.

Comparison of aquatic and terrestrial plants

Terrestrial and aquatic weeds have many similarities. Both groups of plants need water, nutrients, and light to exist. They conduct photosynthesis that allows them to grow and develop. Nevertheless, there are some key differences between terrestrial and aquatic weeds. Generally, terrestrial weeds are rooted in the soil and grow in air. Aquatic weeds can also be rooted in soil and grow in air (emergent), however, aquatic plants can also float on the water surface with their roots in water and their apical portion in the air (floating). Other invasive plants can be rooted in soil with their apical portion remaining under water and not be exposed to the air (submersed). Another aspect of invasive aquatic plants that needs to be understood is their reproductive strategy. In many situations, these invasive weeds possess extensive sexual and asexual reproductive capabilities. Some plants produce copious amounts of seeds that can easily be dispersed by wind and water. Other plants can asexually develop extensive amounts of daughter plants that cause exponential reproduction rates and provide extensive amounts of plants for dispersal. Many invasive plants can reproduce by fragmentation where small portions of the plant break off of the parent and develop into new plants.

Control methods

Many of the same control methods that are utilized in the management of terrestrial weeds are also employed in the management of aquatic weeds. Biological, chemical and mechanical control methods are available for many of the troublesome aquatic weeds. Various approaches may be required to utilize each of these methods in the aquatic habitat. In order to develop effective management approaches, the growth form of the target weed (emergent, floating or submersed) and its reproductive strategies need to be understood.

Biological

Insect biological control agents have been developed for many of the floating and emergent weeds. They generally operate in the same way as those developed for terrestrial weeds. Effective insect biological control agents have been developed for the management of alligator weed (*Alternanthera philoxeroides* (Mart.) Griseb.), purple loosestrife (*Lythrum salicaria* L.), water lettuce (*Pistia stratiotes* L.), *Salvinia molesta* D.S. Mitch., water hyacinth (*Eichhornia crassipes* (Mart.) Solms) and other emergent and floating plants (Coombs et al. 2004). The use of insect biological agents to manage submersed aquatic plants requires that the agent be able to feed on the plant under water. The release of these agents and subsequent monitoring of their impact on submersed vegetation are often difficult and require specialized equipment and techniques. Some insect agents have been identified and are currently being released on *Hydrilla verticillata* (L. f.) Royle (Van Driesche et al. 2002) and their initial impact appears to be promising. A patent has been secured for a fungal pathogen that is being examined as a potential biological control agent of hydrilla. This endemic pathogen attacks hydrilla under water and causes a disease that stresses and kills the plants. This product has not been approved for commercial use; however, the initial field testing shows potential. Managers attempting to utilize biological control agents need to understand that they generally do not work rapidly, but once established, they often persist and maintain themselves (Coombs et al. 2004).

Chemical

Applicators need to realize that the number of herbicides and surfactants available are more limited when attempting to manage aquatic plants. Label requirements are usually more restrictive for aquatic habitats. Managers need to examine where in the community the plant is located (floating, emergent, or submersed) and understand its reproductive biology. Often emergent plants can be treated with equipment similar to that used in treating terrestrial plants. Floating plants sometimes offer a different challenge, but in many situations, treatments can be similar to those used for terrestrial plants. If the infestation is not completely confined to an area, infestations may move in relatively short periods of time when impacted by wind or currents. If this occurs, the floating plant populations can disperse and make treatment significantly more difficult. If submersed plants are being targeted, then application methods can be extremely different depending on the material being applied. Major concerns in using herbicides underwater are to ensure that there is an adequate concentration of the herbicide and it remains in contact with the target plant long enough to produce the desired impact. Compounds that promote adhesion are often required to assist in keeping the herbicide in contact for the required time (Netherland et al. 2005). Herbicides generally produce their impact more rapidly than biological control agents but may require additional applications to achieve the desired management situation (Westerdahl and Getsinger 1988).

Mechanical

Mechanical control equipment for aquatic weeds often mimics equipment utilized in terrestrial systems. In many situations terrestrial equipment is modified to operate in aquatic habitats. Backhoes and harvesting equipment have flotation devices attached so that they can be utilized in unstable soils or floating on water (Figure 1). Other equipment is specially designed to work in aquatic environments; e.g., mowing equipment that cuts submersed aquatic vegetation (Figure 2). In addition, shade cloth material similar to that used in commercial farming operations is used to suppress emergent and submersed vegetation in high use areas. In some cases, lakes and small ponds are dewatered to remove the habitat available for the growth of emergent, floating, and submersed aquatic plants. Mechanical control methods are often utilized when rapid management is needed in relatively small areas or when other control methods such as herbicides are prohibited from use around water control intakes.

Figure 1. Floating backhoe removing salvinia from an infested lake.

Figure 2. Specially designed mowing equipment for cutting submersed aquatic plants.

Integrated

Approaches have been developed to integrate the use of the various control methods. Depending on the habitat and target plant, different control strategies are employed to capitalize on the strengths of the various control methods. Managers can utilize control methods sequentially or in combination to rapidly impact the target plant and hopefully provide long-term management.

Dispersal

The dispersal of invasive aquatic weeds needs to be examined when developing a management strategy. Natural mechanisms exist that will cause plants to disperse. The rivers of North America can act as a conduit to move invasive plants within a water system and plants can be transported by animals between drainage systems. A major factor that contributes to the intentional and unintentional dispersal of aquatic weeds is man. The movement of people and equipment between water bodies plays a primary role in the dispersal of invasive aquatic plants. There has also been documentation of individuals' intentionally moving vegetation from infected water systems to uninfected systems to promote habitat development and fisheries.

Education

A major consideration to mitigate the spread and introduction of aquatic weeds is to educate the public on the subject. There is a lack of awareness in the general population on problems caused by both aquatic and terrestrial weeds. A number of government and private organizations work to stress the need to save our habitat. Some people feel that the establishment of any plants will save or restore habitats. They are unaware that the placement of exotic species into native habitats may have a deleterious impact. Education efforts need to be fostered that inform people about native communities and the impact that invasive aquatic plants can produce. The population needs to be educated to realize that some plants can cause significant problems when placed outside their native range.

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Biography

Dr. Alfred F. Cofrancesco is the Civil Works Technical Director for Environmental Engineering and Sciences at the U.S. Army Engineer Research and Development Center, Vicksburg Mississippi. His research focuses on ecosystem restoration and the management of invasive species. Dr. Cofrancesco oversees the Corps of Engineers Invasive Species Research Programs, represents the Corps of Engineers on the Aquatic Nuisance Species Task Force and has served since 1991 as Chairman of the USDA-APHIS, Technical Advisory Group for Biological Control Agents of Weeds. He holds a Ph. D. in Biology from the University of Southern Mississippi.

Control of Phreatophytes for Water Supply Enhancement in Alberta

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Abstract

Phreatophytes, or "spring loving" plants, have extensive roots systems and grow in riparian areas. These plants have significant impacts on water supplies by capturing groundwater that provides baseflow to streams and by clogging water canals. Phreatophytes have been scarce north of 39 degrees latitude, but more frost-tolerant hybrid species have developed. Non-native Russian olive populations have been found in the Milk River in both Montana and Alberta. The Alberta water agency has begun studies of phreatophyte invasions and control practices including public education programs on these issues and approaches.

Resumen

Las plantas Phreatophytes, o "amantes de la primavera", tienen un amplio sistema de raíces y crecen en áreas ribereñas. Estas plantas ocasionan impactos significativos en el suministro de agua, porque capturan las aguas subterráneas que proporcionan descarga para los arroyos y porque obstruyen los canales de agua. Phreatophytes han sido escasos al norte de los 39 grados de latitud, pero especies híbridas más tolerantes a las heladas se han desarrollado. Poblaciones de oliva no nativas de la Rusia son encontradas en el Río Leche en Montana y Alberta. La agencia encargada del agua en Alberta comenzó estudios de las invasiones de phreatophyte y las prácticas para su control incluyendo programas de educación pública en estos temas y enfoques.

1 Presenter.

Introduction

Phreatophytes, or “spring-loving” plants, are small deciduous trees with deep and extensive roots systems that grow along floodplains and tolerate a wide range of saline or alkaline soils. Often non-native species, phreatophytes such as tamarisk (also known as salt cedar or pink cascade) and Russian olive have many impacts on water supplies. With their extensive root systems, these plants capture large quantities of water from tributary aquifers before they can reach rivers as baseflow, and reduce water in conveyance irrigation ditches. In addition to impacting water quantity, phreatophytes are recognized to impact water quality and habitat. These species may leave salt residue, inhibiting the growth of native species. Fire hazards are also a risk associated with these plants (Water Science and Technology Board 2002). Because of these negative effects on water resources, water managers and water agencies have developed phreatophyte control programs in the areas where these plants have been the most prevalent, particularly in the southwestern and lower mid-western United States.

Tamarisk (*Tamarix* spp.) is one of the most prevalent and damaging phreatophytes, and the term “tamarisk” is sometimes used to refer to all phreatophytes. Native to southern Europe and central Asia, tamarisk was brought to the Untied States for ornamental purposes and has been used for bank stabilization and shelterbelts. Russian olive (*Elaeagnus angustifolia* L.), another common phreatophyte, was introduced for shelterbelts and has been found to spread quickly and compete with native plant species, such as cottonwoods.

Phreatophytes have generally been associated with the Southwestern United States, and considered scarce north of 39 degrees latitude (which runs through Kansas, Colorado, Utah, Nevada, and northern California). More recent research, however, has identified more frost-tolerant hybrid species and recent northern migration of these species, including occurrences in Alberta. As awareness of the impacts of these plants on water supplies increases in Alberta, as well as in the northwestern United States, water agencies in these areas have begun to explore programs for greater understanding of phreatophytes and their occurrence, including educational programs for water managers and the public, and approaches to phreatophyte control.

This paper introduces the emerging phreatophytes issue in northern states and western Canada, particularly in Alberta, and the potential impact of phreatophytes on stream yields and water supply. The environmental determinants of tamarisk distribution and established physical approaches to phreatophyte control are summarized. Institutional approaches to phreatophyte control, including the importance of defining multi-agency institutional arrangements to address this problem, are also presented. Finally, an overview of current water planning and invasive species control approaches in Alberta are reviewed, with potential application to the control of phreatophytes to prevent impacts to water supply.

Distribution and Spread of Phreatophytes

Phreatophytes generally grow in sites with intermediate moisture, minimal erosion, and high water tables. Dense patterns of phreatophytes grow where the water table is less than 7.5 meters, ideally between 1.5 and 6 m. Phreatophytes can grow from elevations below sea level to elevations more than 2100 m high (Barranco 2001, Figure 1). Some of the environmental factors that influence the distribution and spread of tamarisk include:

- rapid growth (3–4 m in one season)
- high seed production (600,000 seeds produced annually)
- longer season of seed release
- wide dispersion of seeds by wind or water
- high tolerance of salinity, fire, and drought conditions
- low susceptibility to livestock grazing or pesticides (USGS 2005)

Phreatophytes have an extensive range, indicating their adaptability to a wide range of elevations and climate patterns. Within the United States, they can be found in the Southern Pacific Border, Columbia Plateau, Upper Basin and Range, Lower Basin and Range, Middle Rocky Mountains, Wyoming Basin, Southern Rocky Mountains, Colorado Plateau, Great Plains, Black Hills Uplift, Upper Missouri Basin and Broken Lands (see Figure 2).

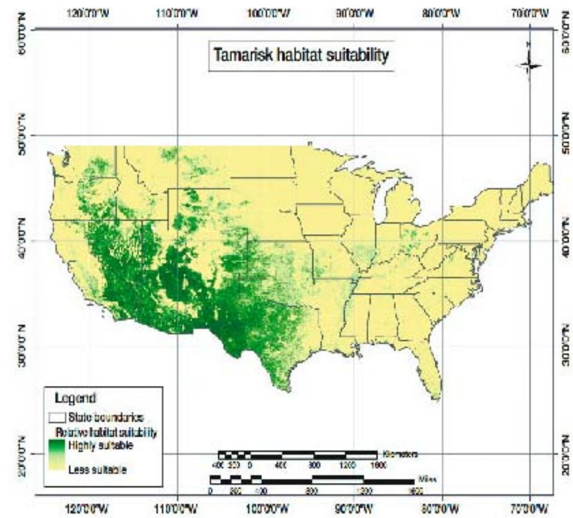

Figure 1. Tamarisk habitat suitability map for the Continental U.S. (Morisette et al. 2006).

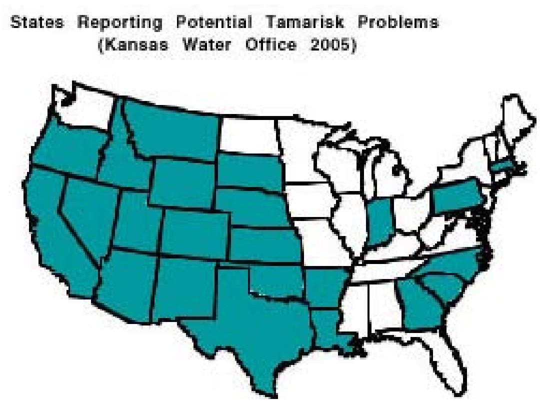

Figure 2. States reporting potential Tamarisk problems (Kansas Water Office 2005).

Historically, phreatophytes have been associated with the American southwest and have not been considered a problem in northern states or Canada. The United States Geological Survey's (USGS) Fort Collins Science Center has found tamarisk to be relatively scarce north of 39 degrees north longitude, with northern expansion of the plant's range limited by frost tolerance. However, tamarisk has been found increasingly in northern states, including Montana (Lesica and Miles 2001, Lesica and Miles 2004). USGS studies have found that hybrid species have developed that are more frost tolerant, and that the native *Salix exigua* is not commonly affected by frost and is abundant in the northern United States and much of Canada (USGS 2005). In addition, known phreatophyte species, including the Russian olive, have been identified in the Prairie Provinces (Haber 2002). Pearce and Smith (2001) found in a recent study that Russian olive populations have increased in the Milk River in both Montana and Alberta, already outnumbering native cottonwoods, and are predicted to become the dominant plant species along the Milk River unless controlled.

Potential Impacts of Phreatophytes on Water Supplies

Phreatophytes are recognized as an environmental concern and are considered noxious weeds. Their long root interferes with natural aquatic systems by consuming large amounts of water and consequently stressing native plants. Also, they can inhibit other plants' growth because of the salt excreted by their stems and leaves. Their dense and massive rooting system can cause flooding and slowing of river flows, resulting in the increase of sediment accumulation along the riverbank and impacts water quality (Barranco, 2001).

Phreatophytes greatly impact water supply; overall, the water yield of riparian zones is reduced (Barranco, 2001). A single tamarisk plant, for example, can absorb 200 gallons of water a day (Barranco, 2001). Phreatophytes can lower groundwater levels and intercept groundwater flows to streams, thereby reducing baseflow. Steinwand et al. (2006) found that groundwater uptake accounts for 60 to 81 percent of evapotranspiration in phreatophytes.

Phreatophytes have also been found to impact canals and other water delivery systems. Transit losses from deliveries from the John Martin Reservoir in the Arkansas River in Kansas have been attributed to groundwater level decreases caused by phreatophytes (Kansas Water Office 2005). Along the Colorado River, Barranco (2001) attributed 568,000 acre-feet of water lost per year to consumptive use by tamarisk (Barranco, 2001).

Phreatophytes grow primarily in riparian areas where their root systems can clog watercourses, cause flooding, and impair navigation in the streams and rivers they surround. Their dense growth in riparian areas results in accumulation of sediments along the riverbank. This, in turn, leads to plant colonization further into a floodplain and widening of the riparian zone, resulting in severe reduction of stream flow or rechanneling.

Other environmental impacts attributed to phreatophytes include changes in water and soil chemistry, impacting plant growth and agriculture, and fire hazards. Soil chemistry changes are caused by the salt deposition left by the stems and leaves of the phreatophyte. A crust is formed by the salt that is excreted above and below the soil surface, creating an environment that is unsuitable for native plants. Phreatophytes have also been found to cause fire hazard because of their rapid regrowth and accumulation of brush, which can easily ignite.

Control Methods

Physical

All phreatophyte control methods are intended to remove plants and prevent regrowth, and are similar to other invasive plant species removal methods. Phreatophytes typically have extensive root systems that can grow to 100 feet or more. Because these plants often regrow from the root crown buds, eradication of the plants can be very challenging. There is a wide range of phreatophyte control techniques, including mechanical, chemical, and biological methods that should be selected on the basis of local conditions. Removal of phreatophytes using chainsaws may be the most widely used approach, but other methods are also common.

To be successful, mechanical methods must include removal of the roots, often coupled with herbicide applications, to prevent the plants from regrowing from the root crown buds. Mechanical methods include: hand-cutting with herbicide application; mechanical removal with heavy equipment; hand herbicide application; aerial herbicide application; and biological control (e.g., goats, Chinese leaf beetle) (Tamarisk Coalition 2006b). Removal of phreatophytes without adequate revegetation can lead to failure of the control program due to sedimentation and erosion, habitat loss, and other issues.

Extensive materials have been prepared on approaches to control phreatophytes, including cost estimates and evaluations of effectiveness. The Tamarisk Coalition, based in Grand Junction, Colorado, has published a guide entitled "Options for Non-Native Phreatophyte Control" (Tamarisk Coalition 2006b), available through the Kansas Water Office website at: http://www.kwo.org/Options_for_Tamarisk_Control_033106.pdf. As identified in the Tamarisk Coalition's guide, the components of a phreatophyte management program include: planning with an inventory and mapping, control, revegetation, monitoring, and maintenance. San Souci and Doyle (2008) have recently proposed the use of a decision support system using satellite imagery as a way to mapping and monitoring tamarisk. Phreatophyte control programs may be incorporated into overall "Integrated Pest Management" programs, which may also include preventative measures, as well as public and landowner education on non-native species.

Concerns have been raised regarding phreatophyte control methods resulting in disturbance of fish and wildlife habitat, including loss of trees for nesting birds and loss of shade over streams for fish. This issue has specifically been considered with respect to the impacts on endangered bird species, such as the willow flycatcher, which has habitat extending into southern Alberta (Warner and Hendrix 1984). Some phreatophyte removal methods, such as the use of large machinery or aerial control, may also impact native plant species (Tamarisk Coalition 2006b).

Institutional

Several of the American western states have developed comprehensive phreatophyte control programs. While these programs have generally been associated with the southwestern US, the Kansas Water Office identified more than 20 states with potential tamarisk infestation problems, including eastern states such as Massachusetts and North Carolina, states in the Great Lakes region such as Indiana, and northern states such as Idaho and Montana (Kansas Water Office 2005, Figure 2).

In 2005, Kansas implemented a 10-year strategic plan for the comprehensive control of tamarisk and other non-native phreatophytes. The objectives of these control activities are "the reestablishment of native vegetation that can be sustainable, as well as the restoration of stream flow and native habitat." This program recognizes that the success of the program requires long-term control, revegetation, monitoring, maintenance, and funding, and strong leadership at the local, state, and federal levels. Consequently, the program focuses less on the control methods and more on the organizational structure, roles and responsibilities for implementation of the program. Specific issues addressed include funding, communication, and education. A partnership approach is illustrated by the 24 agencies and organizations that participated in the development of this plan.

The Kansas 10-Year Plan developed out of a Water Issue Strategic Team which in 2003 identified tamarisk and other non-native phreatophyte control as an issue in need of further coordination and study. The goals of the Water Issue Strategic Plan include: assessments of the extent of the infestation of tamarisk and other non-native phreatophytes in Kansas; the role of tamarisk as a water consumer and its effect on water quality; and, the best approach and tools for implementing available control methods.

While the projects and activities of the Water Issue Strategic Plan are continuing, there was recognition that a comprehensive, formal and long-term plan was needed. The 10-year plan included an inventory of tamarisk and other non-native phreatophytes; control and management efforts; education; research; and, funding. The plan also included a clear presentation of the organizational structure used for implementation, including the roles of the governor and state legislature, state and federal agencies, local communities, non-profit organizations, and universities.

Some other important institutional arrangements and approaches to phreatophytes control are proposed by the Colorado Department of Natural Resources (2004), the Southeast Utah Tamarisk Partnership (2007), and the Colorado Headwaters Invasives Partnership (2007). In addition, one case of tamarisk control was successfully reported at Coachella Valley Preserve in Southern California (Wildland Invasive Species Program 2001).

Developing institutional approaches to phreatophyte control may be challenging in that, from the perspective of an individual water providers, it can be difficult to tie specific phreatophyte control methods to changes in water availability, and thus to assess the financial "return on investment" associated with phreatophyte control (Butler et al. 2005). In addition, in some states using *prior appropriation* water law, use of vegetation control methods to increase water deliveries may be specifically prohibited when determining quantity of water available under a water right or license. In spite of these difficulties in tying specific phreatophyte control methods with economic, financial, or quantitative water supply benefits, phreatophyte control methods are often identified as a key step towards improving water supply availability within state and regional water supply planning efforts, such as in a recent review completed for the Colorado River Compact States. These programs often require a long-term controlled approach with continued public education and maintenance activities.

Prospects for Phreatophyte Control Programs in Alberta

Federal and provincial level non-native (also called exotic, alien, or invasive) species control programs are common in Canada, including the Alberta Invasive Plants Council (AIPC). These programs typically focus on impacts of non-native plant invasions on plant ecology through their reduction of native plant species, and on wildlife habitat. However, phreatophyte control programs specifically designed to address water yield issues do not yet exist.

Irrigation districts typically have extensive vegetation management programs for their canals and other infrastructure. For example, the Western Irrigation District (WID) in Strathmore, Alberta, uses both chemical removal of vegetation and physical removal, sending out crews to conduct slashing and hand-picking of vegetation in areas where chemical methods cannot be used.

The WID has also recognized the tremendous water losses associated with rows of poplar trees along the banks of the canals. In the 1980s, trees along the WID canals could be used to easily locate the canals from great distances. The trees created some suitable habitat for wildlife and provided trees in an otherwise treeless prairie area. However, recognizing the water losses associated with these poplars, WID has embarked on a heavy-duty mechanical control program resulting in the removal of trees along many miles of irrigation canals within the district limits.

Phreatophytes are sometimes used deliberately in Alberta for shelterbelts (also called windbreaks) in windswept areas. Where phreatophytes are removed, revegetation of non-phreatophyte species would be necessary to maintain the benefits of shelterbelts, particularly to control soil erosion.

The AIPC may provide a mechanism through which phreatophyte control programs can be started, while working in partnership with water resource management entities. An inventory of Alberta phreatophytes and educational programs on phreatophyte impacts and control methods would be valuable.

The Alberta Sustainable Resource Development (ASRD) agency has recently developed a decision support tool to assess risks and prioritize responses to threats of invasive alien species in Alberta (Millar 2008). As applied to phreatophytes, this risk assessment approach can be used to provide an initial, qualitative evaluation of the exposure and effects indicators associated with phreatophytes in Alberta. Initial responses to the exposure and effects indicator tests from the ASRD decision support tool, with respect to phreatophytes in Alberta, are as follows:

Exposure Indicators

Is it here?

Phreatophytes have been found to be present in the Milk River, and there has been anecdotal evidence of the presence of phreatophytes in other river basins. A formal survey would establish greater certainty as the presence and range of phreatophytes within Alberta river basins.

Can it get here?
As found within the Milk River basin, phreatophytes can travel to Alberta along trans-boundary rivers, as well as through transport into the country by similar methods used by other invasive species.

Can it survive?
The survival of phreatophytes in Alberta may increase due to the development of hybrid species with higher levels of frost tolerance. In addition, climate change may produce an increase in the number of frost-free days, further increase in the level of survival of phreatophytes, and enabling further maturation of the plants.

Will it establish and will it spread?
Further studies would be required to address these questions.

Effects Indicators

- Environmental impacts could include reduction of instream flows and associated impacts to aquatic and riparian habitat.
- Economic impacts would be associated with any demands for water supply for municipal, industrial, and agricultural uses. Additional economic impacts to agriculture would be associated with increased soil salinity.
- Social impacts may be greatest for agricultural communities, as well as potential impacts on tribes.

This initial application of the ASRD risk assessment approach suggests that phreatophytes are a risk to be further reviewed and prioritized by the Alberta invasive species and water management communities.

Alberta Environment (AENV) has embarked on a provincial water strategy called "Water for Life" to achieve "a healthy and sustainable water supply for the environment, for our communities, and for our economic well-being." As part of this effort, AENV commissioned a comprehensive survey of alternative water storage and management methods that can help increase available water supplies to meet Alberta's water needs. The survey included a consideration of methods that can augment or prevent reduction of source waters to Alberta's water supplies, such as vegetation management methods (AENV 2008). The review of vegetation management methods as a potential means of alternative water management provided the initial materials for this paper.

Conclusions

This paper focuses on the environmental impacts of phreatophytes, the recent emergence of more frost-tolerant species of phreatophytes on the Montana–Alberta border, and the importance of developing an institutional response to this issue. Examples from Kansas and other states illustrate a strategic approach to creating cooperative programs between state or provincial agencies, irrigation districts and other stakeholders, to deal with phreatophytes impacts and control practices, including public education. Alberta Environment (AENV) has begun to review potential "next steps" towards understanding the potential impacts of phreatophytes on water supplies in the province and towards supporting the development of phreatophyte control programs to prevent impacts to water supplies.

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Biography

Cat Shrier is President and Founder of Watercat Consulting LLC, a consulting practice created to enlighten, support, and facilitate communication and understanding among scientists and engineers, policymakers and regulators, stakeholders and the public on water issues and opportunities for wise use, preservation, and management of water resources. She also has led the development of the Aquifer Storage Institute. Since 2006, Cat has completed a survey, as part of Alberta's provincial Water for Life strategy, of Alternative Water Supply Storage and Management Methods that could be used in Alberta, including phreatophyte control. She is currently working with Alberta Environment on public education document on alternative water supply storage and management methods, and partnership programs with water managers and watershed coalitions to support the investigation and use of such methods within the province. Since 1984, Cat has worked with and for federal and state legislative offices, regulatory agencies, and consulting firms in Washington, DC; New Jersey; Virginia; North Carolina; Colorado; and Alberta. Currently based on Capitol Hill in Washington, DC, she has been working with state agencies, municipalities and other water providers to identify and resolve institutional issues (permitting, policy, public perception, and planning) related to the integration of innovative water management approaches. She is a licensed professional geologist in North Carolina, and has a Ph.D. in Civil Engineering/Water Planning from Colorado State University; M.S. in Environmental Science & Engineering/Environmental Management & Policy from the University of North Carolina at Chapel Hill; and bachelors degrees in Geology (North Carolina State University; *summa cum laude*) and Government (Dartmouth College).

Ana Carolina Coelho Maran has a MSc in Water Resources and Environmental Engineering and a bachelor's degree in architecture and urban planning, both from UFPR Parana Federal University (Curitiba, PR, Brazil). Coelho has more than 7 years experience in water resources planning and management and development of spatial decision support systems. She is currently working on the development of the Alberta-based DSS that supports evaluation of impacted and compensation wetlands sites and provides rules for compensation. From 2003 to 2006, she served as a Water Resources Specialist for the Brazilian National Water Agency, where she developed DSS to support definition of Federal Government priorities for water resources planning and management projects; developed strategic plans in accordance with State Water Resources Institutions and existent Watershed Committees; supported updates to the Water Resources National Plan; and participated in water resources conflict resolution processes.

She previously worked as a consultant for a spatial system technology company, where she developed information systems and monitoring plans for metropolitan regional water sources and performed socioeconomic diagnostic watershed analyses. She is completing her doctoral studies at Colorado State University (Fort Collins, CO, U.S.), specializing in water resources planning and management and DSS.

How Weeds Cross Borders. Some Pathways for Federal Noxious Weeds

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Abstract

Enforcement of the United States Department of Agriculture, Animal and Plant Health Information Service, Plant Protection and Quarantine import regulations are meant to circumvent human-assisted pathways for weed introduction. These pathways include air cargo, maritime cargo, land transportation, passenger baggage, and the Internet, that bring in plants for propagation, consumption, aquarium and horticultural trade, handicrafts and herbal medicines. Since 2003, Customs and Border Protection of the Department of Homeland Security has taken over the enforcement of PPQ regulations. Several designated U.S. federal noxious weeds, their common or sometimes unique pathways of entry, as well as APHIS regulations to control or prohibit their entry into the U.S. are discussed.

Resumen

Reforzar los reglamentos de importación de la Oficina de Sanidad Vegetal y Cuarentena (PPQ) del Servicio de Inspección de Sanidad Agropecuaria (APHIS) del Departamento de Agricultura de EE.UU. tienen el propósito de evitar las vías de introducción de malezas causadas por el ser humano. Estas vías incluyen: los cargamentos aéreos, marítimos, el transporte terrestre, el equipaje de los pasajeros y la Internet; donde se introducen plantas para la propagación, el consumo, el comercio hortícola y de acuarios, las artesanías y las medicinas a base de hierbas. Desde el 2003, la Oficina de Aduanas y Protección de las Fronteras del Departamento de Seguridad Nacional de EE.UU. ha asumido el control en el cumplimiento de los reglamentos de la PPQ. Se discuten las diversas malezas nocivas federales de los EE.UU. y los medios de introducción más comunes y a veces exclusivas, así como los reglamentos del APHIS para controlar o prohibir la entrada a los EE.UU.

Introduction

In the last hundred years a dramatic increase in travel and trade has opened up countless pathways by which noxious weeds, as well as pests and diseases, can spread to different parts of the globe. These pathways include air travel, shipping routes, vehicles such as trains and trucks, and the importation of plants and plant products such as crops, fruits, vegetables, spices, herbal medicines and handicrafts. Also included are horticultural trade and aquarium trade pathways that import ornamentals and aquatic plants for propagation. More recently, plants and seeds sold on the Internet provide a pathway for potential noxious weeds to invade the environment. Modern high speed transportation, as well as trade facilitation agreements such as the General Agreement on Tariffs and Trade (GATT) in 1995 and the North American Free Trade Agreement (NAFTA) in 1994, have allowed invasive species to spread faster and further than ever before.

The Animal and Plant Health Inspection Service, Plant Protection and Quarantine (APHIS/PPQ) is an agency within the United States Department of Agriculture (USDA) which has the mission to protect and promote U.S. agriculture and natural resources by preventing the entry, establishment and spread of foreign pests, noxious weeds and diseases in the U.S. Before 2003, PPQ under the Agricultural Quarantine Inspection (AQI) program, performed inspections of cargo and baggage at international airports, seaports and border stations to exclude pests and diseases at the ports of entry. Also, the Beagle Brigade, a "Detector Dog" program, helps sniff out prohibited agricultural products.

In March 2003, the Department of Homeland Security (DHS) was established to address a broader range of threats, including agricultural threats, to American security. Some functions of the AQI program were transferred to DHS Customs and Border Protection (CBP), which now conducts port of entry inspections. APHIS continues to establish policies and regulations regarding the quarantine status and permissibility of commodities, inspects propagative plant material, provides for pest identifications and fumigations, conducts risk assessments and provides training for CBP inspectors. In 2007, APHIS and CBP also established a Task Force to periodically review progress made and future needs. Thus the two agencies work closely and cooperatively to safeguard American agriculture and natural resources.

The Smuggling, Interdiction and Trade Compliance Program (SITC) was created by APHIS to monitor potential high risk smuggling pathways through market surveys and by working with DHS/CBP at the ports of entry to intercept smuggled products. Once a smuggling pathway is identified, it is shut down, often resulting in civil and/or criminal prosecution, and is followed by recalls.

Noxious Weeds Program

The APHIS Federal Noxious Weed program is designed to prevent the introduction and spread of nonindigenous invasive plants within the United States. APHIS noxious weed activities include exclusion, permitting, detection and eradication of incipient infestations, survey, data management, public education, and (in cooperation with other agencies and state agencies) integrated management of introduced weeds, including biological control organisms.

The Plant Protection Act of 2000 provides the authority to prohibit or restrict imports, exports or interstate movement of plant pests and noxious weeds. Under the Code of Federal Regulations 7 CFR 360, APHIS currently lists approximately 100 taxa that are defined as federal noxious weeds.

Pathways of Entry

In order to detect and exclude invasive weeds at the 90 ports of entry it is important to identify significant pathways through which these enter the U.S. A pathway is a route through which a plant or pest moves from its origin to its destination. The pathways may be characterized as presenting a "high", "medium" or "low" risk for the introduction of weeds. Identifying and understanding the high risk pathways is important to: prevent the entry of invasive species; find methods to control their movements; and, prevent their establishment in the United States.

Natural Pathways

Plants have always spread in nature by various natural pathways such as wind and ocean and river currents. In fact plants have evolved an amazing array of dispersal mechanisms for spreading their spores, seeds and fruits. In addition to these aquatic and atmospheric pathways, plants or their propagules may spread by ecosystem disturbances and unusual weather events.

Man-Made Pathways

However man-made pathways have a greater significance in the spread of plants around the world. These pathways include transportation, travel and tourism and international trade. There have been both accidental and deliberate introductions of non-native species, with the latter resulting in a greater number of invasions.

Traditional Asian Herbal Medicine Pathway

Thousands of plant species are used for medicinal purposes worldwide and traded internationally. Oriental medicine systems include Traditional Chinese Medicine, also known as TCM, as well as Japanese and Korean medicine. Herbal medicines in TCM sometimes include plant (and animal) products that are prohibited or regulated by APHIS or protected by the Convention of International Trade in Endangered Species (CITES). Federal noxious weeds and parasitic plants that are prohibited by USDA and are used in Traditional Asian Medicine include *Cuscuta* sp., *Imperata cylindrica* (L.) P. Beauv., *Striga asiatica* (L.) Kuntze, *Alternanthera sessilis* (L.) DC., *Cassytha filiformis* L., *Cistanche* sp., *Ipomoea aquatica* Forssk., *Loranthus* sp., *Taxillus* sp., *Orobanche* sp., *Sagittaria sagittifolia* L., *Aeginetia indica* L. and *Monochoria vaginalis* (Burm. f.) Kunth.

Cuscuta sp., a parasitic federal noxious weed, is imported as loose seed or as compressed Cuscuta cakes. Species commonly used are *Cuscuta chinensis* Lam. and *Cuscuta japonica* Choisy. Since 2005, infestations of the highly invasive, non-native dodder suspected to be *Cuscuta japonica* have been found in several California counties. In 2005/2006, the California Department of Food and Agriculture (CDFA) collaborated with USDA/SITC in a market survey of dodder seed cakes and tested seed viability at the CDFA Plant Pest Dignostics Laboratory. Over 50% of these were found to be viable. In October 2006, APHIS issued an industry alert and notice to all importers of Asian herbal medine that whole and viable dodder seed is prohibited entry into the U.S. However, products containing dodder seed powder, crushed seed, or heat treated (inert, ashy grey to white) seeds are enterable.

The inflorescence of cogongrass, *Imperata cylindrica* "Mao Gen Hua" is imported in herbal medicine as "Inflorentia Imperatae" or "Flos Imperatae". These are full of viable seeds and prohibited under 7CFR 360. Dried and sliced rhizomes "Bai Mao Gen" or "Rhizoma Imperatae" can be inspected and released since they are incapable of propagation. *Striga asiatica*, witchweed, another parasitic federal noxious weed, is sold as "Herba Strigae". The dried herb may have dried leaves, flowers and fruits with seeds.

Handicrafts and Dried Botanicals Pathway

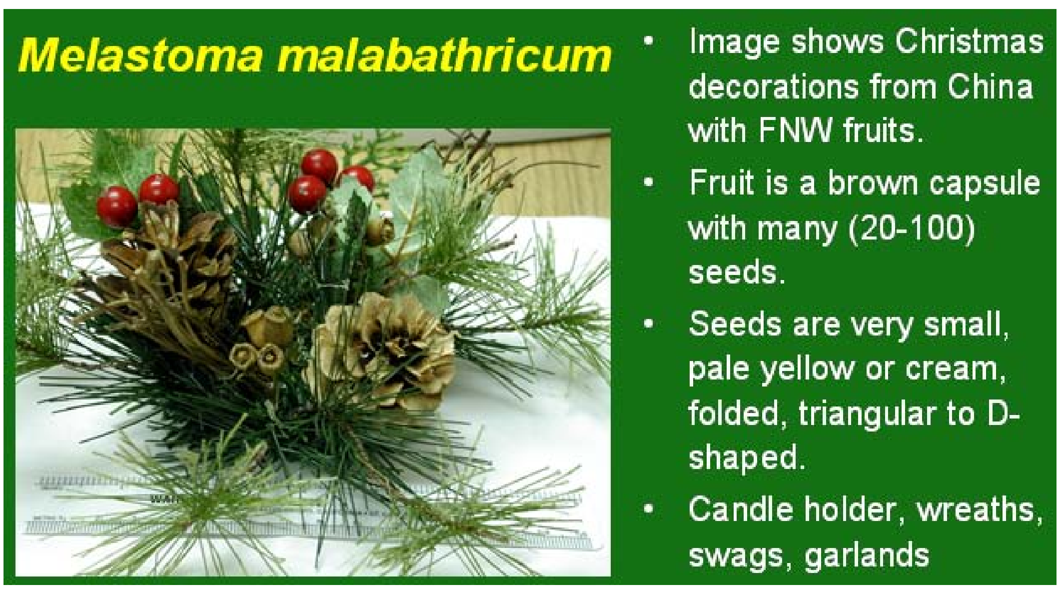
A large variety of handicrafts are imported into the U.S. from around the world. These include Christmas decorations, dried botanicals, potpourri and other miscellaneous handicrafts. Sometimes these include prohibited federal noxious weeds and other regulated plant materials. In 2004, the port of Elizabeth, NJ, received several containers of Christmas decorations from China manifested as "artificial" flowers which included wreaths, swags, candle rings, garlands and Christmas trees. While the handicrafts were largely artificial, they included some dried botanicals such as *Pinus* cones, grapevine and fruits of the federal noxious weed *Melastoma malabathricum* L. Each decoration piece had several of these fruits, a dry capsule containing about 20–100 small seeds. The shipment was prohibited entry. Again, in April 2007, SITC Officers found an item from the Phillipines in handicraft stores, manifested as "Hairybell Pencil Cluster Stem" and designed with fruits of *Melastoma malabathricum*. The product was confiscated and destroyed. A traceback by SITC revealed that about 1128 units had been imported and distributed to consignees throughout the United States. This resulted in a national recall for the product. Most recently, grapevine wreaths from China, being sold in stores were found to be contaminated with fruits of *Melastoma malabathricum*.

Food/Spice Pathway

Some federal noxious weeds enter the U.S. not as contaminants or hitchhikers but as the commodity itself. These are used as vegetables and spices by various ethnic communities for culinary purposes.

Ipomoea aquatica *Forssk. (Water Spinach)*

Water spinach is a federal noxious weed and in the U.S. populations have caused environmental damage by infesting lakes, ponds and river shorelines, and by displacing native plants. It is a creeping, climbing aquatic herbaceous vine cultivated as a leafy vegetable in southeast Asia. A common and important pathway for entry of this federal noxious weed is through passenger baggage, where passengers, mostly from Asia, bring in seeds for the purpose of cultivation. The countries of origin to look for are China, Vietnam, Korea, Thailand, Philippines, Japan, Cambodia, Hong Kong, Indonesia, Singapore, Laos, Myanmar (Burma), and Malaysia. The seeds are packaged and labeled variously in different languages as “ung choi”, “tung tsoi” (Chinese), “kangkong” (Malay), “paagboong”, “phak bung” (Thai), and “rau muong” (Vietnamese). Since *Ipomoea aquatica* can reproduce sexually by seeds and vegetatively by stem fragmentation, both shoots and seeds are prohibited. It is also grown illegally by some ethnic communities in the U.S. in their backyards and ponds, and even commercially, and sold in Asian stores, where it is frequently intercepted by SITC officers in market surveys. In addition, it is cultivated in California and Texas under permit.



Solanum torvum *Sw. (Turkey Berry)*

Turkey berry, a U.S. federal noxious weed, is a broadleaved, evergreen, shrub or small tree that invades a variety of ecosystems in Florida. The fruits are edible and used as a vegetable in southeast Asia, the Caribbean and east Africa. Fresh fruits are frequently intercepted in passenger baggage from these parts of the world. Sometimes they are imported frozen.

Heracleum mantegazzianum *Sommier & Levier (Giant Hogweed)*

The dried fruit of giant hogweed is a native of the Caucasus and is used as a pickling spice in the Middle East. The most common interception is in passenger baggage from Iran. Because of its distinctive aroma it is easily detected by dogs of the Beagle Brigade.

Paspalum scrobiculatum *L. (Kodo Millet)*

Kodo millet, *Paspalum scrobiculatum*, is a minor grain crop in India where domesticated forms have been developed in the southern Deccan Plateau. The processed grain, also known as “kodri” or “samo” millet, is imported for consumption and sold in Indian grocery stores. However, it may be contaminated with unprocessed grains that may be viable and capable of propagation.

Aquarium Trade Pathway

The worldwide trade in plants for aquariums is a multi-million dollar industry. Some of the worst invasive species that have become serious environmental weeds were introduced as aquarium and water garden plants. The most common pathway of entry for aquatic weeds into new areas is through discarded aquarium material, dumped into rivers, lakes, and streams. These species account for environmental and economic losses of millions of dollars by choking up waterways and lakes, restricting native plants, and harming fishes and other aquatic animals. However, they continue to be sold through aquarium supply dealers and over the Internet, even though some are on the U.S. federal noxious weed list.

The most frequent interceptions are of *Alternanthera sessilis* and *Hygrophila polysperma* (Roxb.) T. Anders. which are usually intercepted in cargo from Thailand, Singapore, Malaysia and Indonesia. These are imported as plants or cuttings for propagation. Other imported plants are *Salvinia molesta* D. S. Mitchell, *Hydrilla verticillata* (L. f.) Royle , *Limnophila sessiliflora* (Vahl) Blume and *Eichhornia azurea* (Sw.) Kunth.

Seed Shipments

Grain and Spice Seed Shipments

One of the commonest pathways for weeds to enter the U.S. is as contaminants in shipments of spice seeds such as cumin and coriander. Commonly encountered weed seeds include *Asphodelus fistulosus* L., *Cuscuta* sp., *Avena sterilis* L., *Panicum* sp., *Pennisetum* sp., and other rare contaminants such as *Emex spinosa* (L.) Campd. Regulatory actions for such contaminant weed seeds include cleaning the shipment, or devitalization by heating or grinding the seeds. For spice seeds grinding is often an appropriate option to mitigate the risk. Depending on the size of the weed seeds, appropriate U.S. standard screen sizes are used through which the milled products must pass. The grinding process and milled products may be monitored and checked by APHIS.

Niger Seed Shipments

Niger seed, *Guizotia abyssinica* (L. f.) Cass., shipments are an important pathway for the entry of noxious weeds. The seed is sold as bird feed and is usually imported into the U.S. from Ethiopia and India, and sometimes from Burma. Frequent seed contaminants are *Cuscuta, Paspalum scrobiculatum*, and *Setaria pallidefusca* (Schumach.) Stapf & C. E. Hubbard which are federal noxious weeds, as well as *Digitaria* sp.*, Oryza* sp., *Eleusine coracana* (L.) Gaertn., *Sorghum halepense* (L.) Pers., *Themeda* sp., *Stipa* sp., *Hyptis suaveolens* (L.) Poit., *Alysicarpus rugosus* (Willd.) DC., *Cassia obtusifolia* L., *Blainvillea latifolia* (L. f.) DC., *Achyranthes* sp. and *Richardia scabra* L.

According to APHIS regulations shipments must be heat sterilized by heating the seeds to 250° F for 15 minutes to sterilize dodder and other noxious weed seeds. This prevents them from growing and being introduced as new weeds. USDA-approved heat treatment facilities in the U.S. are located at Linden, NJ, and Baltimore, MD. Facilities outside the U.S. are in Singapore and India and shipments arriving from there must be accompanied by a Phytosanitary Certificate of sterilization. Further, viability testing is conducted to monitor the heat treatment.

Hitchhikers

Weeds and their propagules can enter the U.S. as "hitchhikers" on animals, humans, fruits and vegetables, or vehicles such as aircraft, ships, trucks and trains. *Rottboellia cochinchinensis* (Lour.) W. D. Clayton, itchgrass, is known to hitchhike on trains, trucks and other vehicles and is frequently found growing along railroad tracks and along highways in several southern states. Recently it has been known to hitch a ride into the U.S. on pineapple imports from Costa Rica.

Pineapple in Costa Rica has become an important agricultural product for exportation with the U.S. being a major market. Since November 2005, several commercial shipments have been refused entry because of *Rottboellia cochinchinensis* seeds being found in the pineapple crowns. The crowns presumably increase the market value of the fruit but are ideal for hitching a ride by weed seeds and other pests. Other noxious weeds found, though in fewer numbers, are *Mikania micrantha* Kunth, *Spermacoce alata* Aubl., *Saccharum spontaneum* L., *Ischaemum* sp. and *Paspalum* sp. In the first three months alone, 40 containers with about 715,000 kg of fruit was returned to origin resulting in economic losses surpassing $2,500,000.

In a series of teleconferences between the Costa Rican Ministry of Agriculture and Livestock and APHIS various ways were discussed to mitigate the risk of weed seed introduction by controlling the weed at the sites of production, by various treatments of the fruit, and by proper handling and labeling of shipments. Subsequent phytosanitary inspection of pineapple production sites in Costa Rica showed inadequate weed control and patches of *Rottboellia cochinchinensis* in border areas, buffer areas and along roadsides. In May 2006, AHIS personnel visited production areas and packaging houses of pineapples to help mitigate the risk of contamination by these weed seeds.

The Internet

The Internet has opened up a new and convenient mechanism to facilitate international trade and the number of Internet users is growing at a rapid pace. Although the Internet is not in itself a pathway, it provides a forum whereby international trade is easily initiated. A number of exotic and even endangered plant and animal species are being traded via the Internet by commercial importers or individuals buying plants for personal use. Besides plants and seeds sales include insects, birds, mollusks and mammals. In the U.S. there are several popular auction sites such as e-Bay, Yahoo, Google and internet forums where plant and seed catalogs can be advertised. Aquatic plants for aquariums, such as *Hygrophila polysperma,* and other federal noxious weeds are openly sold on e-Bay. Currently the USDA does not have any strategy to monitor and control plant trade via the Internet. Until recently APHIS had utilized the Agriculture Internet Monitoring System (AIMS), developed by the Center for Integrated Pest Management at North Carolina State University, in association with the USDA. This tool utilizes FAST datasearch technology which allows regulators to rapidly search the Internet for websites advertising APHIS-regulated species. A search using AIMS in December 2004 found 1209 websites selling noxious weeds. After identifying sites that may be violating federal laws, the system allows one to report information and take regulatory action. However, the AIMS tool is no longer being used by APHIS.

Conclusion

The best way to "manage" weeds is to prevent them from getting established in the first place. Studies have shown that the number of invasive species increases with the degree of international trade and that more resources should be directed at the introduction stage (Westphal et al. 2008). It is also the least time-consuming and inexpensive method of managing them. Because weeds are not restricted by man-made boundaries, plants or seeds cross borders freely and will travel by several modes of transport and along various pathways around the globe. Therefore countries must cooperate and coordinate programs to work across these borders. DHS Customs and Border Protection and USDA/APHIS are working in collaboration to exclude these invasive species at the ports of entry — the "first line of defense".

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Literature Cited

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Biography

Dr. Indira Singh was awarded her Masters degree in Botany from Lucknow University, India and PhD in Plant Genetics from Indian Agricultural Research Institute, New Delhi, India. She did her Post Doctorate in Microbial Genetics from the University of Florida in Gainesville, Florida. She has worked on Plant Tissue Culture for crops at Colorado State University, Fort Collins and on the Molecular Biology of Plant Defense Mechanisms at Iowa State University, Ames.

Dr. Singh joined the United States Department of Agriculture in 2000 as Plant Protection and Quarantine Officer and later worked as Botanist/Identifier in New Jersey. In 2006 she joined the Plant Safeguarding and Pest Identification staff at USDA/APHIS Headquarters in Riverdale, MD.

2008 WEEDS ACROSS BORDERS
CONGRESO MALEZAS SIN FRONTERAS
MAUVAISES HERBES SANS FRONTIÈRES

THE BANFF ACCORD
Weeds Across Borders IV
Alberta, Canada

The economic and ecological threat of weeds (invasive plants and noxious weeds) continues to increase without respect to jurisdictional borders. The scientists, practitioners, and policy makers in attendance view cooperation, collaboration, and communication as part of a North American strategy to address this issue of continental concern. In order to prevent and control the spread of weeds, we agree to share information including but not limited to: technical transfer, training tools, status assessments, public awareness, best management practices, and research results. By pulling together, Canada, Mexico, and the United States will save time and resources far into the future.

Signed
May 30, 2008

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