Plant Invasions: Policies, Politics, and Practices

PLANT INVASIONS:
POLICIES, POLITICS, AND PRACTICES

Proceedings of the 5th Biennial Weeds Across Borders Conference

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WAB 2010 would also not have been possible without the generous support of our sponsors. A very special thank you to Bonnie Harper-Lore, who helped ensure continued financial support for WAB, including WAB 2010, from the US Federal Highway Administration (FHWA). We are also grateful to: Gina Ramos and the Bureau of Land Management for matching the FHWA's support for WAB 2010; the US Fish and Wildlife Service for providing event leadership and administrative support; and the Federal Interagency Committee for the Management of Noxious and Exotic Weeds (FICMNEW) for providing crucial organizational, financial, and administrative support over the years. For a complete list of sponsors, see the following page.

Special thanks to the WAB 2010 Coordinating Committee:
Stephen Darbyshire, Agriculture and Agri-Food Canada
Jenny Ericson, US Fish and Wildlife Service
Francisco Espinosa García, UNAM-National University of Mexico
Cory Lindgren, Canadian Food Inspection Agency
Russell Jones, US Environmental Protection Agency
Les Mehrhoff, Invasive Plant Atlas of New England
Gina Ramos, US Bureau of Land Management

Emily Rindos was the lead editor and designer of these Proceedings and provided superb coordination of conference logistics and materials. Liz Galli-Noble, Stephen Darbyshire, and Jenny Ericson also provided valuable feedback throughout the process of editing and preparing these Proceedings.

The National Conservation Training Center and its staff went out of their way to make sure the conference ran smoothly and that all participants were comfortable, well taken care of, and very well fed. Thank you to Bill Gregg, Dale Nisbet, and Frank Archuleta for leading informative field tours.

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On behalf of the Coordinating Committee, thank you to the members of the Trilateral Committee for Wildlife and Ecosystem Conservation and Management for their endorsement of WAB 2010 and their continued interest in promoting trilateral coordination on the issue of invasive species. This type of multi-national recognition helps confirm that WAB remains vital and on track.

Finally, thank you to the over 100 conference presenters, session moderators, and attendees. Many of you traveled great distances to participate in WAB 2010 and without each and every one of you the conference would not have been such a success, nor would it have been so enjoyable. We also thank the many organizations and individuals who helped us promote this year's event.

For more information on WAB 2010, including the conference agenda, speaker biographies, PowerPoint presentations, links to past WAB Proceedings, and photos, please visit the conference website: http://www.weedcenter.org/wab/2010.

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DEDICATION

Les Mehrhoff
(1950–2010)

The initial vision for the theme behind Weeds Across Borders (WAB) 2010 came from our dear friend and colleague, Les Mehrhoff, who passed away on 23 December 2010. Les was a stalwart proponent of collaboration and communication across borders, especially when it came to invasive species. He was a respected botanist and much-admired naturalist who worked tirelessly to raise awareness—at all levels—of the ecological threat invasive species pose to native flora and fauna. Les was also a man of considerable vision, wit, and charisma.

The idea of holding WAB 2010 at the National Conservation Training Center (NCTC) in Shepherdstown, West Virginia, originated with Les. He considered NCTC a natural choice because of its proximity to Washington, DC, and its location at the confluence of multiple pathways which facilitate the movement of invasive species up and down the Eastern Seaboard, including the Appalachian Trail, the Shenandoah River, and the railway. The idea arose during one of those wacky conversations that always seemed to occur when you were out botanizing with Les. You never knew exactly where the conversation was going to end up.

This particular conversation took place in Banff, Alberta, Canada, during the WAB 2008 conference. We were sprawled out on the grass, chatting and enjoying brown bag lunches, when Les' vision for WAB 2010 began to unfold. "Wouldn't it be great if we could hold the next WAB at that place in West Virginia, you know, NCTC?" he said with characteristic enthusiasm. "We could focus on the trails and rivers that take this stuff across borders and between states and up to Canada. We could talk about how Japanese stiltgrass travels on peoples' boots and tents as they hike the Appalachian Trail and how seeds of some invasive plants move with the currents of the Shenandoah River. You've even got the railroad running through there, picking up all kinds of stuff on the tracks and transporting it across the country!"

A lot of hard work and exactly two years later, the Coordinating Committee, including Les, proudly kicked off WAB 2010 at NCTC with a packed agenda and a cadre of excellent speakers.

Les, we will miss you and your wacky charm, your dogged commitment to the invasive species mission, and your willingness to run with an idea no matter how big or complex it might initially sound.

—Jenny Ericson

FOREWORD

By Jenny Ericson
US Fish and Wildlife Service and Co-Chair, Federal Interagency Committee for the Management of Noxious and Exotic Weeds (FICMNEW)

The theme of the Weeds Across Borders (WAB) 2010 conference—"Plant Invasions: Policies, Politics, and Practices"—was selected to emphasize the importance of leadership at all levels in confronting the challenges posed by invasive plants in Canada, Mexico, and the United States.

It is widely accepted among natural resource managers and regulators throughout North America that people must work together across jurisdictional lines to manage invasive species, maintain healthy, non-invaded ecosystems, safeguard local and national economies, and, in some cases, even protect human health. The biennial WAB conference series provides a forum for international cooperation by educating, sharing, and disseminating knowledge about weed management, regulatory issues, and concerns regarding weed dispersal across and between jurisdictional boundaries.

The venue, the National Conservation Training Center (NCTC) in Shepherdstown, West Virginia, was chosen to highlight the importance of the pathways, roads, and trails that perpetuate the movement of invasive plants across political boundaries through states, parks, and recreational areas.

The Weeds Across Borders concept took shape in the 1990s as a result of dialogue among US federal agencies and their newly-established Federal Interagency Committee for the Management of Noxious and Exotic Weeds, known as FICMNEW. Members of this group recognized that weeds do not respect political boundaries and acknowledged that no single agency possesses all the resources necessary to prevent and control weed invasions on a landscape scale. As an initiative sponsored by FICMNEW, the WAB conference series was created to promote the sharing of information across political borders and to encourage partnerships that would cross jurisdictional boundaries. To date, WAB has been held in Tucson, Arizona, US (2002); Minneapolis, Minnesota, US (2004); Hermosillo, Sonora, Mexico (2006); Banff, Alberta, Canada (2008); and Shepherdstown, West Virginia, US (2010).

Much of the funding for WAB 2010 was provided by the US Federal Highway Administration (FHWA). Bonnie Harper-Lore—the driving force behind previous WAB conferences, and recently


Annie Simpson

FICMNEW members presented Bonnie Harper-Lore with a handmade bowl, crafted out of wood from the invasive Callery pear tree, for her steadfast dedication to the Weeds Across Borders mission.

Bonnie Harper-Lore

Jenny Ericson

WAB participants on the field tour at Harpers Ferry National Historical Park.

retired invasive species expert with FHWA—provided an historical perspective of the events during the Wednesday evening session, beginning with reflections from the first conference in 2002 and ending with an inspired challenge to continue supporting these crucial continental partnerships, information sharing, and cross-boundary program coordination. As a tribute to the steadfast support and dedication Bonnie has shown over the years—organizing and giving life to WAB—FICMNEW honored her with a special gift, a handcrafted bowl cut from the wood of the invasive Callery pear tree *(Pyrus calleryana)* created by Annie Simpson (US Geological Survey and FICMNEW member).

The agenda for WAB 2010 was designed to highlight new research, partnerships, legislation, and programs from the countries of Canada, Mexico, and the US. The two-part field tour took place at (1) Flowing Springs Park in Ranson, West Virginia, with a specially-guided tour led by Bill Gregg, recently retired invasive species expert with the USGS; and at (2) Harpers Ferry National Historic Park in Harpers Ferry, West Virginia, where local experts discussed strategies and techniques along with the difficulties of managing invasive species along the area's pathways, corridors, rivers, and trails.

The conference was opened by the distinguished Michael Bean, Counselor to the Assistant Secretary for the Fish, Wildlife and Parks in the US Department of the Interior, and by Jay Slack, Director of NCTC. The first session of the conference consisted of status reports provided by each of the three countries: Canada, Mexico, and the US, represented respectively by Cory Lindgren of the Canadian Food Inspection Agency; Patricia Koleff of CONABIO (Comisión Nacional para el Conocimiento y Uso de la Biodiversidad); and Lori Williams of the US National Invasive Species Council. In addition, Juan Carlos Cantu of the Defenders of Wildlife-Mexico Program gave a special update on the invasive species legislation recently adopted by the Mexican government.

Les Mehrhoff, founding director of the Invasive Plant Atlas of New England (IPANE), facilitated a panel on Cooperation and Horticultural Partnerships, which focused on the horticultural industry and collaborative efforts in the global trade of invasive plants. We were fortunate to have John Zaplatynsky, President and CEO of GardenWorks, Ltd., provide us with an overview of his Canadian retail garden center operations as well as his perspective as an industry professional. We were equally delighted to have Giuseppe Brundu join us from Sardinia, Italy, to speak about the European Union's effort to implement a Code of Conduct, which was drafted for horticulture and invasive plants and targets trade and industry in Europe and the Mediterranean countries. This effort follows an action taken by the European Commission in 2008 which presented policy options for an EU strategy on invasive species.

The session on Applied Research Reports highlighted efforts to develop and implement Weed Risk Assessment (WRA) models by Canada and the US to predict weediness and assess the invasive potential of new plants prior to importation. Both of the efforts, presented by Alec McClay and Tony Koop, respectively, are based on or are similar in style to the Australian system. We also heard about a first attempt to eradicate *Polygonum convolvulus* in Guanajuato, Mexico. And we learned about the significance of anthropogenic dispersal corridors in determining distribution of cogongrass *(Imperata cylindrica)*.

There were many informative presentations in the New Issues and Networking session, including a demonstration of Google Street View, an online tool with the potential for application to roadside invasive species detection and monitoring efforts.

The WAB 2010 Keynote Speaker, Curt Meine, renowned Aldo Leopold biographer, explored invasive species issues within the framework of Leopold's Land Health Concept. According to Meine, the incidence of invasive species was among Leopold's key indicators of land health. Furthermore, he shared insights gained from reviewing Leopold's thoughts on conservation with respect to efforts to build resiliency into both human and natural systems, in particular.

The panel on Border Management focused on facilitating cross-border cooperation, trade secrets as a policy barrier to cooperation, tribal lands, and challenges in Alaska. Bruce Lewke of US Customs and Border Protection reported that Federal Noxious Weeds from 25 different countries had been intercepted 113 times over the past 18 months as a result of cargo inspections at ports of entry.

Lewis Ziska, a plant physiologist with the US Department of Agriculture, facilitated a panel on the Economic and Ecological Impacts of Invasive Plants. Discussion topics ranged from the economics of border enforcement, to the bio-economics of invasive species, to physiology-based predictions of range shifts as illustrated by the recent case of kudzu *(Pueraria montana* var. *lobata)* invading Canada. Bethany Bradley from the University of Massachusetts at Amherst discussed the strengths and weaknesses of envelope modeling for invasive plant management. Results from her invasive cheatgrass *(Bromus tectorum)* research help predict the likelihood that climate change will shift the spatial distribution of invasion. This may include an expansion of invasive plants in the future, as well as unprecedented opportunities for restoration.

The final two sessions of the conference focused on Awareness and Education Programs, and Early Detection and Rapid Response (EDRR) efforts. Both sessions consisted of presentations that illustrate the importance of engaging citizen scientists, local communities, and volunteers in invasive plant management. Between the two sessions, Sheilah Kennedy, Owner and Operator of S-K Environmental, provided a demonstration of her vehicle washing system in the parking lot behind the NCTC lab.

The final day of the conference was dedicated to a training workshop on EDRR organized by Randy Westbrooks (USGS) and Les Mehrhoff (IPANE).

In May 2010, WAB received endorsement from the Trilateral Committee for Wildlife and Ecosystem Conservation and Management. The Executive Table of the Trilateral Committee, which consists of representatives from Canada, Mexico, and the US, expressed great interest in promoting cross-national dialogue on invasive species issues.

As has been the case since 2002, the WAB 2010 conference successfully brought together more than 100 engaged participants from five countries, six Canadian provinces, and 27 US states. The biennial WAB conference series provides a platform for the continued sharing of information and pooling of resources, and fosters multi-national cooperation. We hope the international interest in WAB will continue to gain momentum in the coming years and we look forward to WAB 2012, scheduled to be held in Mexico's Yucatan Peninsula.

HISTORICAL PERSPECTIVE

The Past, Present, and Future of Weeds Across Borders

By Bonnie Harper-Lore
US Federal Highway Administration (Retired)

The Past According to Weeds Across Borders

Weeds Across Borders (WAB) was the first effort to bring together one continent of scientists, practitioners, and policy makers to share information on the complex issue of invasive plants. We invited the movers and shakers of the plant world; professional people willing to cross political boundaries to listen, learn, and share. The United States federal weed committee known as the Federal Interagency Committee for the Management of Noxious and Exotic Weeds (FICMNEW) took the first step and all of you came when we called to begin a cooperative partnership. I am so proud to have been a part!

The 2002 conference, in Tucson, Arizona, was possible in large part because of Tom VanDevender's knowledge, professional network, and the Sonora Desert Museum's intimate setting. A book-signing fiesta drew us together one evening. and it remains the best food conference ever.

The 2004 conference was held in Minneapolis, Minnesota and resulted from the hard work of the North American Weed Management Association with Collie Graedick on the ground. The US Forest Service's DeSoto Forest Blues Rangers traveled across the country to entertain us with original weed songs set to the blues for free. It was here that an ad hoc group formed at the end of the conference, asking for a trilateral agreement to support further interaction on the issue of invasive plants.

In 2006, WAB took us to Hermosillo, Mexico with Tom VanDevender and Francisco Espinosa Garciá's leadership. Excellent interpreters facilitated the information exchange, which led to the first bilingual WAB proceedings. The desert field trip revealed Mexico's invasive species story and everyone's knowledge increased. The University of Sonora worked quietly behind the scenes.

WAB 2008, held in Banff, Alberta, Canada, was the success story of Stephen Darbyshire and the Alberta Invasive Plants Council. We enjoyed a strong agenda, thought-provoking lectures, and an educational day in the field. It was here that trilateral agreement talks were discussed further and the Banff Accord[1] was signed by attendees.

Every conference brought us closer in a common cause—the war on weeds. The context, food, entertainment, and field trips taught us more about each other and each other's weed work while building relationships.

Current Assessment of Our Progress in the War on Weeds

In 2010, you have listened, learned, and networked in Shepherdstown, thanks to the leadership of Jenny Ericson and her committee. Yet the weeds are still winning! Time is not on our side. It is the people at this conference—the scientists, practitioners, and policy makers who are thinking outside the box and are pushing and shoving the issue toward new solutions continentally—who will make a difference. It is this group that can make things happen in the future!

Here are the pieces we still need to put into place in the trilateral war on weeds puzzle:

[1] The Banff Accord: An agreement to prevent and control the spread of weeds by sharing information, including, but not limited to: technology transfer, training tools, status assessments, public awareness, best management practices, and research results. The Banff Accord was signed at the Weeds Across Borders 2008 conference in Banff, Alberta, Canada by representatives from Canada, Mexico, and the United States on 30 May 2008.

Awareness One CWMA, one county, one neighborhood at a time is not fast enough in this battle. Without support from every family across the continent, we will not win. We need a united awareness campaign that reaches everyone with the same message. It must be a simple message that connects families to stewardship of the land they live on. With the public's support the other pieces will follow.
Appropriations Appropriations by each country's legislature to fund cooperative action are needed.
Authority Executive Order 13112 is not a strong enough authority in the US! In each country, one entity (public or private) needs to take charge; for example the Department of the Interior, Department of Agriculture, or the Environmental Protection Agency in the United States. A trilateral agreement or a memorandum of understanding could pressure this authority to materialize.
An Alliance of Centers Perhaps with the leadership and experience of CONABIO, we can determine a Center in each nation to which Early Detection and Rapid Response data reports are sent, compiled, and analyzed. Merely gathering locations and size of weed populations on the ground is not enough. This information must be translated into action: management strategies, partnerships, shared weed warnings, and legislation. The big picture of the continent's environmental health is at stake.

Conclusion

This conference began because I thought our nation's highways were part of the problem as a vector in spreading weeds. No matter what you control on your land, it does not matter unless adjacent lands are also controlled. Reach out to highway departments. They are open to partnerships. Most maintenance districts are trying to use best practices in maintenance and construction, but they need your support. Some 12 million acres of roadsides cross private and public sector lands. Without their cooperation you cannot win the war on weeds.

While in search of understanding past highway decisions to plant kudzu, I reviewed research reports dating back to the 1930s. Transportation researchers spent time looking for a silver bullet, an easy answer, or one size fits all tool to solve erosion control problems, economic pressures, and public demands for safety and mobility. They missed the ultimate truth…everything is connected! In the future their solutions and yours must be connected, as an ecological approach from each of the three countries including, parklands, forests, rangelands, wetlands, and the highways that cross them…at a federal level, at state, estado, and provincial levels, and at local levels. This can translate into an ecological approach at a continental level. The real silver bullet is the dedication and hard work of those of you who take home what you learned at this conference and take action!

PRESENTATION MANUSCRIPTS

National Strategy for Invasive Species as a Framework to Develop Weed Management Policies in Mexico

Patricia Koleff[1]

Ana Isabel González

Georgia Born-Schmidt

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Abstract

Alien invasive species (AIS) are one of the major drivers of global environmental change. They cause severe social, environmental, and economic impacts, amounting to billions of dollars and outweighing any tangible benefits. Biological invasions threaten biodiversity and have become a true challenge to policy makers in many countries and to organizations around the globe. The effects of AIS are compounded by other threats such as deforestation, overexploitation, pollution, and climate change. Furthermore, biological invasions weaken the resilience of ecosystems and are likely to cause synergic effects, of which the magnitude is still unknown. Unfortunately, Mexico is no exception to the AIS problem and the Ministry of Environment is currently developing a National Strategy for AIS; the main objective is to contribute to the conservation of natural capital and human well-being through actions oriented towards prevention, control, and eradication of the most noxious AIS. The strategy is designed to align and coordinate the efforts of a broad range of government agencies and stakeholders; work towards a diagnosis of the situation; evaluate the effects of AIS on Mexico's biodiversity and economy; set up management, control, and eradication programs; and address gaps in specific regulations to mitigate problems. One of the main issues that will be addressed by this strategy concerns the challenges posed by terrestrial and aquatic invasive weeds, which constitute 70 percent of the exotic, invasive, and potentially invasive species registered for the country. Furthermore, advances have been made in the development of priorities to establish a national weed management strategy. The publication of the National Strategy on Invasive Species in Mexico will provide a framework to convert these identified priorities into actions.

Resumen

Especies exóticas invasoras (IAS) pueden impulsar el cambio ambiental global, que a menudo es difícil dar marcha atrás. Causan graves repercusiones sociales, ambientales y económicos de montaje hasta miles de millones de dólares. La invasión biológica es reconocida como una de las amenazas más importantes para la biodiversidad y un verdadero desafío a los responsables políticos en muchos países y organizaciones de todo el mundo. Se suma a otras amenazas como la deforestación, la sobreexplotación, la contaminación y el cambio climático, lo que debilita la resistencia de los ecosistemas y la probabilidad de causar efectos sinérgicos, cuya magnitud aún se desconoce. México constituye una excepción en relación con el problema de las NIC y sufre los impactos del mismo que el descrito anteriormente. El Ministerio de Medio Ambiente, a través de un Comité Asesor coordinado por la CONABIO, está desarrollando actualmente una estrategia nacional para la NIC, cuyo objetivo es contribuir a la conservación del capital natural y bienestar humano a través de acciones orientadas hacia la prevención, control y erradicación de las NIC. La estrategia está diseñada para alinear y coordinar los

[1] Presenter.

esfuerzos de una amplia gama de organismos gubernamentales y los interesados; trabajar por un diagnóstico de la situación, evaluar los efectos sobre México, la biodiversidad y la economía de los oficiales administrativos, el establecimiento de gestión, control y erradicación de los programas y hacer frente a la regulación lagunas para asistir el problema. Una de las principales cuestiones abordadas por esta estrategia se refiere a los desafíos representados por el gran número de especies exóticas que necesitan ser evaluados, junto con sus vías e impactos, con las prioridades establecidas en marcha la acción. Especial énfasis debe ser dirigido a las malezas invasoras terrestres y acuáticos, que constituyen el 70 por ciento del total de especies exóticas, especies invasoras y potencialmente invasoras registradas para el país. Se han logrado avances con respecto al desarrollo de las prioridades para establecer una Estrategia Nacional de Manejo de Malezas. La publicación de la Estrategia Nacional de AIS para México a finales de 2010 proporcionará un marco para convertir estas prioridades en acciones.

Introduction

Alien invasive species (AIS) cause severe social, environmental, and economic impacts, amounting to billions of dollars and outweighing any tangible benefits (Pimentel et al. 2005). Biological invasions have been recognized as one of the most significant threats to biodiversity, especially because they affect ecosystem services and add up to other threats, such as deforestation, overexploitation, pollution, and climate change. Furthermore, biological invasions weaken the resilience of ecosystems and are likely to cause synergic effects whose magnitude is still unknown (Figure 1). Mexico constitutes no exception regarding the AIS problem and suffers the same impacts known worldwide. AIS represent a serious menace to native Mexican biodiversity and ecosystems, and pose a major threat to a wide range of resources in diverse environmental, social, cultural, and economic sectors. The National Invasive Species Information System is at the outset of data collection and already includes a list of 2,819 weed species, 2,201 native species, and 618 exotic species in Mexico (Vibrans 2010). In comparison, the United States has registered 2,100 weed species.

Since ancient times, human movement has been a vector for the introduction of exotic species into new environments. As trade continues to increase, especially in live plants (with soil), new opportunities for pest introductions and infestations arise (EFSA 2007).

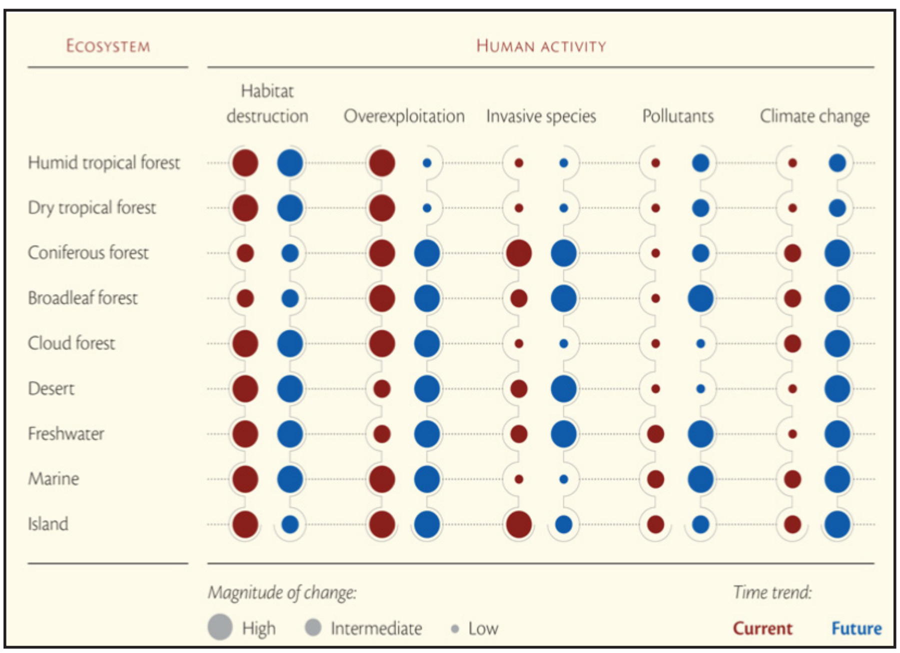

Figure 1. The impact of human activity on ecosystems in Mexico (CONABIO 2009).

Therefore, to face the challenges posed by the issue of AIS and as a response to the commitments made by Mexico through the Convention on Biological Diversity (CBD), which states in Article 8(h) that the parties "acquire the commitment to undertake specific actions to prevent the introduction of, control or eradicate those aliens, which threaten ecosystems, habitats or species," and the National Biodiversity Strategy (CONABIO 2000), Mexico identified the need to create a national strategy on AIS. This strategy will address strategic components which need to be strengthened through the coordinated actions of involved stakeholders.

Main Activities Related to AIS in Mexico

Some important but reactive and isolated efforts have been made so far; however, they were focused mainly on species that impact agriculture (pests of crops, livestock, or commercial forest species) and human or animal health. In spite of a few examples, coordinated interagency actions to prevent, control, and eradicate AIS, or to mitigate their effects, are currently absent. A lack of information concerning invasion status, pathways of introduction, current distribution, coverage, population size, ecology, impact, and economic loss is both a consequence as well as a reason for this.

Recent AIS related activities include the cactus moth *(Cactoblasitis cactorum)* risk analysis carried out in 2002, which led to a list of actions necessary to prevent the moth from entering Mexico. In 2006, specialists compiled a list of AIS of high impact for Mexico, as well as a series of actions to address the issue. A couple of years later, in 2007 and 2008, an AIS information system and website were created for Mexico with the aim of providing information on different topics regarding AIS within the country.

The creation of the Weeds of Mexico website (http://www.malezasdemexico.net), led by Dr. Heike Vibrans, was another important step toward gathering information regarding the issue. It provides good quality, vouchered photographs, descriptions, conventional and interactive keys, and other support for the identification of the approximately 3,000 weed species estimated for Mexico. It also offers useful information on each species in a blog-like factsheet, including a guide to reliable and relevant websites, and an opportunity for information exchange and collaboration between interested individuals, both scientists and laypersons (Vibrans 2010).

Between 2006 and 2010, a number of Risk Analysis/HACCP workshops were held in different parts of the country to start building up knowledge and capacities regarding AIS prevention. Further important activities took place in 2009, one of which was the successful eradication of the cactus moth after a collaborative effort lead by the Ministry of Agriculture, Livestock, Rural Development, Fisheries, and Food (SAGARPA) in coordination with the Ministry of the Environment and Natural Resources (SEMARNAT) and with international support from the US Department of Agriculture's Office of External and Intergovernmental Affairs. Later in 2009, a symposium regarding the status of knowledge on AIS in Mexico was held at the University of Nuevo León in Monterrey. That same year, the first national definition of AIS was published in an ecosystem assessment: Natural Capital of Mexico (CONABIO 2009; see Aguirre and Mendoza et al. 2009).

Regulation and Public Policies

Mexico has well established legal and technical framework to manage pests, and quarantine procedures for plants and animals through phytosanitary and sanitary measures [Federal Law on Plant and Animal Health; General Law on Wildlife (LGVS)]. The governmental entities responsible for applying those measures are SAGARPA and its decentralized agency, the National Service of Agro Alimentary Health, Safety, and Quality (SENASICA). Regarding environmental legislation, the picture is somewhat different. Until recently, environmental legislation provided only general guidelines to regulate the problem of AIS. AIS were addressed in some laws, regulations, norms, and agreements, which contain several articles referring to them as exotic species; for example, the National Law for Environmental Protection (LGEEPA), General Law on Sustainable Forest Development, and the LGVS. This gap has been recognized and both LGEEPA and LGVS were recently modified. As of April 2010, the changes, which include expanding some articles and adding the term "exotic invasive species" for the first time, were made official. The modifications request the development of AIS lists for Mexico and seek to forbid the introduction of AIS or species that might carry AIS into the country. This is an important first step; however, further modifications will be necessary in the near future. Examples of public policies regarding species with effects on agriculture, forestry, and the environment include: Mexican Official Emergency Regulation NOM-EM-040-FITO-2003, which temporarily implemented a system to prevent the introduction, spread, and establishment of the cactus moth in national territory (this norm has expired); Mexican Official Regulation NOM-043-FITO-1999, which includes specifications to prevent the introduction of quarantine weeds to the country; and an agreement to establish requirements and plant health guidelines to control and mitigate the dispersion risk of the pink hibiscus mealybug *(Maconellicoccus hirsutus)* from areas under plant health control to pest free areas in Mexico.

Proposals to Address Biological Invasions

Most efforts to address AIS have failed to acknowledge species that have an effect on both productive activities and the environment; disjointed and uncoordinated efforts have hampered or decreased the effectiveness of the actions implemented. As a result of these unsuccessful efforts, stakeholders have finally begun to develop coordinated actions that have resulted in successful advances (for example, cactus moth actions, island eradications, modernization of the aquarium trade, and so on). In spite of of these advances, there was still a need for national guidelines to address the issue in a comprehensive and synchronized manner. One example of such a coordinated attempt is the development of a formal weed strategy. Until recently, there was no systematic approach to help farmers deal with weeds recognized as AIS and, consequently, efforts undertaken by individual farmers had varied outcomes. The inappropriate use of herbicides, which often fails to affect the target and may have negative impacts on the environment, is one serious consequence of individual efforts. Scientists from two institutions, the Colegio de Postgraduados and the Universidad Nacional Autónoma de México, proposed the implementation of a national weed management strategy which would require the participation of farmers, authorities, agronomists, agrochemical companies, and the scientific community (Espinosa García and Vibrans 2009).

The National Strategy on Invasive Species: A Systematic Approach to Address Invasive Species in Mexico

In response to the different challenges posed by AIS and to fulfill the commitments made by Mexico through the CBD and the National Biodiversity Strategy, the need for a strategy on AIS in Mexico was identified. To comply with this task, an advisory committee was established and formed by academic specialists, civil organizations, and representatives of different areas of the federal government (Figure 2). These individuals provided knowledge and experience to consolidate this planning tool for Mexico, which, as required by SEMARNAT, was coordinated by CONABIO, in close collaboration with the National Commission of Natural Protected Areas (Comité Asesor Nacional sobre Especies Invasoras 2010). One of the main issues that this strategy will address concerns the challenges posed by terrestrial and aquatic invasive weeds, which constitute around 70 percent of the exotic, invasive, and potentially invasive species registered for the country. The publication of the Mexico's National Strategy will provide a framework to convert these identified priorities into actions. Actions related to AIS required by the National Biodiversity Strategy include:

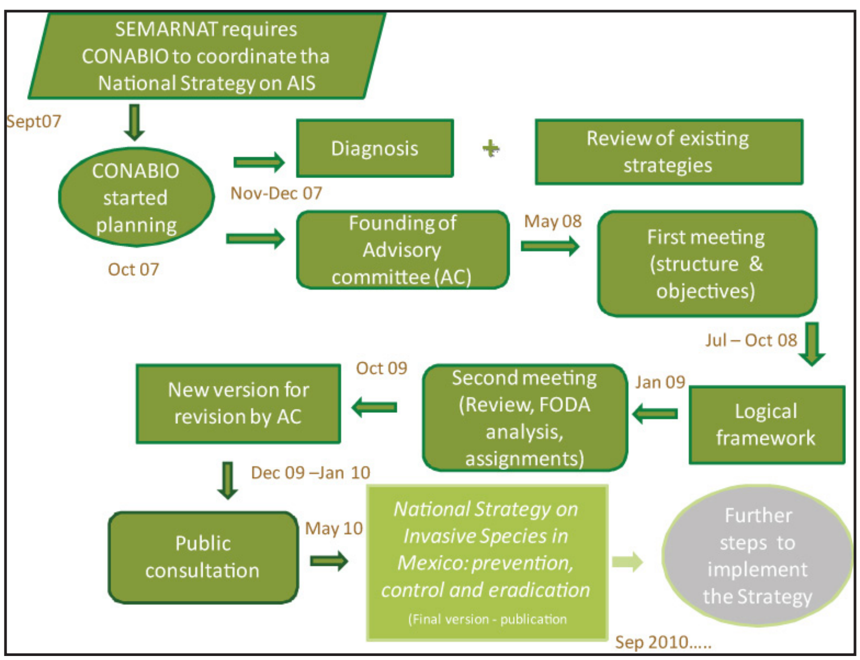

Figure 2. The process for developing the National Strategy.

- Developing an inventory of current AIS;
- Supporting research on AIS pathways, establishment, early detection, and monitoring;
- Eradicating the most noxious species, especially in priority protected areas and islands;
- Identifying and creating legal instruments to regulate the entry and movement of AIS within Mexico;
- Promoting the use, production, and commerce of native species instead; and
- Using risk assessment protocols and impact assessment studies before authorizing movement or entry of exotic species.

The focus of the National Strategy, as stated in its mission, is to contribute to the conservation of natural capital and human well-being through actions oriented toward the prevention, control, and eradication of AIS in Mexico with the coordinated, proactive, and responsible participation of all involved stakeholders. The vision statement reads that, by 2020, Mexico will have efficient prevention, detection, and early response systems, as well as instruments under an appropriate legal framework accounting for the needs of prevention, mitigation, control, and eradication of AIS. The following cross-cutting strategic actions are the driving forces that will enable the implementation process and fulfill the objectives of the strategy.

Legislation and regulation

The legal and normative framework must be comprehensive and capable of addressing the challenges, gaps, inconsistencies, and weaknesses posed by the different aspects of the AIS issue. Additionally, it must promote the harmonization of legal instruments and the cooperation among different sectors, among federal entities, and within different government levels.

Capacity development

Within the strategy's framework, each of the activities undertaken must contribute to building scientific, technical, human, and institutional capacities in order to strengthen the abilities of the country in terms of invasive species.

Coordination

It is essential to have the collaboration and consensus of key stakeholders in order to carry out the necessary actions to respond to the problems caused by AIS in an efficient, transparent, and harmonious way. In accordance with the latter, it will be necessary to define and establish protocols and agreements of coordination and cooperation among inter-governmental and inter-institutional entities, and engage the participation of a well informed citizenship.

Divulging information and communication

The success of the actions derived from this strategy depends not only on timely actions from authorities but on the support and cooperation of society. It is of fundamental importance that such activities rely on easily accessible, updated, and trustworthy information, allowing an understanding of the context of the issue by different users.

Knowledge and information

Decision making and implementation actions must be based on scientific information of the highest quality. Therefore, it is necessary to strengthen the mechanisms to obtain, exchange, manage, and access information at the national level; strengthen the scientific research that generates knowledge for a better understanding of biological invasions, their impacts, and restoration processes; and improve productive practices and promote the use of native species.

The three main objectives of the National Strategy are: (1) prevent, detect, and reduce the risk of introduction, establishment, and dispersal of AIS; (2) establish control and eradication programs that minimize or eliminate the negative impacts of AIS populations and favor restoration and conservation of ecosystems; and (3) adequately and efficiently inform citizens, thereby enabling them to assume responsibility for their actions.

The public consultation of the National Strategy caused a broad echo—clear evidence that the importance of the issue is finally being recognized across all involved sectors. A broad willingness to actively participate in the implementation of the National Strategy was expressed repeatedly in the statements given; however, the National Strategy must be followed by a series of coordinated actions in order to unfold its power and not lose momentum. The next steps to be taken are:

- Publish the National Strategy by September 2010;
- Adopt the National Strategy and assign responsibility;
- Coordinate all involved sectors;
- Create synergy and avoid duplication of efforts;
- Continue and reinforce the actions that have already proved to be effective;
- Establish an action plan; and
- Develop indicators to help monitor progress and point out where corrective actions need to be applied.

AIS pose a variety of threats to ecosystems, including land fragmentation, deforestation, overexploitation, pollution, and climate change; weaken their resilience; and are likely to cause synergic effects of an unknown magnitude. Considering threat factors separately can lead to erroneous decisions about future human impacts on biodiversity. Therefore, it is fundamental to investigate the relationships between and synergistic effects of AIS on biodiversity and to consider adequate measures for adaptation and mitigation.

Conclusion

The National Strategy is designed to align and coordinate the efforts of a broad range of governmental agencies and stakeholders; work toward a diagnosis of the situation; evaluate the effects of AIS on Mexico's biodiversity and economy; establish prevention, management, control, and eradication programs; and address gaps in specific regulations to respond to the problems posed by AIS. Without the implementation of a strong and consistent national framework, which the National Strategy on Invasive Species in Mexico provides, it is likely that stand-alone activities on AIS will continue for some time.

Acknowledgments

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New Initiatives in Canada's Response to Invasive Plants (2008–2010)

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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. Canada has initiated a number of projects that align with the Weeds Across Borders 2010 conference theme of "Policies, Politics, and Practices."

The Canadian Food Inspection Agency is Canada's regulatory/quarantine agency and as part of its invasive plant program, the following new initiatives are underway: (1) a Canadian Invasive Plant Framework, which seeks to develop strong, active partnerships and to clearly articulate the roles and responsibilities of all levels of government and Canadians in the prevention, early detection, response, and management of invasive plants; (2) a new Invasive Plant Policy is being developed to guide the regulation of invasive plants as pests and establish the parameters for regulatory action on the import and domestic movement of invasive plants; (3) a Least Wanted Invasive Plants of Canada project has been initiated to identify Canada's least wanted plants and regulate them as quarantine pests under the Plant Protection Act as well as under the Seeds Act; (4) pest risk analysis methods are being reviewed and adapted for use in assessing and screening potential invasive plants, including intentionally imported plants for planting; and (5) an Early Detection and Rapid Response plan for invasive plants is under development. Agriculture and Agri-Food Canada also provides research and technology that address invasive plants in Canada. They conduct research on weeds and invasive plants; conduct surveys, diagnostic work, biological control, and management programs; as well as plant ecology and biodiversity research examining the threats from invasive plants.

New trends have seen Canadian provinces reviewing and revising their regional regulations so that they embrace a broader concept of invasive plants, which is more than just pests of arable land. They have been developing partnerships with stakeholders and providing greater support for various management programs, such as establishing invasive plant councils that address regional issues, education, and management.

Resumen

Las plantas invasoras son aquellas especies de plantas nocivas cuya introducción o propagación amenazan el medio ambiente, la economía o la sociedad, incluida la salud humana. Incrementos en el comercio internacional, viajes, el transporte y el turismo han creado nuevos y únicos caminos para la introducción intencional y no intencional de las plantas invasoras. Canadá ha iniciado una serie de proyectos que se alinean con el tema de la conferencia políticas, política y prácticas.

Canadian Food Inspection Agency es la agencia reguladora/cuarentena de Canadá y como parte de su programa de plantas invasoras las siguientes nuevas iniciativas están en marcha. Un Marco

[1] Presenter.

Canadiense de Plantas Invasoras tiene por objeto desarrollar una fuerte colaboración activa y articular claramente los papeles y responsabilidades de todos los niveles de gobierno y los canadienses en la prevención, detección temprana, respuesta y manejo de plantas invasoras. Una nueva política de Plantas Invasoras se está desarrollando que guiarán la regulación de las plantas invasoras como las plagas y establece los parámetros para las acciones reguladoras de la importación y el movimiento interno de las plantas invasoras. El proyecto de las plantas invasoras menos deseadas de Canadá se ha iniciado que identificara las plantas menos deseadas de Canadá y las regularla como las plagas de cuarentena bajo la Ley de Protección Fitosanitaria, así como en virtud de la Ley de Semillas. Métodos de análisis de riesgo de plagas están siendo revisados y adaptados para su uso en la evaluación y selección de potenciales plantas invasoras, incluidas las plantas intencionalmente importados para la siembra. Un EDRR plantas para plantas invasoras se está desarrollando. Agricultura y Agroalimentación de Canadá también proporciona investigación y tecnología que se ocupan de las plantas invasoras en Canadá. Llevan a cabo investigaciones sobre las malezas y plantas invasoras, hacen encuestas, trabajo de diagnóstico, control biológico y los programas de manejo, así como la investigación en ecología de plantas y en biodiversidad examinando las amenazas de las plantas invasoras.

Las nuevas tendencias que se han visto las provincias de Canadá es examinar y revisar sus reglamentos regionales a fin de adoptar un concepto más amplio de las plantas invasoras, por ejemplo, algo más que las plagas de la tierra cultivable. Ellos han desarrollado asociaciones con las partes interesadas y proporcionan un mayor apoyo a los distintos programas de manejo, como el establecimiento de Consejos de plantas invasoras que se ocupan de las cuestiones regionales, educación y manejo.

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. It is not just nuclear bombs and wars that threaten us, though these rank very high on the list at the moment: there are other sorts of explosions… ecological explosions…like potato disease, a green plant like the prickly pear, or an animal like the grey squirrel… make no mistake we are seeing one of the great historical convulsions in the world's fauna and flora."
> —Charles Elton, *The Ecology of Invasions by Animals and Plants (1958)*

Invasive plants are those harmful plant species whose introduction or spread threatens the environment, the economy, or society, including human health. Expanding international trade and human travel, transport, and tourism have created new and unique pathways for the intentional and unintentional introduction of invasive plants. Canada has initiated a number of projects that align with the Weeds Across Borders 2010 conference theme of "Policies, Politics, and Practices." This paper summarizes some of the new initiatives and trends in response to the increasing threat of invasive plants in Canada.

Updates

Canadian Food Inspection Agency

The Canadian Food Inspection Agency (CFIA) was established in 1997 to safeguard Canada's food supply and the plants and animals upon which safe and high quality food depend. The CFIA, as an agent of the Government of Canada, is the primary agency charged with preventing invasive plants from entering Canada. Under the International Plant Protection Convention (IPPC) framework, the CFIA is recognized as Canada's National Plant Protection Organization and, in this role, is responsible for prescribing phytosanitary measures necessary for the safe import, export, and domestic movement of plants and plant products in Canada. The International Standards for Phytosanitary Measures, developed under the IPPC, provide guidance to member countries for implementation of the Convention at a national level. Legislative authority for the CFIA is provided by the Plant Protection Act and Regulations, as well as under the Seeds Act and Regulations.

Facts and Figures (Source: Canadian Food Inspection Agency 2008, *Invasive Alien Plants in Canada Summary Report*)
• There are about 1,229 alien vascular plant species reported at present in one or more locations in Canada.
• Of these alien vascular plant species, 486 are considered weedy or invasive.
• Ontario, Quebec, and British Columbia have the most invasive plant species.
• About 58 percent of invasive alien plant species appear to have arrived in Canada through intentional introduc tions from other countries.
• About 49 percent were introduced unintentionally, such as weed seeds mixed in with imported soil or crop seeds.
• Most invasive alien plant species came to Canada from 1800 to 1900. It seems that the pace of introduction during the past century has slowed to approximately 0.58 species per year.
• Nationwide, annual costs of invasive plants to the agricutural community are estimated at CAN$2.2 billion, on an agricultural land base that produces $15 billion of plant products.

Specifically, the CFIA regulates the intentional introduction of new plants known to be invasive in other regions of the world but not yet present in Canada[2]. The CFIA can also regulate those plants present in Canada but which have a limited distribution and are or will be under official control[3]. Official control programs may be implemented by the Government of Canada or in partnership with provincial and territorial governments.

The CFIA encourages partnerships that increase the capacity to respond proactively, and that address the introduction of invasive plants not yet present in Canada, and those present but not yet widely distributed and where an official control program can be implemented. The CFIA: (1) regulates the environmental release of plants which may cause harm to the environment under Part V of the Seeds Act and Regulations; (2) addresses the potential spread of invasive plants through the sale of seed using the Weed Seeds Order; (3) employs risk analyses (that is, risk assessment, risk management, and risk communication) to determine the risk of new potentially invasive plants to Canada; and (4) conducts surveys, monitors, manages, and controls regulated invasive plants in partnership with other stakeholders. The agency also promotes and develops education and awareness programs, and engages in international discussions (for example, the IPPC) and projects aimed at controlling the introduction and spread of invasive plants.

Invasive plants are recognized as a cross-commodity issue involving various branches and sections within the CFIA. Below are a few of the CFIA initiatives currently underway.

Canadian Invasive Plant Framework

The CFIA, along with its partners and stakeholders, is leading the development of a Canadian Invasive Plant Framework (CIPF). The Framework emphasizes the importance of preventing introductions through partnerships, and proposes the development of a National Invasive Plant Forum that will strengthen national collaboration and communication. The scope is broad and includes all invasive plants. The objective is to prevent introduction, and minimize and manage the risks invasive plants pose to Canada's economy, environment, society, and international trade.

It is widely recognized that responding to invasive plants is a shared responsibility and the active involvement of all levels of government, non-government organizations, and stakeholders is essential. Invasive plants have gained international attention as globalization, climate change, and increases in international trade have elevated the risks of invasive plant introductions. The CIPF emphasizes the importance of preventing introductions through partnerships and is built upon, and consistent with, the goals and objectives of the Invasive Alien Species Strategy for Canada. The CIPF identifies the roles and responsibilities of all stakeholders in Canada's response to invasive plants. It recognizes the need to blend regulatory and non-regulatory approaches where each partner contributes expertise, resources, and tools.

The CIPF is being developed through broad consultations with government partners and

[2] This represents a "quarantine pest" which is a pest of potential economic importance to the threatened area, and not yet present there, or present but not widely distributed and under official control as defined by the IPPC.

[3] Official control is the active enforcement of mandatory phytosanitary regulations and the application of mandatory phytosanitary procedures with the objective of eradication or containment of quarantine pests or for the management of regulated non-quarantine pests as defined by the IPPC.

non-government stakeholders and is being coordinated by a federal government steering committee consisting of Agriculture and Agri-Food Canada, Environment Canada, Fisheries and Oceans Canada, Natural Resources Canada, Parks Canada, and the Canadian Food Inspection Agency.

Invasive plant policy

This policy will guide the regulation of invasive plants designated as pests and establish the parameters for regulatory action on the import and domestic movement of invasive plants. The policy is enabled by the Plant Protection Act and Seeds Act and related regulations. Invasive plants will be regulated in the same manner as other pest organisms. The decision to regulate will be based upon risk analysis; if a plant species presents a significant risk to Canada and meets IPPC criteria, it will be considered for regulation as a quarantine pest. The major pathways by which invasive plants enter Canada and spread are: seed for propagation; plants for planting (for example, ornamentals); and as contaminants of grain, hay, straw, and soil. Broad stakeholder consultations on the policy are underway.

Least Wanted Invasive Plants of Canada

A Least Wanted Invasive Plants of Canada pilot project is underway to identify Canada's potentially least wanted plants that could be regulated as pests under the Plant Protection Act as well as prohibited noxious weeds under the Seeds Act. The project will expand on efforts to prevent the introduction and spread of invasive plants in Canada. A preliminary list of plants that may be regulated is being consulted upon. Prior to the regulation of any new plants, stakeholder consultations will occur. Pest risk analysis methods are being reviewed and adapted for use in assessing and screening potential invasive plants, including intentionally imported plants for planting.

Canadian Weed Risk Assessment

The CFIA continues to test and refine methods for weed risk assessment. Most recently, the CFIA assessed the Australian Weed Risk Assessment system (AWRA), for use in Canada. The AWRA was designed as a pre-introduction screening system and has been applied in a number of other countries. Overall, results showed that the AWRA system was very successful at rejecting major weeds and most minor weeds; however, it also rejected a large number of non-weeds, which is problematic in a regulatory context (McClay et al. 2010). The CFIA is continuing work on developing a more reliable system for Canada that retains the benefits of the Australian system (spreadsheet-based scoring system, shorter service time than traditional pest risk assessments) while still complying with the guidelines for pest risk analysis established by the IPPC. Current work on developing a new approach to weed risk assessment is being done in cooperation with the United States Department of Agriculture (USDA) in an attempt to harmonize methodologies between the US and Canada. Testing is underway, and it is hoped that this new approach may be available for use next year.

Figure 1. Kudzu is an invasive plant first found in Canada in 2009. The development of Early Detection and Rapid Response programs will help prevent further infestations in Canada. Photo: Diane Mooij, Canadian Food Inspection Agency.

Early Detection and Rapid Response

Early Detection and Rapid Response (EDRR) are widely recognized as the most efficient strategies for the control of invasive species. The overall function of the EDRR strategy is to prevent the establishment of an invasive species before it can spread widely (Figure 1). An EDRR plan for invasive plants is under development in Canada and is based upon three components: (1) detection and identification; (2) assessment; and (3) planning and responding. The detection and identification component includes a well-structured detection network supported by identification. Detection surveys can be conducted by experts using formal guidelines such as those provided by the IPPC or by interested citizens. Once a suspect new invasive plant is detected, it needs to be identified through expert verification in a timely fashion. There are a number of existing resources in Canada that provide expert taxonomic identification, however a national tool is needed.

Once a plant has been detected and identified as a species of concern, a risk assessment is conducted to determine its potential risk to an area which could be national, provincial, or regional in scope, and in some cases to help determine if regulatory action is required.

A timely response to a weed incursion is potentially a complex undertaking that requires rapid mobilization and coordination of a diverse team of people and resources. For successful eradication, a rapid response against a small founder population needs to be launched as quickly as possible after detection.

Canadian Invasive Plant Network

Canada's capability and capacity to detect and identify invasive plant threats is scattered amongst various federal, provincial, and territorial government organizations, the regions and municipalities, as well as academia, nongovernmental organizations, and the private sector. The CFIA, in partnership with a multijurisdictional EDRR working group, has initiated a Canadian Invasive Plant Network (IPCANnet) pilot project, to support expansion of national communication and development of the EDRR model to help prevent the introduction and spread of invasive plants in Canada. IPCANnet is intended to establish an integrated mechanism for rapid, authoritative detection and identification of invasive plants. The goal is to foster communications between professionals, researchers, regulatory officials, and those with expertise in the detection and identification of invasive plant species.

Agriculture and Agri-Food Canada

Agriculture and Agri-Food Canada (AAFC) is a federal department with a broad mandate for matters pertaining to agriculture and products derived from agriculture. The impact of invasive alien species is one of the key issues facing Canadian agriculture identified in AAFC's Action Plan for Biodiversity in Canada. Furthermore, addressing the risks to agricultural interests posed by invasive alien species is identified as one of the key results under the biodiversity/bioresources priority of the AAFC Science and Innovation Strategy. Within AAFC, the Research Branch, Prairie Farm Rehabilitation Administration and Environment Branch, and Programs Branch (through its Pest Management Center), are most involved in addressing invasive plants in Canada.

The Research Branch of AAFC: (1) provides scientific expertise necessary for the identification, characterization, and management of invasive plants; (2) develops and maintains a reference collection of plants (that is, the vascular plant herbarium in Ottawa); (3) implements a Canadian biological control research program; provides spatial modelling capabilities (for example, to determine climate change impacts); (4) provides national quarantine importation clearance facilities in Ottawa; and provides quarantine research facilities in Lethbridge, Saskatoon, and Ottawa. The Research Branch also coordinates review of submissions for the release of classical biological control agents. These activities support regulatory decision making by the CFIA relative to invasive plants and the CFIA mandate for plant health protection.

The Research Branch has recently begun a revitalizing program focused on hiring new scientists. A number of key research positions have been identified for research into invasive species with programs to be established at several sites across Canada.

The Prairie Farm Rehabilitation Administration and Environment (PFRA&E) Branch conducts prairie weed surveys detecting invasive plants in agricultural crops; conducts field trials of weed control methodologies (for example, mechanical and chemical), as well as the ecology, genetics, and herbicide resistance of weeds; monitors and manages invasive plants on federal lands that are community pastures; and provides extension services on integrated weed management and grazing practices on rangelands and pastures in western Canada. The PFRA&E Branch uses a science base for the control of invasive plants, provided primarily by the Research Branch, to develop, test, and promote management strategies for farmers. Through the Pest Management Center, the AAFC Programs Branch facilitates the implementation of biological control approaches for invasive plant management, and generates data to support registrations of herbicides to combat priority weeds.

Provincial and Territorial Initiatives

New trends have seen Canadian provinces reviewing and revising their regional regulations so that they embrace a broader concept of invasive plants, for example, more than just pests of arable land. They have been developing partnerships with stakeholders and providing greater support for various management programs, such as establishing invasive plant councils that address regional issues, education, and management.

In partnership with regional and local governments, many provinces and territories are delivering operational invasive plant programs; have developed education and outreach programs aimed at preventing new incursions; developed early detection systems; conducted surveillance activities; and developed and implemented response and management plans (for example, classical biological control programs, herbicide programs, integrated vegetation or pest management programs, and educational programs) for invasive plants established in a region. Some provinces have developed and operated provincial online databases to record survey and inventory data, track invasive plant distributions, and facilitate coordination of management efforts. Provinces have and are developing memorandums of understanding with other levels of government so that effective and efficient response plans are in place prior to incursions.

Most provinces have weed control legislation and regulations. These are often updated or amended and a growing awareness of the broad effects of invasive plants is having an impact on the ways in which these jurisdictions view the utility of their legislative tools and how best to improve them. Both Saskatchewan and Alberta have recently revised their noxious weed regulations.

Invasive Species/Plant Councils

Invasive plant councils (IPCs) and invasive species councils (ISCs) play a significant role in addressing invasive plants in Canada as well as in sharing and coordinating information needs. In most provinces and territories, partnerships have been formed and continue to evolve, resulting in the formation of societies and councils that are dynamic in nature. British Columbia, Alberta, and Ontario have IPCs, while the Yukon, Saskatchewan, Manitoba, New Brunswick, and Alberta have established ISCs. In Nova Scotia, an Invasive Species Alliance has been formed. Quebec has formed an inter-departmental committee on invasive species.

IPCs develop strategic plans and form smaller regional committees to address local incursions. They encourage actions to help detect, prevent, and manage invasive plants. By building collaboration on key actions, they raise the profile of invasive plants across diverse interests, including governments; influence and encourage required regulatory measures; and engage the public at large in identification and detection activities that lead to early detection and prevention. IPCs promote coordinated research; develop and distribute educational and outreach materials; and assist in the development of regional and provincial databases that support early detection.

IPCs play a role in networking with other provincial, regional, and federal councils, as well as with provincial and federal governments. They work in cooperation with other stakeholder groups to inform policy and decision makers and assist in prioritizing issues for action. Ensuring collaboration and networking between councils and across provincial borders is recognized as a key role of IPCs. By building linkages across Canada, IPCs work to share expertise, network on common issues, and help ensure a coordinated national response to invasive plants that transcend borders.

Conclusion

New initiatives and activities are taking place at a number of levels in Canada. Many new regulatory-based activities are being undertaken by the CFIA at a national level and new research programs are being established by AAFC. At the provincial and territorial level, governments are actively pursuing partnerships and reviewing their management tools. New non-governmental councils are being founded and are establishing broad networks. There is a realization of the urgency to address the issue and a recognition of the partnerships required for effective control of invasive plants.

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Working *with* the United States Horticulture Industry

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Abstract

Plants have been sold and planted in the United States for hundreds of years. With a horticulture industry valued at about $17 billion annually, selling and providing new plants to the public is an important part of the US economy. Any efforts to curtail the horticulture industry impacts peoples livelihoods, therefore the industry needs to be part of the discussion whenever controls on invasive plant species are considered.

Several efforts have occurred in the last 10 years to help facilitate this dialogue. Nationally, one workshop in 2001 focused on voluntary efforts to address invasive plant issues and resulted in the St. Louis Declaration. This workshop brought stakeholders together to develop findings, principles, and voluntary codes of conduct to deal with invasive plants. At the regional level, states have attempted multistate approaches to regulate invasive species.

These efforts are facilitated through the plant board system and have been used most often to date for regulating invasive insect pests. The New England states have shared information when developing procedures for listing invasive plants to create some uniformity in the area. States have included horticulture industry members on state invasive species councils or invasive plant task forces.

The horticulture industry does have a stake in this issue and wants to be a part of the solution. Here are a few considerations to facilitate this process: make certain that horticulture industry representatives are at the table; develop clear definitions and criteria to be used when evaluating plants for invasiveness; interact with horticulture industry members in their own territory; and ensure that there is continuing dialogue and follow-up communication.

Resumen

Las plantas han sido vendidas y plantadas en los Estados Unidos durante cientos de años. Con una industria hortícola valuada alrededor de $17 mil millones, la venta y proporcionar nuevas plantas al público es una parte importante de la economía de los EEUU. Todos los esfuerzos para reducir la industria hortícola impacta los medios de subsistencia de los gente, por lo tanto la industria tiene que ser parte de la discusión cada vez que los controles sobre las especies de plantas invasoras son consideradas.

Varios esfuerzos se han producido en los últimos 10 años para ayudar a facilitar este diálogo. A nivel nacional, un taller en 2001 se centró en los esfuerzos voluntarios para abordar las cuestiones de plantas invasoras, resultó en la Declaración de San Luis. Este taller reunió a los interesados junto a las conclusiones desarrolladas y de los principios y códigos de conducta voluntarios para hacer frente a las plantas invasoras. En el plano regional los estados han tratado de enfoques multi-estados para regular las especies invasoras.

Estos esfuerzos se ven facilitados a través de la junta de sistema plantas y se han utilizado con mayor frecuencia hasta la fecha para la regulación de insectos plaga invasores. Los estados de Nueva Inglaterra han compartido información en el desarrollo de procedimientos para la inclusión de las plantas invasoras para crear una cierta uniformidad en la zona. Los Estados han incluido miembros la industria de la hortícola en los consejos estatales de especies invasoras o en grupos de trabajo de plantas invasoras.

La industria hortícola tiene un interés en el problema y quiere ser una parte de la solución. Aquí

hay algunas consideraciones para facilitar este proceso. Asegúrese de que los representantes de la industria hortícola están en la mesa. Desarrolle definiciones claras y criterios que se utilizarán en la evaluación de las plantas por su capacidad de invasión. Interactuar con los miembros de la industria de la horticultura en su propio territorio. Asegúrese de que el diálogo es permanente y haga comunicaciones de seguimiento.

Value of the US Horticulture Industry

The horticulture industry is an important part of the United States economy. The popularity of this industry is evidenced by the 85 million people who participate in lawn and garden activities and the $35 billion they spend on lawn and garden products, including new plants (ANLA 2007; NGA 2007). The nursery industry supplying these plants is valued at $17 billion annually (USDA 2007). While most plants perform well in the landscape, a few can be problematic. Approximately 50 percent of woody plants in the US are not native to North America (Niemiera and Von Holle 2009). The economic costs associated with invasive plants runs about $34 billion each year (Pimental et al. 2000). *Melaleuca* is a prime example of a tree endemic to Australia that was introduced to the US with devastating impacts on the Florida everglades. The horticulture industry clearly has a stake in the invasive plant debate.

Dialogue with the US Horticulture Industry

Over the past 10 years several efforts have occurred to facilitate dialogue with the horticulture industry. One of the major national efforts was a workshop held in 2001, entitled "Linking Ecology and Horticulture to Prevent Plant Invasions." This workshop brought together stakeholders interested in the invasive plant issue to develop voluntary strategies to prevent the spread of non-native invasives. One of the outcomes of the workshop was the St. Louis Declaration, which established findings, principles, and voluntary codes of conduct that the stakeholder groups agreed to follow when dealing with invasive plants. The findings determined that: people are dispersers of plants; plant introduction is a foundation of modern horticulture; a small portion of plants become invasive; and plant species are not invasive in all regions.

The principles the group agreed to were: (1) plant introduction should minimize unintended harm; (2) invasive plant prevention and management should be regional; (3) prevention and early detection are most cost effective; (4) research, training, and public education are essential; and (5) use of voluntary and regulatory tools is necessary; and the effort must be collaborative and broad based. Voluntary codes of conduct for dealing with invasive plants were developed for the stakeholder groups present, which included government, nursery professionals, the gardening public, landscape architects, and botanical gardens. To date, 47 organizations have endorsed the use of these codes of conduct.

Another national effort working with the horticulture industry is developing an invasive plant curriculum to be included in state nursery professional certification programs. This ongoing project has involved the National Invasive Species Council, the American Nursery and Landscape Association, and Michigan State University.

At the regional level, discussions have occurred at several venues. Regional industry meetings, such as New England Grows and the Mid Atlantic Nursery Trade Show, hold educational sessions with their annual trade show events. Several of these meetings have included invasive plant lectures or round table discussions. The Plant Board system conducts regional meetings, which bring state plant regulatory officials together to discuss issues of concern. These sessions have provided opportunities for industry, environmental interests, and government to discuss roles with respect to regulating invasive species, including invasive plants. The Invasive Plant Atlas of New England has been a valuable source for data regarding occurrences of invasive plants in the region. These data have been important for states as a basis for developing state invasive plant lists.

States have engaged the horticulture industry in various ways through educational presentations and invasive species councils or committees. Some of these councils are legislated to include horticulture representation while others have been established for a specific purpose, as was the case in Maine. In 2008, the Maine Department of Agriculture was directed by the state legislature to study the invasive plant issue with the main goal of establishing criteria for listing invasive plants. A committee was established with broad representation including the horticulture industry and a report with recommendations was provided to the legislature.

Conclusion and Next Steps

The horticulture industry does have a stake in preventing the spread and establishment of invasive plants and wants to be a part of the solution. Here are a few considerations to facilitate this process: (1) make certain that horticulture industry representatives are included in discussions and decision making; (2) develop clear definitions and criteria to be used when evaluating plants for invasiveness; (3) interact with the horticulture industry members at their businesses and association meetings; (4) provide new information to help keep the industry informed and educated and be willing to learn from them; and (5) most importantly, ensure that there is ongoing and collaborative communication and decision making.

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The European Code of Conduct on Horticulture and Invasive Alien Plants

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Abstract

Ornamental horticulture has been recognized as the main pathway of recent plant invasions in Europe and worldwide. It is estimated that 80 percent of current invasive alien plants in Europe were introduced as ornamental or agricultural/forestry plants. The European Union foresees a global strategy to tackle biological invasions, also taking into account that so far there is little consistency of approach between countries or regions on the assessment and management of these risks.

The horticulture industry in Europe has brought great benefits, both social and economic, and has made a vast array of plant diversity available to the public. About 17,000 taxa are grown in gardens and new introductions are constantly being sought. There are strong incentives to introduce new plants into horticulture and these are often welcomed by the public, who show a fascination for novelty in this as in other areas.

The Code of Conduct on Horticulture and Invasive Alien Plants was prepared by Vernon Heywood and Sarah Brunel as a joint collaboration of the Council of Europe (CoE) and the European and Mediterranean Plant Protection Organization (EPPO). On the basis of this document, EPPO is developing "Guidelines on the Development of a Code of Conduct on Horticulture and Invasive Alien Plants" that are directed to national plant protection organizations. General guidelines of the Code and first country implementations will be presented and discussed in relation to European mean features of plant invasion processes.

Resumen

La horticultura ornamental ha sido reconocida como la principal vía de las recientes invasiones de plantas en Europa y en todo el mundo. Se estima que el 80 por ciento de las actuales plantas exóticas invasoras en Europa fueron introducidas como plantas ornamentales o forestales/agrícolas. La Unión Europea está previendo una estrategia global para hacer frente a las invasiones biológicas, teniendo también en cuenta que hasta ahora hay poca coherencia de planteamiento entre los países o regiones sobre la evaluación y manejo de estos riesgos.

La industria de la horticultura en Europa ha traído grandes beneficios, tanto sociales como económicos, y ha puesto una amplia gama de diversidad de especies vegetales a disposición del público. Unos 17,000 taxones se cultivan en los jardines y se busca constantemente la introducción de nuevos. Hay fuertes incentivos para introducir nuevas plantas en la horticultura y éstas son a menudo bien acogidas por el público, que muestran una fascinación por la novedad en éste como en otros ámbitos.

El Código de Conducta sobre la Horticultura y Plantas Exóticas Invasoras preparado por Vernon

[1] Presenter.

Heywood y Brunel Sarah como una colaboración conjunta del Consejo de Europa (COE) y la Organización Europea y Mediterránea de Protección de Organización (EPPO). Sobre la base de este documento, la EPPO está desarrollando "Directrices para la Elaboración de un Código de Conducta sobre la Horticultura y Plantas Exóticas Invasoras" que se dirigen a las organizaciones nacionales de protección fitosanitaria. Las pautas generales del Código y de las primeras aplicaciones de un país se presentan y discuten en relación con características del medio europeo de procesos de invasión de la plantas.

Introduction

In Europe, it is estimated that 80 percent of the invasive alien plants are voluntarily introduced for ornamental and agricultural purposes, and international trade is increasing every year (Reichard and White 2001; Dehenen-Schmutz et al. 2007; Hulme 2007). Similarly, the majority of woody invasive plants in the United States were introduced for horticultural purposes (Reichard and White 2001; Niemiera and Von Holle 2009). This major pathway must be addressed urgently to prevent the entry and spread of invasive alien plants as, at present, few legislative or management programs are in place. Voluntary measures to tackle the problem and raise awareness among the horticultural sector and the public should therefore be considered a priority.

Following the example of initiatives in the US and the United Kingdom, the European and Mediterranean Plant Protection Organization (EPPO) and the Council of Europe (CoE) have collaborated in drafting a Code of Conduct on horticulture and invasive alien plants for European and Mediterranean countries (Heywood and Brunel 2009).

The Code of Conduct and its Contents

The EPPO/CoE Code of Conduct is targeted at governments and the horticultural industry and trade—plant importers, commercial nurseries, municipal nurseries, garden centers, and aquarists—and to those who play a role in deciding what species are grown in particular areas, such as landscape architects, municipal parks and gardens departments, and recreation and leisure departments.

Its aim is to enlist the cooperation of the horticultural trade and industry and associated professionals to adopt good practices in: (1) raising awareness on this topic among professionals; (2) preventing the spread of alien invasive species already present in Europe; and (3) preventing the introduction of possible new plant invaders into Europe. An outline version of this code is being developed by EPPO and is directed at national plant protection organizations.

The provisions of the Code cover all the main aspects of introduction, production, and sale of plants and provide information and recommendations on the following points:

- Be aware of which species are invasive in your area;
- Know exactly what you are growing and ensure that material introduced into cultivation is correctly identified;
- Be aware of regulations concerning invasive alien plants;
- Work in cooperation with other stakeholders, both in the trade, conservation, and plant protection sectors;
- Agree on which plant species pose a threat and cease to stock them or make them available;
- Avoid using invasive or potentially invasive alien plants in large-scale public plantings;
- Adopt good labeling practices;
- Make substitutes for invasive plants available;
- Be careful how you get rid of plant waste and dispose of unwanted stock of plants and plant-containing waste;
- Adopt good production practices to avoid unintentional introduction and spread;
- Engage in public relations and outreach activities; and
- Take into account the increased risks of alien plant invasions due to global change.

Launching the Code of Conduct: How to Make it Work?

This new and promising initiative requires promotion and implementation within countries. A workshop was organized by EPPO and the CoE in Oslo, Norway in May 2009 to make this

Code of Conduct known and gather recommendations for further implementation.

This workshop was an opportunity to hear professional views and opinions on the initiative through the International Association of Horticultural Producers and National Plant Protection Organizations. These institutions are aware of the problem and are willing to work together to tackle the issue. At the workshop, it became evident that the Code offers an opportunity for dialogue to build partnerships between the different sectors involved (government, horticultural industry, and so on).

Presentations made during this workshop, along with a list of participants, are available on the EPPO website: http://www.eppo.org. Lessons were learnt on how such a code has been implemented in North America. Initiatives taken in the European and Mediterranean region were also presented (for example, Belgium, France, Italy, the UK, Spain, and Sweden), focusing, for instance, on the selection of alternative native species or on approaches at a local scale with professionals.

These exchanges are summarized in a recommendation on how to draft and implement national codes of conduct on horticulture and invasive alien plants and are addressed to governments and National Plant Protection Organizations, the horticultural sector, and international organizations (also available on the EPPO website).

Sticks and Carrots

A voluntary code can be defined as a non-legislative commitment made by one or more parties operating in more than one state. Designed to influence, control, or benchmark behavior, it is to be applied in a consistent manner or to reach a consistent outcome (Webb 1999). Voluntary codes can be and have been developed and implemented worldwide by industry, government, non-governmental organizations (for example, consumer, environmental, and human rights groups), and standards associations (for example, in the forestry sector). Although such codes are voluntary in the sense that there is no legislative requirement that parties must enter into, this is not to suggest that they have no legal implications or lack effective means of enforcement. In both private lawsuits and government regulatory enforcement actions, courts can and do take voluntary standards into account when deciding whether a particular behavior constitutes due diligence, that is, whether a reasonable standard of care was exercised (Webb 1999).

Of particular interest, the recommendation from the Oslo workshop on the Code of Conduct encourages governments to consider regulation and voluntary approaches as complementary strategies and not self-excluding mechanisms, presenting voluntary measures as a first step that, if not successful, may lead to a regulatory approach.

In fact, when implementing such Codes of Conduct, governments should particularly underline the benefits and establish appropriate incentives for compliance and possible sanctions or penalties for non-compliance aimed to encourage the use of the Code of Conduct by the horticultural industry. Examples of benefits for compliance are: being part of a private certification scheme or a group (trade association); avoidance of new, more restrictive regulation; positive public image for users of Codes of Conduct; and access to information about new products and technologies. In cases of non-compliance, we can expect to see damage to the reputation of non-users, negative publicity for the whole industry, banishment from an association, withdrawal of use of logos, possible fines, and possibility of civil liability by importers for environmental damage ("polluter pays" principle).

Communication and Indispensable Involvement of the Professionals

Communication with the public is regarded as an essential element for the success of the Code of Conduct even if, so far, it has not been taken enough into consideration. Governments should confront the wider public with the issue of invasive alien plants and emphasize people's responsibility when choosing garden species through television programmes, articles, and field demonstrations. In this sense, they should prepare communication materials aimed at the nursery industry and the conservation sector, and provide journalists with suitable information regarding invasive alien plants.

The horticultural sector obviously has a major role to play and, in particular, should:

- Consider withdrawing invasive species

from import, breeding, or sale;
- Influence the supply chain to limit or stop invasive alien plants from entering the market;
- Increase awareness of the sector's responsibility to prevent, release, and proliferate invasive alien plants;
- Use, promote, and disseminate the Code of Conduct, encourage good practices at all levels, and help raise public awareness of invasive alien plants;
- Look for alternative species to invasive alien plants, in particular for landscaping and gardening; and
- Educate staff and influence consumer choices.

The Code of Conduct is available in English and French. A Spanish version has recently been published and other countries, such as the Czech Republic and Italy, are in the process of translating it in their national languages.

Code of Conduct and European Strategy: How and Where is Synergy Possible?

At the very end of 2008, the European Commission (EC) took a major step toward facing the problem of biological invasions. In fact, on 3 December 2008, the EC adopted a Communication presenting policy options for an EU Strategy on Invasive Species. In particular, the Communication examines the evidence regarding the ecological, economic, and social impacts of invasive species in Europe; analyses the effectiveness of the current legal situation for tackling this problem; and describes four possible options for a future EU strategy. In addition, the Commission highlights measures that can be put into place immediately, including a Europe-wide early warning system to report on new and emerging invasive species. As stated in the cited report, voluntary codes of conduct could be drawn up to encourage responsible behavior by retailers, users, and consumers (Kettunen et al. 2008) This option would not require new legislation, as assessment, control, and inspection procedures already exist in member states. However, even with a proactive approach the coverage would not be complete. Considerable legal uncertainty would remain and the level of response to the threat of invasive species would likely vary considerably between member states. A system that is built on voluntary undertakings by member states and voluntary codes of conduct would only be as effective as the weakest link in a chain (Kettunen et al. 2008). Most of the main aims of the Code of Conduct can be seen as complementary to those highlighted both in the European Strategy on Invasive Alien Species (Genovesi and Shine 2003) and in the Global Strategy on Invasive Alien Species (McNeely et al. 2001), such as the requirements for building public awareness and engagement, for strengthening national policy and legal and institutional frameworks and, finally, for prevention.

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A Retail Response to Invasive Plants

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Abstract

This presentation will focus on how a retail garden centre company responded to the issue of invasive plants in their marketplace. It will highlight: (1) how the problem was first identified; and (2) how the company reacted and developed policies and procedures to halt the sale of invasive plants and educate their customers on more suitable alternative plants. The company took this position because it was consistent with their leadership position in the market and previous decisions to stop the sale of cosmetic pesticide products. Company staff and management worked with outside stakeholders to identify the most serious invasive plants and developed internal policies and customer communication materials.

Much of the final outcome came as a result of working with the resources and expertise of the other stakeholders to gain greater awareness in a broader community and to forumlate a solution to the invasive plant problem. The situation is an excellent example of many groups working together to achieve a common goal.

Resumen

Esta presentación se centrará en cómo una empresa jardinería comercial respondió a la problemática de las plantas invasoras en su mercado. Se resalta cómo el problema fue identificado por primera vez, cómo la empresa reaccionó desarrollado políticas y procedimientos para detener la venta de las plantas invasoras y educar a sus clientes en plantas de alternativas más adecuadas.

La compañía ha adoptado esta postura porque era coherente con su posición de liderazgo en el mercado y las decisiones anteriores para detener la venta de productos cosméticos de plaguicidas. Personal de la empresa y de control trabajaron con las partes interesadas externas para identificar las plantas invasoras más importantes y desarrollaron las políticas internas y material de comunicación para el consumidor.

Gran parte del éxito final fue el resultado de trabajar con los recursos y conocimientos de las otras partes interesadas para obtener un mayor conocimiento en una comunidad más amplia del principio de una solución al problema de plantas invasivas. La situación es un excelente ejemplo de muchos grupos trabajando juntos para lograr un objetivo común.

Good morning, buenos dias, bonjour, I am John Zaplatynsky, President and CEO of Canada GardenWorks, a retail garden centre company located in British Columbia, Canada. I am here at the Weeds Across Borders 2010 conference for two reasons: our industry association representative asked me to present on her behalf as it is not her favourite task and I owe her, and secondly, word leaked out that our company was presented with a leadership award by the Invasive Plant Council of British Columbia because of actions we have taken to halt the spread of invasive plants in our area. I am here this morning to share our story with you.

The issue of invasive plants has been with us for some time. Several years ago the issue of purple loosestrife raised public awareness as it was clogging many streams and marshes in British Columbia's Lower Mainland. That was about 10 years ago—and then the issue seemed to go quiet. About five years ago, the issue became more prominent, as people who visited local parks and nature preserves became aware of the problems being caused by English ivy, periwinkle, English laurel, and buddleia. These plants were weakening first and second growth forests and disturbing undergrowth because of their rapid spread on the forest floor. As people began to question these plants, it hit home with us as they were all plants that had been commonly sold in local garden centres, ours included. This started an internal discussion between our owners, management, and staff—how should we respond? I had served on our provincial industry board in the mid–late 1990s and our national industry board until about five years ago, and the invasive plant issue was rarely discussed. My first understanding of the serious nature of the problem came on a garden centre tour to New Zealand six years ago. On an island one can grasp the significance of introduced plants and animals and the problems they can create.

To put the situation into perspective, I will provide you with a brief overview of our company; the environment in which we operate; how we developed our position and practices; as well as the resources and partners we worked with to establish our position.

Canada GardenWorks Ltd. is a 26-year-old garden centre company owned and operated by senior management. We have seven locations in Vancouver, in British Columbia's Lower Mainland, and in Victoria, on Vancouver Island. We employ up to 225 people in peak season and position our company to attract the mid to upper end market. Our target demographic group is homeowners who enjoy gardening and are looking for quality and selection in garden products, sold by people who can provide solid information. We do not view the "big box" stores as our competitors, but see them as introducing younger, more price conscious consumers to gardening. When they want a better experience we hope they come to see us!

Our residents enjoy active, outdoor lifestyles and British Columbia has often been the birthplace of "green" initiatives, much like California in the United States. We have a wonderful climate and temperate weather, enabling people to garden almost 10 months a year.

The past three years have seen an increased awareness of the problem created by invasive plants. A short distance from my home is a wonderful ocean-side park full of second growth 100 foot tall cedars and Douglas firs, where my wife and her friends walk their dogs every weekday morning. She started seeing people gathered in the park conducting organized "ivy pulls"—pulling ivy from the trees so they would not be strangled. Around the same time, customers came into our stores asking why we were selling English ivy as a groundcover and English laurel as a hedging plant. The gardening public was ahead of industry and government on this problem.

We quickly began to realize we had to develop a position on the invasive plant problem. We had several key staff members become engaged with local organizations, the community, industry, and government. All of these stakeholders formed special committees to address the issue. We wanted to understand the issues and to sort out the different views we were hearing. Just like climate change there seemed to be many views. There were also a few umbrella groups formed to bring all these stakeholders together to create a greater awareness and get people working together to solve the problem. Our staff and management were keen to participate and establish solutions as they believed it was consistent with our earlier decision to halt the sale of cosmetic pesticides. We felt that people were looking for us to take a stand.

We looked to many resources to help us understand the problem more fully and determine which invasive plants caused the greatest risk to our environment. There was plenty of conflicting information and we wanted to make sure we were going to be able to best advise our customers on how to deal with the problem and what alternative plants they should consider for their gardens. The groups we counted on most included:

Greater Vancouver Invasive Plant Council A regional umbrella government body representing the dozen or so municipal governments in the Lower Mainland.

British Columbia Landscape and Nursery Association Our industry association of garden centres, landscapers, and growers. This organization has a difficult challenge as many of the member growers export plants all over North America and plants that might be "invasive" in our area are not invasive in other areas.

Evergreen Foundation A Canadian charitable organization dedicated to preserving green spaces in urban areas of our country.

Washington State Noxious Weed Control Board Another source we utilized, located in a very similar West Coast climate zone, they have depended upon research conducted by the University of Western Washington, which is located just across the border from Vancouver, where four of our stores are located.
Invasive Plant Council of British Columbia An umbrella organization of government, industry, and community groups was very helpful.
Master Gardeners A volunteer organization based out of VanDusen Botanical Gardens in Vancouver.

This group provides volunteers that work in garden centres on spring and summer weekends and was invaluable in helping spread the word on actions and alternatives.

To summarize, our objectives were:

- To work with industry, government, and community groups to identify the most serious and common invasive plants;
- To halt the sale of these plants and encourage the use of alternatives; and
- To work with the above organizations to help educate the public about appropriate courses of action.

Figure 1. Example of a sign placed in our store, indicating that we were no longer selling certain plants.

In June 2008, we sent the first letter to our garden centres outlining our position. We knew that we could potentially lose sales (our estimate was in the vicinity of Can$25,000–300,000) unless we could convince our customers that our suggested alternatives possessed similar characteristics without threatening to harm our environment.

The list includes 10 plants we identified as the biggest concern, in the sense that they were invasive and commonly sold in garden centres. There are others that are also very problematic but are seldom, if ever, seen for sale in a retail garden centre. We also know that the list is dynamic and will change as more research is done by the organizations with whom we worked.

The list includes:

- English ivy *(Hedera helix)*
- Dead nettle *(Lamiastrum gaeobdolon)*
- Periwinkle *(Vinca minor)*
- Scot's broom *(Cystisus scoparius)*
- English holly *(Ilex aquifolium)*
- Spurge laurel *(Daphne laureola)*
- Yellow flag iris *(Iris pseudoacorus)*
- Butterfly bush *(Buddleia davidii)*
- Goutweed *(Aegopodium podagraria)*
- English or cherry laurel *(Prunus laurocerasus)*.

Because of staff turnover and new buyers, plus the continuing availability of many of these plants elsewhere, we re-issued our policy again early this year. We still find customers asking about these plants. In fact, while in one of our stores just last week, I spoke to a customer asking for periwinkle. When I indicated that we did not sell it because of its invasive plant status, he said, "Oh well I know where I can buy it somewhere else." The task of educating is neither easy nor short!

We placed signs in our stores, indicating the plants that we were no longer selling and the most suitable replacements (Figure 1). We also listed several websites that customers could visit for further information. Overall, our customers understood and appreciated our position and our staff was very pleased that we had taken this action.

Additional signing recommended other alternatives. As you can see, some of these plants are not on our list as you would never find them for sale in a garden centre in our area. As I said earlier, there was the potential of many lost sales and customer ill will. This did not happen. In fact, the past two years have seen some of the best sales we have ever experienced in perennials and woody ornamentals. I also have with me a few copies of the "Grow Me Instead," a brochure developed by the Invasive Plant Council of British Columbia. It is a very useful reference tool as it shows invasive plants and the problems they cause, then lists and shows photos of at least three alternatives. The nice thing is that for each invasive it shows one or two native plants that are suitable alternatives, so it not only works to help solve the invasive plant problem; it also raises the awareness of native plants at the same time.

Thank you very much for your time and interest. It has been a pleasure to share our story with you. We found it was a wonderful experience to be responsive to a problem and the concerns of our customers and staff. Our business has continued to prosper and I hope our reputation has been enhanced as well. It is nice to know that doing the right thing will bring benefits. Thank you!

Progress in Development of a Modified Australian Weed Risk Assessment System to Predict Weediness of Plant Species Introduced into Canada

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Abstract

The Australian Weed Risk Assessment system is widely used and recommended as a preintroduction screen to predict the risk of introduced plant species becoming invasive or weedy. We have been working to assess the usefulness of this system for Canada, and to adapt it to improve its performance. Our initial evaluation used a "minimally modified" version of the system, with four questions that refer specifically to Australia being replaced with suitable equivalents for Canada. It was tested against 152 plant species with at least a 50-year history of introduction into Canada, which were classified as major weeds, minor weeds or non-weeds on the basis of the opinions of a panel of experts. This version correctly rejected all major weeds and most minor weeds, but also incorrectly rejected many non-weedy species. The high rate of false positives is thought to be partly because of insufficient weight attached to climatic adaptation, which is an important factor limiting the establishment of introduced species in Canada. Further work on the system has focused on developing improved approaches to estimating the suitability of species to the Canadian climate, using hardiness zones and degree-day totals, and on eliminating questions that do not contribute to predictive power. Preliminary results suggest that these modifications may improve the performance of the system for Canada.

Resumen

El Sistema Australiano de Evaluación de Riesgos de Malezas es utilizado o recomendado en muchos países como filtro pre-introducción para predecir el riesgo de que las especies de planta introducidas se conviertan en malezas o invasoras. Evaluamos la utilidad del sistema para Canadá, e hicimos algunas modificaciones para mejorar su actuación en el contexto canadiense. En la etapa inicial del trabajo utilizamos una versión del sistema con un mínimo de modificación, las cuatro preguntas que refieren específicamente a Australia siendo reemplazadas por sus equivalentes adecuadas para el Canadá. Esta versión del sistema fue verificada contra un conjunto de 152 especies introducidas desde hace por lo menos 50 años en Canadá, que fueron clasificadas por un panel de expertos como "malezas importantes," "malezas de menor importancia," o "no malezas." Rechazó correctamente todas las malezas importantes y la mayoría de las de menor importancia, pero también rechazó erróneamente

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muchas de las especies no consideradas como malezas. Esta alta tasa de falsos positivos se atribuye parcialmente a la falta de énfasis sobre la adaptación climática, que es un factor limitante importante para el establecimiento de especies introducidas en el Canadá. Nuestros esfuerzos para adaptar el sistema se han enfocado en una mejor estimación de la adaptación climática, utilizando las zonas de resistencia y los días-grado acumulados, además de la eliminación de las preguntas que no contribuyen al poder predictivo del sistema. Los resultados preliminares indican que estas modificaciones pueden conducir a un sistema más eficaz para uso en el Canadá.

Introduction

As the lead agency responding to invasive plant issues under Canada's National Invasive Alien Species Strategy, the Canadian Food Inspection Agency (CFIA) is responsible for developing strategies for the regulation of invasive alien plants. Risk assessment for new potential invaders is an essential element of this responsibility. The CFIA has been using a risk assessment process based on standards established by the International Plant Protection Convention (FAO 2004; FAO 2007). However, this process is lengthy and time-consuming, and not well suited to the rapid assessment of new introductions or potential invaders, or for screening large numbers of species.

As an alternative that might be more practical for use in these situations, we have been evaluating the potential of an adapted version of the Australian Weed Risk Assessment (AWRA) system (Pheloung et al. 1999). This system uses a set of 49 questions addressing various aspects of a species' biology, biogeography, and impacts. Scores for these questions are combined in a mainly additive way to give an overall score, which is then used to make decisions about accepting or rejecting the species for introduction. The AWRA has been tested in a number of different geographic areas and jurisdictions and has been reported to give consistently reliable results (Gordon et al. 2008a). We tested the system against 152 plant species that had been introduced into Canada at least 50 years previously. These ranged from species that had never naturalized, through naturalized species and minor weeds, to major invaders. The system was used essentially in its original form, except that four questions that refer specifically or by implication to Australian conditions were replaced by equivalent questions for Canada.

In our first evaluation (McClay et al. 2010) we found that the system performed well in identifying weedy species, with all major weeds and 86 percent of minor weeds being rejected. However, there was a high rate of false positives, with 44 percent of non-weedy species being rejected, a much higher rate than found in most previous evaluations of the system for other geographic areas. We also found substantially higher scores across all categories than had been found in most previous evaluations of the system.

This high rate of false positives is problematic for a system that may be used to make decisions on the acceptability of new species proposed for introduction, particularly where there is economic pressure to promote introductions of species as new crops. It will be difficult to justify the exclusion of a proposed new crop using a system that incorrectly rejects almost half of non-weedy species.

Following up on this first evaluation, we have been working to identify reasons for this shortcoming in the system and to develop more accurate versions of the system.

Modifications to the System

In an effort to identify potential sources of error in our evaluation of the system, we looked for possible differences in interpretation of the questions and in the level of evidence required to give "yes" or "no" answers to some of the questions. We reviewed the guidance on answering the AWRA questions provided by Gordon et al. (2010) and identified a few areas in which our practices had differed. In particular, the criteria for question 2.03, "broad climate suitability" were made stricter, and we required more specifically documented evidence for the various modes of dispersal.

We also re-examined the way in which species were assigned to the "major," "minor," and "non-weed" categories. We originally consulted a panel of 14 Canadian experts to assess the weedy or invasive status of each species, following the approach used by Pheloung et al. (1999) and Daehler et al. (2004). However, other authors

Table 1. Questions omitted in the revised version of the Weed Risk Assessment system.

4.01	Produces spines, thorns or burrs
4.04	Unpalatable to grazing animals
4.06	Host for recognised pests and pathogens
4.07	Causes allergies or is otherwise toxic to humans
4.08	Creates a fire hazard in natural ecosystems
4.10	Grows on soil types found in Canada
5.04	Geophyte
6.03	Hybridizes naturally
6.04	Self-compatible or apomictic
6.05	Requires specialist pollinators
6.07	Minimum generative time
7.02	Propagules dispersed intentionally by people
8.03	Well controlled by herbicides
8.04	Tolerates, or benefits from, mutilation or cultivation
8.05	Effective natural enemies present in Canada

with whom we were comparing results had categorized their species in different ways, using published literature and regulated weed lists (for example, Gordon et al. 2008b). We therefore recategorized our species following the alternative approach, to determine whether that had an impact on our results. This recategorization was based on published accounts and rankings such as Holm (1991), White et al. (1993), Catling and Mitrow (2005), the Biology of Canadian Weeds series (see Cavers et al. 2003), and Canadian provincial noxious and regulated weed lists.

We also omitted a number of the questions, based on our findings that many of the questions did not contribute to the predictive power of the system (McClay et al. 2010). Questions omitted are listed in Table 1.

An important potential reason for the high rate of false positives was thought to be the relative lack of emphasis on climate matching in the AWRA system. In comparison with the areas from which invasive plants species are likely to be introduced, most areas of Canada have severe climates with cold winters and short growing seasons. Although climate information is used in some questions, it is still possible to get a score in the "reject" range for species that are not suited to Canadian climates if they have sufficient other undesirable characteristics. In our original evaluation of the system (McClay et al. 2010) we modified question 2.01, "Species suited to Canadian climates" using the USDA hardiness zones (Magarey et al. 2008) in which the species could grow. Species hardy to Zone 6 or below were considered to have a high level of suitability to Canadian climates, those hardy to Zones 7–9 an intermediate level, and those hardy only to Zone 10 or above a low level. We also replaced the original question 2.04 with "Native or naturalized in regions with cold winters." Despite these modifications, we suspected that many false positives were species that were weedy or invasive elsewhere but would not be well adapted to Canadian climates. This is supported by Figure 1, which shows that there are very few false positives among species from Zones 1–3 but that these become increasingly frequent among species from higher hardiness zones.

We therefore made some further modifications to how the system uses climatic information, including how we estimated climatic suitability and how this information was used to generate scores. The basic structure of the Australian system was retained, but we developed a different way of generating answers to question 2.01 (climate suitability). This incorporates both hardiness zones (which reflect the severity of the winter) and growing degree-days (which reflect the time available for plant development during the growing season). We produced a world map of degree-days above 10°C from data provided by Roger Magarey (USDA–APHIS) and divided it into zones of 0–1,000 DD (which includes most

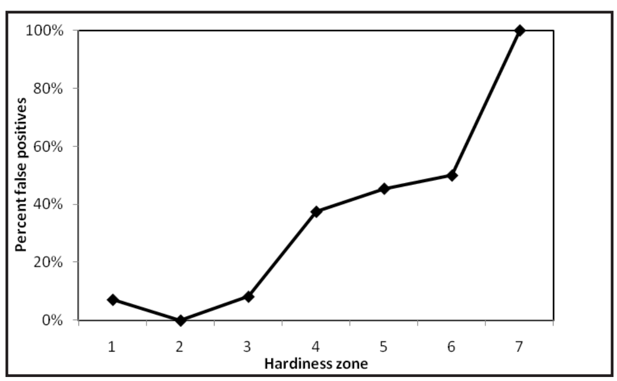

Figure 1. False positives as a percentage of all positives, by hardiness zone. Data from McClay et al. (2010).

Table 2. Revised measure of climatic suitability for use in question 2.01 of the Weed Risk Assessment system for Canada.

	Hardiness Zone (USDA–NAPPFAST)		
Degree Day Zone	**1–3**	**4–6**	**7–9**
1 (0–1,000 DD)	High	Medium	Low
2 (1,000–1,500 DD)	Medium	Medium	Low
3 (>1,500 DD)	Low	Low	Low

of Canada), 1,000–1,500 DD (which includes small parts of Canada) and >1,500 DD (which lies entirely outside Canada). This was then used in conjunction with the hardiness zones to produce a revised measure of climatic suitability, on the same low/medium/high scale as that used in the original AWRA: see Table 2. Thus, for example, a species that is hardy down to zone 2 and can develop in less than 1,000 degree-days above 10°C would get a rating of "high" on the question "Species well adapted to Canadian climates." The hardiness and degree-day requirements are estimated based on the species' known distribution (including the native, exotic, and cultivated ranges).

We also modified the scoring for the "weed elsewhere" questions (3.02 to 3.04). In the Australian system, the scoring of these questions interacts with the "climatic suitability" questions, so that a species that is known to be a weed elsewhere gets a higher score if it is also adapted to the Australian climate. We adjusted this interaction to increase the sensitivity of this component of the score to the climatic match for Canada. For example, in the original Australian system, a species that scores "yes" on question 3.04 ("environmental weed elsewhere") receives one to four points depending on the answers to the "climate match" and "history of introduction" questions; thus, there is only a spread of three points between the worst and best climatically adapted species. In our revised scoring system, this spread widens to six points. Similar adjustments were made to the scoring for the "disturbance weed" and "weed of agriculture" questions.

Features of the revised Weed Risk Assessment system thus included: stricter adherence to the published guidelines for interpretation of questions; a new definition for suitability to Canadian climates; a revised scoring system giving more weight to climate matching for species that are known to be weeds elsewhere; and a reduced question set omitting those questions which had not been found to have predictive value. This system was developed with a training set consisting of half the 152 species originally used in McClay et al. (2010), and then tested against the remaining 76 species.

Results and Discussion

After revising the scores based on a stricter interpretation of the questions, the resulting scores differed very little from the original ones. Thus it did not appear that variations in the interpretation of questions were responsible for the higher scores we found in comparison with most other evaluations of the system, or for our high level of false positives.

In the new categorization of the test species, 40 of our 152 test species changed categories, giving revised totals of 52 "major" weeds, 66 "minor" weeds, and 34 "non-weeds." The changes are summarized in Table 3. Again, this recategorization by itself did not lead to a major change in the proportion of false positives.

With all elements of the revised system in place, the system performed well in separating the three categories of test plants. As can be seen in Table 4, the spread in scores between major weeds and non-weeds was noticeably increased by the new scoring system, suggesting that giving greater weight to climate matching should improve the predictive power of the system for Canada.

Table 3. Revised categorization of the 152 test plant species. Bold numbers show the number of species that remained in their original categories, and the arrows show the directions in which species moved after revision.

	Revised Categories					
Original Categories	Major weed		Minor weed		Not a weed	Totals
Major weed	**41**	→	9			50
Minor weed	11	←	**38**	→	1	50
Not a weed			19	←	**33**	52
Totals	52		66		34	

Table 4. Scores (mean ± standard deviation) for the three categories of test plants under the original and revised scoring systems, and using the revised categorization of major, minor, and non-weeds.

	Not a weed	Minor weed	Major weed
Original scoring system	4.46 ± 6.67	12.59 ± 7.00	18.96 ± 6.50
Revised scoring system	0.23 ± 6.08	9.74 ± 7.20	16.71 ± 6.10

Further work remains to be done with the system, in particular to determine appropriate threshold scores for acceptance and rejection. Future plans include continued cooperation with the USDA–APHIS risk assessment group to explore the possibility of harmonized approaches to Weed Risk Assessment between Canada and the US (Lindgren and Darbyshire 2010).

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Development of a Weed Risk Assessment Model to Assess Plants for their Invasive Potential Before Being Imported into the United States

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Abstract

Due to changing regulatory needs, the United States Department of Agriculture (USDA) needs a more stream-lined method for conducting Weed Risk Assessments (WRA) to prevent the entry of unwanted weeds and invasive plants. Over the past two years, we have been developing a new WRA model that is similar in style to the Australian WRA system, but uses a modified set of questions that are grouped and weighted differently. We tested the performance of this new model and compared it to that of the Australian WRA using the same set of test species, 204 plants whose invasive status in the US is already known. The effect of using different types of risk scores, different methods of determining risk thresholds, and different secondary screening tools was also evaluated. Model performance was evaluated through Receiver Operating Characteristic (ROC) curve analysis and examination of accuracy and error in predictions. We show that the new model performed better than the Australian WRA and had a greater capacity to discriminate between non- and major-invaders. In general, use of probabilities of invasiveness as risk scores and ROC-derived risk thresholds improved model performance. The new USDA WRA model accurately identified 95 percent of the non- and major-invaders and in future work, we intend to incorporate a simulation into the WRA process so that consequences of assessor uncertainty on the final score can be evaluated.

Resumen

Debido a las cambiantes necesidades de reglamentación, el Departamento de Agricultura de los Estados Unidos (USDA) necesita un método más fluido para la realización de evaluaciones de riesgo de malezas (WRA) para impedir la entrada de malezas no deseadas y plantas invasoras. En los últimos dos años, hemos desarrollado un nuevo modelo de WRA que es similar en estilo al sistema australiano WRA, pero utiliza un modificado conjunto de preguntas que se agrupan y ponderan diferente. Pusimos a prueba el rendimiento de este nuevo modelo y lo comparamos con la del australiano WRA utilizando el mismo conjunto de especies de ensayo, 204 plantas invasoras, cuyo estatus en los Estados Unidos ya se conoce. El efecto de usar diferentes tipos de escalas de riesgo, los distintos métodos de determinación de los umbrales de riesgo, y las diferentes herramientas de inspección secundaria también fueron evaluados. Funcionamiento del modelo se evaluó a través de Características Operativas del Receptor (ROC) análisis de curvas y el examen de la exactitud y el error en las predicciones. Se demuestra que el nuevo modelo se desempeño mejor que el australiano WRA y tenía una mayor capacidad

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para discriminar entre las no y las principales invasoras. En general, el uso de las probabilidades de invasividad, como nivel de riesgo y los umbrales de riesgo derivado del ROC mejoró el rendimiento del modelo. El nuevo modelo de evaluación de riesgo de las malezas del USDA identifica con precisión del 95 por ciento las no y las principales invasoras. En futuros trabajos, tenemos la intención de incorporar una simulación en el proceso de manera que WRA de modo que las consecuencias de la incertidumbre del evaluador en el resultado final puedan ser evaluadas.

Introduction

Introduced plants sometimes escape, naturalize, and become known as weeds and invasive plants. It has been estimated that approximately one out of every 1,000 species introduced becomes a weed (Williamson 1996). These species have numerous direct and indirect impacts on agricultural, natural, and urban systems (Holm et al. 1977; Pimentel et al. 2000; Weber 2003). It has been estimated that weeds and invasive plants cost United States citizens billions of dollars (Pimentel et al. 2000) each year. Because more species continue to be introduced every day, both intentionally and unintentionally, it is likely that some of today's plant imports and contaminants will become tomorrow's new weeds. Given the potential impact of a weed and the challenges associated with management, it should not be surprising that preventing these species from entering the country is one of the best management strategies (White and Schwarz 1998; Pimentel et al. 2000).

A Weed Risk Assessment (WRA) is a systematic process by which available evidence is evaluated to estimate the risk of a given plant becoming weedy or invasive (Groves et al. 2001). Although the content, style, and approach of WRAs vary considerably, they all consider similar kinds of information. WRAs that are used to identify potential invaders before they enter a country are sometimes referred to as screening tools. The word "potential" is used here to emphasize the fact that all we can do is predict the potential status of a plant (invader or non-invader). Although most predictions will be accurate with a good model, there will be some incorrect predictions. Incorrect classifications represent either a false-positive or a false-negative. A false-positive is a non-invasive species identified as an invader, whereas a false-negative is an invasive species identified as a non-invader. Weed screening tools should maximize the number of true predictions, that is, the proportion of true negatives and true positives (Metz 1978; Smith et al. 1999).

One of the most popular WRA tools is the Australian system that was developed by Paul Pheloung and others in 1999 (Pheloung et al. 1999). It consists of 49 yes or no questions about plant status, biological properties, undesirable traits, and environmental compatibility. Question scores are summed across all 49 questions. Australia and New Zealand use this WRA as a tool in regulatory decision making. Researchers from a variety of other geographies have tested the suitability of the Australian WRA for their own regions [for example, Hawaii (Daehler and Carino 2000); Czech Republic (Křivánek and Pyŝek 2006); Florida (Gordon et al. 2008b); and Japan (Nishida et al. 2009)]. Daehler et al. (2004) improved the model by incorporating a secondary screening tool to re-examine species classified as "evaluate further" by the model. The nearly dozen tests of the Australian WRA have shown it is better at identifying major-invaders (approximately 90 percent accurate) than non-invaders (approximately 70 percent accurate). Furthermore, while it accepts very few major-invaders (approximately one percent), it leads to the rejection of a significant portion of non-invaders (approximately 20 percent) (Gordon et al. 2008a).

Plant Protection and Quarantine (PPQ) uses its own WRA tool to evaluate weed potential. Our WRA tool uses a less structured, open-ended process to evaluate many of the same factors that the Australian WRA considers (USDA 2004). Unfortunately, our approach to WRA can take considerably longer. Whereas a species can be assessed in about one to two days with the Australian process, it would take between one and several weeks with the current PPQ model (Parker et al. 2007). Given the importance of preventing the entry of new weeds, PPQ needs a more efficient process. This is particularly important given that PPQ is revising the rules and regulations concerning plants for planting (Q-37 revision; APHIS 2009). Once the revision takes place, many plants will need to be assessed before they are allowed entry into the US.

The goal of this study was to develop a new WRA model for PPQ, similar to the Australian WRA. Our specific goal was to develop a model that maximizes prediction accuracy while maintaining a balance in prediction between non-invaders and major-invaders. Because the US is larger and more climatically heterogeneous than any other area where the Australian system has been tested, we trained and validated the model using a diverse set of species. By designing a new WRA process that can be completed in one to two days, we hoped to meet increasing demand arising from the Q-37 revision. The new PPQ WRA process is consistent with our Plant Protection Act authority and international standards on pest risk analysis (NAPPO 2008; IPPC 2009).

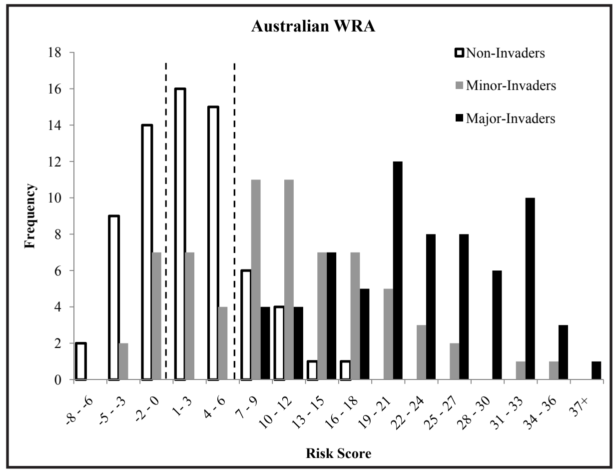

Figure 1. Risk scores from the US test of the Australian Weed Risk Assessment model for all 204 species. Dashed lines show cutoff scores for accept (<1), evaluate further (1–6), and reject (>6) conclusions.

Development of the PPQ WRA Model

Rather than building a new WRA from scratch, we started with the Australian model which has already proven to be accurate, efficient, and simple to use. We sorted the questions into four traditional elements of risk: establishment/spread potential, impact potential, entry potential, and geographic potential. Based on a literature review of other assessment systems (for example, Reichard and Hamilton 1997; Morse et al. 2004; Fox et al. 2005), we added new questions to our model and deleted some which were either difficult to answer or not predictive of invasiveness. For many questions, we used the same scoring as used in the Australian WRA. From the beginning, our intent was to keep risk scores from the four risk elements separate so that risk managers could make decisions based on a species' risk profile, rather than on a single risk score. Furthermore, we did not incorporate geographic potential into either establishment/spread or impact, nor did we combine the risk elements in a multiplicative model (for example, Parker et al. 2007) as we did not want the model to be biased against smaller, more unique geographic areas. This was a particular concern given how diverse the US is. For this study, we did not assess or validate entry potential as we expected most plants to be intentionally introduced, in which case this risk element is unnecessary (ISPM No. 11; IPPC 2009). Thus, for our purposes the predictive power of our model lies with the establishment/spread and impact risk elements.

To develop and test our new model, we identified 204 plants that are known to be major-, minor-, and non-invaders in the US. We used half of these (N=102) to help train the model and the other half to test it. Because we wanted to make sure our new model was just as accurate as the Australian WRA, we assessed all plants using both models and then compared model performance using the same dataset. To ensure risk analysts were assessing questions in the same way, we developed a set of interpretative guidelines for all questions from a set of guidelines developed for the Australian WRA (Gordon 2010, in press). Furthermore, all assessments were reviewed by someone else.

To refine our initial model, we used the training dataset to examine the degree of association between the answers given for each question and the known status of the plant in the US (that is, non-invader, minor-invader, and major-invader). Questions that were very predictive were weighted more in the scoring system. Questions that were not, were weighted less or were eliminated entirely. As with the Australian system (Daehler 2004), we developed a secondary screening tool to look at species classified as evaluate further. These species may represent minor-invaders

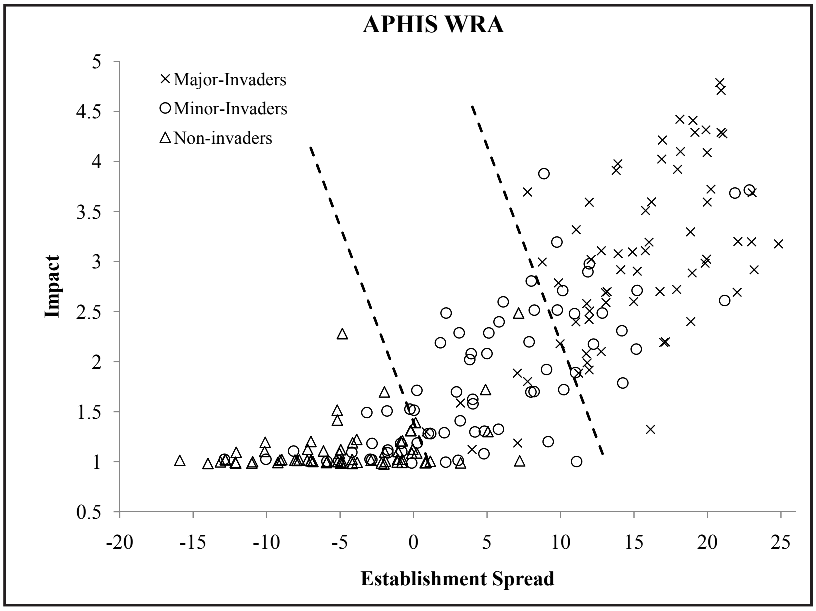

Figure 2. Risk scores from the PPQ Weed Risk Assessment for all 204 species used in this study. Risk scores for both axes were offset by a small random number in order to see overlapping scores. Dashed lines correspond to decision thresholds between regions of low risk (left area), evaluate further (middle area), and high risk (right area).

(species with moderate risk scores) or they may be non- or major-invaders that could not be adequately resolved due to high uncertainty.

Results

The Australian and PPQ WRAs were able to distinguish between non- and major-invaders (Figure 1; Figure 2). As expected, risk scores for non-invaders were the lowest, followed by those of minor-invaders, while scores for major-invaders were the highest. Kruskall-Wallis tests indicated that score means were significantly different ($p<0.0001$) from each other (Aus $x^2=119$; $PPQ_{E/S}$ $x^2=136$; PPQ_{Imp} $x^2=124$). The Australian WRA system uses two cutoff scores to determine policy recommendations for assessed species.

Species with scores less than one are accepted for entry, while those with scores greater than six are prohibited entry (rejected). All others that fall between these two values are placed in the evaluate further category (Pheloung et al. 1999). Because the PPQ model uses two risk elements to identify the invasive/weedy potential of a species, our decision thresholds are represented as cutoff lines on a two-dimensional risk space (Figure 2). Unlike the Australian system, the PPQ system does not make policy recommendations (accept or reject). Instead, it simply categorizes a species as low risk, evaluate further, or high risk.

As a measure of model performance, we examined the accuracy and error associated with the models. Accuracy is the number of individuals correctly identified out of all individuals in that group. In diagnostic tests, accuracy represents the true positive and true negative portion of the determinations (Metz 1978; Smith et al. 1999). Ideally, these values should be as close to one as possible. Major-invader accuracy for both models was high and very similar, with the Australian model doing slightly better than the PPQ model (0.971 vs. 0.941). For non-invader accuracy, however, the values were much more divergent. In this case, the new PPQ model did much better than the Australian system (0.971 vs. 0.794; Table 1). Comparison of results for the US test of the Australian system showed that our results fall within the range of that of other studies and that the Australian system is generally more accurate at identifying major-invaders than non-invaders (Table 1).

Error refers to the number of individuals incorrectly classified (Metz 1978; Smith et al. 1999). Thus, in our case, a false-positive is a non-invader incorrectly classified as reject or high risk, and a false-negative is a major-invader incorrectly classified as accept or low risk. Ideally, these values should be as close to zero as possible. In our study, the new PPQ model did not commit any errors, whereas the Australian model rejected about nine percent of the non-invaders (Table 1). While it may be tempting to claim that the new PPQ model is error-free, it is much more likely that this is just a result of the particular set of species that comprised our test dataset. Examination of our training dataset shows that our model committed one error when a non-invader was classified as high risk. Regardless, comparison of these results to that of other tests of the Australian systems

Table 1. Comparison of model performance among several tests of the Australian WRA and the US test of the Australian and PPQ WRAs (this study). Only tests that incorporated a minor-invader category and a secondary screening are shown. Values shown below do not consider minor-invaders, either as non-invaders or major-invaders. The portions of species categorized as evaluate further are not shown. The "false +" portion represents the number of non-invaders classified as reject/high risk, while the "false -" portion represents the number of major-invaders classified as accept/low risk.

	Accuracy			Error		
Test	Major-Invader (True +)	Non-Invader (True -)	Overall	False +	False -	Overall
US-Aus WRA	0.971	0.794	0.882	0.088	0.000	0.044
US-PPQ WRA	0.941	0.971	0.956	0.000	0.000	0.000
Hawaii & Pacific[1]	0.818	0.848	0.843	0.076	0.045	0.071
Czech Republic[1]	1.000	0.873	0.885	0.019	0.000	0.017
Bonin Islands[1]	0.927	0.622	0.767	0.222	0.024	0.128
Florida[1]	0.919	0.729	0.836	0.083	0.016	0.045
Japan[2]	1.000	0.520	0.838	0.380	0.000	0.128
Canada[3]	1.000	0.481	0.735	0.442	0.000	0.225

[1]Values recalculated from data in Gordon et al. 2008a

[2]Study described in Nishida et al. 2009, but additional data from T. Nishida (personal communication)

[3]McClay et al. 2005

suggests that the new PPQ model does have a lower error rate than the Australian model.

We combined the estimates for accuracy and error to generate an estimate of the overall accuracy and error of the models. From this perspective, it is quite clear that the new PPQ model is performing better than the Australian system (Table 1).

The New PPQ Model

At the heart of the PPQ predictive model are three logistic regression equations that give the probability any given plant is a major-, minor-, and non-invader. For each plant they sum to one. The only variables in the equations are the two for the establishment/spread risk and impact risk scores. These risk scores summarize the biotic potential of the species to be invasive and weedy. These equations were generated by the software package JUMP using data from the 102 species in the training dataset.

In our study, we used ROC curve analysis to help us evaluate where to create the decision thresholds for our three conclusions. ROC curve analysis is a decision-making tool that evaluates the impact of different cutoff scores on the accuracy and error of a test. In our approach, we chose thresholds that balance non- and major-invader accuracy. In the new PPQ WRA process, if the probability of a major-invader is 38.8 percent or greater, then the species being assessed has a high risk of being weedy or invasive. In contrast, if the probability of a non-invader is greater than 44.9 percent, then the species has a low risk of being weedy or invasive. In all other cases, the assessed species has moderate risk scores and is identified as requiring further evaluation.

Species classified as evaluate further by the main model are assessed with a secondary screening tool. In this study, we found that the best predictor of invasiveness is whether the species is invasive elsewhere. This was not surprising given that numerous other researchers have come to the same conclusion (Panetta 1993; Ruesink et al. 1995; Gordon et al. 2008a; Gordon et al. 2008b.) Thus, our secondary screening tool starts with that question. If a species demonstrates it is not invasive elsewhere where it has been introduced, it is classified as low risk. If it is invasive elsewhere, it is classified as high risk. All other cases continue down this decision tree, where we consider other factors that we found associated with invasive plant status in the US. Even after this secondary screening tool, a species may still require further evaluation. These species may either be subjected to a more thorough WRA, where additional information or expert opinion is considered, or they may be subjected to experimental evaluation (for example, greenhouse and field trials) where they may be evaluated with a different set of criteria.

Conclusion

The results of the US test of the Australian WRA are consistent with that of other studies, both in terms of the overall performance of the test but also in that the model favors rejection of major-invaders. The new PPQ WRA model has a higher level of accuracy and lower error rate than the Australian model. While these results may or may not be statistically different, they are certainly biologically meaningful, particularly for non-invaders that are more frequently rejected by the Australian model. With respect to our goal of efficiency, this new WRA process can be completed in one to two days, which is considerably faster than our previous process. Furthermore, the information is summarized on a highly consolidated two-page WRA and the Plant Epidemiology and Risk Analysis Laboratory of PPQ has begun using this new model for WRAs.

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A First Attempt to Eradicate a Quarantined Weed in Mexico: The Example of *Polygonum convolvulus* in Guanajuato

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Abstract

We present a report on the first attempt in Mexico to eradicate a damaging, exotic species, *Polygonum convolvulus*. This quarantined agricultural weed has been registered in several states and is also the most frequently encountered seed contaminant in wheat grain shipped from the United States and Canada to Guanajuato. Its climbing, vine-like characteristics make it particularly damaging to small cereal plants such as wheat and barley. It was registered in Guanajuato in 2007 and in 2008 the state was surveyed systematically. Sixty-eight populations on 4,000 hectares were found. The most intensive eradication efforts were made in the municipalities of Purísima de Covarrubias, Irapuato and Horta, Abasolo. The weed was controlled by hand pulling before flowering by dedicated workers during the 2008 summer/winter season. The initial populations in spring 2008 had a mean of 45.81 plants per square meter, whereas the average population in the beginning of the 2009 season was 1.31 plants per square meter, and the number of populations (either at the beginning or the end of the 2009 summer season) dropped to 11. Shipments from infested areas to the mills were controlled and collaboration between farmers and mills was sought. We describe the methods and difficulties encountered and present a cost-benefit analysis.

Resumen

Presentamos un informe sobre el primer intento en México para erradicar una perjudicial, exótica especie, en este caso una maleza agrícola, *Polygonum convolvulus*. Es una especie en cuarentena en el país, sin embargo, ha sido registrada en varios estados y es también encontrada con más frecuencia contaminando semillas en los envíos de grano de trigo desde los EE.UU. y Canadá a Guanajuato. Debido a su hábito doblarse con el viento, esta planta es especialmente nociva para los cereales pequeños como el trigo y la cebada, que son importantes cultivos de invierno en varias regiones agrícolas. En el estado de Guanajuato, se encontró por primera vez en 2008. En el año siguiente, el estado hizo una encuesta sistemática de la maleza y fue encontrada en 4000 ha. El esfuerzo de erradicación se hizo más intenso en los municipios de Purísima de Covarrubias, Irapuato y Abasolo. Sesenta y ocho poblaciones fueron localizadas en esta región, que fueron controlados a mano antes de la floración por dedicados trabajadores durante el verano y el invierno del 2008. La población inicial en la primavera del 2008 tenia una media de 45.81 plantas por metro cuadrado, mientras que la población media en el comienzo de la temporada del 2009 fue 1.31 por metro cuadrado, y el número de poblaciones (ya sea al comienzo o al final de la temporada de verano 2009) se redujo a 11. Los envíos procedentes de las zonas infestadas a los molinos fueron controlados. Asimismo, se solicitó la colaboración de los agricultores y los molinos. Describimos los métodos y las dificultades encontradas y presentamos un análisis de costo-beneficio.

[1] Presenter.

Introduction

Mexico (still) has less invasive plant problems than the United States and Canada (Espinosa-García et al. 2004); however, both intentional introduction of plants for forage and ornamental purposes, and commerce with unprocessed foodstuffs and seeds have increased heavily. Introductions of new exotic weed species are observed regularly.

Mexico has had legal tools for addressing invasions of quarantined weeds for almost 15 years. Species listed in the applicable norm, NOM-043-FITO-1997 (SAGARPA 2000), have been found repeatedly in the country; however, various non-legal impediments (mainly lack of personnel) have so far limited both documentation and eradication efforts.

Also, no protocols or reaction plans exist yet for quarantined plants. So, managers of eradication efforts have to design their own program, often with limited information.

Here, we report on a major regional effort to eradicate a noxious weed that is still in the initial stages of invasion, but nevertheless already has a relatively large area of infestation. We also show that it is possible to act effectively with the existing legal and organizational infrastructure.

Guanajuato State is important for cereal production in Mexico (Figure 1). Wheat and barley are planted on about 150,000 hectares in the fall/winter cycle and maize and sorghum on 600,000 hectares during the spring/summer cycle. Weeds have been studied on various occasions, but little effort has been expended on the early detection of novel exotic species or potential invasives.

Polygonum convolvulus L. (synonym *Fallopia convolvulus* (L.) Löve) is a major weed affecting crops in temperate climates, and widely distributed in both of Mexico's major trading partners—the US and Europe. It is particularly damaging to small grains, such as wheat and barley. Apart from competing with the crop, it also causes lodging and other losses because of its vine-like characteristics. Its seeds are located high enough to be harvested together with the crop by combines, and are frequently found in grain lots.

During the fall/winter cycle of 2007/2008, seeds of *Polygonum convolvulus* were found in lots of wheat seed sent for inspection from Covarrubias, municipality of Irapuato, and Horta in

Figure 1. A typical landscape of the Bajío, a plain with deep soils and intensive agriculture.

Abasolo, state of Guanajuato. Subsequently, the species was found in fields of these communities and the find was documented officially on 11 January 2008. Interviews with farmers, however, indicated that the species had probably been present for about five years.

An emergency management plan had to be worked out rapidly, as there were no precedents or established mechanisms. Although the NAPPO Pest Fact Sheet (2003) helped, we did not have any local data on the biology, development, adaptation to the area, propagation, temperature, or water requirements of the species.

The objective of management was to eradicate populations of *Polygonum convolvulus* and to impede spread to other areas.

Polygonum convolvulus

Polygonum convolvulus is a climbing, vine-like annual herb from Eurasia, with small white flowers and elongated, heart-shaped leaves (Figure 2). Vegetatively, it can be confused with *Convolvulus arvensis*, another serious weed in cereals. The presence of an ocrea is diagnostic for *Polygonum*.

Being a highly variable temperate and cold climate weed, *Polygonum* is widely distributed in temperate regions of the world, as well as tropical highlands. Most European countries have reported it, and it is known to exist in 29 Asian countries, 10 African countries, as well as Argentina, Brazil, Chile, Peru, Australia, and New Zealand. In North America it is widespread in the US and Canada (NAPPO 2003; this fact sheet is also the source for most of the following general information). Its presence in Mexico is still very limited. Herbarium specimens exist from the Federal District (Mexico City), Coahuila, Tamaulipas, and Guerrero.

The species is a problem weed especially in small cereals, such as wheat, barley, rye, and oats. It may grow in larger cereals such as maize and sorghum. Potatoes, soybean, *Brassica* species, beets, and various vegetables (spinach, asparagus, sunflower, alfalfa, onion, carrot, cotton, peas, and beans), as well as vineyards and gardens may be affected. It is found as a ruderal plant on waysides and vacant lots. Because of its extensive root system, it is relatively resistant to drought and low pH. While it may be found in a wide variety of soils, the highest densities often occur in soils with a high clay component.

Figure 2. Seedlings of various stages; adult plant, inflorescence, and seed of *Polygonum convolvulus* L.

Polygonum can reduce crop yield both by competition and by mechanical means. Infestation densities of 56 or 210 plants per square meter reduce the yield of wheat by 15 or 25 percent, respectively. Wheat seed weight and protein content can be affected negatively.

The seeds of the species do not germinate or emerge simultaneously; rather, they emerge gradually during the crop cycle. This makes it difficult to combat *Polygonum* because some individuals will escape herbicide applications or other control measures, and produce seeds.

The species is an additional host of some other crop pests, such as *Heterodera schachtii*, *Longidorus elongates*, and *Pratylenchus penetrans*.

Declaration of the Presence of a Noxious Weed

For legal purposes, it is sufficient to document the presence of one individual of any quarantined species, in order to declare an infestation. In this case, the infestation was declared on 11 January 2008 by the State Representation of the Ministry of Agriculture, Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación (SAGARPA). It is preferable for this declaration to be emitted by government personnel, as the follow-up requires an exercise of authority. Once the official declaration has been made, control and eradication measures can legally be taken by state governments, state committees for plant protection, and farmers.

Populations of *Polygonum convolvulus* in Guanajuato

Following the declaration, systematic searches were organized immediately. Teams of six trained technicians were sent to the grain-growing regions of 28 municipalities and searched for the species on foot, by car, and by interviewing farmers.

Each time a population was found, the individual field was evaluated, and the population size and distribution were documented (see Figure 3a). A wider search was then made in concentric circles (Figure 3b) in order to find associated populations. We recommend this search to cover about 1,000 hectares in every case. The coordinates of the corners of every positive and negative field

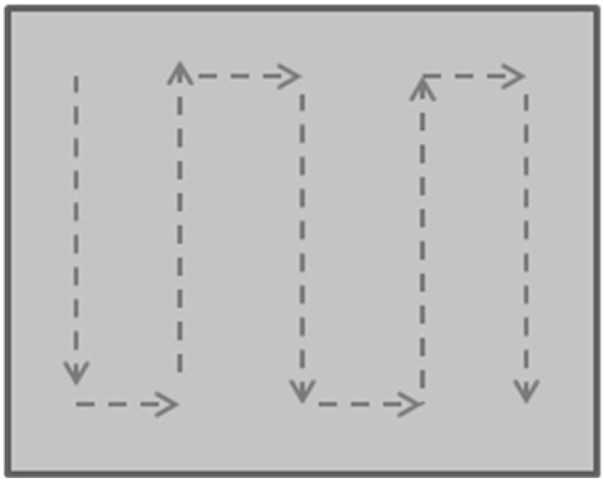

Figure 3a. Search pattern within infested fields.

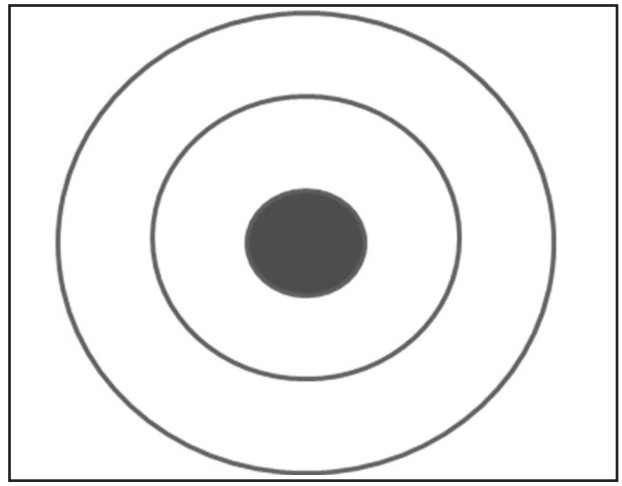

Figure 3b. Search pattern to find associated populations.

during detailed searches were documented and used for GIS analysis and for producing a color-coded map for the follow-up efforts.

In the first effort, 23 populations of *Polygonum convolvulus* were found. Eventually, 68 populations were documented on about 4,000 hectares, in the communities of Irapuato, Abasolo, Celaya, Ocampo, Valle de Santiago, Apaseo el Alto, Cuerámaro, San Luis de la Paz, Guanajuato, Silao, Salvatierra, and Dolores Hidalgo, all in the state of Guanajuato. The populations were generally compact, which helped eradication efforts.

Monitoring

Positive fields were monitored weekly around and within the fields by a dedicated group of five technicians. The results were reported to a coordinator.

Host Crops of *Polygonum convolvulus*

In Guanajuato, *Polygonum convolvulus* was found mainly in wheat and barley, but also in husk tomato (*Physalis philadelphica*), zucchini, strawberry, alfalfa, sorghum, maize, common bean, oat, castor bean (*Ricinus*), broccoli, canola, safflower, garlic, carrots, avocado, peach, pomegranate, sweet potato, and lettuce, as well as in vacant lots and field margins. Any crop can be infested, but the major dispersion risks are associated with small grains and alfalfa because of their harvest mechanisms (threshing in one case, and harvest for hay in the other).

Manual Control

Because of the absence of data on herbicide effectiveness and the variety of crops affected, control was achieved mainly by manual uprooting (Figures 4a and 4b). Both owners and contracted team of laborers did this work; the latter were paid from a dedicated government fund for phytosanitary campaigns to which both the state and the federal government contribute. The pulled plants were dried in plastic bags and then incinerated in metal drums (Figure 4c). This was labor-intensive and not ideal, but was the only possibility for early eradication at the time.

Effects of the Control Measures on Populations

Of the initial 68 populations found, only 10 still had *Polygonum* in the summer of the second year (2009), and only three still had it in the winter (two coincided, for 11 populations in the second year).

Figures 5a and 5b show the average population densities at the beginning and end of the crop cycle in populations of the areas of Purísima de Covarrubias, Irapuato, and Horta, Abasolo, Guanajuato. The maximum population density was 1,500 plants per square meter and the minimum density one plant per field, so there was much variation.

In most fields, eradication efforts were successful and no individuals were found during the second crop cycle. However, the opposite case was also observed: low initial populations mushroomed under disinterested owners.

Figure 4. Manual control of *Polygonum convolvulus*. 4a (top left): Searching the field; 4b (bottom): Eliminating plants; and 4c (top right): Burning the dried residue.

The infestations were much lower during the spring/summer crop cycle, as can be observed in Figure 5. This is due to higher temperatures in summer, and to the higher percentage of row crops, such as maize and sorghum. Cultivation helps to control the seedlings of *Polygonum*; also, these crops can be walked in without damaging the crop, so direct chemical and mechanical control is much easier.

In Guanajuato, many farmers use their own seeds. Certified seed material is also available; the certification is extended by a public institution, the National Service of Seed Inspection and Certification. The seed material is grown in lots that are subject to inspection both in the field and in storage. Lots must be identifiable in order to provide traceability and any fields destined for certified seed must be absolutely free of *Polygonum*. Systematic inspections of seed-growing areas have not shown any *Polygonum* populations—the populations were found exclusively in the areas where crops are grown for industrialization.

Experiments on Chemical Control in the Field

During the fall/winter crop cycle of 2007/2008, two preliminary experiments in highly infested wheat fields (881 plants per square meter) showed that Prosulforon and Fluroxypyr only suppressed the species, but did not kill it after 21 days (dose: 40 grams per hectare and 300 milliliters per hectare respectively, with water at 300 milliliters per hectare).

In the spring/summer cycle of 2008, a larger group of herbicides was examined for their effect on the species. In this trial, populations of P. convolvulus were lower and more dispersed. The following herbicides were tested at 1× (high commercial dose) and 2× (twice the highest commercial dose): ammonium glufosinate; foramsulfuron + iodosulfuron; mesosulfuron + iodosulfuron; 2,4-D amine; paraquat; fluroxypyr; 2,4-D ester; imazethapyr dicamba; metribuzin; glyphosate; fomesafen; and prosulfuron.

The following treatments controlled Polygonum: ammonium glufosinate at 1× and 2×; metribuzin at 2×; dicamba at 2×; and glyphosate at 2×. However, the only herbicide that was used in practice was ammonium glufosinate at 1×, because the others were too toxic for the crops. More research is needed on the optimum application conditions, effect of weed growth stage, and effect on crops.

Populations along field borders and irrigation channels can be controlled with non-specific herbicides such as ammonium glufosinate, paraquat, or paraquat + diuron, in order to avoid spread of seeds. As with manual control, the treatment should be applied before seed set.

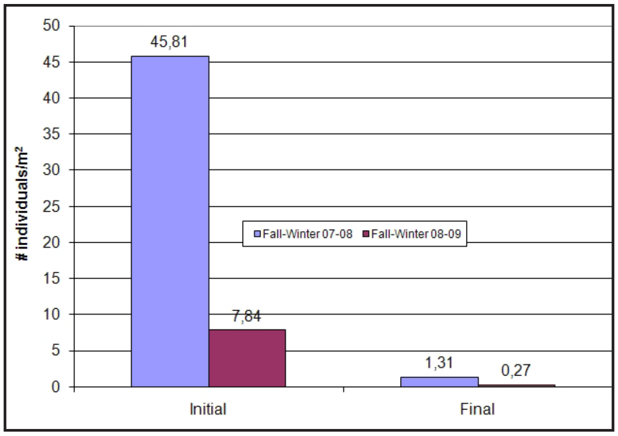

Figure 5a. Average population densities at the beginning and end of the fall/winter crop cycles of 2007/2008 and 2008/2009.

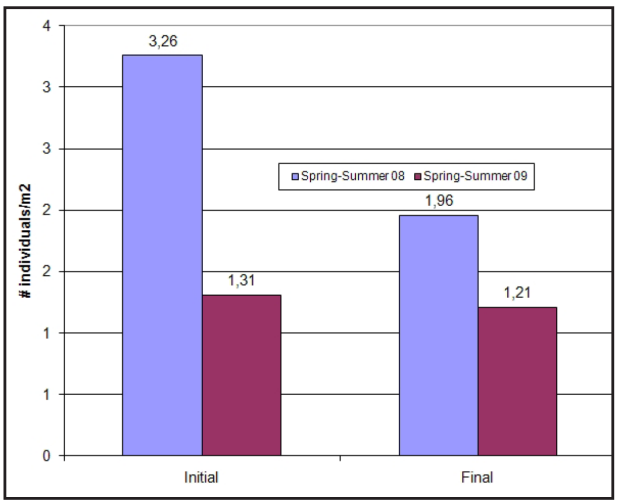

Figure 5b. Average population densities at the beginning and end of the spring/summer crop cycles of 2007/2008 and 2008/2009. Please note the different scale.

Other Control Measures

Polygonum brigades inspected fields with known infestations prior to harvest. Mature plants with seeds were removed by hand and fields with only seedlings were declared fit for harvest. In both cases a document authorizing harvest was extended to the farmer.

Another important prevention measure was the reviews of agricultural machinery, especially threshing machines. In 2008 and 2009, all threshing machines in the infested areas were inspected. Analysis of threshing residue at the installations of the State Plant Protection Committee did not find *Polygonum* seeds in 2008 or 2009.

There are four large storage facilities in the region, both for wheat and for barley. They were contacted and agreed to provide both samples from the quarantined areas and the remnants or impurities for analysis. Seven of 63 samples were positive in the Irapuato region; the storage centers were ordered to send those lots to mills and avoid use as seed. Also, an official notice was sent to farmer's associations in the region, asking them to avoid using grain from infested fields for seed.

Apart from monitoring local infestations and their destinations, we also monitored imports of wheat, barley, and canaryseed, both from other regions of Mexico and from the US and Canada. No quarantined seeds were found in the Mexican samples, but *Polygonum convolulus* was very common in foreign material; other seeds of legal relevance found were *Thlaspi arvense*, *Aegilops cylindrica*, *Vaccaria hispanica*, *Galeopsis tetrahit*, *Lithospermum arvense*, *Agrostemma githago*, and *Silene noctiflora*.

To raise awareness in the affected communities, meetings were organized early in the process to show the plant and its characteristics, and inform individuals of its importance, biology, and control measures. In later meetings we explained the measures taken and the situation in the region. Farmers were again invited to participate in the efforts, and were handed a printed chart with photos of the plant and additional information.

Owners of infested fields were issued official notices and personally invited to participate in the eradication measures. Owner collaboration was excellent, nearly 90 percent to 95 percent; however, the remaining 5 percent to 10 percent of disinterested owners are the source of new infestations, an effect observed anecdotally, and thus increased the cost of eradication measures. Though it is legally possible to oblige owners to combat quarantined weeds, this is very labor-intensive and expensive, so it was not tried.

Costs and Benefits

Costs of the eradication measures of *Polygonum convolvulus* in Guanuajuato were somewhat over 3,300,000 pesos (approximately US$300,000). Most of the cost went to pay the eradication teams. In Irapuato, about 1,000,000 pesos (US$90,000) were spent.

The measures protected a wheat and barley production area of about 150,000 hectares and additional areas with other crops. The focus was on wheat and barley because of the damage caused in these crops, and because of the dispersion danger.

If the whole area was infested, and assuming additional costs for combat or reduced yield [at a low of 800 pesos (US$60) per hectare, this would result in a damage of 120 million pesos (US$10 million) per year]. So, while the program costs of four million pesos for Guanajuato and Irapuato may seem high for a developing country, the cost-benefit ratio is minimally 1–30 (that is, one peso spent on early eradication saves 30 pesos in later costs), and could be substantially higher if additional costs were incurred. Even a simple postponement of infestation for several years would be worthwhile in economic terms.

Conclusion

We show that a quarantined weed can be managed with the current legislation and infrastructure in Mexico. *Polygonum* is susceptible to some herbicides, but no general recommendations are possible due to the variety of crops that may host it. It is particularly important to focus on avoiding the production and dispersal of seeds. Despite considerable outlay, this campaign had an excellent cost-benefit ratio, even under very conservative assumptions.

However, coordination of government, intermediaries, and farmers over a several-year period of time is essential. This is not possible in many areas. The often under-staffed and under-funded personnel of the phytosanitary agencies may focus on more immediate threats by pests and diseases; accessible intermediaries may be lacking; and farmers may not be organized or interested. Also, available funding may vary considerably from year to year. The interplay of these factors can be observed in various sites outside of Guanajuato where *Polygonum* has been found.

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Anthropogenic Dispersal Corridors Override Large-scale Natural Disturbance in Determining Distribution of a Widespread Invasive Grass (*Imperata cylindrica*)

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Abstract

Disturbance, especially that caused by human activities, has been demonstrated repeatedly as a significant correlate of invasion. This study aimed to quantify the relative contribution of natural versus anthropogenic disturbance on invasion by an economically and ecologically significant invasive grass, *Imperata cylindrica* (L.) Beauv. (cogongrass). Anthropogenic and natural disturbance, along with land cover and soil characteristics, were considered as covariates of cogongrass distribution by examining remotely sensed pre- and post-Hurricane Katrina forest cover data (forest cover change between years 2004 and 2006), in conjunction with disturbance data collected during field surveys. Results indicated that anthropogenic disturbance, particularly that associated with road maintenance or timber harvesting, was the most important predictor of cogongrass infestations. These findings reinforce the hypothesis that anthropogenic disturbance differs qualitatively from natural disturbance, and they indicate particular forms of human disturbance that appear to facilitate spread of this exotic grass within the southeastern United States. Consequently, successful control of cogongrass and similar invaders will entail managing dispersal corridors for eradication, concomitant with maintenance of appropriate ecological buffers to reduce further spread of established populations and proper sanitation of equipment used for forestry practices and right-of-way management.

Resumen

Perturbación, especialmente las causadas por las actividades humanas, se han demostrado en repetidas ocasiones como una significante correlacion con la invasión. Este estudio tuvo como objetivo cuantificar la contribución relativa de las perturbaciones naturales versus antropogénicas en la invasión de un económico y ecológicamente importante pasto invasivo, *Imperata cylindrica* (L.) Beauv. (cogongrass). Perturbaciones antropogénicas y naturales, junto con los conjuntos de plantas y las características del suelo, se consideraron como covariantes de distribución de cogongrass mediante el examen de datos de sensores remotos de la covertura de los bosques antes y después del huracán Katrina, (el cambio de la covertura forestal entre los años 2004–2006), en relación con los datos de la perturbación recolectados durante los estudios de campo. Los resultados indican que las perturbaciones antropogénicas, en particular las relacionadas con el mantenimiento de carreteras o la extracción de madera, fue el predictor más importante de las infestaciones de cogongrass. Estos hallazgos refuerzan la hipótesis de que las perturbaciones antropogénicas difieren cualitativamente de perturbación natural, y ellas indican las formas particulares de perturbación humana que parecen facilitar la propagación de este pasto exótico en el sureste de Estados Unidos. En consecuencia, el control exitoso de cogongrass y de los invasores similares supondrá el manejo de corredores de dispersión para la erradicación concomitante con el mantenimiento de reguladores ecológicos adecuados para reducir la propagación de las poblaciones establecidas.

[1] Presenter.

Introduction

Imperata cylindrica (L.) Beauv., known commonly as cogongrass, is a highly invasive C_4 perennial grass species introduced into the United States in the early 20th century (Tabor 1952). This species presently infests more than one million acres (0.4 million hectares) in the southern US, from eastern Texas to South Carolina, with the heaviest infestations in Florida and along the Gulf Coastal Plain in Mississippi and Alabama (MacDonald 2004; Lowenstein and Miller 2007). Cogongrass has been associated with degradation of native ecosystem diversity and alteration of ecological processes, especially in fire-dependent communities (Lippincott 2000). Cogongrass is also problematic in agricultural systems, causing lower crop yields and higher control costs (Terry et al. 1997; Akobundu and Ekeleme 2000).

Cogongrass produces abundant rhizomes that may comprise almost 100 percent of below-ground biomass (Tominaga 1993; Holly and Ervin 2006; MacDonald 2004) and that serve as highly effective vegetative propagules (Tominaga 2003). Rhizomes are documented to be an agent in human-assisted dispersal of cogongrass, particularly in association with activities that cause soil disturbance, such as plowing of fire breaks during forest management, cultivation of row crops, and road right-of-way management (Tabor 1952; Loewenstein and Miller 2007; and references therein). In addition to vegetative spread, cogongrass also has a high capacity for natural or human-assisted spread by seed; one plant may produce 3,000 or more wind-dispersed seeds (MacDonald 2004, 2007), and seeds can have greater than 95 percent viability during the first three months after production (Schilling et al. 1997; Holly and Ervin 2007).

As is the case with many invasive species, cogongrass is well adapted to human disturbance (MacDonald 2004), and is frequently observed to establish in open habitats, such as recently harvested forests, roadsides and power lines, and other rights-of-way (Faircloth 2007). Established stands are prone to fire, and those fires may burn considerably hotter than fires fueled by native plant species, owing to accumulation of large amounts of above-ground biomass (MacDonald 2007). Despite its tendency to occur in open, disturbed habitats, cogongrass also seems tolerant of shaded conditions (Faircloth 2007; MacDonald 2007) and demonstrates plasticity in allocating shoot-to-root biomass in response to light availability (Holly and Ervin 2007).

Although invasion ecology frequently focuses on anthropogenic disturbance as an agent facilitating the spread of invasive species, especially plants, natural forces are capable of creating habitat conditions identical to those of human-disturbed areas. For example, after Hurricane Fran struck North Carolina in 1996, Boutet and Weishampel (2003) found reduced height and increased spatial variability in forest canopies. In another case, light availability was increased three-fold in hurricane-damaged plots, and light variability doubled in undisturbed forests (Carlton and Bazzaz 1998). Such increases in resource and microhabitat variability can enhance the ability of colonizing species, such as invasive plants, to establish in disturbed areas. Storm disturbance of forests also can provide new pathways for

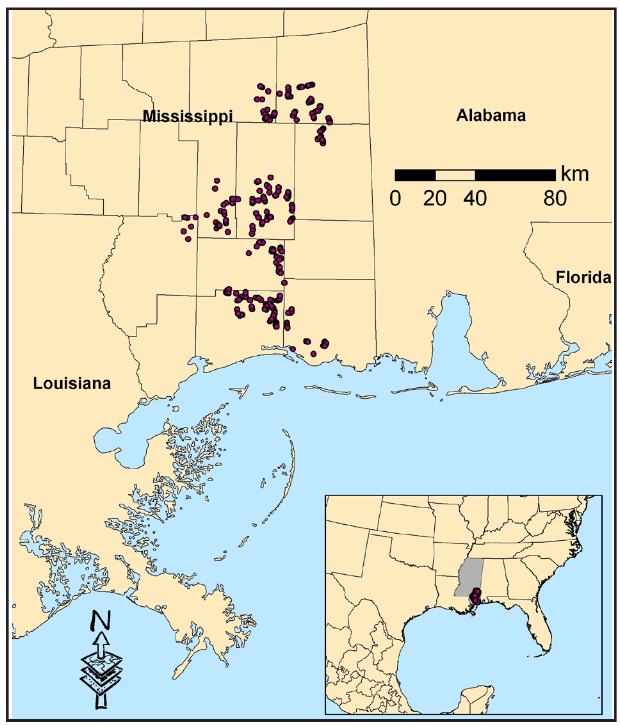

Figure 1. The location of the study area in DeSoto National Forest in southeastern Mississippi. The locator map in the lower right depicts the general location of the study area, at the continental scale. Political boundaries within Mississippi in the larger map represent counties.

dispersal. This effect would be greatest when the timing of damage corresponds with natural seed or fruit dispersal. For example, Yager et al. (2005) showed that wind can disperse spikelets of cogongrass considerably farther through relatively open, savanna-like habitats than through pine forests with a dense shrub understory.

Southern Mississippi, as well as other US states along the northern Gulf of Mexico, was subject to severe, large-scale, natural disturbance during the autumn of 2005, with the passing of Hurricanes Katrina and Rita. Since that time, there have been numerous anecdotal reports of increased frequency of certain invasive plant species. The present study uses cogongrass presence and absence data from within the DeSoto National Forest in southern Mississippi to evaluate the relative importance of forest loss between 2004 and 2006 on cogongrass distribution, in comparison with human land use and associated forms of anthropogenic disturbance. While not all forest loss during that period was caused by Hurricanes Katrina and Rita, the magnitude of those storms was expected to provide an estimate of the effects of large-scale natural disturbance on the distribution cogongrass in the region.

Methods

Study area

DeSoto National Forest is situated in the Lower Gulf Coastal Plain physiographic region of the United States and is the largest national forest in Mississippi (153,189 hectares; Figure 1). The southernmost areas of this forest are within 50 kilometers of one of the original sites of cogongrass introduction to North America, providing an ideal location to receive heavy and prolonged exposure to invasion by cogongrass.

Cogongrass data collection

Cogongrass presence and absence data were collected from September–November 2007 and January–February 2008. The road survey methodology may be considered a systematic and stratified design—systematic in that a 9.2 × 8.0 kilometer grid system (74 square kilometers, as set up in the Mississippi Atlas & Gazetteer©, Delorme Inc., Yarmouth, ME) was used to distribute sampling intensity across the entirety of DeSoto National Forest. The survey was stratified in that a series of 3-kilometer road survey transects in each of five road categories (gravel roads, paved county roads, state highways, US highways, and federal interstate highways) were targeted in each 74 square kilometer grid. The sampling design does not represent a selection of true "random" points across DeSoto National Forest, but is much more targeted to surveying in proximity to various road types across the region of interest. This type of sampling design was chosen after a previous sampling season in which strictly random points were surveyed across the region, where the infrequency with which cogongrass was detected warranted a more targeted sampling

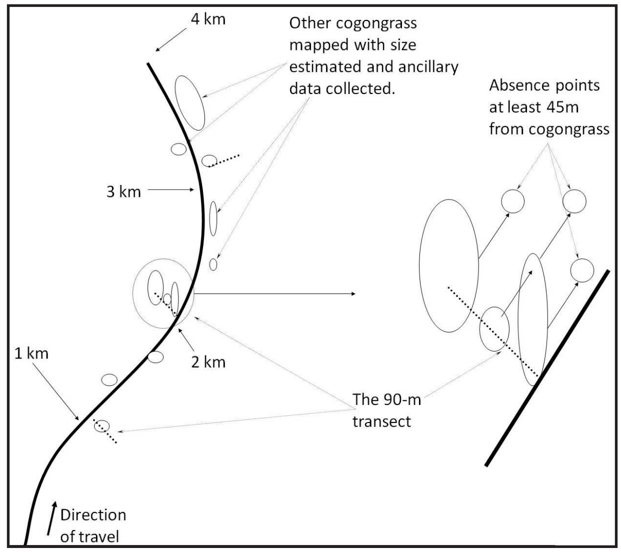

Figure 2. Illustration of field survey methodology. Each 3 kilometer road survey route was divided into three 1-kilometer subsections, and one 90-meter transect was established at the first *Imperata cylindrica* (cogongrass) patch encountered in each subsection. The largest patches in each of three distances (0–30 meters; 30–60 meters; and 60–90 meters) along the 90-meter transect were recorded, and absence points were obtained by walking 45 meters parallel with the road from each recorded patch along the perpendicular transect. All subsequent patches encountered were recorded, but no additional transect was created for these patches. There were three transects per 3-kilometer stretch of road, for each of up to five road types, in each grid cell of the road atlases used for the surveys.

scheme (Ervin et al., unpublished data).

In each road category, within each 74 square kilometer map grid across DeSoto National Forest, one 3-kilometer road segment (subdivided into three 1-kilometer sections) was surveyed according to the following methodology, with up to 15 kilometers of road sampling per grid (Figure 2):

1. Within a map grid cell, the first section of road in each category given the most logical route of travel to that grid cell was determined and survey started.
2. At the first cogongrass patch in each 1-kilometer section of the 3-kilometer transect, a 90-meter sampling transect, divided into three 30-meter sub-sections, was established perpendicular to the road.
3. Along each transect, the largest patch of cogongrass within each 30-meter subsection of the 90-meter transect (0–30 meters; 30–60 meters; 60–90 meters) was recorded along with associated environmental variables. Up to three cogongrass patches per 90-meter transect could therefore be recorded and a total of three 90-meter transects were possible on each 3-kilometer road segment (one per each 1-kilometer sub-section of each 3-kilometer survey). Data for each patch included: spatial position [global positioning system (GPS)] coordinates (UTM, WGS 1984, Zone 16N), patch area, disturbance regime present, and resident forest community.
4. After each cogongrass patch was recorded, a 45-meter transect parallel to the road was walked in an effort to record an absence point in the general vicinity of the cogongrass occurrence. A distance of 45 meters was chosen here to ensure the data point would represent a separate grid cell in the 30-meter grain geographic information system (GIS) data being used (Table 1).
5. If no cogongrass was encountered on a given 3 kilometer stretch of road, a single absence point was recorded at the termination of the 3-kilometer road segment.
6. Between the 90-meter transects, but along the 3-kilometer section of road, all cogongrass patches and associated ancillary data were recorded. However, if patches were within 30 meters of each other, only the largest patch was recorded.

Influencing variables

We used four categories of data in these analyses: (1) local-scale human disturbance and potential dispersal corridors; (2) forest change between 2004 and 2006; (3) broader-scale land cover/use; and (4) abiotic environmental variables (Table 1). The first two of these categories represent the two competing influencing hypotheses on which this paper is focused. The latter two represent "null" hypotheses of sorts, in that landscape context or local environment could have a greater influence on distribution of cogongrass than either human or natural disturbance processes.

Disturbance type included five categories of local disturbance: fire, mowing, storm, soil, and none (storm disturbance was recorded here as a direct observation of recent natural disturbance at each site). These data were obtained during field surveys described above. Proximity to road data were based on the specific distance categories included in the surveys: 0–30 meters; 30–60 meters; and 60–90 meters from the roadside. These

Table 1. Potential predictor variables used in these analyses, by category.

Human Disturbance & Dispersal †	Forest Change †	Land Cover - Land Use	Abiotic Environment
Disturbance Type	GIS forest change between 2004 & 2006	Land cover observations	Soil organic matter
Disturbance Intensity		GIS land cover data	Soil sand
Proximity to Road			Soil silt
Road Type			Soil clay
			Soil pH
			Canopy cover (light)

† Represents the two major competing hypotheses for this paper.

categories were used, rather than actual measured distance, in an effort to match our spatial resolution with that of available GIS data layers.

Forest change data were obtained through a GIS system in which the surveyed points were overlaid upon a rasterized map layer that included categories of historically non-forest, forest, and loss of forest between 2004 and 2006 (data provided by the Mississippi Institute for Forest Inventory; http://www.mifi.ms.gov). The time period for these data included forest cover one year before and one year after Hurricanes Katrina and Rita struck the northern Gulf of Mexico Coast (Autumn 2005).

Broad-scale land cover data included 12 categories from the National Land Cover Database 2001 [NLCD 2001; Multi-Resolution Land Characteristics (MRLC) Consortium Database at http://www.mrlc.gov]. Those GIS data were accompanied by on-site observations of land cover during our field surveys, including general land cover (categories of developed, mixed forest, or evergreen at our survey points) and specific categorization of land use (categories of fallow, forest, grazed, industrial, managed, natural, residential, riparian, or rights-of-way at our survey points).

Soil data were extracted from the US Department of Agriculture (USDA) Natural Resources Conservation Service–Soil Survey Geographic Database (http://soils.usda.gov/survey/geography/ssurgo). Canopy cover data were obtained from the MRLC Consortium as 30-meter resolution tree canopy density data.

Statistical modeling

Binary logistic regression was used to model the predicted habitat of cogongrass because this form of statistical analysis is particularly well suited for discrete binary response variables and is able to adequately handle multiple continuous and categorical independent variables. Logistic regression analysis also has the added benefit of using Maximum Likelihood methods in the derivation of model parameter estimates and thus is not bound to any particular type of distributional assumption. Logistic regression models were created using forward stepwise likelihood ratio modeling in PASW version 17.0 (SPSS Inc., Chicago, Illinois).

The survey data were analyzed in two series. The first series consisted of all data collected: perpendicular transects as well as points along roads between transects. The second series used only the transect data, in order to better balance not only presence versus absence data, but also data at different distances from the roadside. In each series, the total set of data points was randomly split in half in order to use one half for developing statistical models, leaving the second half for model validation. The models were developed in a forward stepwise manner, with potential incorporation of all influencing variables mentioned above; an alpha of 0.05 was used at each step for addition of variables to the models.

The survey methodology resulted in there being no absence points within 30 meters of roadsides in a strict transect-only dataset. This caused failed convergence in the initial modeling attempts. To solve this problem, caused by quasi-complete separation in the data (that is, the near-road data category consisted only of presence points; see Allison 2008), we added the near-road absence points from the all-data data set into the transect data set.

Models were assessed with a variety of metrics, including Nagelkerke R^2 (an indication of model fit to the data), Receiver Operating Characteristic (ROC) curves, presence and absence prediction accuracy, sensitivity and specificity, and Cohen's kappa (Fielding and Bell 1997; Manel et al. 2001). The area under the curve (AUC) for ROC curves approximates the probability that a given model will rank a randomly chosen positive occurrence higher than a randomly chosen negative occurrence (which is the desired outcome). This metric, in addition to visual inspection of the curves, was used in conjunction with the other metrics to compare models generated for the two competing hypotheses and to evaluate the relative merits of the models.

General patterns in the data were assessed via Chi-squared analyses of observed field data, in comparison with expectation of a 50 percent change of observing cogongrass at a sample point within each category of disturbance, each distance-from-road class, and each category in the forest change data.

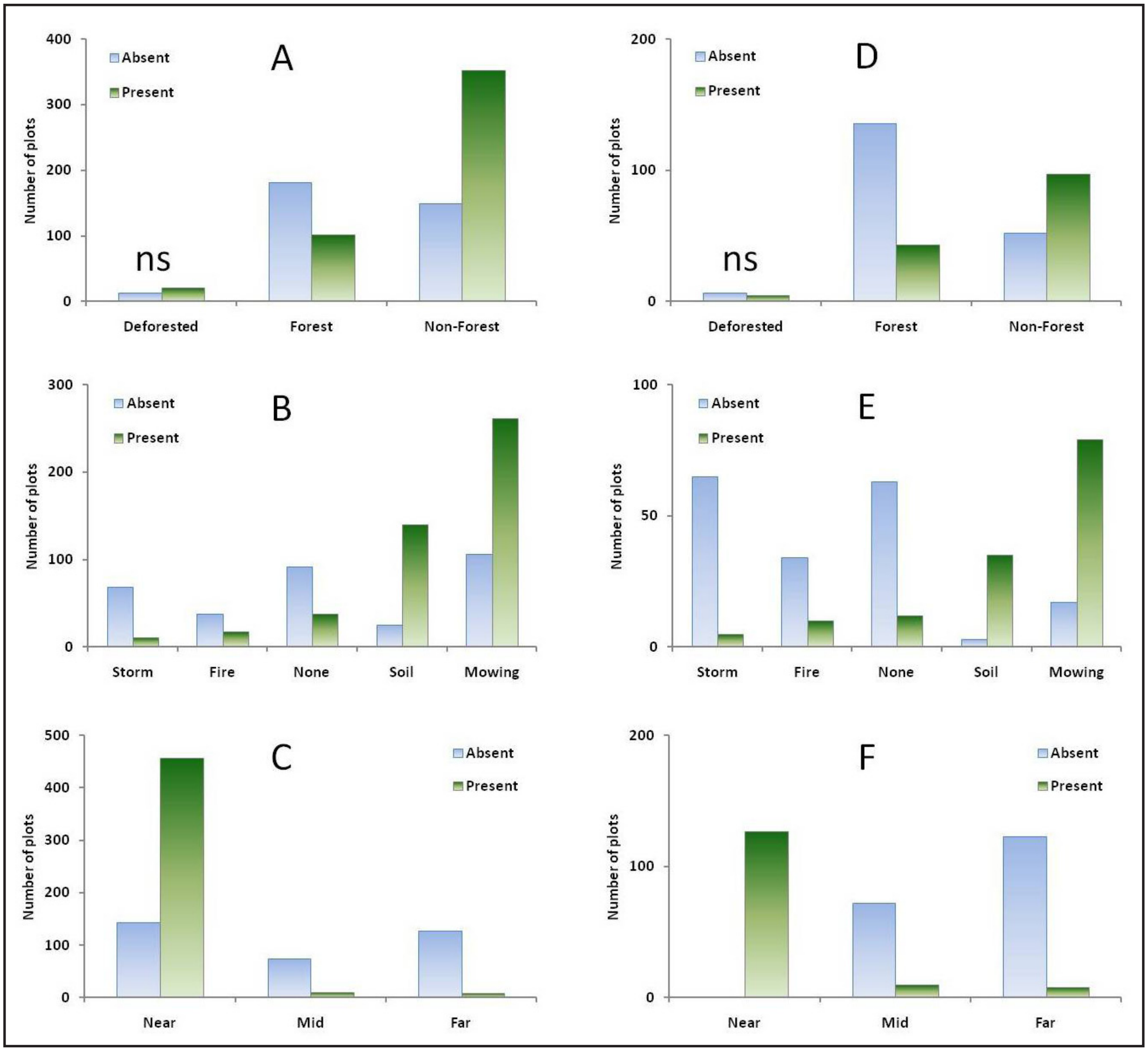

Figure 3. The effects of forest change (A, D), disturbance type (B, E), and proximity to road (C, F) on occurrence of cogongrass. Panels A–C represent all survey data, whereas panels D–F represent transect data only. Chi-squared tests were used to determine whether data differed from patterns expected with a 50 percent chance of cogongrass occurring at a point in each category represented by the bars. The two non-significant results are indicated by "ns;" green bars indicate number of plots with cogongrass, and blue are absences.

Results and Discussion

Disturbance type and proximity to road were significantly related to the presence of cogongrass in our field surveys, based on Chi-squared analyses (for all analyses with significant differences, $P < 0.001$; Figure 3). The only pairs of presence-absence comparisons that did not yield a pattern significantly different from expected were those for the 35 plots categorized as having lost forest cover between 2004 and 2006. In both the all-data and transect data comparisons, forest loss during this time period appeared to have no effect on the likelihood of encountering cogongrass (Figure 3: A, D). The other comparison related to natural disturbance effects on cogongrass distribution was that among plots categorized in the field as having received storm-related disturbance (80 plots; Figure 3: B, E). In these comparisons, however, it appeared that sites with obvious storm disturbance were less likely to be infested

Table 2. Anthropogenic disturbance factors associated with cogongrass distribution.

Factor	Level	Coefficient	P-value	Odds Ratio
All-Data Model				
Disturbance Intensity			<0.001	
	Low	0.64	0.19	1.90
	Medium	1.05	0.02	2.86
	High	2.44	<0.001	11.42
	None	0.00		1.00
Proximity to Road				
	Near (0–30 m)	4.23	<0.001	68.77
	Mid (30–60 m)	1.05	0.19	2.86
	Far (60–90 m)	0.00		1.00
Road Type				
	Gravel	3.66	<0.001	39.05
	County	2.73	<0.001	15.38
	State	2.27	0.004	9.73
	Interstate	3.06	0.005	21.35
	US Highway	0.00		1.00
Constant		-7.36	<0.001	0.00
Transect Data Model				
Factor	**Level**	**Coefficient**	**P-value**	**Odds Ratio**
Disturbance Type			0.005	
	Soil	2.12	<0.001	8.36
	Fire	1.01	0.15	2.75
	Mowing	0.92	0.07	2.52
	Storm	-1.15	0.31	0.32
	None	0.00		1.00
Proximity to Road			0.004	
	Far (60–90 m)	-1.87	0.001	0.15
	Mid (30–60 m)	-0.82	0.16	0.44
	Near (0–30 m)	0.00		1.00
Constant		-1.16	0.01	0.31

with cogongrass at the time of the surveys. This may be because of the lower likelihood of encountering cogongrass in forested sites (Figure 3: A, D). Field observations of storm damage were much more obvious in forested areas, where tree damage was apparent. Regarding the effects of anthropogenic disturbance on cogongrass distribution, there were clear correlations between cogongrass presence and proximity to road (Figure 3: C, F) as well as soil disturbance and mowing (Figure 3: B, E).

Similarly to the patterns described above, logistic regression models indicated the most important variables influencing cogongrass distribution were those associated with human disturbance (disturbance type, disturbance intensity, road type, and proximity to road; Table 2). Proximity to road significantly influenced cogongrass presence/detection in both models (the all-data model and the transect data only model), with plots nearest the roadside being substantially more likely to contain cogongrass. In the all-data model, near plots were almost seventy times more likely than far plots (centered at 75 meters from the roadside) to have cogongrass present but only about three times more likely than plots centered 45 meters from the roadside (see odds ratios in Table 2). The model built with transect data only was considerably weaker than that developed from all data (Table 3). The transect data model had a poor fit to the data (R^2 of 0.32), was very poor at predicting cogongrass presence, and exhibited a low kappa value (an assessment metric that integrates several other assessment criteria). In contrast, the all-data model performed fairly well across all metrics, and most levels of the significant factors also had high statistical significance (Table 2).

For transects, near-road plots were approximately seven times more likely than far plots to have cogongrass present and about twice as likely as mid plots. Among road types, in the all-data model, plots along gravel roads were almost forty times more likely than US highways (typically four-lane, high-traffic-volume, paved roadways) to be infested with cogongrass, with paved county roads and interstate highways being next most likely to be invaded.

Gravel roads and paved county roads typically are most likely to be impacted by some of the land management activities that seem most likely to spread cogongrass. These include forest management (harvest, thinning, plowing of fire breaks), road grading (use of large tractors to smooth the gravel surfaces), and cutting of water diversions off the roadside into drainage ditches. These activities are discussed more below. Interstate highways

Table 3. Model assessment metrics.

	Nagelkerke R^2	Area Under ROC Curve	Presence Prediction	Absence Prediction	Sensitivity	Specificity	Cohen's Kappa
All data models							
Model	0.56	0.89	0.95	0.68	0.81	0.91	0.65
Validation	n/a	0.84	0.93	0.57	0.76	0.84	0.52
Transect data models							
Model	0.32	0.79	0.27	0.95	0.70	0.75	0.27
Validation	n/a	0.76	0.20	0.91	0.50	0.72	0.14

seem to receive considerable maintenance in the way of mowing, but little activity that directly disturbs the soil. Thus, it is likely that their high rate of invasion may be the result of spread of seeds by tractors and/or maintenance of disturbed plant assemblages and high light availability.

As might be expected regarding local-scale human disturbance, high-intensity disturbance was very important in the all-data model (Table 2). In the model derived from transect data only, disturbance type was very important, and within that, soil disturbance yielded an eight-fold higher likelihood of cogongrass presence, versus plots in areas with no disturbance at all. Fire, mowing, and storm-caused disturbances all were non-significant forms of disturbance in that model.

One interesting aspect here is the frequency with which soil disturbance and cogongrass were observed to co-occur along roadsides (integrating a number of the influential variables identified in these analyses). As mentioned previously, along gravel roads, one frequently finds evidence of road grading and water diversion ditches, both of which represent a severe disturbance to the soil along roadsides. These activities influence cogongrass distribution in at least two ways. First, these activities create disturbed microsites favorable for colonization by ruderal species. Second, the machinery used to conduct these activities is rarely cleaned after passing through a patch of cogongrass (or other invasive plant species). This lack of sanitation serves to remove vegetative propagules, such as rhizome fragments, from one area and transport them to another area, the second of which serves as a suitable colonization site, owing to the disturbance mentioned above.

Results thus support several common assertions made by land managers and researchers working with cogongrass (Faircloth 2007; Lowenstein and Miller 2007). First, cogongrass is often found in areas of high human-mediated disturbance as illustrated by the high frequency of occurrence in mowed locations and areas that had experienced anthropogenic soil disturbance (Figure 3). Second, roads and their associated rights-of-way appear to be acting as dispersal corridors and/or habitat in which the grass is able to thrive (Figure 3; Table 2). Third, it appears that well established forest interiors (buffered by an edge of dense vegetation) are relatively free from invasion unless there has been an anthropogenic dispersal vector created in the area (for example, logging roads or water drainage ditches). These results are similar to those found for another invasive grass, *Microstegium vimineum* (Trin.) A. Camus (Japanese stiltgrass), in Pennsylvania (Mortensen et al. 2009).

While the sampling scheme may have biased the results toward indicating presence along roadsides, our data set included 221 points more than 30 meters from the roadside (213 of which were included in the transect-only analyses). In the analyses of transect data, proximity to road remained an important variable, despite roadside points representing only 38 percent of the data. Also, there were 144 absence points along the roadsides in the all-data analyses; those could have dampened any sampling artifacts that might have biased the models.

Nevertheless, cogongrass was encountered only 19 times at distances greater than 30 meters from the roadside (out of 221 plots at those distances). This pattern provides strong support that cogongrass is utilizing road rights-of-way, with their associated anthropogenic disturbance regimes, as preferred habitat and/or dispersal corridors.

Human activities along roadways are well known to influence distributions of invasive plant species. Watkins et al. (2003), for example, found numerous plant species associated with roadsides in hardwood forests of Wisconsin. In plant surveys that extended 150 meters from roadways, 25 percent of the more than 100 species they encountered were associated primarily with roadside habitats, versus approximately 10 percent of the species appearing adapted strictly to forest interiors. Other work has shown that plants may use roadsides as dispersal corridors (Tikka et al. 2001), although it has been suggested that the patterns observed could represent dispersal or simply the occupation of disturbed roadside habitats (Christen and Matlack 2006). Humans also may inadvertently transport high numbers of species and individual propagules along roadways, as hitchhikers on automobiles (Hodkinson and Thompson 1997; Lockwood et al. 2007). So it is no surprise that cogongrass is associated closely with human disturbance, but it was unexpected that human disturbance would have such an overwhelmingly disproportionate effect, in comparison with natural disturbances in the study area.

Acknowledgments

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Assessing the Invasive Potential of *Miscanthus* Biofeedstocks in Illinois

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Abstract

Biofuels have been promoted as a "green" alternative to petroleum and worldwide efforts are underway to rapidly choose candidate species for full scale deployment. Because candidate biofeedstocks share key traits with weeds (that is, rapid growth, clonal spread) and many are known to become naturalized and even invasive, there is concern that biomass crops may escape cultivation and exacerbate the invasive species problem. To date, efforts to minimize invasiveness among biofuel candidates have focused on the pre-entry stage, using screening protocols that rely on qualitative trait-based and climate-matching approaches. We argue that these approaches should be followed by post-entry screening, using field trials that quantify components of the invasion process. We present an overview of the methods we are using to develop a quantitative risk assessment for two candidate feedstocks, *Miscanthus* × *giganteus* and *Miscanthus sinensis*, in Illinois. To understand both the spatial scale at which escape may occur from production fields, and the speed at which established populations may spread, we developed empirical estimates of dispersal kernels for wind-borne *Miscanthus* seeds. To estimate demographic rates for potential escaped populations we have established foci of invasion by planting *Miscanthus* in sites adjacent to agriculture and in natural vegetation communities. Future work includes estimating the impact *Miscanthus* has on native communities and using empirical estimates of dispersal and demography to parameterize models of *Miscanthus* population spread.

Resumen

La rápida expansión de la planta bioeconomía ha aumentado los incentivos para la distribución de plantas exóticas en grandes escalas espaciales, creando la preocupación de que las especies exóticas se escaparán del cultivo y se conviertan en malezas nocivas. Esta preocupación es particularmente relevante en el impulso global para cultivar cultivos para biocombustibles. Candidatos para bio-materia prima comparten rasgos fundamentales con las malezas (por ejemplo, un rápido crecimiento, propagación clonal) y muchos se saben que se naturalizaron y aun son invasoras. Estamos utilizando varios métodos complementarios para experimentalmente estimar los componentes del proceso de invasión de dos materias primas candidatos, *Miscanthus* × *giganteus* y *Miscanthus sinensis*, en Illinois. Para comprender tanto la escala espacial en la que el escape puede ocurrir desde los campos de producción, y la velocidad a la que poblaciones establecidas se pueden diseminar, nosotros empíricamente estimamos núcleos de dispersión de propágulos de *Miscanthus* transportados por el viento. Cariopsis fueron capturados en trampas pegajosas a diferentes distancias, de hasta 400 metros, de una fuente de 600 espiguillas *Miscanthus* experimentalmente colocadas. En comparación con *M. sinensis*, la distribución exponencial negativa de las distancias de dispersión de cariopsis de *M. giganteus* era mucho más larga de cola, alcanzando hasta 400 metros. La distribución de la dispersión estaban de acuerdo con los pesos cariópside, con cariopsis de *M. sinensis* pesando más del doble de los *M.* × *giganteus*. Trabajos futuros incluyen el uso de las estimaciones empíricas de la dispersión y la demografía para parametrizar ecuaciones modelo integro diferenciales de las tasas de propagación de *Miscanthus* de las poblaciones establecidas.

[1] Presenter.

Background: Biofuels and Weeds Share Key Traits

Recent expansions in the cultivation of plant material for horticulture, food, and fuel have increased the speed and spatial scale at which plants are being dispersed around the globe (Mack 2001; Dehnen-Schmutz et al. 2007). This fact is worrisome because many plant invasions, including some of the most damaging (that is, kudzu), are a direct result of cultivation (Mack et al. 2000). Due to specific plant characteristics, there is a growing concern that cultivation of biofeedstocks may follow this trend (Raghu et al. 2006). Biofeedstocks are being promoted worldwide as a means to generate fuel while avoiding the short- (for example, oil spills) and long-term (for example, climate change) consequences of fossil fuel production. However, it has been argued that the full set of environmental impacts of biofuel production, including their invasive potential (Raghu et al. 2006; Barney and Ditomaso 2008), have not been thoroughly examined (Scharlemann and Laurance 2008).

Agronomists worldwide are considering the cultivation of non-native species for biomass production. It is known that the act of cultivation alone, protecting plants from biotic and abiotic stresses, can facilitate invasion (Mack 2000); however, concern for the invasive potential of biofeedstocks has stemmed from the traits and history of the specific species under consideration. There is a long history of research focused on predicting which plant attributes are associated with invasive success, and it has been recognized that a suite of plant traits and a history of invasion are often the best predictors (for example, Hayes and Barry 2008). Traits of successful plant invaders include rapid growth, no pests or disease, and C_4 photosynthesis, which also characterize an ideal biofuel species (Table 1; Heaton et al. 2004; Raghu et al. 2006).

Whether a species has a history of invasion elsewhere is often one of the most reliable predictors of invasion success in a specific locale (for example, Radosevich et al. 2007). This is a cause for concern, because many candidate biofuel species, including *Miscanthus sinensis* (see below), are known to be invasive or become naturalized outside of their range (Raghu et al. 2006; Barney and Ditomaso 2008). For example, the Asian grass *Arundo donax* (giant reed) is being considered for biomass cultivation on 20,000 hectares in central Florida (Lewandowski et al. 2003) despite a long history of invasion in the western US (Khudamrongsawat et al. 2004).

Table 1. Traits of an ideal biomass energy crops (Heaton et al. 2004) and their association with invasive species/invasiveness (adapted from Raghu et al. 2006).

Traits	Present (P) or contributing (C) to success in invasive species	Illustrative references
C_4 photosynthesis	P, C	a
Long canopy duration	P, C	b
Perennial	P	b
No known pests or diseases	P, C	c
Rapid growth in spring	P, C	b
Sterile seeds	P	d
Partitions nutrients		
Components in fall	P, C	b
High water-use efficiency	P, C	e

[a]Mack 2001, [b]D'Antonio and Vitousek 1992, [c]Keane and Crawley 2002, [d]Gray et al. 1991, [e]Görens and van Wilgren 2004.

Prior to large-scale deployment, the relative costs and benefits of each biofuel candidate should be evaluated. Currently there are extensive agronomic projects underway to quantify the energy-production potential of biofuel candidates but efforts to quantify the environmental costs of biomass crops remain consistently understudied.

Two *Miscanthus* Biofuel Candidates: *M.* × *giganteus* (*Mxg*) and *M. sinensis*

Plant life-forms under consideration as biofuel candidates include grain crops, trees, succulents, and microalgae, but in the Midwest, perennial rhizomatous grasses are attracting special attention. Due to their ability to rapidly sequester carbon (Clifton-Brown et al. 2001; Stewart et al. 2009) and relatively low input requirements (Heaton et al. 2008) grasses in the genus *Miscanthus* are being intensively studied in Illinois. *Miscanthus* is a genus of approximately 14 species of rhizomatous warm-season grasses, with *M.* × *giganteus* (*Mxg*) and *M. sinensis* being the most actively researched for biomass production (Hodkinson 1997). The relative merits (that is, biomass yields) and costs (that is, unintended escapes) of *Mxg* and *M. sinensis* are currently under debate (Stewart et al. 2009; Quinn et al. 2010).

The native range of *M. sinensis* extends from Russia in the north to Taiwan in the south (Stewart et al. 2009). Since the late 1800s *M. sinensis* has been cultivated in the US for horticulture and has escaped planting to establish naturalized populations throughout eastern and midwestern US states (Quinn et al. 2010). Mature *M. sinensis* plants reach a height of two meters and biomass production yields can reach up to 19.4 tons per hectare (reviewed in Stewart et al. 2009). In the Midwest, the cultivation of *M. sinensis* for biomass production is being pursued by both public and private research institutions. The ability of *M. sinensis* to produce viable seed, which facilitates establishment in the field, makes it an attractive biofuel candidate compared to crops that must be established by rhizome (Christian and Haase 2001). However, viable seed production has also contributed to its success as an invader (Meyer 2003; Quinn et al. 2010).

In central Japan, the ranges of *M. sinensis* and *M. sacchariflorus* overlap and their interbreeding forms the hybrid *M.* × *giganteus* (*Mxg*) (Stewart et al. 2009). *Mxg* attains larger sizes than either of its parent species, growing up to 3.6 meters in height and biomass yields reaching up to 29.6 tons per hectare (Heaton et al. 2008). *M.* × *giganteus* has a triploid genome and therefore only sterile seeds are reported to be formed under natural conditions (Lewandowski et al. 2000). It has been argued that due to *Mxg*'s sterility the probability of escape is minimal (Lewandowski et al. 2000). However, the fact that other sexually sterile species have been demonstrated to be successful invaders directly contradicts the argument of *Mxg*'s minimal risk. Recruitment via vegetative propagation can be sufficient to enable invasions on a landscape scale. For example, in the case of *A. donax* despite that very few viable seed are produced, invasion of riparian areas in California was driven solely by rhizome fragmentation/dispersal (Khudamrongsawat et al. 2004). Additionally, the sterility conferred by triploidy has been shown to be temporary in some cases. Viable seed formation through genetic recombination events, known collectively as the "triploid bridge," has been shown to be rare, but occurs at some non-zero probability (Ramsey and Schemske 1998).

Pre-entry screening

We argue that separate pre- and post-entry assessment systems should be used to evaluate the invasive potential of biofuel candidates (Cousens 2008; Davis et al. 2010). The climate-matching and trait-based screening approaches already in use (Barney and Ditomaso 2008; Buddenhagen et al. 2009) can serve as pre-entry sieves to exclude problematic species. Using these approaches, data are compiled for a species (that is, ecological, economic, historical) to produce a numerical score indicating potential weediness. This score is then compared to a threshold criterion allowing for the threat of escape to be categorized as acceptable, not acceptable, or further evaluation is needed. Conducting pre-introduction assessments should be attractive to industry considering that they have been shown to result a net economic gain (Keller et al. 2007).

Using the Australian Weed Risk Assessment System (WRA), Barney and DiTomaso (2008) found that the risk of *Mxg* invasion was acceptably low, although *M. sinensis* was not considered. It is of some concern that the relatively minor invasion risk posed by *Mxg* was attributed to the lack of seed production (Lewandowski et al. 2003), considering that *M. sinensis* produces fertile seed and efforts are currently underway to develop fertile *Mxg* varieties (Yu et al. 2009).

Because qualitative assessment systems, such as the WRA, often rely on incomplete data and subjective scoring, they are not 100 percent accurate in identifying weeds (Davis et al. 2010). The consequences of mistakenly releasing an invasive species for widespread deployment as a biofuel crop would be substantial, both in economic and ecological terms. We argue that results indicating minimal invasion risk for a species using the WRA, or similar systems, should not be interpreted as a final determination that the species in question is safe for full scale deployment. Instead, careful post-entry screening evaluations should be conducted for all biofuel candidates.

Post-entry screening: goals

The total risk that *Miscanthus* biofeedstocks pose for Illinois ecosystems can be broken into the risk of exposure (in the case of potential invaders, this includes their dispersal to a site and subsequent demographic success there) and hazard (negative ecological impacts) (Simberloff and Alexander 1998). Currently we are conducting post-entry screening evaluations to understand the exposure and hazard associated with *Mxg* and *M. sinensis* by using field trials, specifically we are addressing the following questions: (1) what is the probability that escaped populations will form and persist?; and (2) what is the potential impact of escaped populations on native plant communities?

Post-entry screening: dispersal and demography

We will be evaluating the potential of naturalized populations of *Miscanthus* to form as the result of a multi-stage process: (1) propagule dispersal from production fields; (2) propagule establishment in non-arable areas; and (3) population growth over time as determined by size-specific demographic rates.

Understanding dispersal ability is extremely important for quantifying the invasive potential of biofeedstocks because dispersal influences both the probability of escape and the speed at which an escaped population can spread (Neubert and Parker 2004). Rhizomatous grasses can disperse via seeds and rhizome fragments; therefore, we are performing separate experiments to evaluate wind dispersal of *Miscanthus* seeds and water dispersal of rhizome fragments. To characterize the seed dispersal kernels of *Mxg* and *M. sinensis*, in collaboration with Dr. Lauren Quinn, we conducted a controlled seed release and capture experiment in Champaign, Illinois during the winter of 2010. Six hundred panicles of each *Miscanthus* species were exposed to wind for five weeks on a release structure two meters above the ground. Separate trials were run for *Mxg* and *M. sinensis*. Seeds were captured on 250 sticky traps arranged in 14 annuli radiating out from the release point up to a distance of 400 meters. Preliminary results for *M. sinensis* show that the dispersal kernel fits a log-normal distribution, similar to other wind dispersed species (Greene and Johnson 2000). Over 95 percent of the captured seeds landed within 50 meters of the release point but several traveled over 300 meters from the release point, giving the distribution a long-tail. Long-tailed dispersal kernels have been shown to yield faster rates of spread for invasive plant populations than shorter-tailed kernels (Neubert and Parker 2004). This fall we will begin a set of experiments designed to evaluate the potential for rhizome fragmentation and dispersal.

We are pursuing our goal to estimate rates of establishment and population growth in two distinct environments: (1) marginal lands directly adjacent to agricultural production fields, and (2) native plant communities where *Miscanthus* propagules are likely to arrive. We had separate motivations for choosing these environments. Lands adjacent to agriculture, which in the future may be adjacent to biomass production, will likely receive the greatest *Miscanthus* propagule pressure. Therefore, the risk of escaped *Miscanthus* population forming may be greatest in these areas. The impact of an escaped *Miscanthus* population may be the most acute in native plant communities where biodiversity and ecosystem processes could be altered (Parker et al. 1999). Therefore, it is important that we understand if an escaped *Miscanthus* population could form and persist in native plant communities in Illinois. We chose to consider two Illinois native vegetation types that are the most likely to receive *Miscanthus* propagules. Floodplain forest could receive *Miscanthus* rhizome fragments that are dispersed by watercourses during flooding events. Successional fields could receive wind-blown *Miscanthus* seeds and rhizome fragments dispersed by machinery.

The empirical demographic and dispersal data we collect will be used to model the spatial population dynamics of escaped *Miscanthus* population in specific environments. Using an integrodifference equation model that allows for stage-specific demographic and dispersal rates (Neubert and Parker 2004) we hope to estimate the rates at which escaped *Miscanthus* populations could spread in marginal lands adjacent to agriculture, floodplain forest and successional fields.

Post-entry screening: impacts on native plant communities

Plant populations that escape cultivation are extremely variable in their impacts on native communities, from those with no measurable impact to those causing a shift to an entirely different ecosystem (Parker et al. 1999). Predicting the impacts of a non-native species on ecosystems is notoriously difficult because the scale and intensity of ecological impacts are thought to depend on both the traits of the invader and those of the native ecosystem (Parker et al. 1999; Simberloff 2010). Additionally, the impacts of an invader may only be apparent at certain population densities (Yokomizo et al. 2009). We are currently initiating an experiment aimed at understanding the impacts of *Miscanthus* on two native plant communities, floodplain forest and successional fields.

Conclusion

To date the global push to rapidly develop biofuel feedstocks has not been matched by an effort to understand the environmental consequences of these crops. Concerns that candidate biofeedstocks pose a significant invasion threat have been raised for over four years (Raghu et al. 2006), yet little research has been performed in support of minimizing this risk. Here we present an outline of the ongoing research we are conducting to understand the invasion risk posed by *Miscanthus* × *giganteus* and *M. sinensis*. We hope that the data generated from these studies will help guide management decisions surrounding the deployment of these crops in Illinois.

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Google Street View: A New Online Tool with Potential Application to Roadside Invasive Species Detection and Monitoring

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Abstract

The diversity, quality, and usability of digital geographic datasets available online are increasing year after year, and the ways in which biologists and GIS specialists are able to apply these data to biological issues such as invasive species are increasing accordingly. Google's *Street View* function within its *Google Maps* online application was first made available in May 2008. *Street View* provides 360° horizontal and 290° vertical panoramic views from along roadways. Images are taken from a camera system mounted on a car roof at about 2.5 meters high, with pictures taken roughly 10–20 meters apart. The area covered by *Street View* has been greatly expanded since its inception, to the point that virtually all primary and secondary highways in the United States and southern Canada are now covered, along with many minor roads. The comprehensive imaging of hundreds of thousands of kilometers of roadside offers interesting opportunities in invasive species detection, management, and monitoring. This talk will introduce *Google Street View* and discuss some recent preliminary applications to invasive plant issues as well as potential future invasive plant applications.

Resumen

La diversidad, calidad y facilidad de uso de conjuntos de datos geográficos digitales disponibles en línea están aumentando año tras año, y las formas en que los biólogos y especialistas en SIG son capaces de aplicar esos datos a cuestiones biológicas como especies invasoras están aumentando en consecuencia. *Google Street View* una función de *Google Maps* es una aplicación en línea que estuvo por primera vez disponible en mayo de 2008. *Street View* dispone de vistas panorámicas de 360° horizontal y 290° vertical a lo largo de las carreteras. Las imágenes son tomadas de un sistema de cámaras montadas sobre el techo de un vehículo a la altura de alrededor de 2.5 metros, con fotografías tomadas alrededor de 10–20 metros de distancia. El área cubierta por *Street View* se ha ampliado considerablemente desde su inicio hasta el punto de que prácticamente todas las carreteras primarias y secundarias de los Estados Unidos y el sur de Canadá ya están cubiertos, junto con muchas carreteras menores. La imagen global de cientos de miles de kilómetros de carretera ofrece interesantes oportunidades en la detección de especies invasoras, manejo, y seguimiento. Esta charla introducirá *Google Street View* y discutirá algunas recientes aplicaciones preliminares de cuestiones de plantas invasoras, así como posibles futuras aplicaciones en plantas invasoras.

[1] Presenter.

Introduction

The rate of introduction and establishment of species outside of their natural distribution has steadily increased in recent decades, aided by human movement, anthropogenic disturbance of natural areas, and climate change. Throughout the world, the proliferation of exotic invasive plant species within natural ecosystems is one of the greatest threats to native biodiversity and the integrity of natural ecosystems.

A coordinated and proactive approach to preventing the introduction, establishment, and spread of exotic invasive plant species is an essential component of any successful invasive species management strategy (Hobbs and Humphries 1995; Randall 1996). Coupled with Early Detection and Rapid Response, preventative measures represent the most effective way to mitigate the impacts of bioinvasions, both in terms of outcome and cost; controlling or locally eradicating an invasive species in the early stages of establishment will reduce costs and increase chances of success while minimizing impacts on natural ecosystems (Moody and Mack 1988; DiTomaso 2000; Rejmánek and Pitcairn 2002).

The successful detection and control of newly established colonies and incipient invasions rests on the availability of adequate survey data, which can be costly and difficult to acquire through on-the-ground efforts, particularly where larger management areas are concerned. Given resource and time constraints, surveys are often focused on a selected subset of invasive species and must be limited to prioritized areas. Survey methods used must balance ability to produce accurate, pertinent data and efficiency.

In identifying priority areas for survey, sites with the highest likelihood of receiving invasive plant propagules must first be considered. Disturbed areas along road rights-of-way and roadside edge habitats play a major role in the establishment and spread of exotic invasive plant species by providing readily available sites for colonization and effective dispersal pathways (Shuster et al. 2004; Christen and Matlack 2006; Hulme 2009; Mortensen et al. 2009). These areas represent long, narrow habitat corridors which can be virtually continuous over significant distances, potentially allowing invasive species to spread over long distances unhindered by barriers to dispersal and spread and providing opportunities for spread into natural habitats (Christen and Matlack 2006; Lelong et al. 2007).

Regular and often intensive disturbance of roadsides through vegetation management, vehicle traffic, and road maintenance contributes to the spread of exotic invaders. Disturbances eliminate native species, increase resource availability, and move propagules (Parendes and Jones 2000; Lonsdale and Lane 1994; Mortensen et al. 2009). The abundance of exotic plant species in a given area has been shown to be positively correlated with road density (Dark 2004; Zedler and Kerchler 2004) and exotic plant richness and cover on roadsides is known to generally increase with road size (Lundgren et al. 2004; Mazerolle 2006). Given the importance of roadsides as sites for the introduction and spread of invasive species, these areas can be used to estimate invasive species distributions and should be considered a priority when elaborating a surveying strategy (Shuster et al. 2004).

Remote sensing methods have been used for several decades as a more cost-effective alternative to on-the-ground surveys. The tools available for these types of survey methods have greatly evolved over time, from low-resolution aerial photographs to multispectral sensors (Lass et al. 2005). The diversity and quality of digital geographic datasets have increased through time as have the ways in which biologists and Geographic Information System (GIS) specialists are able to apply these data to biological issues such as invasive species. Some online resources now allow for a range of new remote sensing possibilities, including the use of interactive on-the-ground virtual views. Foremost among these new resources is Google's *Street View* application.

We recently carried out a preliminary evaluation of this online application's potential for use in the survey of exotic invasive plant species.

Google Street View

The Google Corporation first launched *Street View* as an additional feature to its *Google Earth* and *Google Maps* web mapping services in May 2007, allowing users to access virtual views of sites on a map from the vantage point of a vehicle travelling along a street or road. Although initially only available for a few major cities and exclusive to the United States in its first year, coverage has since significantly expanded to many primary and secondary roads in rural areas and now includes regions in many other countries around the world.

Presently, at least partial coverage is available in over 20 countries in North America, Europe, Asia, and Oceania (Figure 1). In the contiguous US and southern Canada coverage is now significant, with extensive imaging available for most towns and cities as well as all primary and secondary highways and a large number of smaller roads. Although less comprehensive, coverage in Mexico is ongoing and now includes most major highways and a large number of towns and cities.

Image quality and functionality have also significantly improved in recent years, as data-collecting equipment and image-processing technology have become more sophisticated. In its current iteration, *Google Street View* provides full-screen 360° horizontal and 290° vertical panoramic ground-level views, allowing the user to easily pan the view in any direction and navigate along a road where data is available (Figure 2). While viewing *Google Maps* or satellite images, clicking and dragging the "Pegman" *Street View* icon causes all roads and streets for which images are available to be highlighted in blue. Dragging and releasing the icon to a particular location brings up *Street View* imaging for the selected location. Once *Street View* mode is active, clicking and dragging the mouse cursor in the viewing area allows the user to pan the view, double-clicking in the view brings the selected area into closer perspective, and double-clicking along the road axis navigates the view.

The initial inception of *Street View* as a primarily US-focused project and the subsequent early coverage of the contiguous states are somewhat of a mixed blessing for these jurisdictions. While imaging in these areas is extensive, including virtually all primary and secondary highways, as well as a large number of rural roads, early coverage was largely carried out using first and second generation equipment which garnered lower-resolution images. The Google Corporation has, however, stated that all coverage where the service was first made available will gradually be updated in coming years using the latest generation of imaging equipment.

The current generation of imaging equipment used by Google involves an array of nine directional cameras mounted on a car roof at a height of 2.5 meters and linked to a GPS unit and laser range scanners. Digital near-high definition images are recorded simultaneously by all cameras in the array while the vehicle is in motion, typically at somewhat regular intervals of 10 to 20 meters. Collected images are then processed to create the

Figure 1. *Google Street View*'s world coverage as shown through *Google Maps* (*Google Street View*, May 2010).

360° panoramic views available on the website. While exclusively the property of Google Inc., the digital images produced are freely accessible for non-commercial use.

Methods

Google Street View's potential for use as a viable exotic invasive plant species survey method was evaluated through a series of systematic and non-systematic trials carried out using imaging of New Brunswick and Nova Scotia highways and secondary roads.

Since *Street View* coverage in these two Canadian provinces was, for the most part, carried out in 2009, image quality is intermediate, with a resolution significantly superior to that available in much of the US, but slightly inferior to that of areas recently covered using fourth generation imaging equipment.

Figure 2. Interactive ground-level panoramic image available through Google's *Street View* application. Red circles indicate autumn olive (*Elaeagnus umbellata*) shrubs. The location shown above is in Cumberland County, Nova Scotia (*Google Street View*, May 2010).

A total of approximately three hours were devoted to a number of separate trials, the majority of which involved the surveying of road sections that had previously been included in vehicle-based invasive plant surveys in 2001 and 2002. From these previously studied areas, ten 1-kilometer long road sections were randomly selected and surveyed using *Google Street View*. This allowed for general comparisons to be made between on-the-ground and "virtual" surveys, thereby allowing us to broadly gauge the effectiveness of *Street View*-based methods.

During trial surveys, an average of approximately 15 seconds was spent panning the view to both sides of the road at every image-capture location along a surveyed section.

Additionally, known population sites for several highly invasive species in Atlantic Canada were also verified in order to evaluate the detectability of various species and growth forms.

Results and Discussion

Preliminary trials show that detectability is highest for tall graminoids such as common reed (*Phragmites australis*) and reed canary grass (*Phalaris arundinacea*), tall forbs such as purple loosestrife (*Lythrum salicaria*) and sweetclover (*Melilotus albus* and *officinalis*), and certain distinct shrub and shrub-like species including Japanese knotweed (*Polygonum cuspidatum*) and autumn olive (*Elaeagnus umbellata*). Glossy buckthorn (*Frangula alnus*), a tall shrub considered to be among the most aggressively invasive plant species in Atlantic Canada, was also detectable to a certain degree, largely dependent on the distance from the road and the season in which the images had been captured.

Because vegetation management practices often restrict the presence of woody plants to the outer edges of road rights-of-way, invasive tree, shrub, and vine species are often located farther from the point of image capture and are therefore more difficult to distinguish from surrounding vegetation. However, several exotic woody species possess vegetative or reproductive characters that clearly distinguish them from other species in the local flora, making them detectable in virtual surveys. With the exception of particularly showy species, smaller graminoids and forbs frequently went undetected, even at higher densities.

In comparing *Street View*-based surveys to previous on-the-ground surveys of the same areas, it is evident that many invasive plant populations easily go unnoticed or are simply not detectable in virtual surveys. Even for species readily detectable in *Street View*, our preliminary trials showed that on average nearly 35 percent of colonies known to be present had not been detected during trial surveys. Primary factors rendering colonies inconspicuous were small patch sizes and densities, distance from road, and height of the surrounding vegetation.

From a preliminary list of 49 exotic plant species presently considered highly invasive in Atlantic Canada, our results suggest that approximately 20 are readily visible in *Street View* imaging. Approximately 15 species are harder to distinguish but detectable where image clarity is good and time of image-capture is conducive. The remaining 14 species are non-detectable or only detectable in optimal conditions.

A number of previously unknown populations of reed canary grass (*Phalaris arundinacea*), purple loosestrife (*Lythrum salicaria*), and glossy buckthorn (*Frangula alnus*) were discovered while viewing digital imaging of areas previously covered in vehicle-based roadside surveys.

At an average of 15 seconds spent at every image-capture location along a route, speed of virtual surveys was found to be only slightly slower than on-site surveys done from a vehicle moving approximately 15 kilometers per hour. When comparing time and cost-effectiveness of both survey methods, one must also consider the travel time and frequent stops typically involved in vehicle-based road surveys as well as additional costs related to vehicle use.

Trials show that the potential to detect invasive plant populations varies greatly from area to area, sometimes changing significantly along a route from one image-capture location to the next. These discrepancies are most importantly due to factors affecting image clarity, such as the resolution obtained by the imaging equipment as well as weather, level of ambient light, and position of the sun when photographs were taken. Since some species are only detectable at certain phenological stages, the time of year in which imaging was carried out is also key.

The level of knowledge and expertise of the observer can also be an important limiting factor, perhaps more so than in on-site surveys. Since species identifications can only be based on characters visible at a distance (habit, color, general leaf shape, and so on), extensive first-hand experience and good knowledge of the native flora can be necessary to distinguish targeted invasive species from the surrounding vegetation.

Applications to Invasive Plant Management

Despite some limitations, *Google Street View*'s utility in invasive plant management seems promising. Its greatest potential may be in its use as a cost-effective method to carry out exploratory or reconnaissance surveys covering vast and previously unsurveyed transportation corridors. Also, this method could be equally useful in more systematic surveys involving the sampling of randomly selected right-of-way sections.

Carried out concurrently, both virtual and on-site roadside surveys could be complementary in covering a given area, with the more costly and effective on-site searches reserved for higher priority sites.

For the purposes of monitoring, images captured during *Street View* coverage could help glean additional information on known populations by providing a view of density and extent at a previous point in time.

Although data collected remotely is largely limited to location, abundance, and qualitative descriptions of patch size and density, this type of information is the most meaningful in invasive species management and is often initially sufficient. For more comprehensive or intensive survey strategies requiring the collection of detailed quantitative data, use of remote surveying could complement on-site efforts by aiding in detection and identifying sites where follow-up is necessary.

It should be stressed that although road corridors are important sites for the introduction and dispersal of exotic invasive species, they typically only represent a small portion of any given area and many invasive species can readily disperse beyond these zones. Additionally, the ground-level panoramic views provided by *Street View* do not allow for the detection of all species and populations. For these reasons, we recommend that caution and good judgment be applied and that reliance on remote surveying methods be tempered by the knowledge that failure to detect does not equal absence.

Conclusions

This preliminary investigation shows that the extensive ground-level imaging and interactive 360° panoramic views made available through

Google Street View have several potential applications to the management of exotic invasive plant species. Most notable is the potential for this online resource to effectively be used in invasive species surveys.

Despite certain limitations in terms of detectable species, a lower rate of detection, and inconsistencies in image quality, a significant portion of Atlantic Canada's most highly invasive species was found to be readily detectable through *Street View*-based surveys.

We propose that, particularly when complementing on-site efforts, ground-level panoramic imaging can represent a viable and highly cost-effective method for gathering meaningful information on the presence and distribution of invasive species within an area of interest.

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What is the North American Weed Management Association?

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Abstract

The North American Weed Management Association (NAWMA) is a network of public and private professional weed managers that serves the educational, professional improvement, and networking needs of on-the-ground, local vegetation, or exotic plant managers throughout North America.

NAWMA is comprised of county weed managers, and local area managers from state, federal, and provincial land management agencies and its members are involved in implementing county, municipal, district, state, provincial, and federal noxious weed laws. Furthermore, NAWMA's membership is actively involved in invasive species legislation at state and federal levels and travels annually to Washington, DC to meet with top officials and discuss on-the-ground needs and issues faced by land managers.

NAWMA welcomes new members—individuals who are interested in making a difference in invasive species issues and becoming a part of a continent-wide network of people involved in preserving our natural resources from the threat of invasive weeds and non-native exotic vegetation.

Resumen

NAWMA es una red pública y privada de profesionales del manejo de malezas que están involucrados en la aplicación de cualquiera de las fases de las leyes de malezas nocivas de un condado, municipales, distritales, estatales, provinciales o federales. Hay asociaciones estales de malezas activas y las de vegetación en carretera y sociedades dedicadas a las organizaciones de ciencias de las malezas. Otras organizaciones se centran en la legislación federal y otros están comprometidos con administradores de nivel medio federales y estatales.

Hasta NAWMA, no había ninguna organización en América del Norte al servicio de la educación, la mejora profesional y la necesidad de la creación de redes sobre el terreno, la vegetación local o manejo de plantas exóticas. NAWMA trabaja activamente en la legislación sobre especies invasoras a nivel estatal y federal incluyendo viajes anuales a Washington, DC para reunirse con altos funcionarios para tratar sobre el terreno las necesidades y los problemas que nuestros programas enfrentan.

NAWMA da la bienvenida a nuevos miembros activos interesados en hacer una diferencia en cuestiones de especies invasoras y convertirse en parte de una amplia red de personas en América del Norte involucradas en la preservación de nuestros recursos naturales de la amenaza de la invasión de malezas y no nativa exótica vegetación.

Introduction

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NAWMA Background

NAWMA was formed in 1992 with 14 members. Today, we have 240 members from 28 US states and 35 members from three Canadian provinces. The 2010 NAWMA Board of Directors is made up of the following members:

Greg Hensel, Minnesota (President)
Fred Raish, Colorado (Vice President)
Patricia Rawlek, Alberta (Treasurer)
Aaron Foster, Wyoming
Sheilah Kennedy, Washington
Charlie Brooks, Nebraska
David Heck, South Dakota
John Cantlon, Colorado
Mark Cardinal, Alberta
Jeff Vogel, Kansas
Tim Higgs, Utah.

There are eight county employees, one state employee, two private industry representatives, and one major chemical company representative on the board. We all bring different backgrounds to the board and have a passion for weed control and NAWMA. Each year, six people are elected or re-elected to the board. If you are interested in becoming a member of NAWMA, visit our website at http://www.nawma.org.

Since its first year, NAWMA has been involved in National Invasive Species Awareness Week (NISAW), formerly National Invasive Weed Awareness Week (NIWAW). During NIWAW, we would have an annual face-to-face board meeting in Washington, DC; and 15–20 members would attend as NAWMA representatives. We worked hard on federal legislation for weed control and supported and fought for the Noxious Weed Control Act of 2004. The Act was passed, but was not appropriated. NAWMA also supports the 100th Meridian Invasive Species State Revolving Loan Fund. NAWMA will again be represented at NISAW in 2011.

Organization

NAWMA has 11 committees that are doing work for us: Weed Free Forage, Trade Show, Personal Improvement, Nominations, Mapping Standards, International Issues, the Healthy Habitats Coalition, Early Detection Rapid Response, Biological Control, Awards, and Audit.

Mapping Standards

The Mapping Standards Committee coordinates the efforts of provincial, federal, state, and county agency personnel toward establishing, developing, maintaining, reviewing, and updating national invasive plant mapping standards.

NAWMA's mapping standards were designed to be compatible with most existing invasive species inventories and contain the data fields required to satisfy the three basic elements of weed inventories: (1) what is the weed?; (2) where is it located?; and (3) how large is the infestation?. Mapping standards ensure that all information being collected by weed managers is compatible and can be shared seamlessly. Therefore, mapping standards enable more efficient and successful management efforts.

Approved in 2002, NAWMA's mapping standards (available at: http://www.nawma.org/Mappingpg.html) are endorsed by the Federal Interagency Committee for the Management of Noxious and Exotic Weeds and are used by many government and private agencies.

Weed Free Forage

The Weed Free Forage Committee was formed in 1997 and is led by Adrianne Peterson from Sublette County, Wyoming. She will travel anywhere and anytime to talk about NAWMA's minimum standards for weed free forage certification. To date, 22 states, two counties, and one Canadian province have signed a Memorandum of Understanding (MOU) with NAWMA's Weed Free Forage Committe.

Adrianne is currently working to include British Columbia, Manitoba, and Saskatchewan in the weed free forage program. Finally, NAWMA is also working to establish minimum standards for certified weed free gravel.

Personal Improvement

The Personal Improvement Committee takes care of the Certified Manager of Invasive Plants (CMIP) program, a certification program sponsored by NAWMA, in cooperation with Central Community College in Hastings, Nebraska. We conduct a closed book exam for the continuing education of invasive plant managers. Other duties of this committee include: identifying ways to promote personal improvement efforts; developing and distributing materials to aid in personal improvement; requesting feedback from users to improve materials; providing guidance on the use of materials for continuing education; developing a database of educational opportunities for weed control managers and making this database available to the membership; and encouraging states to develop and/or improve weed manager certification programs.

Early Detection and Rapid Response

The Early Detection and Rapid Response (EDRR) Committee coordinates the efforts of provincial, federal, state, and county agency personnel toward establishing, developing, maintaining, reviewing, and updating EDRR standards. Their goal is to disseminate information concerning EDRR programs, approaches, and leadership; establish standards and policy; and identify contacts from each state to provide and coordinate EDRR leadership.

International Issues

The International Issues Committee keeps the NAWMA board abreast of weed management issues and provides direction in the development of uniform and effective international, national, provincial, and state weed management legislation and regulations. The US Environmental Protection Agency's Zero Drift Standards, and the need for National Pollutant Discharge Elimination System permits for herbicide use on or near water, is just one example of this committee's interests.

Biological Control

The Biological Control Committee coordinates the efforts of provincial, federal, state, and county agency personnel toward establishing, maintaining, reviewing, and updating biological control standards in order to disseminate information concerning biological control standards to all affected and interested parties.

Healthy Habitats Coalition

Board member Fred Raish represents NAWMA on the Healthy Habitats Coalition (HHC) Committee. HHC is an undertaking of many partners, including chemical companies, state and local weed control groups, the Weed Science Society of America, NAWMA, and others. Its mission is to secure a full-time lobbyist to present a unified message to the people in power. Currently, Tracee Bentley from Park Resources is the lobbyist working for HHC. Other goals of HHC are to: expand the understanding and awareness of invasive species management and restoration needs and the application of associated scientific knowledge to support a cooperative approach to ecosystem management; enhance the resource and infrastructure that supports increased invasive species appropriations that improve the government's capacity to prevent and control invasive species and; improve agency effectiveness by supporting changes in policy, regulations, and direction that improve the government's ability to preserve and protect human activities and wildlife populations.

Update on NAWMA

This year, NAWMA is taking a new approach to invasive weed education. We are trying to partner with DuPont and NASCAR driver, Jeff Gordon, to educate fans and the public about invasive weeds. Board member Sheilah Kennedy brought this up to the president of DuPont, Jim Collins, at this year's board meeting in Delaware. Collins thought it was an ingenious idea and gave the go-ahead to work on it. Needless to say, Sheilah seized the opportunity and ran with it; hopefully, it will involve a NASCAR race in 2011 and provide some great educational opportunities for the public. NAWMA raffled off NASCAR tickets at it's annual conference in September 2010.

The 20th annual NAWMA conference will be held in Winnipeg, Manitoba in September 2011. Membership applications and conference registration may be found on our website.

Thank you for your time and the opportunity to speak to you about what NAWMA is doing.

Sustaining Cooperative Weed Management Areas in the Long-term

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Abstract

Cooperative Weed Management Areas (CWMAs) have become increasingly prevalent across the United States as a mechanism by which communities can address their weed management needs, with 301 currently documented. Some CWMAs include two or more states, or partner across national borders. These groups are characterized by collaborative approaches that result in a sharing of expertise, resources, and action at the local level. They are often dependent upon volunteers to provide leadership or labor. Many CWMAs experience a honeymoon period of high hopes and energy after formation. As these organizations mature, however, some function more successfully than others, while some disband. This paper explores the factors that allow CWMAs to be effective in the long-term. These include clear and achievable goals and objectives; good leadership skills; a willingness to embrace change and evolve as priorities shift; an emphasis on results; a critical mass of participants and members; sharing of responsibilities; and organizational support for participants to attend. Without a committed and funded leader, few landowners are able to sustain the role of group chair. They often lack sufficient skills or time to write and administer grants or to facilitate meetings. A 2006 survey of CWMA chairs in Nevada found that inadequate funding and lack of manpower were the two greatest impediments to success. A 2007 case study of the Estes Valley CWMA found that lack of group structure and identity, loss of key leaders and defined leadership roles, unclear CWMA boundaries, and lack of formal structure contributed to the demise of that group. Additional examples of successes and failures, including data collected in 2010, will be shared during this presentation.

Resumen

Cooperative Weed Management Areas (CWMAs) se han vuelto cada vez más frecuentes en los Estados Unidos como un mecanismo por el cual las comunidades pueden satisfacer sus necesidades de manejo de malezas, con 301 documentadas actualmente. Algunos CWMAs incluiyen dos o más Estados, o socios a través de las fronteras nacionales. Estos grupos se caracterizan por enfoques de colaboración que resultan en un intercambio de conocimientos, recursos y medidas a nivel local. A menudo dependen de voluntarios para proporcionar un liderazgo o trabajo. Muchas CWMAs experimentan un período de luna de miel de grandes esperanzas y energía después de su formación. A medida que estas organizaciones maduran, algunas funcionan con más éxito que otras, mientras que algunas se disuelven. Este trabajo explora los factores que permiten CWMAs ser eficaces a largo plazo. Estos incluyen objetivos claros y alcanzables, buenas habilidades de liderazgo, la voluntad de abrazar el cambio y evolucionar a medida que cambian las prioridades, énfasis en los resultados, una masa crítica de participantes y miembros, el reparto de responsabilidades, y apoyo organizativo a los participantes que asisten. Sin un líder comprometido y financiado, unos pocos propietarios de tierras son capaces de mantener el papel de presidente del grupo. A menudo carecen de las habilidades o

[1] Presenter.

tiempo suficiente para escribir y administrar subsidios o para facilitar las reuniones. En una encuesta en 2006 entre los directores CWMA en Nevada se encontró que la financiación insuficiente y la falta de mano de obra fueron los dos mayores obstáculos para el éxito. Un caso de estudio en 2007 de la CWMA del Estes Valley encontró que la falta de estructura de grupo e identidad, la pérdida de líderes claves y la definición de las funciones de liderazgo, no claros límites de CWMA, y la falta de estructura formal ha contribuido a la desaparición de ese grupo. Otros ejemplos de éxitos y fracasos incluyen datos recogidos en 2010 serán compartidos durante esta presentación.

Introduction

During the past 20 years, many communities across the United States have experienced growing frustration over the lack of effective weed management. While some counties have weed districts, weed superintendants, or other mechanisms to control noxious weeds, these approaches are not intended to provide the broad, multi-agency coordination needed to manage weeds on large land masses. By the late 1990s, local grass-roots organizations devoted to weed management had begun to sprout throughout the western states. These informal organizations came to be called Cooperative Weed Management Areas, or CWMAs. A CWMA is a local organization that integrates all noxious weed management resources across jurisdictional boundaries to benefit entire communities. In 2003, this approach was formalized in the publication "CWMA Cookbook: A Recipe for Success" (VanBebber 2003). In 2006, a second "Cookbook" was published to assist in the formation of CWMAs in the eastern half of the nation (Midwest Invasive Plant Network 2006).

CWMAs are characterized by the following elements:

- A defined geographical area distinguished by a common geography, weed problem, community, climate, political boundary, or land use;
- Involvement or representation of the majority of landowners and natural resource managers in the defined area, including federal, state, and local partners;
- A steering committee;
- A commitment to cooperate; and
- A comprehensive plan that addresses the management or prevention of one or more noxious weeds or invasive plants.

In different parts of the country, CWMAs may have different names or structures as they respond to local needs. Some of the more common names include:

- Partnerships for Regional Invasive Species Management (PRISMs)
- Cooperative Invasive Species Management Areas (CISMAs)
- Weed Management Areas (WMAs)
- Resource management teams
- Invasive task forces
- Early detection networks.

Currently, there are more than 300 CWMAs across the nation (Figure 1). The proliferation of groups suggests a growing understanding that effective weed control programs must consider many factors in addition to weed biology, including social, economic, and legal considerations (Anderson et al. 2003).

CWMAs often begin with great enthusiasm and energy, yet some survive while others do not. Studies have attempted to characterize the elements contributing to the success of CWMAs. Most high-achieving groups have many of the following attributes:

- They are led by a "champion" with energy, commitment, leadership skills, and available time.
- They share a common vision with clear and achievable written goals and objectives.
- Trust develops among members.
- Members share responsibilities.
- The actions of the group help to build community support for weed management.
- Group members ignore jurisdictional boundaries and work across political boundaries.
- They place an emphasis on results.
- Groups embrace change as priorities evolve (size, emphasis, constituents, and

so on) and are not afraid to shift their focus.

- A critical mass of members participate, and there is official support for members to attend during work hours.

A study of rangeland collaboratives in Arizona identified challenges, with two-thirds of the groups interviewed noting difficulties in maintaining the partnership (Fernandez-Gimenez 2004). Specific elements that were mentioned included difficulties in getting and keeping volunteers, lack of funding and time to implement projects, ill-defined roles, difficult agency bureaucracy, and declining budgets. They found it problematic to: build trust, particularly between the government and environmentalists or ranchers; unite in common purposes; share perspectives; reach agreement; develop plans; and educate the public. Similar issues have been experienced by CWMAs.

Identifying Group Characteristics

In an effort to better understand the needs and characteristics of Nevada CWMAs, a survey was sent to group chairs in 2006 (Donaldson 2006). Nineteen chairs responded and rated the importance of a number of goals for their groups (Figure 2). Little difference separated the importance placed on inventory and mapping, coordination, raising awareness, and education and outreach. It should be noted that respondents selected from a pre-determined list of goals.

Barriers to Group Survival

In the same survey, chairs were asked to select the three greatest impediments to their success from a list of eight factors; Fifteen groups (78.9 percent) selected inadequate funding (Figure 3).

Chairs indicated a high level of comfort with meeting management (mean 4.47 on a scale from one, difficult for me, to five, totally comfortable)

Figure 1. Distribution of CWMAs in the United States in spring 2010 (301 total). CWMAs often begin with great enthusiasm and energy, yet some survive and others do not. Other studies have attempted to characterize the elements contributing to the success of CWMAs. Image taken from: http://www.invasiveplantcenters.org/cwmamap.cfm.

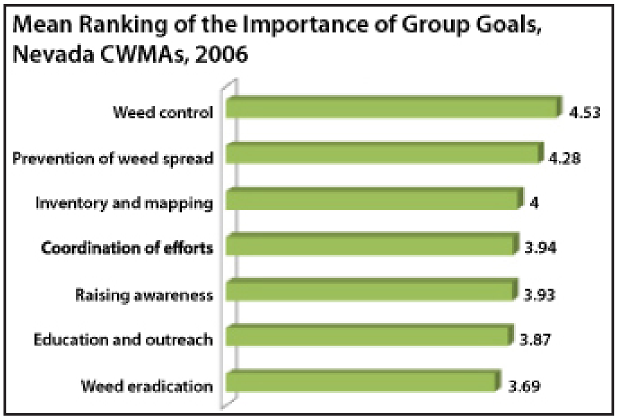

Figure 2. Mean ranking of the importance of group goals, on a scale from one (less important) to five (more important), n=19 (Donaldson 2006).

and the lowest level of comfort with grant-writing (mean 2.92).

Since 2006, a number of other studies have attempted to understand the elements important to the success of local weed management programs. Hershdorfer et al. (2007) used case studies of local weed management programs in four western states to understand the relationship between certain program attributes and group performance. They found that while community involvement and interagency coordination do contribute to group performance, inadequate funding for control and education, coupled with a lack of locally enforceable weed regulations, impaired group functioning. In a strategic plan published for the Lemhi, Idaho CWMA in 2009, a history of the group notes that their effectiveness and capabilities were greatly increased by several events: (1) the availability to secure annual federal funding for the CWMA via the Department of Agriculture; (2) signing cooperative agreements with the Bureau of Land Management and US Forest Service with multi-year funding; and (3) the hiring of a dedicated, full-time county weed superintendent.

While it is not surprising that lack of funding presents a serious barrier to group efforts, inadequate funding is not enough to explain the failure of some groups. An indepth study of the Estes Valley, Colorado WMA reveals more about the factors that led to the demise of that group. Initially, the group was successful in obtaining funding from several sources. Once the funding ended, however, the group became dysfunctional. Analysis of the data collected revealed the following elements contributing to group failure:

- Lack of group structure and identity. The group was not formalized with by-laws, a Memorandum of Understanding (MOU), etc.
- Formal leadership roles were not defined and key leaders were lost when their job responsibilities changed.
- The boundaries of the WMA were not well-defined, and group members did not have a clear understanding of the group boundaries. Most interviewees underestimated the size of the WMA. The lack of understanding of the geographical scope of the group contributed to a loss of identity.
- Lack of sustained funding and manpower. The group obtained initial funding to allow control work to be conducted. The funding was used to hire consultants, and the group itself focused primarily on education and outreach. Group members did not know the locations of or results from control plots, and thus had no sense of ownership in the work. Once the funding lapsed, the group did not receive additional funding and did not have a plan for sustainable funding. At that point, the group found it easier to defer to the county weed district as an alternative.
- Loss of a sense of crisis and a lapse in community interest. The group formed during a time when two noxious weeds were spreading rapidly, lending a sense of urgency. Once the group formed and pursued weed management activities, it appears that motivation lessened as the appearance of a "crisis" situation decreased. More community involvement and education, including annual reports, were needed to help residents appreciate the results of the group actions.

In 2010, a qualitative survey of CWMAs in Nevada asked group members to identify barriers to success. Some of the issues identified were similar to those identified in previous studies, while others were new.

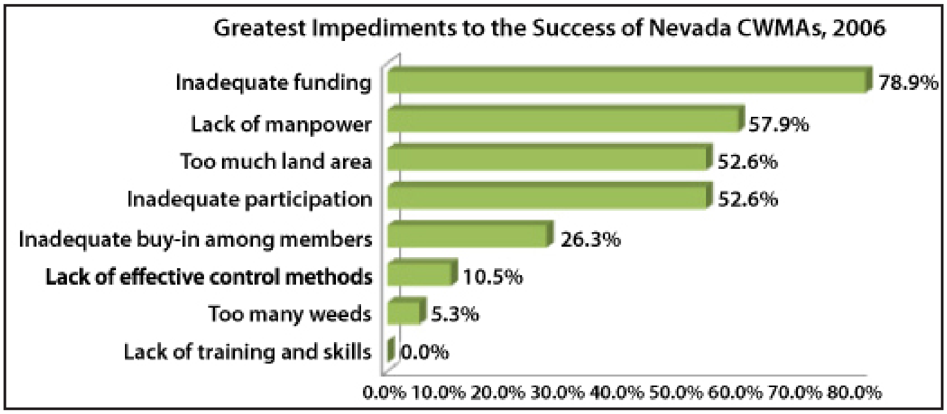

Figure 3. In a 2006 survey, respondents were asked to select the three greatest impediments to their CWMA's success (Donaldson 2006).

Geographic area

Particularly in the western states, many groups encompass large geographc areas, sometimes 10,000 square miles or more (Figure 4). Group members must travel long distances to attend meetings, and their expenses are often not reimbursed. They feel separated from sources of support and information at the state level. One respondent said, "One of the greatest barriers is that we are so scattered. People live far away from each other and have trouble staying cohesive. There's a lack of guidance."

Funding

The need for adequate funding that allows groups to control weeds and document measureable success is essential to group survival. One group member noted that it is "...crucial to have sufficient funds so CWMAs feel they're doing something significant and effective." When asked what would happen if grant funds were no longer available from the Nevada Department of Agriculture (NDOA), respondents noted, "Two thirds of our funding comes from NDOA pass-through grants. The ability to treat and do outreach would be severely limited," and "It would hurt our CWMA greatly. There would be less involvement and implementation because we need money to buy supplies to use on the weeds."

Buy-in

Both group members and residents must support the need for group activities and weed management. Support includes not only funding, but also volunteer labor for control projects or outreach, and support from agency officials to allow their staff to participate in the group. Respondents noted, "Public [sic] doesn't understand the negative financial impact noxious weeds have on productive ground and natural resources," and "It comes down to people showing up and being strong participants and leaders in the organizations. These numbers are few and seem to continue dwindling from year to year."

Leadership

After groups form, a honeymoon period often results, in which groups are very active and members are fully involved. With time, however, as job responsibilities change, many groups find themselves with a leadership void. The position of leader or coordinator is integral to group success. This person keeps members informed, facilitates meetings, serves as a central point of contact and information for the group, retains documents, and keeps members motivated and involved. A passionate and committed coordinator with good leadership and administrative skills helps to focus and keep members productive. Respondents noted, "Just finding someone to lead and coordinate is extremely difficult," and "Without a coordinator working to keep things going, I'm afraid the group would fizzle. It's hard to get people to come together to meetings and probably wouldn't happen if coordinator didn't do a phone campaign the week before to get written reports or commitments from stakeholders."

Burnout

As groups mature, if the leadership position is not transitioned, the risk of burnout increases, especially in small groups that rely on the coordinator for the majority of group activities. Some

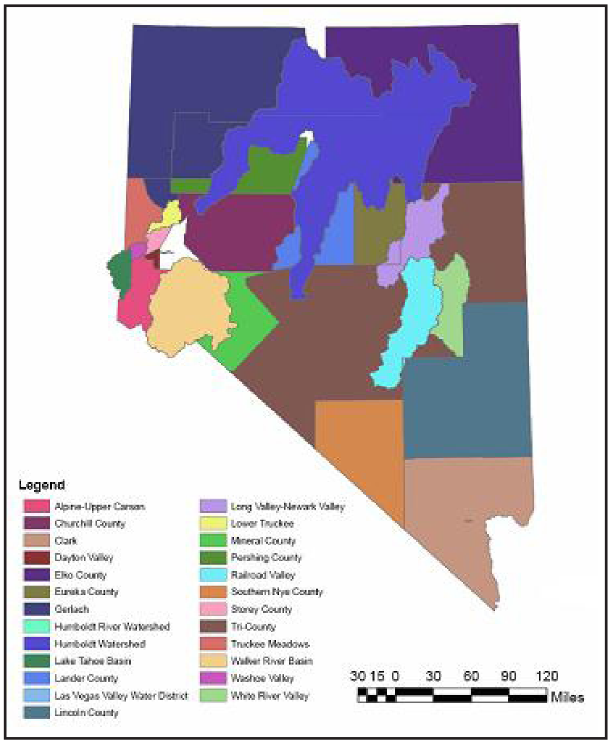

Figure 4. Nevada's Cooperative Weed Management Areas, January 2009.

groups seek to overcome burnout by hiring a paid coordinator. Others transition the leadership role, or share the leadership burden with a co-leader or vice chair.

Regardless of the solution, groups agree that they, "...must have dedicated, passionate coordinators. We'd have to find another staff person with the passion, commitment, and support of their agency to coordinate the group [if current coordinator quit]."

Time and knowledge

Members perceive one of the strengths of the group as being the "combined knowledge available through the group members, and members' willingness to share and help all involved." However, they also note that members and volunteers have limited time and skills, and can be selective about the support they provide. Said one respondent, "If you rely on volunteers, they may not have the time, skills, level of commitment, or resources and experience to address all the needs of the group. Volunteers come and go, and can choose what they do and don't do. Most volunteers are not skilled in grant-writing and project administration."

Summary

By identifying barriers to success, CWMAs can plan to overcome those barriers. This includes recruiting, training, and supporting group leadership; planning ahead for adequate funding; sufficient public education and outreach to maintain a sense of urgency for weed management; a forum for sharing group knowledge; recognition of geographic barriers to participation; and regularly celebrating successes. As CWMAs mature nationwide, support will be needed to keep them productive.

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Weeds Cross Borders Project: United States–Canada Collaboration

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Abstract

Okanogan County, at 3.1 million acres, is the largest county in the State of Washington. Programs that cross jurisdictional boundaries, as well as cooperation and partnerships, are vital. This presentation will outline the process taken by the Weeds Cross Borders project to develop a Memorandum of Understanding between Okanogan County and two weed districts in Canada, and how laws, policies, and regulations were addressed within those jurisdictional boundaries. Discussion topics include: identification of priority areas and target species, control measures, surveying and mapping efforts, public outreach and education activities, and legislative tours.

Coordination and implementation efforts, as well as the strengthening of partnerships, continue as the Weeds Cross Borders project expands, the public becomes more involved, and new partners join project efforts. The project has been a huge success. Support for the project continues to grow and efforts to seek and secure long-term funding through combined agency budgets persist. Together, we can and will continue to make a difference.

Resumen

El condado de Okanogan, 3.1 millones de acres, es el condado más grande en el Estado de Washington. La presentación bosquejara y presentara el proceso adoptado desde 2000 para desarrollar un memorando de entendimiento entre el condado de Okanogan, Washington y dos zonas de malezas en Canadá y cómo las leyes, políticas y reglamentos se abordaron dentro de los límites jurisdiccionales. Las áreas prioritarias se identificaron, especies blanco se identificaron, las medidas de control, estudio/mapas, divulgación, educación, utilización grupos para el de control a mano y Giras de Legislativos serán discutidos. Coordinación, ejecución y fortalecimiento de las alianzas continuará en la medida que el proyecto se expande, el público estará mas involucrado y nuevos socios aunaran esfuerzos. Cross Borders Proyect sigue siendo un gran éxito como el apoyo para el proyecto sigue creciendo con el compromiso de buscar y obtener financiación a largo plazo a través de los presupuestos combinados de las agencias y del Congreso de legisladores. Juntos hemos, podemos y vamos a seguir haciendo una diferencia.

Introduction

The Weeds Cross Borders project is a collaborative effort by land managers, state agencies, and regional invasive plant committees in the greater Okanogan region of the United States and Canada. Okanogan County, Washington alone encompasses an area of 3.1 million acres and is the largest county in the state. It is therefore that programs which cross jurisdictional boundaries are essential. In order to provide an integrated long-term noxious weed program for landowners and land managers on both sides of the border, emphasis must be placed on pulling people, programs, agencies, and imaginary lines together.

The Weeds Cross Borders Coordinated Weed Management Area (CWMA) project began as an effort to work around the differing legal requirements on both sides of the border in order to implement weed control actions. Strategic meetings were held to discuss shared programs, new invaders, and coordination and control programs, and led to a coordinating group.

Once the Weeds Cross Borders CWMA boundaries (Figure 1) were outlined, the organizers contacted all the necessary agencies and began the process of developing a Memorandum of Understanding (MOU) to formally establish the group. CWMA members held Individual meetings with agency representatives to address their concerns, how they might participate, and what they might contribute to the project (considering agency budgets and staff). The information gathered from each meeting was compiled to address the concerns and comments about the project, mostly regarding budgets (for example, budget requirements that prevent the use of agency money and staff time outside the county). Eventually, the necessary adjustments were made to ensure that interested groups on both sides of the border were able to participate in the project, and a draft MOU was developed and presented to each agency for review.

The MOU was eventually signed by the Washington State Department of Transportation, South Okanagan–Similkameen Invasive Plant Society, Boundary Weed Management Committee, British Columbia Ministry of Transportation, Washington State University–Okanogan County Extension, Washington State University–Ferry County Extension, Ferry County Noxious Weed Control Board, and Okanogan County Noxious Weed Control Board.

First Steps

Once formally established, Weeds Crosss Borders project participants surveyed and mapped a five-mile radius on both sides of the border. Meetings were then held to discuss the findings and review the maps. A "top 10 species" priority list was requested from each agency involved and the results were compiled to form a list of five priority species. With the list in place, project

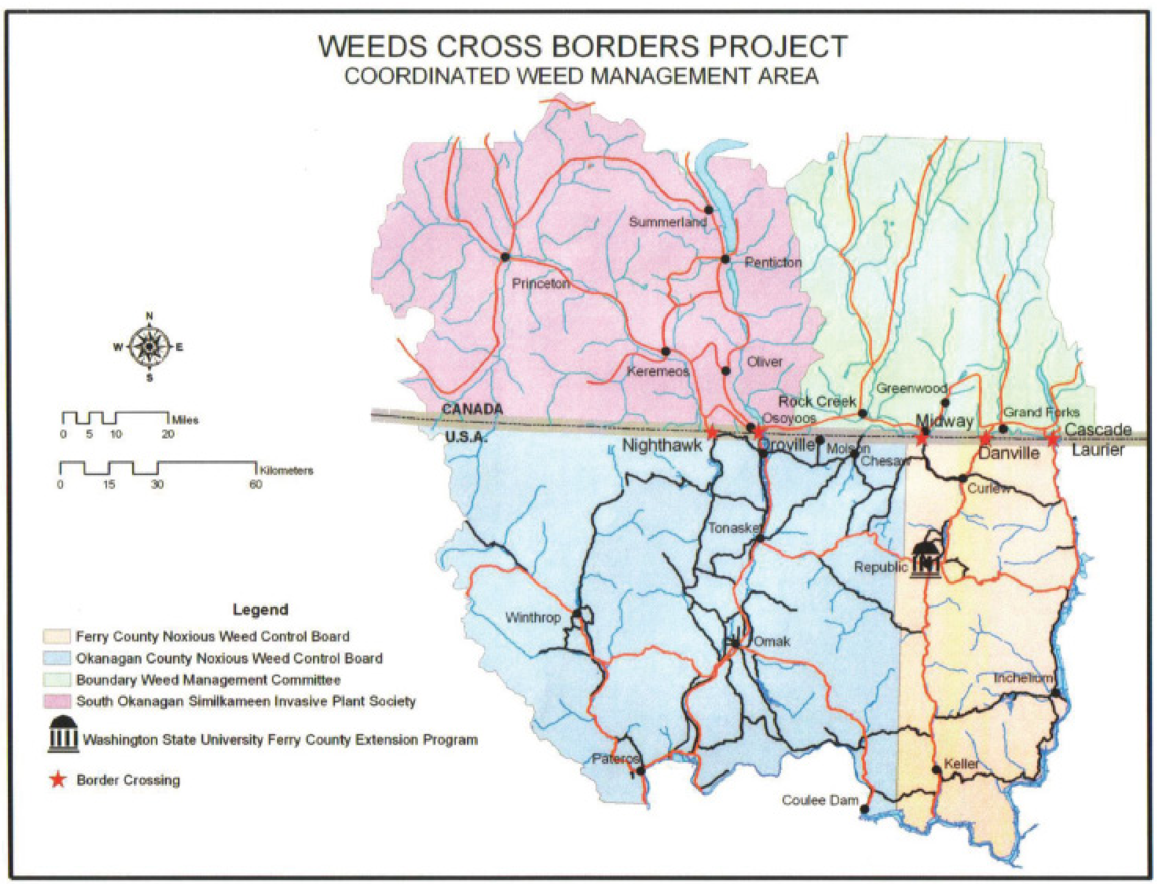

Figure 1. Weeds Cross Borders Coordinated Weed Management Area boundaries.

participants analyzed control strategies, taking state and provincial weed laws into account. Priority species, weed law discrepancies, and control strategies included:

Mirabilis (Mirabilis nyctaginea)

Mirabilis, also known as wild four o'clock, is listed as a "Class A" noxious weed by Washington State Noxious Weed Law RCW 17.10 and requires eradication, while British Columbia requires no control. Mapping efforts identified mirabilis along Canada Highway 97, three miles from the Canada–US border. Until then, the closest known mirabilis population within Okanogan County was located approximately 40 miles south of the border. In order to reduce the spread of mirabilis along Highway 97 and into Washington, Lisa Scott of the South Okanogan–Similkameen Invasive Plant Society developed a long-term site specific control program.

Musk thistle (Carduus nutans)

Musk thistle, also known as nodding thistle, is listed as a "Class B" noxious weed in Washington, a designation that requires prevention of all seed production, while British Columbia is focused on biological control efforts. Musk thistle was found along the Canadian border, across the fence from landowners in Okanogan County. Barb Stewart of the Boundary Weed Management Committee developed a long-term, site-specific control program, working with landowners on the Canada side of the border to prevent seeds from blowing across the fence, and coordinated musk thistle hand-pull crews to remove the plants from both sides of the fence line to create a buffer zone area.

Puncturevine (Tribulus terrestris)

When puncturevine, a "Class B" noxious weed in Washington, was located in the Oroville, (Okanogan County) Washington area, it was cause for concern in British Columbia, where control is required. The Okanogan County Noxious Weed Control Board developed a long-term program utilizing hand-pulling and site-specific herbicide treatments to prevent the spread of puncturevine into Canada.

Purple loosestrife (Lythrum salicaria)

Okanogan County shares Lake Osoyoos, a popular recreation site, with Canada. When purple loosestrife was found to be infesting areas around the lake, biological control agents were placed at all infestations on both sides of the border. Because Lake Osoyoos tributaries drain into the Okanogan River, which empties into the Columbia River (also in Okanogan County), high emphasis was placed on preventing the spread of purple loosestrife from traveling south and infesting waterways in several counties.

Education and Public Outreach

Education and public outreach has been an important part of the Weeds Cross Borders project from the outset. In the early stages, project organizers contacted and sent informational newsletters on the project to all landowners within a five mile radius of the border (on both the US and Canada sides). The newsletters, which were sent to everyone residing within the project area, requested help from landowners—and anyone else interested—in project efforts. A booklet, titled "Weeds Cross Borders: A Guide to Identifying Invasive Plants and Weeds," was designed to promote invasive plant identification. The booklet was a collaborative effort by the Okanogan County Noxious Weed Control Board, Washington State University–Ferry County Extension, Boundary Weed Management Committee, South Okanagan–Similkameen Invasive Plant Society, Ferry County Noxious Weed Control Board, Washington State Department of Transportation, and the British Columbia Ministry of Transportation. Each year, 5,000 copies of the newsletters and booklets are printed and distributed at educational meetings to the public free of charge.

Additional Weeds Cross Borders education and outreach efforts include: a series of press releases, flyers, poster displays, weed cards, and calendars. In 2009, several "Weeds are a Pain in the Grass" signs were created and placed at several strategic locations along highways in Canada, and Okanogan and Ferry Counties. The signs list the project partners as well as the phone number for the Okanogan County Noxious Weed Control Board office.

Legislative Tours

Tours were organized for state and federal representatives and senators from Washington, and members of British Columbia's legislative assembly, in 2000 and 2002, and annually from 2004–2007. The tours were designed to update legislators from both countries on the progress of the Weed Cross Borders project. Stops along the tour included the project's top priority noxious weed sites, where tour guides discussed the program and the overall need for it, and gave an overview of the long-term problems likely to arise if an integrated approach to control priority species is not utilized.

Legislative tours continue to be an effective way to introduce newly elected Representatives and other lawmakers to the Weeds Cross Borders project. In 2007, S-K Environmental provided a vehicle washing demonstration for tour participants, washing several vehicles crossing the US–Canada border. Sheilah Kennedy, owner of S-K Environmental, explained to the tour participants that the WB 500 Portable Invasive Species Rinse and Reclaim System is the most effective invasive prevention tool available for boats and other vehicles, and that it can be incorporated into any Early Detection and Rapid Response program.

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Facilitating Cross-border Cooperation

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Abstract

The US Department of State is the senior foreign affairs agency of the US government. It leads in establishing bilateral and multilateral frameworks through which we develop and implement policies with partner countries. The Department manages our borders with Canada and Mexico through several joint commissions, both bilateral and trilateral. While primarily focused on making our borders safe and secure, our challenges are diverse, ranging from rivers and lakes to efforts aimed at limiting the trafficking of drugs and activities of organized crime. The Department works with other federal agencies and states along the borders to ensure that our policies are appropriate and effective.

Resumen

El Departamento de Estado de los EEUU es una agencia superior de asuntos exteriores del gobierno de EEUU Lleva en el establecimiento de los marcos bilaterales y multilaterales a través del cual desarrollar y aplicar políticas con los países socios. El Departamento gestiona nuestras fronteras con Canadá y México a través de varias comisiones mixtas, bilaterales y trilaterales. Aunque principalmente se centra en hacer de nuestras fronteras seguras, nuestros desafíos son diversos, que van desde los ríos y lagos a los esfuerzos destinados a limitar el tráfico de drogas y las actividades de la delincuencia organizada. El Departamento trabaja con otras agencias federales y estados a lo largo de las fronteras para garantizar que nuestras políticas son apropiadas y efectivas.

Good morning! I am going to talk about the role of the Department of State in developing and managing border relationships with our two land neighbors, Canada and Mexico. We have several structures in place for developing policies that support our mutual interests. Some of them also touch on invasive species.

I don't have to tell you that the problem of invasive plants is one that gets little publicity, in contrast to some invasive animals. And yet the damage to our economy is significant and serious.

The Department of State plays an important facilitating role in the ongoing struggle against non-native invasive species. We generally work through the National Invasive Species Council along with our interagency colleagues, led by the departments of Interior, Agriculture and Commerce. We also work with agencies such as Customs and Border Protection and the Forest Service, which are represented on this panel. Our effort to address this ongoing invasion necessarily involves our neighbors and trading partners.

In this session, I want to focus on how the Department of State has helped engage Canada and Mexico. We could delve into our relations with the Caribbean, which was dubbed "America's Third Border" during the previous administration. Do not forget that we also share a maritime border with Russia. But these other relationships are outside the focus of my talk, as neither of them is a true land border.

As you probably know from your schoolbooks, the United States and Canada have a long history interlocked with our colonial parentage. The need to manage our border grew as settlements stretched across the continent.

It is interesting to see it as you drive through the border at certain places. In preparing for this meeting, I learned that there are people out there with jobs that require them to go out from time to time to identify exactly where the border is. No, the border doesn't move, but it isn't fenced and policed like many around the world. Rather, there are posts or markers that occur in spots, and the ground is manicured between them. The border was surveyed and marked in the 1870s, after it was defined in treaties.

There are two principal mechanisms for managing our border with Canada: the International Boundary Commission and the International Joint Commission. I will talk about each one in turn.

The job of managing the physical border is that of the International Boundary Commission. It was set up by a treaty in 1908 and later was made permanent caretaker of the border. This is no small task—the boundary is over 5,000 miles long, and there are over 8,000 border monuments and reference points. The vista along the boundary is supposed to be 20 feet wide.

The Commission is overseen by two commissioners. The American one is appointed by the President and reports to the Secretary of State. Officially, the Commission maintains the boundary in a so-called "effective state of demarcation." They inspect it regularly. They repair, relocate, or rebuild damaged monuments or buoys as needed. They keep the vista cleared and have new boundary markers erected at locations like new road crossings.

The other joint body we have with Canada is the International Joint Commission. Set up under the 1909 Boundary Waters Treaty, it prevents and resolves disputes between our two countries. It serves as an independent and objective advisor to the two governments. The Commission, or IJC, rules on project applications affecting boundary waters. It assists in protecting the trans-boundary environment, and it alerts our governments to emerging issues along the boundary that could lead to disputes.

The IJC was created because both countries recognized the effects of each other's actions on lake and river systems along the border. Our water needs can differ and come into conflict from time to time. The IJC can be asked to approve applications for dams or canals. It can set conditions to limit water levels and flow rates in order to protect different interests. Those interests can range from shoreline properties to farmers and shippers.

We don't have time here to look exhaustively at the work of the Commission. For now, I would like to zero in on water quality in the Great Lakes, which is a major part of the Commission's work, and is near to my heart as a native Michigander.

Much of the IJC's work on the Great Lakes dates from the US-Canada Great Lakes Water Quality Agreement of 1972. It is devoted to controlling pollution and cleaning up wastewater from industries and communities. Our governments have since amended that Agreement twice to enable work on persistent toxic substances and on 43 areas of concern. The US and Canada currently are in negotiations to further update the Agreement.

Now it's not just because I'm from that area that I cite the Great Lakes. Rather, I wanted to note that the Agreement includes a commitment to assess and support scientific research that deals with ecosystem sustainability in the Great Lakes. In particular, that entails oil and gas drilling and non-native species proliferation.

The IJC holds public meetings every two years to discuss progress in cleaning up the Great Lakes. Those meetings are an opportunity to influence the work of the Commission. The IJC is always open to new ways to work with other levels of government and with individuals, as well as research and environmental organizations, and unions and business.

Now let me move on to talk about our partnership with Mexico. The border challenges we face are different in several ways. I am not going to address the matter of immigration, which has been in the media a lot lately because of developments in the state of Arizona, nor am I going to address the serious problems of drug trafficking and organized crime. However, they have a lot to do with our overall approach to the border.

The US and Mexico have a shared interest in creating a 21st Century border that promotes the security and prosperity of both countries. We have launched initiatives together for developing such a framework for border management. The initiatives are based on several principles: joint border management, co-responsibility for cross-border crime, and a shared commitment to the efficient flow of legal commerce and travel.

Our relationship with Mexico is economically important. The country is the number one or number two destination for exports from 22 states. Cross-border trade contributes enormously to the economic vitality of both countries, especially in the border region. We consider engaging border communities, as well as state, local, and tribal governments, to be an essential part of collaborative border management.

In contrast to the two commissions we have with Canada, the US and Mexico manage their border through a single entity—the International Boundary and Water Commission. This Commission has its roots in the treaty that ended the Mexican-American War in 1848, and the Gadsden Treaty of 1853. Temporary joint commissions were set up to demarcate and manage the new boundary. The US and Mexico set up the International Boundary Commission in 1889, which is the direct predecessor to the modern-day commission.

One of the biggest challenges through the years has been managing the water of the Rio Grande. We have concluded various agreements for that purpose. The Water Treaty of 1944 formally recast the boundary commission as the International Boundary and Water Commission. It said that the commission's jurisdiction should include the Rio Grande and the Colorado River, as well as the land boundary. That treaty allocated water to each side in very specific terms, based on flow rates of tributaries and complicated formulas. Subsequent treaties have helped to resolve all remaining boundary differences.

Like the IJC with Canada, the US-Mexico joint commission—the IBWC—deals with issues like water sanitation. However, it also has the core task of demarcation of the land boundary, and a range of tasks involving the Rio Grande and Colorado River. Some of the work of the IBWC in recent years has dealt with invasive species.

The US and Mexico have worked through the Commission on aquatic and riparian invasives affecting the Lower Rio Grande and Lower Colorado River. Among the invasives addressed over the last decade are giant salvinia *(Salvinia molesta)*, quagga mussels *(Dreissena bugensis)*, hydrilla *(Hydrilla verticillata)*, water hyacinth *(Eichhornia crassipes)*, saltcedar *(Tamarix* spp.*)*, and a species of arundo known as carrizo or giant rivercane *(Arundo donax)*.

Before closing, I feel that I should give a brief word about trilateral cooperation. First, under the North America Free Trade Agreement (NAFTA), there are side agreements. One of them paved the way for the Commission for Environmental Cooperation (CEC) in North America. The lead implementer of the CEC in the US Government is the Environmental Protection Agency. The mission of the CEC includes addressing regional environmental concerns, helping to prevent potential trade and environmental conflicts, and promoting enforcement of environmental law.

Outside of NAFTA there is another trilateral entity that is managed on the US side by the US Fish and Wildlife Service. It is the Canada/Mexico/US Trilateral Committee for Wildlife and Ecosystem Conservation and Management. The Trilateral Committee involves wildlife agencies of the three countries. It is aimed at conserving and managing biological diversity and ecosystems of mutual interest. While neither of these is a border agreement, they do address shared environmental issues and could play roles in responding to invasive incidents.

To summarize, the Department of State plays an important role in establishing the frameworks through which we manage our borders with Canada and Mexico. Grounded in bilateral treaties—or a multilateral one in the case of NAFTA—those bodies operate autonomously to address and solve problems of mutual concern. Water is a chief focus of both border regimes, but they also have other concerns to address. My colleagues in the Department work closely with both bilateral commissions and our interagency partners as we seek to ensure that our relations remain as cordial and friendly as they are today.

Peeling Back the Onion: Conflicting Policy Objectives and Biosecurity in United States Government Agencies

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Editor's note: This paper is based on the content of two presentations, "Bioeconomics of Invasive Species and the Horticulture Industry" by John Peter Thompson and "Trade Secrets: A Potential Policy Barrier to Cooperation in Biosecurity Along Global Trade Pathways" by John Waugh. Abstracts for the original presentations are published at the end of this volume.

> "God grant us the serenity to exercise our bounded rationality freely in the systems that are structured appropriately, the courage to restructure the systems that aren't, and the wisdom to know the difference."
> —*Donella Meadows* (Meadows 2008)

Executive Summary

Government policy must balance a wide range of potentially conflicting objectives in an atmosphere of uncertainty. In the United States, as in all other states engaged in international trade, policies must balance trade promotion and the management of potentially deleterious impacts resulting from trade. The protection of national interests by government agencies with biosecurity responsibilities is an example of this phenomenon. We use the US Department of Agriculture (USDA) as a microcosm of the government policy dilemma, in order to illustrate the (often hidden) trade-offs made in balancing policies and managing risks.

Government policy is impaired when associated agencies fail to share information on invasive species and associated pathways with one another. Several different government agencies are involved in oversight of the trade pathway, where information sharing is a particular challenge. These include, *inter alia,* port authorities, Customs and Border Protection, the USDA, and the US Fish and Wildlife Service. Invasive species prevention and control is not a core responsibility of any of these agencies. In some cases, agencies have conflicting responsibilities, which inhibit information sharing. Policy review is indicated in order to expose hidden compromises that impair policies, as a first step in the elimination of conflicting roles and responsibilities. The presence of conflicting policies militates in favor of a comprehensive and legally binding national biosecurity policy encompassing prevention and control of invasive species.

Biosecurity

Biosecurity is the sum of risk management practices intended to defend against biological threats, including pests, pathogens, and invasive species (NASDA 2001). Historically, biosecurity has been a multi-jurisdictional issue involving law enforcement, public health, conservation, transportation, and agricultural interests.

Vectors of biosecurity risks include natural processes such as migration and human agency, through commerce and transportation, including all types of vessels and vehicles, all types of materiel, people and other living organisms including livestock, horticultural stocks, agricultural commodities, pets and captive wildlife (Reaser and Waugh 2008). Many introductions are intentional, for public benefit, such as new plants and plant varieties in horticulture and agriculture. Others are purely unintentional, in the form of "hitchhikers" on or in intentionally introduced organisms or on inanimate objects such as ships hulls, in ballast water, and in packing material. Another class of biosecurity risk is introduction with the intention of doing harm, in the form of weaponized or highly infectious human or agricultural pathogens, for example. All share in common the need for vigilance at transit points such as ports and other points of exposure to the environment conducive to release, capacity for their identification and risk classification, and surveillance and rapid response systems to contain outbreaks.

Managing Risks in a Complex Policy Environment

Well-informed policy decisions are based upon high-quality data (Executive Order 13112). Risk assessments and surveillance systems break down when the authority and expertise are distributed among different agencies, but the information is not. Risk management may not be the primary mission of the agency. There may, for example, be barriers to risk management in the form of liabilities.

Example of Competing Mandates: The Department of Agriculture[1]

Public support for a government role in agriculture goes back to the origins of the US. George Washington recommended, in his last annual address to Congress in 1796, that it establish a National Board of Agriculture (Keller 2009; NASS 2010). The USDA was finally created in 1862 under the administration of President Abraham Lincoln as an independent agency without Cabinet status (7 USC §2201). The precursor to the USDA was the Agricultural Section of the US Patent Office, the function of which was to support the development of useful plant varieties. The first patent ever granted by the Patent Office was for an agricultural product, a method for the manufacture of potash for use in fertilizer.

The law establishing the new Agriculture Department stipulates that its role would be to:

> "…acquire and to diffuse among the people of the United States useful information on subjects connected with agriculture, rural development, aquaculture, and human nutrition, in the most general and comprehensive sense of those terms, *and to procure, propagate, and distribute among the people new and valuable seeds and plants*."

In 1790, nine out of 10 Americans lived on farms. By the dawn of the Civil War, 64 percent of the rapidly industrializing American population still lived on farms; the new Agriculture Department was a fundamentally populist initiative to bring government services to the general public. In his second inaugural address, President Lincoln noted that the "Agricultural Department…is peculiarly the people's Department, in which they feel more directly concerned than in any other. I commend it to the continued attention and fostering care of Congress" (Lincoln 1864).

The USDA was elevated to Cabinet status in 1889 and its mission has evolved with the times. The current vision statement of the department is to be "a dynamic organization that is able to efficiently provide the integrated program delivery needed to lead a rapidly evolving food and agriculture system." "Integrated program delivery" continues to serve food production; the constituents, however, are different; the USDA's clients are now primarily agricultural corporations. Today, fewer than two percent of Americans live on farms and only 17 percent live in rural areas. American agriculture, having long ago transitioned from subsistence to commodity production, is vertically organized on industrial lines and globally integrated. The US is a major food exporter and the promotion of trade in agricultural products is a key function of the USDA.

In the decades after Civil War, the US Supreme Court substantially limited the power of state and local authorities to quarantine plants in deference to national interests in facilitating national commerce. And when responsibility for plant germplasm passed from the Patent Office to the newly created Department of Agriculture,

[1] The USDA is not singled out in this paper for special consideration by virtue of any factor beyond its seniority and the significance of agriculture in US history. It forms a convenient microcosm for the conflicts that the government faces as a whole in balancing economic development and the public interest.

one aspect that did not convey was the extensive capacity for plant propagation. Until later efforts by USDA botanical explorer David Fairchild, commercial nurserymen led the vanguard in finding and distributing new species (Pauley 2007), and regulation of introductions as largely absent.

> "Amateurs and nurserymen devoted a great deal of attention to the task of learning about, acquiring, propagating and caring for new kinds of plants. They created networks that crossed class lines and extended throughout the Northeast and into the Midwest. Building on European traditions, they articulated theories of improvement and, more influentially, a web of meanings that connected particular kinds of plants, their origins, and their potentials with the future development of the American nation…Plants disrupted American's cultural practices, and reordered their cultural categories; they generated new social relations and new national identities." (Pauley 2007)

The USDA's David Fairchild (1869–1954) was the father of systematic plant introduction, which led to a major transformation of American agriculture through the introduction of new agricultural species into the country, including soybeans. In his role as the head of the Department of Plant Introductions (a forerunner of the Agricultural Research Service), Fairchild, a restless botanical explorer and evangelist of useful plant species, combed the world, collecting and introducing to the US over 200,000 plant varieties.

Within the USDA, specialized agencies have also kept pace with the changing times. The Animal and Plant Health Inspection Service (APHIS) is tasked to protect the health and value of US agricultural, natural, and other resources. APHIS also has origins in the Agricultural Section of the Patent Office, where an Office of Entomologist evolved into a Division of Entomology after the creation of the Agriculture Department, and Bureau of Entomology in 1904 (CRS 2005).

A contemporary of Fairchild at the USDA, Charles Marlatt, of the Bureau of Entomology, also helped transform American agriculture through pioneering work in integrated pest management, and developing the capacity within the Department to regulate the movement of species across boundaries in the first decade of the 20th century. This became codified in the 1912 Plant Quarantine Act, which created a Bureau of Plant Quarantine to exercise the authority to regulate importation and interstate trade in nursery stock as vectors of agricultural pests and diseases.

The Bureaus of Entomology and Plant Quarantine were merged in 1934 into a Bureau of Entomology and Plant Quarantine in the USDA. APHIS was established in 1972 with the integration of USDA's veterinary services (CRS 2005). The Plant Protection Act of 2000 is a consolidated APHIS statute (7 USC §7701 *et seq*.).

These institutions have evolved to advance agriculture, and agriculture has evolved to become dominated by large trading interests. When the USDA says that its vision is to provide "integrated program delivery" for agricultural systems, and APHIS protects the health and value of agriculture, they are referring to serving a corporate clientele engaged in global trade in agricultural products, as well as supporting American food security.

To understand why the mission of promoting American agriculture may conflict with biosecurity, it is useful to consider an episode from the earliest days of the American republic. In 1777, during the War of the American Revolution, wheat fields from Long Island to the precincts of Princeton, New Jersey were devastated by a new pest, a member of the gall midge family called the barley midge, or more ominously, the Hessian fly. Observers drew a correlation between the presence of the Royal Army auxiliaries primarily from the province of Hesse[2] (ancestral home of the ruling Hanover dynasty of Great Britain). Contemporary accounts suggested that the damage incurred by the fly was far more difficult to contain than that inflicted by the eponymous soldiers.

Agronomist and future president Thomas Jefferson studied the fly, and like his contemporaries initially concluded that the pest was of native origin, but determined that the fly did not

[2] "Hessian" quickly became a popular epithet equating the despised soldiers with low character, giving an additional layer of meaning to the popular name for the fly, a "useful National Prejudice" in the words of George Morgan, credited with the sobriquet.

infest the wheat grains.

The infestation intensified and spread southward through the breadbasket of the mid-Atlantic states. In the spring of 1788, the English consul in Philadelphia, Phineas Bond, sent a stern warning of the severe infestation to London. In response, a British Order in Council prohibited the importation of American wheat, precipitating the new nation's first major economic crisis. From Paris, Jefferson protested in a letter to Benjamin Vaughan:

> "Your nation is very far from the liberality that treaty inculcates. The proposed regulation on the subject of our wheat is one proof. The prohibition of it in England would of itself be of no great moment, because I do not know that it is much sent there. But it is the publishing a libel on our wheat sanctioned with the name of parliament, and which can have no object but to do us injury by spreading a groundless alarm in those countries of Europe where our wheat is constantly and kindly received. It is a mere assassination. If the insect they pretend to fear be the Hessian fly, it never existed in the grain." (Boyd et al. 1950)

The character assassination of American wheat is a significant observation because the damage was not so much through limited British trade, but through trade with the European continent, which was substantial. Ultimately, science was able to prevail over sentiment, and after it was clearly established that the so-called Hessian fly was common in Europe, the reputation of American agriculture was gradually restored. But the lessons of the Hessian fly include the recursive character of risk assessment; risk can become embedded in the very information used to assess risk.

Managing impressions is essential in preventing irrationality on the part of trading partners and consumers in general. More ominously, the mandate to promote trade for and enhance the value of the products of the industry which an agency is supposed to regulate creates appearance, and possibly the risk of regulatory capture, a condition in which the regulator acts in the interests of those being regulated rather than the public at large.

Trade Secrets

A compounding issue is that of trade secrecy. Monitoring trade pathways requires access to information on imports and exports, including specifics on the traded items, their origins, quantities, and destinations. Since invasive species can be associated with virtually any kind of commodity, from fruit to ceramic tile, spools of steel cable and wine bottles, biosecurity defense requires access to large amounts of sometimes sensitive information.

18 USC §1839 regulates the protection of trade secrets. It defines trade secrets as:

> "…all forms and types of financial, business, scientific, technical, economic, or engineering information, including patterns, plans, compilations, program devices, formulas, designs, prototypes, methods, techniques, processes, procedures, programs, or codes, whether tangible or intangible, and whether or how stored, compiled, or memorialized physically, electronically, graphically, photographically, or in writing…"

18 USC §1902 stipulates that:

> "Whoever, being an officer, employee or person acting for or on behalf of the United States or any department or agency thereof, and having by virtue of his office, employment or position, become possessed of information which might influence or affect the market value of any product of the soil grown within the United States, which information is by law or by the rules of such department or agency required to be withheld from publication until a fixed time, willfully imparts, directly or indirectly, such information, or any part thereof, to any person not entitled under the law or the rules of the department or agency to receive the same; or, before such information is made public through regular official channels, directly or indirectly speculates in any such product by buying or selling the same in any quantity, shall

> be fined under this title or imprisoned not more than ten years, or both."

18 USC §1905 adds:

> "Whoever, being an officer or employee of the United States or of any department or agency thereof…publishes, divulges, discloses, or makes known in any manner or to any extent not authorized by law any information coming to him in the course of his employment or official duties or by reason of any examination or investigation made by, or return, report or record made to or filed with, such department or agency or officer or employee thereof, which information concerns or relates to the trade secrets, processes, operations, style of work, or apparatus, or to the identity, confidential statistical data, amount or source of any income, profits, losses, or expenditures of any person, firm, partnership, corporation, or association; or permits any income return or copy thereof or any book containing any abstract or particulars thereof to be seen or examined by any person except as provided by law; shall be fined under this title, or imprisoned not more than one year, or both; and shall be removed from office or employment."

Clearly, there is significant incentive for caution in the use of data collected in the course of managing trade pathways. Given the alignment of interests between the regulators and industry, and the strong pressure from the top to produce, is the inability to share information a symptom of regulatory capture in this sector?

The Predicament of Security

As noted earlier, the USDA is a microcosm for the predicament of government generally, which must provide a secure environment that balances economic development and the public interest as reflected in health, safety, protection of civil liberties, and protection of the environment. If the mission of the USDA is both to protect the value of agriculture, and regulate it to ensure health and safety, it can become internally conflicted, especially if it is but one of several actors in a risk assessment process that requires its cooperation.

In 1908, David Fairchild, the USDA botanical explorer, who had been actively promoting the planting of flowering Japanese cherries in Washington, received the support of First Lady Helen Taft for a large-scale planting in Washington's monumental core. This led to a donation of 2,000 trees by the City of Tokyo. Charles Marlatt, the USDA entomologist, and his staff discovered that the trees were infected with plant diseases and pests, and burned the trees. The trees were replaced with healthier specimens, with little apparent damage to US–Japan relations, in 1912. *Sic transit gloria mundi.*

Given the need to share information in order to assess risks, and the risks of sharing information generally, a case can be made for consolidating risk management within a single agency, so that all the elements can be assembled and managed with appropriate levels of security.

The USDA is not the only agency with conflicting missions; the Department of Homeland Security (DHS), for example, is by its own admission sharply focused on combating domestic terrorism, yet it has the responsibility for a range of other public safety issues, including that of biosecurity. In 2001, the Agricultural Inspection Service of APHIS was reassigned to the DHS as part of a federal consolidation of border security functions.

When one of the functions is regulatory, the failure to balance competing mandates risks raising the specter of regulatory capture, whether or not the concern is justified. Regulatory capture certainly does happen, as the failure of the Minerals Management Service to effectively regulate offshore oil and gas development illustrates. The Deepwater Horizon tragedy is likely to bring further scrutiny to risk assessment across a range of environmental management functions.

Possible Solutions

A range of steps can be taken to strengthen risk assessment capabilities in the area of biosecurity. The first would be to make the trade-offs and compromises made in balancing conflicting objectives explicit. Stakeholder analysis identifies key actors and their interests within a system (Grimble and Wellard 1997).

This would contribute to a clarification of roles and responsibilities under Executive Order 13112, mandating a National Invasive Species Management Plan, including those of information management, information exchange, and risk assessment (Executive Order 13112).

A further step would be legal review with the aim of harmonizing trade, national security, and environmental protection, and assessing measures necessary to protect agencies and their staff that exchange sensitive data in the course of executing their duties.

The development of a comprehensive national biosecurity policy, with appropriate revisions to federal law and regulations, would further clarify US policy.

Such a review process should consider whether or not risk assessment and regulation needs to be organized separately from other functions in a new agency. Ultimately, this is probably unworkable, because the nature of biodiversity is that of a dynamic system working on multiple scales. Successful biosecurity risk assessment requires the expertise of a range of government experts in a wide range of disciplines. Success will ultimately depend upon policies and information systems that operate across agencies to bring the best expertise and the correct authorities to bear on the problem. The key in all of this is to support the agencies with clear guidance and sufficient resources to act in the public interest.

> "The bounded rationality of each actor in a system—determined by the information, incentives, disincentives, goals, stresses, and constraints impinging on that action—may or may not lead to decisions that further the welfare of the system as a whole. If they do not, putting new actors into the same system will not improve the system's performance. What makes a difference is designing the system to improve the information, incentives, disincentives, goals, stresses and constraints that have an effect on specific actors." (Meadows 2008)

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Invasive Species, Border Enforcement, and Firm Behavior

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Abstract

Food and product imports improve consumer welfare by increasing the availability and diversity of product offerings but may also introduce sanitary and phytosanitary risks. These risks include health risks from adulterated products, diminished productivity from invasive pests, and environmental damage from non-native species. In the United States, US Department of Agriculture budgets devoted to emergency eradication of foreign pests have dramatically increased in recent years along with public attention to food import inspection and regulation. Inspection itself represents a complicated resource allocation problem across multiple sources of risk, and any border enforcement policies may invoke strategic responses by unscrupulous importers looking to minimize the costs imposed by compliance and/or lost revenue. This presentation outlines the economic, policy, and research issues around inspection targeting, "port shopping" and other strategic behavior by importers, and alternatives to traditional border inspection regimes.

Resumen

Los alimentos y las importaciones de productos mejoran el bienestar del consumidor mediante el aumento de la disponibilidad y la oferta de diversidad de productos, pero también puede introducir riesgos sanitarios y fitosanitarios. Estos riesgos incluyen riesgos para la salud por productos adulterados, disminución de la productividad debido a plagas invasoras, y el daño ambiental por especies no nativas. En los Estados Unidos, el presupuesto del USDA dedicados a la erradicación de emergencia de plagas extranjeras ha aumentado drásticamente en los últimos años junto con la atención del público a la inspección y regulación de la importación de alimentos. La inspección en sí constituye un problema de asignación de recursos complicada través de múltiples fuentes de riesgo, y cualquier política de manejo en las fronteras podrá invocar las respuestas estratégicas de los importadores sin escrúpulos que buscan minimizar los costes impuestos por el cumplimiento y/o pérdida de ingresos. Esta presentación resume temas económicos, políticos y de investigación en torno a la inspección dirigida, "la compra en puerto" y otros comportamientos estratégicos por los importadores, y las alternativas a los tradicionales regímenes de inspección fronterizos.

[1] Presenter.

Globalization, and its accompanying increase in trade, has not been without complications. Agricultural producers in the United States claim that increases in imports under trade agreements such as the North American Free Trade Agreement (NAFTA) and the World Trade Organization (WTO), have been the main cause of an increase in invasive species introductions. They argue that USDA–APHIS (Animal and Plant Health Inspection Service) and other responsible government agencies are not adequately addressing these risks. Industry groups have also pushed for more stringent policies concerning invasive species, arguing that the United States' reputation as an exporting country needs to be protected. In contrast, foreign agricultural producers and importers argue that US producers overstate their vulnerability to pests with the aim of imposing more stringent sanitary and phytosanitary measures that effectively serve as protectionist barriers to trade. As trade volumes increase, these issues become more contentious.

The most obvious policy solution for addressing cross-border risk—increasing investment in border control measures to encourage international firms' risk-controlling behavior—is not as straightforward as it may seem. Funding is limited and border control efforts are highly complex, especially given institutional changes such as the transition of agricultural inspections from APHIS to the Department of Homeland Security, Customs and Border Protection in 2003. Increased border measures can cause indirect adverse effects, such as significant delays at the border and significant losses if products reach their final destination damaged or late. Increased border enforcement also causes unintended consequences by increasing firms' incentives for avoiding these measures.

Policy makers hope that border protection measures have a deterrent effect, that forces firms to increase "due care" with respect to pest control. However, agricultural inspection officers indicate that avoidance and evasive behavior on the part of importers is a significant and complex problem. For example, importers of high-risk goods (such as, prohibited goods or goods contaminated with pests) may attempt to circumvent enforcement efforts. Some may take overt action to avoid detection, such as falsifying cargo manifests, or placing contaminated goods in hard-to-reach locations or hidden compartments. A more subtle approach to avoid detection is "port shopping," the practice of directing shipments to ports where importers believe products will undergo less scrutiny based on the enforcement reputation of inspectors at different ports. Importers port shop in order to avoid inspectors who are considered especially effective or well informed concerning companies with poor reputations. Alternatively, firms may respond to increased enforcement with changes in import supply. That is, they may decrease the amount of goods they attempt to import, or import a different mix of goods. Even those importers who have no doubts about the quality of their goods, and have applied appropriate pest-control efforts, have incentives to avoid the inconvenience and delay associated with inspections.

Introductions of invasive species are low-probability, high-consequence events. Thus, collecting data on invasive species and trade, such as how many infected shipments pass through borders undetected or the probability of invasions resulting from these undetected shipments, is a challenge. Moreover, firm behavior, such as placing high-risk goods in hard-to-inspect locations or switching ports of entry, is difficult to quantify. This may explain in part the lack of quantitative research on border enforcement with regard to invasive species management.

To address this need, we undertook a multipart research project, funded through USDA's Program of Research on the Economics of Invasive Species, which resulted in the development of an agent-based model of border enforcement. Agent-based modeling (ABM) or agent-based computational economics, a growing area of research, allows heterogeneous agents to interact, learn, and respond within a defined system, and can predict outcomes that arise from the selection of particular enforcement instruments. These techniques are only just beginning to be applied in agricultural and environmental economics research, and have never been applied to questions of importer and inspector behavior for border enforcement and invasive species management.

We first developed a theoretical model to analyze firm response to border enforcement and a

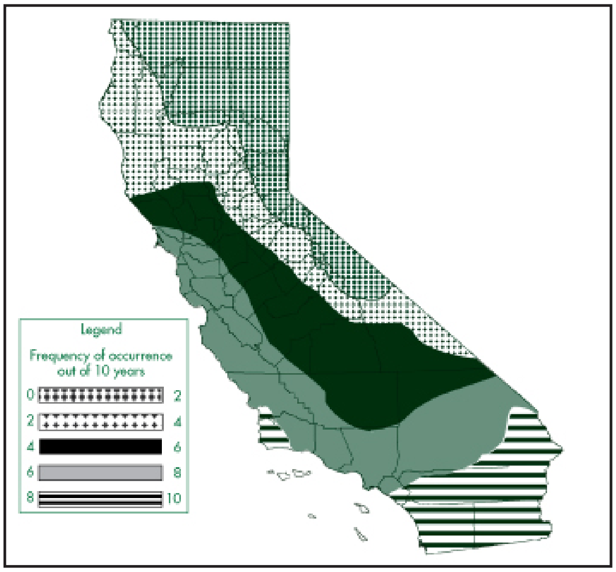

Figure 1. Probability of Adult Flea Beetle Emergence: January 15–31.

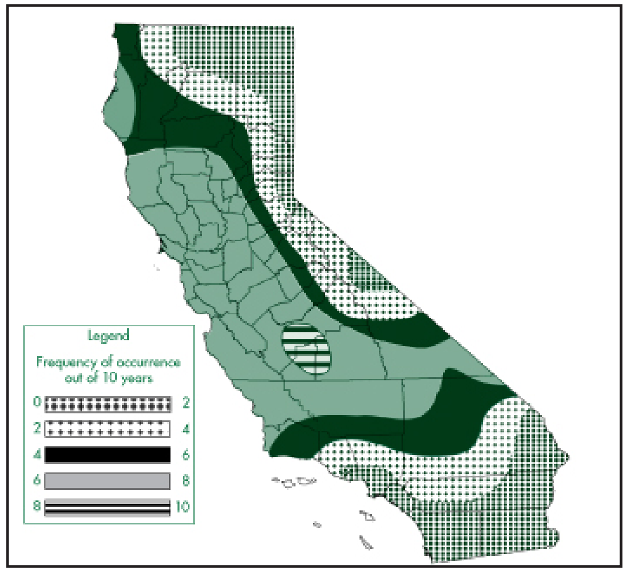

Figure 2. Probability of Adult Flea Beetle Emergence: February 15–28.

spatially explicit damage function to estimate the impacts of invasive species introductions. We then constructed an ABM framework incorporating the spatially explicit damage function, and applied the framework to a representative commodity (broccoli), invasive species [crucifer flea beetle *(Phyllotrela cruciferae)*], ports of entry (Calexico and Otay Mesa, Mexico/US land ports, respectively), and vulnerable locations (California).

We used this framework to evaluate the impacts of port-specific and importer-specific enforcement regimes for a given agricultural commodity that presents invasive species risk. The ultimate objective was to improve the allocation of scarce enforcement resources and to provide an adaptable tool that can be used by policy makers to answer further questions concerning border enforcement and invasive species risk.

The theoretical model, which provided the underlying structure for the ABM, considered two enforcement regimes (destruction versus treatment of contaminated goods) and evaluated both intended and unintended firm response, as well as pest population effects. The results indicated that increased enforcement (in the form of higher inspection intensity) will not necessarily result in reduced pest risk. Importers may respond to increased inspection intensity by lowering shipment amounts and increasing point-of-origin treatment (that is, care), but under certain conditions they may actually respond by decreasing care in order to lower the cost of shipment. Similarly, these same conditions also dictate whether or not firms will increase or decrease the level of care as pest populations increase at the point of shipment. In response to environmental conditions such as increased pest populations, firms may reduce output and increase due care, so a simultaneous increase in enforcement may not be necessary and, in fact, may be suboptimal. This is a critical consideration for policies that prioritize inspections on the basis of changes in the level of pests in specific exporting countries.

This model was extended to a two-port case. The results showed that a change in port-specific revenues or costs will make firms more likely to change their port choice. Less obvious were the results that a change in initial pest populations or a uniform change in enforcement may also bring about a shift in port choice. Of course, whether these changes are expected to be long- or short-term, the cost to firms to shift output between ports, along with firm type, will determine whether a change in port choice occurs.

We selected broccoli as the specific commodity pathway modeled in the project based on the data from the Work Accomplishment Data System collected by the USDA. The vast majority of the US broccoli crop is grown in California—128,500 acres in 2006. The average value of these crops was approximately $4,700 per acre. Broccoli exports in 2002 were valued at over $116.5 million, while imports were valued at $28.1 million, 89.4 percent of them from Mexico. In the upcoming years, trade volumes of broccoli may increase due to changes in broccoli tariffs under NAFTA.

The invasive species of concern for broccoli in our example is the crucifer flea beetle because of its potential as one of the most damaging pests for broccoli in California. Broccoli is shipped from Mexico to California via land ports (Calexico and Otay Mesa), airports (San Diego and Los Angeles), and marine ports (Long Beach). The analysis focused on shipments of broccoli from Mexico to California via two ports—Calexico and Otay Mesa, located in San Diego County. Calexico East handles both commercial and personal border crossings and averaged approximately 289,000 trucks per year between 2001 and 2006. Otay Mesa is the largest commercial crossing along the California/Mexico border and averaged approximately 724,000 trucks per year in the same time frame.

We developed a spatial damage function that estimated the probability of pest establishment, using a degree-day model to predict the occurrence and spread of the crucifer flea beetle in California, and the resulting damage to broccoli crops. Results from this analysis showed that the probability of emergence and spread of the crucifer flea beetle in California was higher from January through June, with the highest probabilities in January, February, and March. Examples of these probability maps are shown in Figures 1 and 2. The model assumes a constant level for the broccoli crop throughout the year. It should be noted that estimates for broccoli crop damage were based only on the influence of weather and climate as predictor variables.

The ABM was created and run in NetLogo, a free software package. A map of California broccoli crops was layered with the establishment probability maps, and additional spatial information on the location of ports of entry and major highways and transportation routes. Through the actions of the importers, the ABM allows the crucifer flea beetles to be introduced and demonstrates the effects of border enforcement policies on broccoli crops. A key aspect of the ABM methodology is the capability to analyze the behavior of heterogeneous actors. In this model, three types of importers were created that differ in terms of infection rates (high, medium, and low) and cost of transportation to the port.

The model incorporates inspection rates for each port and each importer (to capture the effects of potential repeat offenders), and the success rate of inspection (that is, finding an infected shipment when one is present), not only for each port and importer but also for each potential level of pretreatment.

The ABM analysis generated several policy-relevant findings. In addition to increasing pretreatment efforts in response to increased inspection rates, firms may switch away from one port to another with lower inspection rates.

While the model showed the expected reduction in crop damages as inspection rates were increased at a specific port, it also showed the conditions under which marginal damage reduction was flat versus steep. More dramatic damage reduction occurred when inspection rates at both ports were relatively high. The implications are that, under certain conditions, policy makers should not be focused on consistency across ports but rather on ensuring inspection rates at other ports are high. Alternatively, if inspection rates across ports are relatively low, unless inspection rates can be raised significantly and inexpensively at all ports, policy makers should not invest in increasing inspection rates at just one or a few ports.

This analysis highlights the policy importance of distinguishing between inspection rates versus the rates at which these inspections are successful. The results show that crop damages may increase as the base rate of inspection increases, given low inspection and inspection success rates for certain importers. Moreover, increasing enforcement efforts may not necessarily reduce invasive species risk.

Port inspections are essential to reducing or eliminating invasive species risk. Without inspections or the perceptions of inspections, importers lose the incentive to ensure that their shipments are pest-free. Importers will not invest money in pretreatment efforts if there are no potential benefits (such as saving money on violation fines).

That said, given the model's findings that a dramatic decrease in damage follows a decrease in cost of pretreatment, regulators may more successfully reduce invasive species risk by targeting pretreatment costs and effectiveness rather than by expending more effort at the ports. While it is important to make sure that our trading partners are meeting our standards at the border, it may be even more important to help them find better, and cheaper, ways to do so.

Physiology-based Predictions of Invasive Species Range Shifts: A Case Study in Kudzu

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Abstract

Invasive species are expected to move poleward with future climate warming. As the northern-most occupant of North America, Canada can expect numerous new invasive species in the coming years. The effective allocation of limited public resources to protecting biodiversity and precious agricultural lands will depend on Canada's ability to predict which species will pose the greatest threat, and when. Organismal physiology, or the study of how organisms respond to abiotic factors, can offer several tools that can help inform these predictions. I will show how this can be done using kudzu (*Pueraria lobata*), a notorious invasive plant that recently arrived in Canada, as a case study.

Resumen

Se espera que las especies invasoras se mueven hacia los polos por el futuro calentamiento climático. Asi que el ocupante más septentrional de América del Norte, Canadá puede esperar numerosas nuevas especies invasoras en los próximos años. La asignación eficaz de los limitados recursos públicos para proteger la biodiversidad y las preciosas tierras agrícolas dependerá de la capacidad de Canadá para predecir qué especies se plantean como la mayor amenaza, y cuándo. Fisiología de los organismos, o el estudio de cómo los organismos responden a factores abióticos, puede ofrecer diversas herramientas que pueden ayudar dar a conocer estas predicciones. Voy a mostrar cómo se puede hacer usando el kudzu (*Pueraria lobata*), una planta notoria invasora que llegado recientemente a Canadá, como caso de estudio.

Introduction

Canada has historically relied, more or less successfully, on the inhospitability of its climate to prevent the establishment of invasive species. This strategy will lose its efficacy as climate warming makes the temperate environments of Canada's south more habitable. More habitat means that more species can be expected to move. This "fingerprint" of climate change seems to be strong enough to overcome biotic constraints and other limitations to species movement (Parmesan and Yohe 2003). For invasive species, which are generally thought to be less burdened than native species by such limitations (Mitchell et al. 2006), climate change should be an express ticket to new territory. That is, invasive species should be able to track their fundamental niche as it moves across the landscape.

The Fundamental Niche

The fundamental niche is the "climate-space" delimited by physical requirements for fitness and reproduction, excluding any biotic interactions (Kearney and Porter 2004). The niche concept originated with Joseph Grinnell, a zoology professor and the first director of the Museum of Vertebrate Zoology at the University of California – Berkeley. In publishing his short paper "The Niche-Relationships of the California Thrasher" (Grinnell 1917), Grinnell positioned himself as heir to the ideas of Alexander von Humboldt and other keen observers of nature. As early as 1807, Humboldt produced a remarkable drawing of how vegetation follows elevation gradients on the slopes of the volcano Chimborazo in Equador (Humboldt and Bonpland 1807). That species segregate themselves on the slopes of the volcano

[1] Presenter.

according to their climatic tolerances exemplifies the idea of the fundamental niche.

We apply the niche concept in everyday life when we choose plants for our gardens based on maps of hardiness zones. More formally, the niche concept is applied in climate envelope modeling, a powerful technique that projects the climate-space of a species' current range into the future or onto another landscape (Guisan and Zimmermann 2000). Implicit in the niche concept is the idea that every organism has limits to what it can tolerate. Those limits, or thresholds, are dictated by the physiology of the organism (Kearney and Porter 2004). When a physiological threshold is exceeded, the effects can be disproportionate to the change in the climatic variable. For example, a brief but severe drought in the 1950s exceeded the tolerance threshold of ponderosa pines in northern New Mexico, resulting in a 75 percent drop in ponderosa pine cover, and a shift of this forest ecotone to higher elevations (Allen and Breshears 1998; Burkett et al. 2005). This new distribution limit has persisted for two decades (Allen and Breshears 1998), providing evidence that physiological thresholds can indeed delineate species boundaries.

A natural extension of this concept of species boundaries is to dispense with the distribution data usually used to parameterize climate envelope models, and to only use information about species physiology to parameterize predictive models (Kearney et al. 2008). This brand of mechanistic species distribution modeling usually produces better projections than climate envelope models, but the requisite physiological experiments make them intractable for larger projects, especially when contrasted with climate envelope models, which can project invasive potential for over 1,800 plant species in a single study (Peterson et al. 2008). Still, the truth remains that the more we know about an organism's physiology, the more well-defined its fundamental niche can be.

This paper describes one way to reconcile these competing interests: a method that uses distribution information to help identify key life history traits and then connects them with the climatic variables that might be limiting. This method focuses on the empirical effort but should retain much of the predictive power of a full-blown mechanistic species distribution model because traits that contribute less to the model need not be characterized. To illustrate this idea, we apply the method to the invasive species kudzu (*Pueraria montana* (Lour.) Merr. var. *lobata* (Willd.) Maesen).

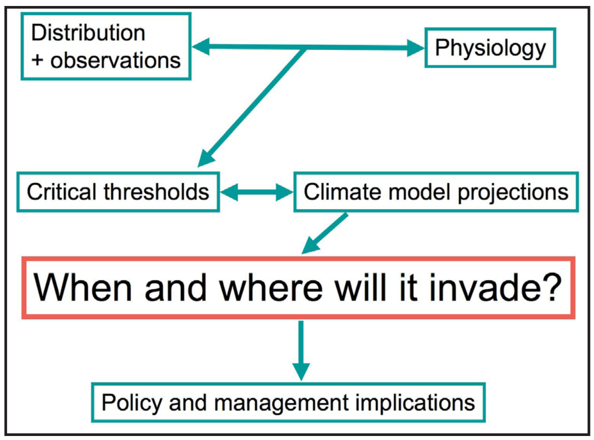

Figure 1. Conceptual schematic illustrating how physiology can help inform projections of future species invasions.

Identifying Life History Traits

The first step in defining the fundamental niche is identifying the life history traits that are most important for the species' fitness and reproduction. Important tools in this step are observations of life history at the current distribution limits and the limits themselves. Once the important traits are identified, they can be linked to a putatively limiting abiotic variable or set of variables using the information from the distribution or other observations. For example, if the distribution limit correlates with a temperature or other climatic isocline, a mechanistic hypothesis can be generated and tested. For kudzu, the northern range limit correlates with a minimum winter temperature isocline (Sasek and Strain 1990), so the first hypothesis we tested was that winter survival of dormant stems (the life history trait) depends on winter freezing temperatures (the abiotic variable). Not to be discounted in formulating these hypotheses is anecdotal evidence from farmers, foresters, and others with experience with the weed in question. For kudzu, the story was that it is sensitive to cold (for example, Miller and Edwards 1983; Mitich 2000).

Overwintering as dormant stems is but one important aspect of kudzu's life history. Supposing it does survive the winter, there are other ways cool temperatures can limit its fitness. These alternative limitations are important considerations because climate variables are often highly correlated. The life history trait that is most likely to influence kudzu success in the spring is the need to establish before it is shaded by other vegetation. This inference comes from observations that kudzu rarely penetrates into forests where light levels are low; it is much more likely to be found along forest edges, in open fields, along roads, and in other high light environments. An important correlate with winter freezing temperatures is springtime frost. Mild sub-zero temperatures can damage young growth by destroying meristematic tissue and arresting growth, or by damaging the photosynthesis apparatus, especially when cool temperatures are combined with high light (Allen and Ort 2001). For example, snow gum seedlings growing near the species' southern distribution limit in Australia tend to be found only in sheltered environments where they avoid the damaging effects of high light and low temperature (Ball et al. 1991). Less severely, frosts can set back growth by several days, which could influence the outcome of a species competition.

Freezing winter temperatures are also associated with cooler, shorter summers. For a species like kudzu, this is important because the life history trait that characterizes its summer invasiveness is its ability to outgrow other vegetation. Growth rate depends on both temperature and carbon availability, so the temperature response of photosynthesis and growth rate are the key physiological parameters to examine here. Some species are able to acclimate to cooler conditions, which means they can make biochemical changes to maintain high photosynthesis rates when grown in cool temperatures. We expect to see acclimation in species that are adapted to cool temperate areas, but not in sub-tropical or warm temperate species (Berry and Bjorkman 1980). For invasive species like kudzu that fall into this latter category, the inability to acclimate to cooler summers could delay invasion, even if it can survive the winter.

Conclusion

Information contained in the distribution of a species, and in the stories people tell about it, can help focus physiological experiments on relevant life history traits. This is important because physiology can help define the boundaries of a species' fundamental niche. If critical physiological thresholds match up with current distribution edges, then this is evidence that the species is at equilibrium with its fundamental niche and not constrained by biotic factors like dispersal or competition. It also means that forecasted changes in the critical threshold due to climate change can be used to project the "when" and "where" of the next species invasion, facilitating Early Detection and Rapid Response efforts.

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Predicting Invasion Risks and Opportunities with Climate Change: Insights from Modeling

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Abstract

Rising temperatures and altered precipitation regimes due to climate change are likely to affect the competitiveness and abundance of invasive plants, ultimately leading to shifts in invasive plant distribution. Forecasting these distribution shifts is a goal of the ecological modeling community. Envelope models (also known as ecological niche or species distribution models) describe suitable climatic conditions for invasion based on the species geographic distribution. These models are increasingly being used to forecast future shifts in invasion risk as both climate change projections and invasive species distribution data become more widely available. Spatially explicit models of future invasion risk have the potential to provide much needed information for management and control efforts. However, envelope models have been criticized for being too simplistic, and there is some debate over how results should best be used.

I will discuss the strengths and weaknesses of envelope modeling for invasive plant management. Envelope models provide a means for testing assumptions about distribution shifts, identifying potential surprises, and, when combined with expert knowledge, informing regional- and landscape-scale management planning. I will present examples of likely distribution shifts of prominent invasive plants in the United States, including results from both model ensembles and sensitivity analyses. These results highlight the potential for large-scale changes in invasion risk, including both expansion of invasive plants and unprecedented opportunities for restoration. Information from envelope and other spatial models provides a starting point for adaptive management aimed at reducing future threats from plant invasions.

Resumen

Aumento de las temperaturas y alteración de los regímenes de precipitación debido al cambio climático pueden afectar la competitividad y la abundancia de plantas invasoras, en última instancia conduce a cambios en la distribución de plantas invasoras. Previsión de estos cambios de distribución es un objetivo de la comunidad de modelos ecológicos. Envelope models (también conocidos como nicho ecológico o modelos de distribución de especies) describen las condiciones climáticas adecuadas para la invasión basados en la distribución geográfica de las especies. Estos modelos son cada vez más utilizados para predecir los cambios futuros en el riesgo de invasión ya que tanto las proyecciones del cambio climático y la distribución de datos de especies invasoras son más ampliamente disponibles. Modelos espacialmente explícitos de riesgo de futuras invasiones tienen el potencial de proporcionar mayor cantidad de información necesaria para los esfuerzos de manejo y control. Sin embargo, los envelope models han sido criticados por ser demasiado simplista, y existe cierto debate sobre cual es el mejor uso de los resultados.

A continuación, voy a discutir las fortalezas y debilidades de los envelope models para el manejo de plantas invasoras. Envelope models proporcionan un medio para probar los supuestos sobre los cambios de distribución, la identificación de posibles sorpresas, y, cuando se combina con el conocimiento experto, información regional y la planificación del paisaje a nivel de manejo. Voy a presentar ejemplos de los cambios probables de distribución de importantes plantas invasoras en los Estados Unidos, incluyendo los resultados tanto de modelo de conjuntos y análisis de sensibilidad. Estos resultados ponen de manifiesto el potencial de cambios a gran escala en el riesgo de invasión, incluyendo tanto la expansión de plantas invasoras y las oportunidades sin precedentes para la restauración. Información de la dotación y otros modelos espaciales proporciona un punto de partida para el manejo adaptable encaminadas a reducir futuras amenazas de invasiones de plantas.

Introduction

Global climate change compounds the challenges associated with invasive plant management. Treatment of invasions already suffers from limited resources, necessitating the prioritization of some weed species and locations over others. The inclusion of climate change in management planning is likely to alter treatment prioritization as different invasive species are projected to shift in distribution and abundance. Invasive plant distribution shifts will increase risks in some locations (Dukes et al. 1999; Bradley et al. 2010), and decrease risks in others (Bradley et al. 2009) depending on the species and on how climate ultimately changes.

Overall, climate change is likely to increase risks from invasive plants (Dukes and Mooney 1999; Weltzin et al. 2003; Thuiller et al. 2007; Bradley et al. 2010). Traits common to plant invaders, such as rapid growth, prolific seed production, and broad environmental tolerance (Pyŝek and Richardson 2007) will allow weeds to expand and colonize land areas newly suitable due to climate change. Further, rising atmospheric CO_2 due to anthropogenic emissions frequently increases competitiveness of invasive plants relative to native plants (Dukes 2000; Smith et al. 2000; Ziska and George 2004; Bradley et al. 2010). However, altered precipitation and rising temperature conditions do not always favor invasive plants. In some areas, climate conditions may move outside of invasive species physiological limits, in other cases, changing climate conditions might make native plants more competitive and limit further invasion. The challenge for ecological forecasting is to predict how invasive plant distributions might shift with climate change, identifying both expanded invasion risk and reduced invasion risk, such that the results can be used to inform management planning and prioritization of treatment.

There are a number of different methods of ecological forecasting. These include, for example, experimental manipulations of climate either in the field or in greenhouses to assess the impacts on invasive plants, repeated observations of invasive plant abundance along ecological gradients, and models based on physiological tolerance. One ecological forecasting method that is increasingly being used to predict plant invasions is species distribution modeling. Distribution modeling (also known as ecological niche modeling or bioclimatic envelope modeling) is an empirically based approach that compares a species distribution to the spatial distribution of environmental predictors such as precipitation and temperature (Figure 1), and uses the calculated relationships to model invasion risk based on the environmental predictors alone. The strengths of a distribution modeling approach include that the results are spatially explicit, and extend across broad spatial areas (Pearson and

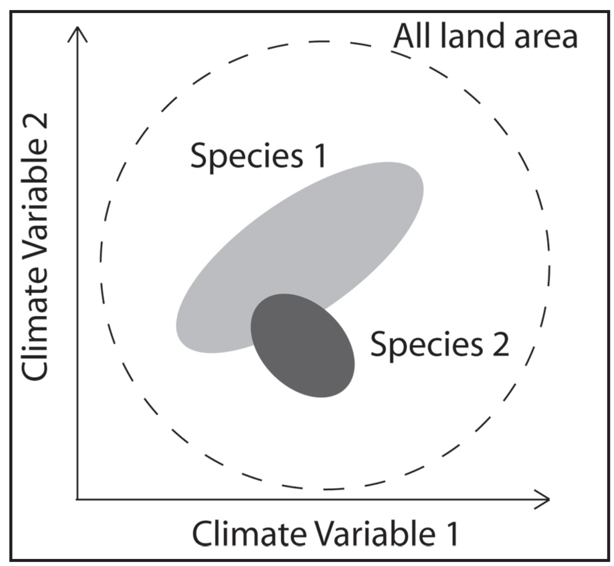

Figure 1. Schematic representation of two species distributions relative to climate variables. Locations on the ground can be represented as points within the total land area (dashed circle), but invasive plants may exist within only a subset of that land area (gray ellipses). If climate conditions fall within one of the gray ellipses, then that location can be defined as climatically suitable for that species, and therefore potentially at risk of invasion.

Dawson 2003). However, because the method is empirically based, it does not include complex relationships between invasive plants and their environment such as biotic interactions, alterations to nutrient or disturbance cycles, or pathways of invasion. Those questions are better addressed by mechanistic models (for example, Jeltsch et al. 2008), but the tradeoff is that mechanistic models can require information that is not readily available, and they may not be spatially explicit.

My aim is to explore some distribution model results for the invasive plant cheatgrass (*Bromus tectorum*) in the western United States. I will focus in particular on what sorts of testable hypotheses can be derived from distribution models, as well as provide examples of distribution model results that can inform weed management and treatment prioritization at regional scales.

Background

Cheatgrass is one of the better known invasive plants in the western US. The species was originally introduced in the mid-1800s accidentally as a seed contaminant in hay and spread along railroad lines and into rangelands (Mack 1981; Knapp 1996). Cheatgrass enhances the grass-fire cycle (D'Antonio and Vitousek 1992), increasing fire frequency in shrub lands which rarely burned prior to invasion (Whisenant 1990). Fires result in loss of habitat for native species, degradation of rangelands, and risks to human settlements. Rapid cheatgrass establishment in burned areas creates near monotypic stands of the invasive species, preventing the return of native plants and further increasing fire risk.

Cheatgrass is widely distributed in sagebrush (*Artemisia* spp.) steppe in the Great Basin and Columbia Plateau (Mack 1981). A regional remote sensing study based on data from the late 1990s mapped 40,000 square kilometers of cheatgrass-dominated land in the Great Basin alone (Figure 2; Bradley and Mustard 2005). This cheatgrass map was used to assess the empirical relationship between cheatgrass distribution and climate in order to create distribution models.

Methods

Distribution modeling identifies empirical relationships between species distribution and environmental variables. Numerous modeling approaches have been built for this purpose, examples include: MAXENT (Phillips et al. 2006); CLIMEX (Sutherst et al. 1999); BIOMOD (Thuiller 2003); DOMAIN (Carpenter et al. 1993); and SPECIES (Pearson et al. 2002). Statistical tools are also commonly applied to distribution modeling, examples include principle components analysis (PCA) and Mahalanobis distance (Farber and Kadmon 2003). For an inter-comparison and explanation of these and other distribution modeling methods, see Elith et al. (2006) and Tsoar et al. (2007).

The results presented are based on Mahalanobis distance, which is a statistical technique that defines major and minor axes using the distribution of the data cloud. The resulting model tends to form an ellipsoidal shape around the data cloud, such as those shown in Figure 1. For more information on this modeling approach, see Farber and Kadmon (2003) and Tsoar et al. (2007).

The best climatic predictors of cheatgrass distribution were calculated based on the seasonal variables that created a projection with the tightest fit to the mapped cheatgrass distribution. Climatic variables were added until the overall fit of the model did not improve. Current climate variable predictors were taken from the PRISM interpolation of US weather stations at four-kilometer spatial resolution (Daly et al. 2002). Future climate conditions were derived from a set of 10 Atmosphere Ocean General Circulation Models (AOGCMs)[1] for 2100. I used the SRES a1b scenario in all cases, a "middle of the road" emissions scenario in which atmospheric CO_2 concentrations approximately double between 2000 and 2100.

Due to the degree of uncertainty associated with any single climate projection, assessments of future invasion risk were carried out in two ways. First, a sensitivity analysis was used to determine

[1] The following AOGCMs were used to project future climate conditions for 2100: Canadian Centre for Climate Modelling and Analysis (CCCma) CGCM3.1; Centre National de Recherches Météorologiques (CNRM) CM3; Geophysical Fluid Dynamics Laboratory (GFDL) 2.1; Goddard Institute for Space Studies (GISS); Hadley Centre for Climate Prediction (HAD) CM3; Institute for Numerical Mathematics (INM) CM3; Institut Pierre Simon Laplace (IPSL) CM4; Model for Interdisciplinary Research on Climate (MIROC) 3.2; Max Planck Institute for Meteorology (MPI) echam5; National Center for Atmospheric Research (NCAR) CCSM3.

how cheatgrass invasion risk might shift given the range of projected future climate conditions. Second, an ensemble modeling approach was used, whereby the model was run for each future climate projection individually and the results were added together to identify overlap in projected invasion risk. Additional information on how the cheatgrass results were calculated can be found in Bradley (2009) and Bradley et al. (2009).

Results and Discussion

Cheatgrass relationship to climate

Based on the climate variables that best model distribution, cheatgrass distribution is most closely related to summer precipitation, annual precipitation, spring precipitation, and winter temperature (Bradley 2009). Frequently, models of invasion risk relative to climate are built based on an invasive plants' known or estimated physiological requirements. These can be derived from field and greenhouse experiments as well as from expert knowledge of managers and scientists who have worked with and observed the species. If one were to guess at climatic predictors for cheatgrass based on its physiology, variables such as spring precipitation and winter temperature would likely be included as they influence how early in the growing season the plant germinates and how large it grows in the spring. However, it is unlikely that summer precipitation would be selected because the plants are typically senesced by early summer.

The empirical relationships derived from cheatgrass distribution and climate therefore present us with a hypothesis that species physiology is not the only factor affecting cheatgrass distribution. Based on these empirical results, we could hypothesize that changes in summer precipitation might influence how cheatgrass competes with native species (Bradley 2009). Cheatgrass is an annual grass growing primarily in the spring, while the native species are primarily perennial shrubs and bunch grasses growing during the summer. Changes in summer precipitation could influence how well native species compete with cheatgrass and resist invasion. An alternative hypothesis relates to fire. The majority of fires in cheatgrass-dominated ecosystems occur in the late summer when conditions are particularly dry. Changes in summer precipitation could also influence the frequency of fire. With increased summer precipitation and moister conditions, we would expect fewer fires, while decreased summer precipitation might increase the likelihood of fires and corresponding plant invasion. These hypotheses are testable through experiments and provide a different perspective on cheatgrass invasion risk than could be determined through species physiology alone. They are also testable through sensitivity analyses, which may provide further evidence to support or refute our hypotheses about how summer precipitation changes might alter invasion risk.

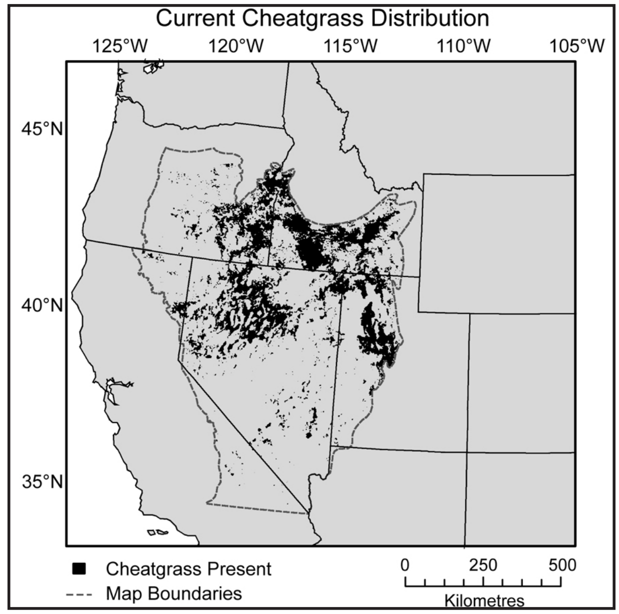

Figure 2. Distribution map of cheatgrass in the Great Basin derived from remote sensing (Bradley and Mustard 2005). Black areas indicate ecosystems that are dominated by cheatgrass, the gray dotted line denotes the boundaries of the distribution map.

Cheatgrass sensitivity to precipitation change

In the Intermountain West (Great Basin and Columbia Plateau), AOGCMs fairly consistently project an increase in fall/winter precipitation and a decrease in spring precipitation. However, there is a high degree of uncertainty associated with projections of summer precipitation. Projections range anywhere from a loss of 50 percent of precipitation to a gain of 50 percent of precipitation. Although the actual amount of precipitation change is low because very little rain falls in the summer, the percentage change could be quite high and could have substantial impacts on future invasion. Cheatgrass distribution is highly sensitive to these large potential changes in summer precipitation (Figure 3). With a 50 percent increase in summer precipitation, the model projects a large reduction in land area climatically suitable for cheatgrass invasion. Some areas remain at risk, including Idaho's Snake River Plain, parts of eastern Oregon and Washington, and most of northern Nevada. However, substantial areas are projected to have reduced risk with increased summer precipitation, including large portions of Utah, Wyoming, and southern Nevada.

With a 50 percent decrease in summer precipitation, invasion risk increases dramatically. The bulk of currently suitable land area maintains climatic suitability, while large portions of Montana and the Four Corners area become increasingly suitable for invasion. The spatial changes revealed by the sensitivity analysis—increased invasion risk with lower summer precipitation and decreased invasion risk with higher summer precipitation—provide further evidence that cheatgrass distribution is strongly affected by competition with native species mediated by summer rainfall.

In addition to providing evidence in support of the previously stated hypotheses about cheatgrass' relationship to summer precipitation, the sensitivity analyses produce further hypotheses about potential distribution shifts with a given change in climate. These hypotheses also could be tested or evaluated through field experiments and long-term monitoring and observation. For example, central Montana is projected to be at increased cheatgrass invasion risk with reduced summer precipitation. This hypothesis could be tested through water addition/exclusion experiments or by comparing invasions in local areas with different summer precipitation conditions.

Sensitivity analyses can also provide information on locations most likely to change and conditions most likely to cause that change. For example, when setting up experimental manipulations in the field, location is important. Selecting an experimental location or observational transect where climate change is unlikely to alter invasion risk (such as the Snake River Plain or northern Nevada) may not produce useful results. However, using sensitivity analyses as a guide might

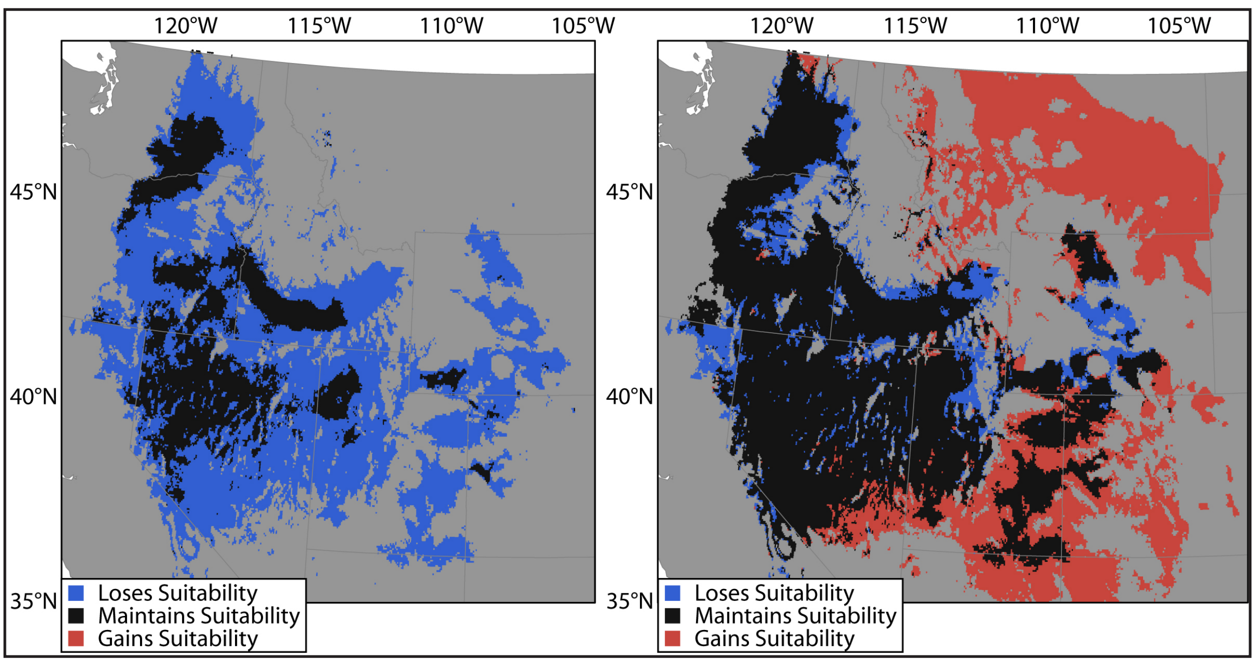

Figure 3. Cheatgrass sensitivity to summer precipitation. The figure on the left shows areas with suitable climate conditions for cheatgrass if summer precipitation increased in the Intermountain West by 50 percent. The figure on the right shows suitable climate if summer precipitation decreased by 50 percent. Black areas indicate continued climatic suitability, blue areas are reduced climatic suitability, red areas are increased climatic suitability.

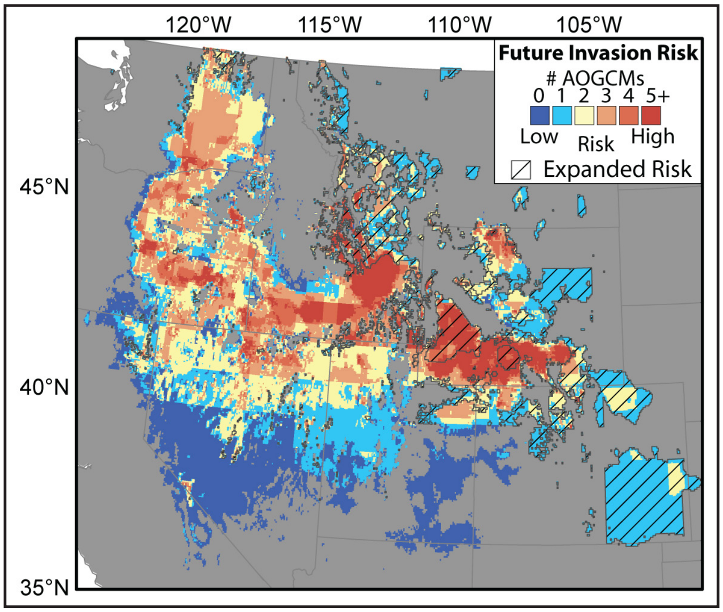

Figure 4. Likelihood of cheatgrass invasion risk in 2100 based on an ensemble of 10 AOGCM projections. Red areas are projected to be climatically suitable by at least half of the models, and can therefore be considered at higher likelihood of maintaining or increasing risk. Blue areas are projected to be climatically suitable by none of the models, and can therefore be considered at higher likelihood of decreasing invasion risk. Hash marks indicate expanded risk relative to current climatic suitability.

lead one to choose locations in Montana or Utah where summer precipitation change is quite likely to alter invasion risk.

Cheatgrass invasion risk based on a model ensemble projection

Although sensitivity analyses are a useful distribution modeling approach for assessing the range of potential distribution shifts with climate change and for creating testable hypotheses about invasive species' relationships to seasonal climate variables, it is unlikely that climate conditions will shift only in a single season. That is, summer precipitation will not be changing in isolation in the western US, but in conjunction with altered precipitation in other seasons, and rising temperatures year round. As a result, another modeling approach is needed to assess likelihood of change in climatic suitability for a given species and location, in this case using AOGCM projections to model invasion risk with multiple concurrent changes in climate. However, due to the uncertainty inherent in climate projections, distribution model results will have higher confidence if they are based on the output of multiple AOGCMs rather than a single climate model. Araujo and New (2007) recommend that multiple models are run and summed together into an ensemble model, which results in a map of potential future distribution based on the number of AOGCMs that predict climatic suitability. An ensemble model projection for cheatgrass invasion risk in 2100 is shown in Figure 4.

Although ensemble models make it difficult to determine how specific climate changes are affecting future invasion risk (sensitivity analyses are more appropriate for that question), they do create hypotheses about likelihood or range shifts. For example, if multiple models agree that a given location is at risk of invasion, then that area could be given higher prioritization for treatment or prevention of new infestations. Conversely, if multiple models agree that a given location will become less at risk from invasion, then treatment of that species might be reduced over the long-term.

One interesting result from both the sensitivity analyses and the ensemble model for cheatgrass is the projection of reduced invasion risk across broad spatial areas with climate change. Lands in states such as Utah and Nevada, which are currently at high risk from cheatgrass, and currently contain many cheatgrass infestations, may become climatically unsuitable for the species by the end of the century. Indeed, cases of reduced invasion risk, or even invasive species retreat, have been projected for several invasive species in the western US (Bradley et al. 2009). Instances of invasive species retreat will create new challenges for weed management, but also represent unprecedented opportunities for restoration. If invasive plants become less competitive with climate change, we may have a short window of opportunity to successfully establish non-invasive species.

I use the term "non-invasive" rather than "native" intentionally, as it is likely that climate change will reduce suitability not only for invasive plants, but for native plants as well. As a result, we will be presented with the challenge not of restoring ecosystems to some state that existed prior to invasion, but instead transforming ecosystems using novel species assemblages that are non-native and non-invasive, but expected to survive in the altered climate conditions. This concept has been referred to as transformative restoration (Bradley et al. 2009; Bradley and Wilcove 2009), and may be increasingly necessary for restoration of invaded and degraded landscapes in the context of climate change.

Conclusion

Based on the model results presented here for cheatgrass, it is likely that climate change will shift the spatial distribution of invasion risk. Although the results shown here were only for a single species, shifting invasion risk is likely for most invasive plants. On average, there is unlikely to be either a wholesale expansion or a wholesale contraction of invasive plants. Rather, it will depend on the species and the location whether risk will increase or decrease. For weed management planning, it will be helpful to be prepared for increased risks from currently rare invasive plants as well as restoration opportunities from currently problematic invasive species. Developing flexible management plans that include some expectation of changing species prioritization—maybe even rapid shifts in species of concern—would increase future treatment success.

Distribution models are not perfect, and should not be taken as precise predictors of future climate conditions or invasion risk. However, models can be used as guides and as hypotheses for improving ecological forecasting. Sensitivity analyses can help constrain the best and worst case scenarios, and can be used to inform the location of and variables tested in experiments. Ensemble models can provide a guide for assessing future invasion likelihood, and may be useful for prioritization of treatment as well as selecting new species for long-term monitoring. All in all, distribution models, particularly when combined with ecological knowledge, provide useful information about invasion risk that should be used to inform weed management planning.

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Vital Signs: A New Model for Engaging and Supporting Citizen Scientists of All Ages

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Abstract

Vital Signs (http://www.vitalsignsme.org) is a web-based science learning environment created by the Gulf of Maine Research Institute (GMRI) to serve Maine's 7th and 8th grade science students, educators, and researchers studying invasive species. This standards-aligned learning environment provides resources and tools to help novices participate actively and successfully in environmental research. It facilitates an engaged community of participants that includes science novices, citizen scientists, and professional scientists and produces data valuable to the experts studying invasive species across the state.

Through the Vital Signs model, novices can participate in all aspects of science research, from making initial observations and posing hypotheses, to peer review, data analysis, and publication. Participants pose questions specific to their community or interest, create hypotheses, collect rigorous data, peer review one another's work, publish comments, participate in discussions, analyze data, and share conclusions. Participants learn about science and environmental research by active participation.

Vital Signs educates and enables a new audience of environmental stewards to monitor invasives species in terrestrial, freshwater, and marine ecosystems. We are building partnerships with scientific organizations that support our educational mission and use our data, including the Invasive Plant Atlas of New England (hosted at University of Connecticut), Maine's Department of Environmental Protection, and Maine's Department of Marine Resources. We currently have two dozen "species experts" from these and other organizations who provide species verification for our database.

Vital Signs is an open community and program. GMRI provides training and support to encourage the integration of Vital Signs into formal education across the state, but the site is public and welcomes anyone to register and participate. The Vital Signs web interface and database itself are built in Drupal, an open source content management and the source code has been released to enable replication of the web infrastructure in part or whole.

Resumen

Vital Signs (http://www.vitalsignsme.org) es una red basada en el aprendizaje en un ambiente científico creado por el Gulf of Maine Research Institute (GMRI) para servir a estudiantes de los grados 7 y 8 de Maine, educadores y los investigadores que estudian especies invasoras. Esta alineado con los estándares ambiente de aprendizaje, proporciona recursos y herramientas para ayudar a los novatos a que participen activamente y con éxito en la investigación ambiental. Facilita una comunidad comprometida de participantes que incluye a los novatos la ciencia, ciudadanos científicos, y científicos profesionales y produce información valiosa para los expertos en el estudio de las especies invasoras en todo el estado.

A través de Vital Signs, los novatos pueden participar en todos los aspectos de la investigación científica, desde hacer observaciones iniciales y plantear hipótesis mediante la revisión paritaria, análisis de datos y publicaciones. Los participantes hacen preguntas específicas para su comunidad o interés, crear hipótesis, recopilar datos rigurosos, revisión los trabajos de otros compañeros, publicar comentarios, participar en debates, analizar datos, y compartir las conclusiones. Los participantes aprenden sobre la ciencia y la investigación del medio ambiente mediante la participación activa.

Vital Signs educa y habilita a una nueva audiencia de administradores del medio ambiente para monitorear especies invasoras en ecosistemas acuaticos, terrestres, y los marinos. Estamos construyendo alianzas con organizaciones científicas que apoyan nuestra misión educativa y utilizan nuestros datos, entre ellos el Atlas de Plantas Invasoras de Nueva Inglaterra (con sede en la Universidad de Connecticut), Departamento de Protección Ambiental de Maine y el Departamento de Recursos Marinos de Maine. Actualmente disponemos de dos docenas de "expertos en especies" de estas y otras organizaciones que verifican las especies para nuestra base de datos.

Vital Signs es una comunidad y programa abierto. GMRI proporciona formación y apoyo para fomentar la integración de Vital Signs en la educación formal a través del estado, pero el sitio es público y da la bienvenida a cualquiera para inscribirse y participar. Vital Signs interfaz de la red y la base de datos por si solas están construidas en Drupal, un proceso de manejo del sistema de contenido abierto. El código fuente ha sido liberado para permitir la replicación de la infraestructura de red en parte o su totalidad.

This paper is about Vital Signs, a citizen science and education program that we have developed in Maine to both give the public a role to play in science research and to support efforts to monitor for invasive species across our state. What I hope you get out of this paper is a description of the organization I work for, the Gulf of Maine Research Institute, and Vital Signs, why and how it was created, and some of the particulars of how it works.

The point of my being at the Weeds Across Borders 2010 conference is two-fold: first, our program was built to scale—the software is open source, the resources are licensed for sharing, and we need partners on the ground who are interested in using the architecture we've developed; and second, even if you don't want to create a Vital Signs program of your own, I sincerely invite your participation and your input on the program we have in Maine.

My organization, the Gulf of Maine Research Institute, is located in the state of Maine, in the northeastern United States. We have taken a neutral stance—we advocate for science, for openness of process, and access to information rather than positions on issues. We are very much committed to serving our state and our region, and we know that sometimes doing this effectively means participating in projects, conferences, and research around the globe. So we are regionally focused, but internationally active.

We have a three-part mission:

1. Science: Our focus is primarily on fisheries ecology research in the Gulf of Maine, all in collaboration with fishermen, using the fishing vessels as research platforms and the fishermen as research collaborators.
2. Community: We work with the stakeholders focused on fishing—fishermen, researchers, environmentalists, and regulators. We convene, facilitate, educate, and build leadership.
3. Education: We are working to raise science literacy across our state. Our strategy is to focus on middle school students, giving them firsthand experience of being scientists. Experts and educators tell us this is the age when students either get hooked on science or decide it is too hard, too boring, too whatever.

Our goal is to give students a chance to step into the role of scientist; to try it on. We try to make these experiences authentic—real science, yes, but real community too. Science is a social enterprise.

Vital Signs is our program designed for the older end of middle school students—grades seven and eight. It involves a whole community of citizen scientists, not just students and teachers. By design, it includes citizen scientists, scientists, resource managers, and the public, as well as students and teachers. Why? Because learning is a social activity. Because middle school students crave being heard by adults. Because experiencing what it means to contribute to society is life-changing. Because research tells us that students are more likely to pursue education and careers in science if, at the end of eighth grade, they imagine that they will become a scientist, technologist, engineer, or mathematician (Tai et al. 2006). And how can you imagine being something that you don't know? We want to cultivate a diverse community of practice around Vital Signs that provides students with diverse role models—from professional scientists to "normal" people who are contributing their free time to scientific pursuits.

Invasive species, it turns out, are an ideal research topic around which to build a program that involves communities and students in real research and effective science learning.

1. As Curt Meine noted during his talk on 3 June 2010, invasive species are a wonderful window into ecology;they are an uncontrolled ecological experiment. Ecologists know that one way to learn about a community is to perturb it. For example, remove the predator or competitor and see what happens. Invasive species issues map beautifully to the things we want our middle school students to start learning: Constancy and Change; Biodiversity; Systems; Skills and Traits of Inquiry; Understanding Inquiry; Nature of Science; Ecosystems; and Evolution. These topics come alive around invasive species.
2. Amateurs can be helpful and scientists need their help. All it takes is identification resources, a digital camera, a GPS unit, and a reporting mechanism.
3. Invasive species are charismatic. Think of Japanese knotweed growing through concrete, snakehead fish walking from pond to pond, a tunicate that covers square miles of ocean bottom. These things are fascinating—and everywhere that a student might be.
4. Invasive species do the teaching themselves. To understand the impact of invasives, just get familiar with a common one. You will see it everywhere. The lesson becomes "sticky."
5. Also, students and invasive species, very roughly, share a similar distribution. Where humans are present, there is a higher risk of invasive species introductions and, consequently, the potential for more student involvement.

We began our invasive species program development process by sitting down with teachers and scientists to craft a program that would serve both education and science. The first thing we did with the teachers and scientists was come up with a list of species that scientists would trust students to identify—natives and invasives. Our list includes terrestrial, freshwater, and marine species because we want to support people taking action in the places that they care about.

We describe Vital Signs as a science learning environment—the program, the tools, the web infrastructure, the training and support, and the community—that produces data for science. We are focused on the educational impact of the program; however, essential to the program is this idea of producing data for science, and participating in a scientific community or practice. If we do not achieve that, then we have failed to meet our educational objective. So yes, education comes first, but being of use to science is critical.

Another note on our approach: think back to the conference field tour. How many of us just asked someone when we wanted to know what something was rather than key it out? And you are all experts!

But with Vital Signs, it is essential that we make the process not only accessible to novices, but appealing to them. We are focused on creating a distributed data collection network. We want students to continue their work with Vital Signs after school. So, even with sophisticated online guides, we realized that we needed to go a step further. By providing printable information about various species and habitats, Vital Signs challenges students to pick one species or several and go outside to look for that or those species. Our educational focus is to help students make a claim and then back up that claim with evidence—photographs and text. We have found that we need to treat "I did find it" the same way as "I didn't find it"—in both cases, data are uploaded. You and I know it is far harder to prove something is not present, and these data are not as reliable. If you treat the data differently, you encourage uploading of poor identifications, because people want to share what they find. Equal emphasis on evidence that a species was or was not found avoids this pitfall. So how does this work?

- Step 1: Visit the Vital Signs website and download datasheets and species identification resources.
- Step 2: Collect the data (images, GPS location, and so on).
- Step 3: Upload the data to the website (peer checks required).
- Step 4: Publish the data to the website, where it will be opened to community comment and expert review.
- Step 5: Data are analyzed through student participation in discussions.

The Vital Signs website http://www.vitalsignsme.org has all the documents, resources, datasheets, and data viewing options, which I will go through in some detail.

We hold trainings for teachers that focus on how to integrate citizen science effectively into science and math learning. We demonstrate the model and by going through the whole process with them—asking a local question, going into the field, peer reviewing, and collecting and uploading the data. We have found that it is very important for teachers to experience the process before they feel comfortable implementing the program.

Participants pick a species from our list. Vital Signs had an AmeriCorps volunteer create species identification resources from images and information found online (and were licensed to be shared). You can view these identification resources on our website; each page has many pictures and "real" words with the English translation. These resources supply a model for the evidence that students require to back up their claim (that he or she did or did not find the species he or she was looking for).

Data are collected on a datasheet, which is also available on our website. We have included instructions and tips as well, but as many of you who have worked with volunteers or large groups know, people do not always read instructions; so we may be modifying this soon. One of the most important elements of the datasheet is that it closely mirrors the online data entry application.

Students and others can use our online data entry application to upload their data, including images, written notes, sketches, written evidence, and water quality measures. The last step before uploading their data is a peer data check. The reviewing team or data contributor completes a checklist (questions include: is the location plausible?; are the pictures in focus?; is the datasheet complete?; is the spelling correct?; and so on), and writes their team name into the system which becomes a permanent record. Students can also do a peer review (questions include: is the evidence compelling?; do the pictures and text match?; are the field notes thorough?; and so on).

The data are then published. Instantly, magically, an e-mail goes to the expert reviewer (scientists like Ann Gibbs, Les Mehrhoff, and passionate citizens like me) who have raised their hands to serve as experts for the species observed. Those species experts evaluate images, sketches, text, and either confirm or question their validity (hopefully with a comment to the data contributors).

Data are also made available for public comment and discussion, hopefully resulting in helpful back-and-forth exchanges between student teams, expert scientists, staff, and citizen scientists. What is really exciting is that these conversations are focused on evaluating the evidence presented and advising on where to look or what to look for next time. The participants are really engaged.

We are interested, however, in moving novices beyond just collecting data and handing it over to scientist. We want to cultivate thinking—critical, collaborative, and creative thinking. So we make the data available in an interactive Google Map display. Maps tend to get people thinking. We also make the data exportable. You can query the database for just the data you want—for example, species observation data where invasive species were looked for, found, and were confirmed by experts.

We also encourage participants to share what they learn in our Project Bank. We have seen some incredibly creative projects, like Invasive Species Comics. These were the work of a language arts teacher and her students. They make invasive species come alive like very few professional publications have in the past.

In my final slide of my Weeds Across Borders presentation, you saw Paul Gregory, an aquatic invasive species specialist with the Maine Department of Environmental Protection looking at a newly-reported infestation of hydrilla in a Maine lake. That picture captured much of what Vital Signs is about:

- We want to grow the ranks of and support more citizen scientists who can detect and report invasive species early.
- We want to increase the number of people ready and knowledgeable enough to participate productively in community meetings to decide how to address invasions in their favorite places.
- Even more generally, we want to increase the number of people who understand the importance of work like Paul's and other scientists.
- We want to increase the number of people who know that they can make a contribution to science and stewardship.
- And finally, we want to make sure that there are young people ready to step into Paul's shoes some day.

I look forward to hearing from you—your suggestions and your questions. Please contact me at sarah@gmri.org.

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The Ontario Invasive Plant Council: Collaboration in the North

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Abstract

The Ontario Invasive Plant Council (OIPC) was founded in April 2007 to facilitate a coordinated and effective response to the threat of invasive plants by providing leadership, expertise, and a forum to educate, motivate, and empower organizations and citizens. The OIPC is made up of a variety of organizations and agencies who work together to bring a collaborative response to the issue of invasive plants. The OIPC has developed partnership educational materials, workshops, invasive plant symposiums, a website with links to various other organizations involved with invasive plants across the province, and much more. This paper discusses the work that the OIPC has been doing, what they are working toward the future, as well as some of the other invasive plant councils across Canada.

Resumen

El Consejo de Plantas Invasoras de Ontario (OIPC) fue fundado en abril de 2007 para facilitar una respuesta coordinada y eficaz a la amenaza de las plantas invasoras proporcionando liderazgo, experiencia y un foro para educar, motivar y capacitar a las organizaciones y los ciudadanos. La OIPC se compone de una variedad de organizaciones y agencias que trabajan juntos para llevar una respuesta conjunta al problema de las plantas invasoras. La OIPC ha desarrollado en colaboración materiales educativos, talleres, simposios de plantas invasoras, un sitio web con enlaces a varias otras organizaciones involucradas con las plantas invasoras a través de la provincia y mucho más. Rachel discutirá la labor que la OIPC ha estado haciendo, lo que se está trabajando para en el futuro, así como algunos otros consejos de plantas invasoras a través de Canadá.

The Ontario Invasive Plant Council (OIPC), a fairly new organization, was created to increase coordination and collaboration for invasive plant issues across the province. This paper gives a brief scope of the issue of invasive plants within Ontario, and Canada overall, and introduces the Council, the work that they have been doing, and some of the issues they have been working on over the past three years. Collaboration is key to ensuring that a duplication of efforts is avoided and effectively ensures that the limited resources used to deal with this issue are being used in the most efficient way possible.

Introduction

In Canada, as in the United States and Mexico, invasive plants pose a major threat to our environment, economy, and in some cases, to human health. While specific monetary figures for invasive plant management in Ontario are limited, the Invasive Species Strategy for Canada (2004) estimated that the cost of invasive plants to Canada's agricultural and forestry sectors is as high as $7.5 billion annually. The Invasive Alien Plants in Canada Summary Report (Canadian Food Inspection Agency 2008) states that "preventative programs are widely recognized as the most effective and cost efficient means of control for invasive alien plants." It also notes that this would include provincial invasive plant councils. According to the report, there are 486 invasive alien plants in Canada, 90 percent of which are found in Ontario. This is likely due to the large amount of trade within the province as well as its high population. It is interesting to note that Quebec and British Columbia have the next highest number of invasive plants and populations. Ontario is also a major hotspot for aquatic invasive species entering and affecting the Great Lakes.

Invasive plants are entering Canada through both intentional and unintentional introductions. The majority of intentional introductions (approximately 73 percent) come through ornamental or landscaping plants, followed by introductions through agricultural crops (approximately 33 percent). Unintentional introductions (approximately 86 percent) are brought to Canada mainly through plant products such as contaminants in seed, forage, produce, and wood products. The second means of introduction is through freight, packing materials, machinery, and equipment.

The Ontario Invasive Plant Council

The OIPC recently conducted a preliminary review of current response mechanisms in the province. This revealed that the current legislation, policy, and investment of human resources by the government are not entirely up to the task of dealing with invasive plants. Existing applicable legislation and policy were initially drafted to curtail the spread of agricultural weeds, and not deal with the broader threat of invasive plants. Work in Canada is being done to close the legislative gaps and new and promising initiatives are being developed, such as Ontario's Invasive Action Plan, as well the federal government's invasive plant framework for Canada, Least Wanted Program, and EDRR Framework for Canada. Through all these programs, the OIPC has expressed interest in helping with their development by facilitating collaboration or reviewing documents and providing insight from a Council perspective.

The OIPC is a non-profit group made up of various agencies and organizations, including representatives from all levels of government, conservation authorities, industry, academics, First Nations, the horticultural industry, and other environmental non-governmental organizations. These partners have come together to ensure a greater awareness as well as a coordinated effort against the threat of invasive plants. Prior to the creation of the OIPC there was no coordinating body to deal with invasive plants in Ontario. The Council started in 2007 at a meeting where a group of concerned individuals from various organizations and agencies realized the lack of collaboration in Ontario when dealing with these plants and committed to forming the OIPC. Since then, an interim board has been working to establish the processes of the Council, finding funding sources, developing key contacts, and working to move forward and attain the goals and objectives that were originally set out from the beginning.

The Ontario Federation of Anglers and Hunters (OFAH) took a lead in the development of the OIPC by offering to house the coordinator and provide administrative support. Being housed within the OFAH, the OIPC has a great relationship with the Provincial Invading Species Awareness Program and is offered experience and expertise from an organization whose program has been in existence for a longer time and has had much success over the 10 years it has been running.

The OIPC's continuous work with a variety of organizations and agencies has enabled the Council to develop and successfully deliver quite a number of projects over the past three years. An Annual General Meeting and Invasive Plant Symposium is held annually to discuss invasive plant work across the province and is a great networking opportunity. The OIPC distributes a monthly newsletter to over 600 people and is able to help in the coordination and participation of various projects with our partners including invasive plant control projects, student training, media events, invasive plant road rallies, landowner workshops, and more.

OIPC Committees

The OIPC has established four provincial invasive plant committees that focus on policy, communication, research and control, and horticultural outreach. These committees were developed based on the needs of the Council; each one is very active and works hard to deliver a variety of objectives.

The Communications Committee was created to develop communication and educational outreach materials on behalf of the Council dealing with invasive plants. Recent projects developed in collaboration with other organizations and agencies include:

- The "Most Un-wanted" fact sheets (kudzu, garlic mustard, dog strangling vine, and buckthorn);
- Media releases;
- Radio public service announcements, such as "The adventures of the Green family";
- Dog-strangling vine and water soldier signs;
- A landowners guide to controlling invasive plants (guide and workshops for landowners);
- Surveys to determine baseline information; and
- Continued maintenance of the OIPC website, including an easy to use calendar that the public can use to disseminate information on upcoming events.

The Policy Committee was created to work on the Council's policy items and to identify and review legislation dealing with invasive plants in Ontario. Recent projects worked on in collaboration with other organizations and agencies include:

- Identification of gaps in government legislation and bringing forth solutions, and conveying the need for collaboration to the policy makers;
- Early development of an Early detection Rapid Response program for the province of Ontario; and
- Identification and development of new policies for the Council.

The Research and Control Committee was created to encourage collaboration on invasive plant research, management, and control projects across the province. Projects worked on in collaboration with other organizations and agencies include:

- Continuous development of a clearinghouse of existing resources to share knowledge across Ontario; and
- Development of a list of invasive plants and definitions for the Council.

The Horticulture Outreach Committee was created to develop outreach and education information aimed at the horticulture industry. This group works closely with industry to reduce the sale of invasive plants in Ontario. Recent projects worked on in collaboration with other organizations and agencies include:

- Early development of a "Grow Me Instead Guide," which identifies an invasive horticultural plant along with three non-invasive alternatives, one of which is a native plant;
- Development of a brochure to explain the group's goals;
- A report from a survey that identified the baseline knowledge of invasive horticultural plants within the horticultural industry; and
- Attending various garden conferences and distributing outreach materials.

The OIPC is also pleased to collaborate with groups across the country and within the US, including the National Invasive Species Working Group (NISWG) and the Midwest Invasive Plant Network. NISWG is a group of representatives from each provincial invasive species council in Canada, who work together on invasive plant issues across the country and strive to keep the lines of communication open and create a common message for Canada.

New Invaders to Ontario

Kudzu *(Pueraria montana)* was discovered in fall 2009 near the town of Leamington, in the southernmost part of Ontario, along a south-facing bank on Lake Erie. A risk assessment was conducted by the federal government and a multi-governmental group discussed management options.

The second new invader, water soldier *(Stratiotes aloides)*, originated in Europe and is commonly used as an ornamental plant in aquariums and water gardens. It was discovered in fall 2008 in Ontario's Trent Severn Waterway and is the only known established population in Canada and the US.

Support for the OIPC

The OIPC has received support from Environment Canada's Invasive Alien Species Partnership Program, the Ontario Ministry of Natural Resources, and the Sault Ste. Marie Invasive Species Centre Partnership Fund. Financial support has come from Dow AgroSciences-Canada, Hydro One, OFAH, and OIPC membership funds.

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Invasive Weed Control on Annette Island, Alaska

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Abstract

The Metlakatla Indian Community is comprised of 12,400 acres of mixed forest and wetlands with a human population of 1,398. Annette Island is the southern-most community in Alaska, connected by ferry to neighboring island communities. In 2003 and 2004, a vegetative survey of southeast Alaska by plant ecologist Nanna Borchert brought invasive plant species to the attention to our community. The next year, the Metlakatla Indian Community applied and received noxious weed control funding from the Bureau of Indian Affairs' Noxious Weed Eradication Program. This enabled us to initiate an invasive plant management plan and to carry out weed control work on Annette Island. One of the first things we did was to apply to our local council for a resolution of support. The next step was to conduct a thorough survey of Annette Island. Our target weeds of concern were: Japanese knotweed *(Polygonum cuspidatum)*, Himalayan knotweed *(Polygonum polystachyum)*, Canada thistle *(Cirsium arvense)*, bull thistle *(Cirsium vulgare)*, annual sow thistle *(Sonchus arvensis)*, orange hawkweed *(Hieracium aurantiacum)*, and tansy ragwort *(Senecio jacobaea)*. These species were chosen because they have a negative impact on the local fishing industry and compete with local, native berry bushes and other wild edibles.

Keeping in harmony with our cultural values, we chose to use manual methods and avoid chemicals that could potentially harm our environment, especially our berries and wild edibles. We have an extensive community education and outreach program. Because humans are the main entry vector of invasive plants, we focus on reaching out to the community and making them our partners in weed control. Weed pull activities involve the youth and provide the materials for them to build their knowledge of invasive species. In conclusion, we are hopeful that with continued effort, we can control known species and prevent the introduction of new invasive species by keeping the community partners in this ongoing project.

Resumen

El Metlakatla Comunidad Indígena es de 12,400 hectáreas de bosque mixto y humedales con una población de 1,398 habitantes. La ubicación de la isla de Annette es la comunidad más austral de Alaska conectadas por ferry a las comunidades insulares vecinos. En el período 2003–2004 una encuesta vegetativa de la planta por el sudeste de Alaska ecologista Nanna Borchert trajo especies de plantas invasoras para la atención a nuestra comunidad. En 2005 MIC (Metlakatla Indian Community) solicitó y recibió el control de malezas nocivas financiación de la Oficina de Asuntos Indígenas de Malezas Nocivas Programa de Erradicación.

Esto nos ha permitido comenzar un plan de gestión de plantas invasoras y para llevar a cabo el trabajo de control de malezas en la isla de Annette. Una de las primeras cosas que hicimos fue aplicar a nuestro consejo local para una resolución de apoyo. El siguiente paso fue realizar un estudio completo de Annette Island. Nuestro objetivo malezas de preocupación son Japanese knotweed *(Polygonum cuspidatum)*, Himalayan knotweed *(Polygonum polystachyum)*, Canada thistle *(Cirsium arvense)*, bull thistle *(Cirsium vulgare)*, y, annual sow thistle *(Sonchus arvensis)*, orange hawkweed *(Hieracium aurantiacum)*, y tansy ragwort *(Senecio jacobaea)*. Nuestras razones para la elección de estas especies es su impacto negativo sobre la industria pesquera local y sus competidores a los arbustos de bayas y otros locales comestibles silvestres.

En armonía con los valores culturales que optó por utilizar métodos manuales evitar los productos químicos potencialmente nocivos para el medio ambiente especialmente nuestros bayas silvestres y

comestibles. Hemos establecido los controles manuales para cada especie. Tenemos una amplia educación de la comunidad y el programa de divulgación. Los seres humanos son el vector de entrada principal de las plantas invasoras, así que se centran en llegar a la comunidad hacerlos socios en el control de malezas. Involucramos a los jóvenes en las actividades de tirar de las malas hierbas el suministro de material para construir en el conocimiento de las especies invasoras. En conclusión, tenemos la esperanza de que con un esfuerzo continuado que podemos controlar las especies conocidas de prevenir la introducción de nuevas especies invasoras, manteniendo los socios de la comunidad en este proyecto en curso.

Introduction

I work for the Metlakatla Indian Community (MIC), on Annette Island, in southeastern Alaska. As the southern-most community in the state, we are connected with other southeast Alaskan communities and to the mainland by the Alaska Marine Highway Ferry System. Part of the federal Annette Island Reserve, the only Indian reservation in Alaska, MIC is the governing body of the island and as such has a unique opportunity to control weeds in the community.

I have been working for MIC since 1998. In 2003, I met Nanna Borchert, a plant ecologist who was conducting a survey of invasive plants in southeast Alaska. Up to that point I had been blissfully unaware of the presence of and dangers posed by invasive weeds. We went on a survey with her and my job changed forever. She pointed out plants that had the potential to be serious invaders and brought to our attention what we could do about the situation. That fall, we approached the local Bureau of Indian Affairs (BIA) office and spoke to them about what we had learned about invasive weeds on Annette Island and the potential weeds had to negatively impact the quality of life of residents of Metlakatla, affecting hiking, walking, subsistence edible food gathering such as berries, and most of all fishing! We were encouraged to submit a proposal to our region's Range Management Specialist for assistance.

Weed Control on Annette Island

The MIC has had an active weed control program since 2005 with support from our local council and the BIA's Noxious Weed Eradication Program Funding. In 2005, our Council approved Resolution 05-43, supporting work on seven species of concern and focusing on manual control methods due to a desire to avoid chemical herbicides.

The weeds of concern in Metlakatla are:

- Japanese knotweed (*Polygonum cuspidatum*)
- Himalayan knotweed (*Polygonum polystachyum*)
- Canada thistle (*Cirsium arvense*)
- Bull thistle (*Cirsium vulgare*)
- Annual sow thistle (*Sonchus oleraceus*)
- Orange hawkweed (*Hieracium aurantiacum*)
- Tansy ragwort (*Senecio jacobea*).

Why these weeds? Firstly, they have the potential to negatively impact the MIC's fishing industry. Japanese knotweed litters streambeds and destroys prime spawning grounds. We identified only two small patches in 2003 and made it a priority to eradicate this incredibly prolific invader. With concerted effort, it has been reduced to a small area with shoots that we pull regularly in the spring and summer. Secondly, these weeds out-compete our native berry bushes and reduce the number and health of these culturally important plants. We witnessed firsthand the berry bushes being continually pushed back. Himalayan knotweed has been especially damaging and has reduced the number and health of both salmon berry and thimbleberry bushes within town limits. We are currently utilizing manual control methods so that we can continue to harvest these important food crops; choosing manual methods and avoiding chemicals that could potentially harm our environment, and especially our berries and wild edibles even further, is in keeping with our cultural values. If this weed escapes further into the wetlands around the areas where it is already present, it would degrade a wide variety of important edible foods (Figure 1). Finally, toxic plants pose a health and safety risk to people and animals, including the local population of Sitka black-tailed deer. Tansy ragwort causes rashes or worse reactions in humans and, in high concentrations, can be deadly to grazing animals.

Figure 1. Himalayan knotweed has almost completely taken over areas that just 15 years ago were dominated by thimbleberry and salmon berry.

In June 2009, we pulled over 40 bags of Himalayan knotweed with the kids (Figure 2). In just over 30 minutes, we completely filled a pickup truck and it took a day and a half to burn the contents of the bags. When we talked to the kids about why they should care about this weed, one of the biggest motivators was the negative impact it has on local berries. The kids learned the importance of reporting invasive weeds so that they can be properly disposed of.

Over the next few weeks, several of the children involved reported to us and the Metlakatla Boys and Girls Club how much they enjoyed the activity and where they had seen more of the weeds we had talked about. Their enthusiasm is contagious and spurs us on to keep up the fight against weeds.

We greatly appreciate the Metlakatla Boys and Girls Club for their cooperation and wholehearted support of this program and for providing a way for us to reach the community's youth. Their involvement has been crucial; teaching the youth about invasive weeds and the threats they pose is especially effective when it's fun and includes hands-on activities.

Expanding Our Efforts

Invasive weeds were impacting our small community but few people realized it. We immediately saw the need to involve the community in efforts to control these invaders and make them partners in weed control. Because humans are the main entry vector of most invasive species, education was necessary. As we learned more about the possible threats posed by invasive weeds, we shared that information with the community using the local newspaper, health fairs, and presentations to students and the Metlakatla Boys and Girls Club. Our goal has been to make this a community-wide effort since the very beginning.

In 2006, the Governor of Alaska declared the last week of June "Alaska Invasive Weed Awareness Week." Each year, we participate by organizing public outreach and weed pull activities with the Metlakatla Boys and Girls Club. We also distribute printed handouts, provided to us free of charge by Alaska's Forest Service office and the Committee for Noxious and Invasive Plant Management, throughout the community. We are aware that change comes slowly and so we have been focusing on educating young people, the future stewards of the land. It has been exciting to see the kids educating their parents and others on the issues of invasive weeds and why they should care.

Outreach projects

Reaching the public is a key part of our program, therefore we attended the local health fair and answered questions and handed out pamphlets.

Our outreach projects have resulted in the high school social studies teacher including a segment on invasive species each year and we act as mentors to high school seniors doing presentations on the topic of invasive weeds. This is a fun and exciting part of our education and awareness work. We also post signs and materials whenever appropriate to help spread the word. Finally, we submit an annual report to the Mayor, Executives,


Figure 2. Himalayan knotweed pull with the Metlakatla Boys and Girls Club.

and Council on the work we have accomplished and our future plans.

Himalayan knotweed project

In August 2009, we hired five youth to help pull Himalayan knotweed. Having the ability to hire and further educate the youth throughout the summer was exciting—they take the knowledge they gain with them wherever they travel and come home full of observations of invasive species in other areas. We hope that this experiment will give us vital information on the best manual control methods for this weed. So far, these efforts appear to have had a negative effect on the knotweed and we will continue to share our results with the invasive weed community in Alaska. Hopefully this will be an effective method to control this weed!

Annual surveys

Beginning in 2006, we conduct an annual island-wide survey of the inhabited and existing road systems of Annette Island. The results are shared with the MIC and BIA, as well as the public.

The survey is conducted in the downtown area and continues along the road to our airport area abandoned housing, left over from the World War II days (Figure 3).

Protecting Our Island

We monitor the entry vectors that bring in these invaders. The ferry terminal can bring invaders from nearby Ketchikan and all the way from British Columbia via the Alaska Marine Highway. The barge system, fuel barge site, airport, breakwaters, and roads are surveyed regularly to reduce the introduction of new invaders. The importation of plant material for gardening is monitored and we try to provide the public and vendors with the knowledge they need to avoid introducing invasive plants. Efforts are being made to establish a cooperative weed management area in our region to assist us with valuable cooperation to continue our battle against invasive species.

Reaching Outside the Community

This past fall we had the privilege of attending the Center for Noxious and Invasive Plant Management's (CNIPM) annual conference in Ketchikan, where we learned about other

Figure 3: The old Coast Guard housing and farm site contains our largest concentration of bull thistle.

terrestrial, marine, and insect invaders we need to be aware of. We were honored to receive an award acknowledging our efforts to control noxious and invasive weeds in our area. However, we still have a lot to do. We must reach out to the neighboring communities as their invasive weeds can affect us. Our closest neighboring community, Ketchikan, has not yet established any controls and therefore, we must prevent their weeds from traveling to our community.

Conclusion

I hope I have given some insight into the work being done on a little Alaskan island.

We look forward to reaching our goals of weed eradication and control, preventing new infestations, and building partnerships within our community; and we are optimistic that the strong cooperation between departments in Metlakatla will enable us to be successful. We will continue to share what we know and what we learn with the Fish and Wildlife Department, Forestry Department, BIA, and other agencies. Together, we will take steps to educate, monitor, and protect our home, Annette Island.

Awareness and Education for Invasive Species: The Montana Statewide Noxious Weed Awareness and Education Campaign and the Center for Invasive Plant Management

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Abstract

Noxious weeds and aquatic nuisance species reduce the economic productivity and ecological integrity of lands and waters in Montana and across the nation. The rate of introduction and spread of invasive species has increased dramatically over the past 150 years as human activities, trade, and commerce have increased. It is imperative that we implement scientifically based, Early Detection and Rapid Response actions, as well as long-term research, prevention, management, restoration, and education strategies to combat the invasive species threat.

This presentation will discuss two programs that are excellent examples of weed awareness, education, and management efforts in Montana. The Montana Statewide Noxious Weed Awareness and Education Campaign and the Center for Invasive Plant Management are recognized across the state, region, and nation as key centers for the awareness, education, and coordination for invasive species management. As a result of efforts by these two programs, natural resource managers and the public are developing an understanding of how humans, natural resources, and the economy are being affected by invasive species. These programs possess the expertise to consistently provide effective outreach and education materials as well as high quality methods for delivering that information to public land users and managers.

Resumen

La Campaña Estatal de Sensibilización y Educación de Malezas Nocivas (SNWAEC) se inició en 1995 como una subcomisión de la Asociación de Control de Malezas de Montana. El objetivo era educar a los ciudadanos de Montana sobre los impactos económicos y ambientales de las malezas nocivas y ser apoyo en todos los aspectos del manejo integrado de malezas nocivas. El grupo desarrolló siete objetivos de comunicación concisa para nueve audiencias objetivo. A través de este proceso hemos desarrollado más de 80 proyectos educativos con personas dedicadas e interesadas con una amplia variedad de experiencia. El desarrollo Anuncios de Servicio Público de 30 segundos con expertos locales ha sido muy exitoso. Otros proyectos han contribuido al desarrollo de la educación para la recreación, la juventud, los propietarios de tierras y productores.

El Centro de Manejo de Plantas Invasoras (CIPM) se inició en 2000 con fondos dirigidos del Congreso. Este proyecto estimula y fomenta la colaboración y la cooperación entre investigadores, educadores y público y los propietarios de tierras privadas responsables de la administración y la restauración de los ecosistemas naturales. Este programa ha tenido mucho éxito en la provisión de fondos para la investigación, la información de plantas invasoras, gestión de recursos, la educación pública y profesional a todos los niveles, el desarrollo de CWMAs y la coordinación entre administradores los de los recursos privados, condados, estatales, y federales.

The Montana Statewide Noxious Weed Awareness and Education Campaign

The Montana Statewide Noxious Weed Awareness and Education Campaign was initiated in 1995 as a long-term statewide mass media campaign designed to reach every Montana citizen by a subcommittee of the Montana Weed Control Association. The campaign has had one program manager, Carla Hoopes, who has enabled the development and completion of a wide range of weed education projects. The program manager is supported by an Executive Committee, comprised of representatives from federal and state land management agencies as well as local and regional stakeholders. The campaign's mission statement reads: "For the people of Montana to realize the economic and environmental impacts of noxious weeds, to become supportive of all aspects of noxious weed efforts, and implement noxious weed management across Montana." With this mission and the slogan, "Pulling together against noxious weeds," the campaign has significantly improved Montana citizens' awareness of noxious weeds.

The campaign was formed when representatives from across the state came together in a series of facilitated meetings; the results of these working sessions and meetings include the campaign mission statement, seven key messages for nine target audiences, and a long-term mass media plan designed to reach every Montana citizen. Efforts by the Executive Committee, along with other stakeholders, helped to create a cohesive campaign designed to engage all Montana citizens. Professional resource managers, including county weed managers and representatives from several groups and organizations, developed campaign messages and identified target audiences. The long-range vision of the campaign is to ensure that every Montana resident develops a comprehensive understanding of noxious weed issues to the extent that individuals work cohesively with government, both public and private, to maintain healthy ecosystems across the state. As the campaign progresses and new projects are initiated, additional stakeholders are enaged. A stakeholder is defined as any individual willing to work hard to achieve the campaign mission.

The group initially developed and focused on seven concise messages for delivery to the identified target audiences. These include:

- Explanation of noxious weed impacts and guidelines for identifying of individual plants;
- How humans are affected by noxious weeds;
- How the environment is affected by noxious weeds;
- Why the general public needs to support all aspects of noxious weed efforts (including the Montana Noxious Weed Trust Fund);
- What the general public can do to help;
- Successful weed management programs in Montana; and
- There are many ways to manage weeds and opportunities to learn integrated control methods.

Following the development of the messages, stakeholders identified nine target audiences. Over the past 15 years, campaign partners have initiated and implemented over 100 education and awareness projects directed specifically toward these audiences.

Public at large

The campaign's main audience consists of Montana's "average" citizens and the goal is to educate these individuals, as well as those with whom they interact, in an enthusiastic and positive manner. Projects include: the campaign website (http://www.weedawareness.org), speaker's kit slide presentations, a noxious weed calendar, collaboration with the Weed Seed Free Forage Program, vehicle license tax for weed control, and weed impact displays and accompanying bulletins.

Youth and youth educators

The youth and youth educator audience is comprised of members and leaders of youth groups, such as 4-H and FFA, county agents, and teachers. The focus is to educate and raise awareness of noxious weed issues among the next generation of managers and leaders. Projects and materials include: noxious weed coloring books, noxious weed bumper sticker contests, weed games, and an ecology program that explains how noxious weeds negatively impact the environment. Several classroom curriculums have been developed for all ages, with the "What's in Your World" project being one that crossed several educational subjects (reading, writing, technical reasoning, and scientific observation).

Environmental and conservation community

This audience includes many formal environmental organizations as well as citizens with environmental interests. Project materials and actions include: a noxious weed calendar, which has been used as a successful education tool for many years; the campaign website; development of weed management areas; presentations at organization meetings; and public service announcements, which discuss invasive species awareness, management, education, biological control, and research topics.

Realtors, developers, and private landowners

This audience includes realtors, land developers, and small acreage private landowners. The campaign developed noxious weed disclosure statements for buy/sell agreements and a four-hour, four-credit elective continuing education course through the Montana Board of Realtors. Additional efforts include noxious weed workshops for landowners and a booklet offering tips on fighting weeds on small acreages in Montana.

Government

This audience includes county, state, and federal agencies and their employees, and public officials. County commissioners are a group with considerable influence on planning and local land development and the campaign has made considerable efforts to educate these individuals, as well as local, state, and national decision makers, on how legislation influences noxious weeds efforts. Professional management has provided assistance in the development of new legislation and a review of existing legislation. Educational events have been conducted at all levels of government for employee awareness of noxious weeds, and the Greater Yellowstone Coordinating Committee has been especially helpful in raising awareness of noxious weeds in the Greater Yellowstone Area.

Recreationists, sportsmen, and tourists

This audience includes many types of public and private land users and their associated industries. Campaign projects have included: adding messages about weed awareness to hunting and fishing license envelopes, public service announcements, Off-highway Vehicle Users partnerships, Lewis and Clark Bicentennial activities, and "Adopt a Road" and "Adopt a Recreation Site" programs.

Utilities and transportation

This audience includes utility and transportation providers and railroads. Considerable education and coordination has provided for equipment cleaning and site rehabilitation during construction and maintenance. These projects have helped prevent the spread of weeds along these rights-of-way. Cooperation along highways and roads at all levels has improved the effectiveness of weed control crews through block management. Coordination and education of the Montana Contractors Association Board has raised awareness and cooperation for ground distributing projects. An outreach program targeting weed free sand and gravel pit operations was initiated in the Greater Yellowstone Area, and is spreading to other parts of the state.

Producers

This audience is comprised of anyone that produces a product off the land. Most of these individuals possess a higher awareness of invasive species issues because of the economic impact they have on agricultural operations. Campaign projects have included: weed committee presentations, the Zero Spread Campaign, best management practices, and integrated weed management resources in a new publication of "Biology and Management of Rangeland Weeds" by Roger Sheley and JK Petroff.

Reservations and Native American nations

This audience is comprised of Montana's Native American nations. The campaign recently initiated a project to expand communication with

Native American educators and has begun developing a pilot project that will adapt the "What's in Your World" program for Native American nations.

The Montana Statewide Noxious Weed Awareness and Education Campaign has been a state and regional leader in the development of weed education messages. The target audiences and messages were identified and developed with a broad base of stakeholders working in collaboration toward a common goal. Including stakeholders from across public and private entities helped recognize common goals and reduced the duplication of educational efforts for the public. This, in turn, increased staff effectiveness and allowed them to get the weed message out to broader audiences across Montana with limited funding. Since its inception, the campaign has increased awareness and understanding of the impacts noxious weeds have on health, land values, recreation, lifestyle, aesthetics, and cultural aspects. It has also increased awareness of the threats posed by noxious weeds to environmental systems, including: increased soil erosion, alternation of natural fire cycles and ecosystem processes; and loss of wildlife habitat, native plants, plant diversity, and forage production. Noxious weeds put Montana's landscapes at risk and citizens must pull together to protect these landscapes and the wild and domestic landscapes that depend on them.

The Center for Invasive Plant Management

The Center for Invasive Plant Management (CIPM) was established in 2000 as a regional center to promote ecologically sound management of invasive plants in western North America by promoting research and public education, and facilitating collaboration and communication among researchers, educators, and land managers. CIPM grew out of a series of stakeholder meetings which involved individuals from 11 western states and Washington, DC. The participants represented state and federal agencies, western universities, commodity groups, agribusiness, ranchers, and conservation organizations.

Initial funding for CIPM was secured through Congressional appropriation. Earmarked funds were transferred to CIPM via the USDI Bureau of Land Management's Montana State Office by the use of six federal assistance agreements. The final agreement, in fiscal year 2006, was completed under the Rocky Mountain Cooperative Ecosystem Studies Unit. In the years since 2008, CIPM has secured the majority of its funding through grants and other project driven funding sources.

CIPM's primary objectives are to: (1) facilitate collaboration and communication among scientists, land managers, policy makers, and the public; (2) serve as a respected, science-based information clearinghouse for ecological management of invasive plants; (3) provide professional development opportunities for land managers and educators; and (4) serve as a resource center for Cooperative Weed Management Areas and other community-led invasive species management groups.

To accomplish these objectives, CIPM is guided by an active Steering Committee, made up of representatives from state and federal agencies, universities, industry, private landowners, and conservation groups from the western region. CIPM and its Steering Committee have developed mission and vision statements as well as periodic strategic plans to guide the Center in four primary program focal areas: education, research, science communication, and policy.

Outreach

CIPM's outreach program component provides services that help communicate and disseminate information to meet the needs of natural resource professionals, educators, and the concerned public. Through collaborative partnerships, CIPM develops a variety of high-quality products and opportunities that build knowledge and increase the understanding of invasive plant ecology, biology, and management. Two examples are CIPM's website (http://www.weedcenter.org) and its plastic weed models and identification cards. The former is a comprehensive online guide to invasive plant information, funding resources, invasive species-related jobs and events, and education and management resources. Secondly, CIPM began distributing plastic weed models and identification cards in 2006. Developed by CIPM, these one-of-a-kind plastic models are excellent tools for enhancing plant identification skills year-round and for all levels of age and expertise. Eight species are currently available, including perennial pepperweed *(Lepidium latifolium)*, garlic mustard *(Alliaria* *petiolata)*, purple loosestrife *(Lythrum salicaria)*, saltcedar *(Tamarix* spp.*)*, yellow starthistle *(Centaurea solstitialis)*, leafy spurge *(Euphorbia esula)*, Dalmatian toadflax *(Linaria dalmatica)*, and spotted knapweed *(Centaurea maculosa)*. Potential new weed models species include Japanese knotweed *(Fallopia japonica)*, Scotch brome *(Cytisus scoparius)*, Canada thistle *(Cirsium arvense)*, blueweed *(Echium vulgare)*, common tansy *(Tanacetum vulgare)*, and oxeye daisy *(Leucanthemum vulgare)*.

Professional development

CIPM-developed online learning products are offered as self-study modules, instructor facilitated workshops, and web seminars. These products are designed as additional components to site-based workshops and training programs or as complete online learning programs. CIPM also provides technical writing and editorial services, and has sponsored research and science initiatives that have resulted in the publication of books, peer-reviewed journal articles, and other science communication products.

Products developed by CIPM include: "Inventory and Survey Methods for Nonindigenous Plant Species" (2006) by Lisa Rew and Monica Pokorny; "Fire as a Tool for Controlling Nonnative Invasive Plants" (2005) by Peter Rice; and "Invasive Plant Management: CIPM Online Textbook" (http://www.weedcenter.org/textbook). The former was recently used as the basis for a free web seminar series, available on CIPM's website.

Research

The Center's research component promotes multidisciplinary scientific investigations that address both site-specific and regional-scale issues, thereby providing a foundation for new approaches to invasive plant management, and for synthesizing and communicating research results to improve on-the-ground land management. Goals of CIPM's research program include: facilitating, supporting, and conducting collaborative research; communicating science by developing technical and educational publications and trainings (online and site-based); and organizing research symposia and workshops.

CIPM serves as partner on several collaborative research projects, assisting with comprehensive ecological and invasive plant research and implementation of timely technology transfer between natural resource managers and scientists. Current collaborations include:

- *Spatial Modeling of Invasive Flowering Rush (Butomus umbellatus) in the Columbia River Headwaters Project.* Partners: Salish Kootenai College, the Confederated Salish and Kootenai Tribes, and the University of Montana.
- *Missouri River Watershed Coalition.* A coalition of parties from six states whose goal is to maintain productive, healthy, and biodiverse riparian ecosystems. CIPM provides formal program coordination.
- *Reproductive Ecology of Saltcedar along the Yellowstone River.* Led by CIPM and Montana State University.
- *Assessing Plant Community and Soil Characteristics after Saltcedar Invasion and Treatment.* Led by CIPM and Montana State University.

The Center provides a critical connection between the research and management communities by effectively conveying research results to natural resource managers and landowners, an important component of promoting ecologically based management. Science communication provides a vital link between research and on-the-ground application of invasive species management.

Through its research grants program (2001–2007), CIPM provided funding to support the collection and analysis of ecological data to better understand the prevention, introduction, spread, management, and ecology of invasive plants. Specific objectives of CIPM's research grants program were: (1) support projects that provide the foundation for new approaches to invasive plant management; (2) document the impact of invasive plant species on ecosystem function; (3) develop and test new decision making tools; and (4) synthesize and communicate research results to improve on-the-ground land management. In just seven years, CIPM awarded over $650,000 in competitive seed-money grants to 76 grantees in 21 states. Many of these grants resulted in full funding from other grant sources. CIPM now actively pursues research targeted grants for invasive species management.

Project coordination

The Center's collaboration and communication program component provides information and organizational assistance to a wide variety of groups. Key goals of this component are: (1) to provide timely information on current events and legislation related to invasive species; (2) assist in locating informational resources, state or regional models, and contacts for specific topics; (3) coordination and facilitation of multi-partner projects; and (4) organization of scientific panels to investigate invasive plant policy issues.

CIPM has coordinated several conferences, technical symposia, and workshops in the western region and across the country. These events, which bring together scientists, natural resource managers, state and federal agencies, and other interested parties, set the stage for creative brainstorming and transfer of knowledge and research results. Organizations and groups for which CIPM has provided event facilitation and coordination include: the Weed Science Society of America, Society for Ecological Restoration, Society for Range Management, Montana Weed Control Association, Land Reclamation Symposium, Tamarisk Coalition, National IPM Symposium, and most recently, the Weeds Across Borders 2010 conference.

Additional groups and organizations to which CIPM provides professional coordination and organizational assistance include the National Invasive Species Council's Invasive Species Advisory Committee, National Network of Invasive Plant Centers, North American Invasive Species Network, National Invasive Species Awareness Week, Pacific Northwest Invasive Plant Council, Missouri River Watershed Coalition, Midwest Invasive Plant Network, Western Weed Coordinating Committee, and the Weed Science Society of America.

Policy

Policy, at the state and national levels, determines priorities for invasive plant management. Ideally, policy is based on the most current science for topics as diverse as wildlands, water quality and quantity, wildlife habitat, fisheries, biofuels, terrestrial and aquatic transportation corridors, land reclamation, risk assessments, wildfire operations, economic impacts, and ecosystem services. Using the expertise of a network of scientists, natural resource managers, government personnel, and non-governmental organizations nationwide, CIPM is able to aggregate quantitative and qualitative data to assist groups and committees in forging effective actions that influence policy.

CIPM provides non-partisan information and resources to those who communicate with state and national policy makers. One such successful project was the Farm Bill Workshop in 2007, for which CIPM invited scientists from across the country to consider invasive plant impacts on wildlife, water quality, water quantity, production (agriculture, grazing, and forestry), and wetlands. Workshop participants assessed the state of the science relevant to Farm Bill conservation programs, considered implications for future management, and developed science-based recommendations that were delivered to the Senate Agriculture Committee in time for their incorporation into legislation. These services are provided as a service; CIPM does not advocate for or against specific policies.

Conclusion

As a result of its achievements in these program components, the Center has become a regionally and nationally recognized source of information for scientists, educators, managers, and the public. CIPM-funded research has helped create a foundation for new approaches to invasive plant management by synthesizing and communicating research results, and has worked to improve on-the-ground land management. CIPM is fulfilling its vision by creating a support network of well-informed invasive plant professionals who have the contacts, information, and resources necessary to accomplish their goals.

2009–2010 Update on the United States Federal Noxious Weed Regulatory Program

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Abstract

Federal Noxious Weeds (FNW) are regulated by the United States Department of Agriculture's Animal and Plant Health Inspection Service (APHIS) Plant Protection and Quarantine (PPQ) based on risk assessment. Authority implemented by the Plant Protection Act of 2000 allows PPQ to require permits for the importation, exportation, or movement in interstate commerce of noxious weeds. Recent APHIS rule changes have added nine species to the FNW list, updated botany, and established a new category under the propagative plant materials quarantine, also known as Quarantine 37 (7 CFR §319.37). The rule establishes a category of plants for planting: Not Authorized for Importation Pending Pest Risk Assessment. A series of factsheets for the FNWs currently regulated is in preparation. Currently, the APHIS weed risk assessment method is also undergoing revision. Funding under the 2008 Farm Bill Title X, Horticulture and Organic Agriculture, Section 10201, Plant Pest and Disease Management and Disaster Prevention, directed the Secretary of Agriculture to make available Commodity Credit Corporation funds to implement the Section. The implementation plan defines strategies—organized into six major areas—to integrate and coordinate plant pest and disease management and disaster prevention activities. Funding areas of particular interest to Weeds Across Borders participants are: (1) enhance plant pest/disease analysis and survey; (3) enhance and strengthen pest identification and technology; (5) conduct outreach and education to increase public understanding, acceptance, and support of plant pest and disease eradication and control efforts; and, (6) enhance mitigation capabilities.

Resumen

Federal Noxious Weeds (FNW) estan regulados por el Department of Agriculture's Animal and Plant Health Inspection Service (APHIS) Plant Protection and Quarantine (PPQ) de los estados Unidos, basado en la evaluación de riesgos. Autoridad implementada por la Plant protection Act 2000 permite que PPQ exiga permisos para la importación, exportación, o el movimiento en el comercio interestatal de malezas nocivas. Recientes cambios en el reglamento de APHIS se han añadido 9 especies a la lista de FNW, actualizado botánica, y estableció una nueva categoría bajo material vegetal de propagación de cuarentena, también conocido como cuarentena de 37 (7 CFR §319.37). La norma establece una categoría de plantas para la plantación: No Autorizadas para la Importación Espera de Evaluación de Riesgo de Plagas. Una serie de hojas de datos para el FNWs actualmente regulados está en preparación. Actualmente, el método de evaluación de riesgo del APHIS es también objeto de revisión. Financiación en virtud de la Ley Agrícola de 2008, Título X, horticultura y agricultura orgánica, Sección 10201, Plantas Plagas, Manejo de Enfermedades y Prevención de Desastres, dirigido por Secretario de Agricultura pone a disposición los fondos de Commodity Credit Corporation para implementar la Sección. El plan de implementación define las estrategias—organizadas en seis áreas principales—para integrar y coordinar las actividades de plantas plagas, manejo enfermedades y prevención de desastres. Financiamiento de áreas de especial interés para los miembros de WAB son: (1) mejorar el análisis y estudio planta plaga/enfermedad; (3) mejorar y fortalecer la identificación de

plagas y tecnología; (5) conducta de divulgación y educación para aumentar la comprensión del público, aceptación y apoyo de los esfuerzos de erradicación y control de plantas plagas y enfermedades; y (6) mejorar las capacidades de mitigación.

APHIS Mission and Structure

The United States Department of Agriculture's Animal and Plant Health Inspection Service (APHIS), Plant Protection and Quarantine (PPQ) mission is to safeguard agriculture and natural resources from the risks associated with the entry, establishment, or spread of animal and plant pests and noxious weeds, in order to ensure an abundant, high-quality, and varied food supply.

The Federal Noxious Weed (FNW) program is a part of the PPQ staff program known as Emergency and Domestic Programs (EDP). A question often asked by the public is "how do noxious weeds differ from invasive species?" Or from ordinary weeds? These questions are discussed in the article "Rapid Response: Putting Early Detection and Rapid Response into Practice," appearing later in this publication. The PPQ national leadership teams develop, communicate, and implement strategic and operational plans for their respective program areas in cooperation with APHIS–PPQ regional offices. PPQ regional program managers implement the programs in the states in cooperation with the state Plant Health Officials (PPQ state directors), and the state Plant Regulatory Officials (state government officials). Most APHIS programs are funded through cooperative agreements with state governments.

PPQ handles regulation of import and interstate movement of regulated pests in the United States. This article will discuss various aspects of the APHIS weed regulatory program, including the legal authority for the US national weed program and the strategic rationale for program management and goals.

The Plant Protection Act (PPA), which was signed into law in 2000, replaced most of the previous weed authorities, including the Federal Noxious Weed Act of 1974. Portions of the 1974 Weed Act, mainly addressing cooperation with federal land management agencies and state programs, were incorporated into the PPA, which consolidated and replaced federal authority scattered across eight previous laws authorizing APHIS weed programs. The Deputy Administer of APHIS, who leads PPQ along with any authorized regulatory employee, is delegated authority by the Secretary of the USDA to enforce the Noxious Weed Regulations.

The APHIS Weed Mission

The APHIS noxious weed strategic plan mission statement states:

- APHIS will use science-based methods to prevent the introduction of parasitic-plant pests and FNW, including those already regulated as well as candidates for regulation, into the US;
- APHIS will exclude, detect, and eradicate newly introduced weeds that pose the highest risk to US agriculture or the environment; and
- APHIS may cooperate with other agencies to achieve environmentally sound and desirable forms of integrated pest management against introduced invasive plants.

Federal Noxious Weeds and Seeds

Regulations are the mechanism for agencies to implement the authority granted to them by law. APHIS regulations for the FNW program (mainly found in 7 CFR §360), define FNW as those plants and plant products listed in the Noxious Weed Regulations at 7 CFR §360.200. A noxious weed is defined by the PPA 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, natural resources of the US, public health, or the environment. This clearly includes a much broader mandate than crop pests, which many stakeholders presume is the limit of APHIS programs.

Plants meeting the definition of a noxious weed are generally prohibited or restricted from entering the US or moving through it (interstate). For transparency with stakeholders, these species are listed in the FNW regulations. All FNW are co-listed as noxious weed seeds (7 CFR §361). Non-native parasitic plants are regulated as Plant

Pests under 7 CFR §330, and may or may not also appear in the FNW list.

Under the PPA, APHIS is responsible for the exclusion, detection, and eradication of newly introduced weeds that pose a high agricultural or environmental risk. These weeds include federally designated noxious weeds as well as parasitic plant pests. Most plants with FNW designation fit the definition of a quarantine pest not yet in the US or, if present, of limited distribution and under official control. Additionally, FNW designation indicates that the plant is capable of causing economic and/or environmental harm, usually determined by a pest risk assessment (PRA), alternatively known as a weed risk assessment (WRA). Plant species that are widely established in the US are not normally proposed for listing as FNW.

Federally Regulated Seeds

The Federal Seed Act (FSA) restricts the entry of seed listed as "agricultural" or "vegetable" to ensure seed purity, mainly that the seed is what the label says, and that the seed is free from noxious weeds as identified in the Act and the imported seed regulations (7 CFR §361.1–10). APHIS cross-lists the FNW to the FSA list of FNW. APHIS administers the foreign commerce provision of the FSA and the Agricultural Marketing Service (AMS) administers the interstate commerce provisions. The FSA recognizes three classifications of seeds: (1) prohibited FNW species; (2) regulated non-quarantine contaminants in agricultural or vegetable seed; and (3) State Noxious Weeds.

State Regulations

States, tribes, and localities may also designate noxious weeds, many of which are not FNW, but are state or local exclusion or management targets. The 50 states (defined to include US territories: American Samoa; the Commonwealth of the Northern Mariana Islands; the Commonwealth of Puerto Rico; the District of Columbia; Guam; the US Virgin Islands; and any other territory or possession of the US), as well as numerous recognized tribes (slightly over 560), maintain authority over federally regulated taxa within their boundaries unless a federal quarantine (a specific federal regulation defining a quarantine) is established or a federal violation is proven, in either case usually with state cooperation or request. State authority covers regulation of sales, movement, and seizing of regulated species within state boundaries in the absence of such a specific federal quarantine. Only a few states do not have noxious weed laws, although some states have very short regulated lists, or have no specific list even if they have a weed law. For summaries of each state's laws, see the National Plant Board website (http://nationalplantboard.org/laws/index.html).

Not all FNW are on all state regulated lists. As of 2010, only Alabama, Georgia, North Carolina, South Carolina, and Vermont regulate all FNW by reference. This means that APHIS actions within state (or equivalent) boundaries may be limited.

APHIS has authority for inspection and warrantless searches in case of suspected federal violations. This is usually implemented by a General Memorandum of Understanding or Cooperative Agreement between a state and PPQ for each state and, in certain circumstances, may facilitate access to private property, in the absence of landowner permission, by PPQ Officers. This is normally done in conjunction with state inspectors to place facilities under notification and to witness actions specified in the emergency action notification.

Additional Provisions

Additional authority for "General Remedial Measures for New Plant Pests and Noxious Weeds" (7 USC §7714) is granted for APHIS to develop a classification system to describe the status and action levels for noxious weeds, including such factors as geographic region or ecological range, and, in conjunction with the classification system, to develop integrated management plans for noxious weeds found in the US. Such management plans typically are developed and managed in cooperation with state regulatory authorities in the infested states.

If APHIS–PPQ orders an owner to treat or destroy a FNW or contaminated commodity, the owner bears the cost. Violators are subject to civil or criminal penalties.

Federal Noxious Weed Categories

The authority for APHIS to establish FNW categories and management plans was established by policy. Currently (mid-2010), the categories are: A1 (Exclusion Targets); A2 (Official Control Targets); and B (Regulated Non-quarantine Seed List Targets). Currently, the A1 category includes 44 taxa; the A2 category includes 62 taxa; and the B category includes nine species. The term *taxa* is used because a few regulated entities include all non-natives or non-naturalized plants in an entire genus, not individual species.

The FNW list is additionally divided by habitat into three parts, with species categorized and listed under Aquatic/Wetland, Parasitic, and Terrestrial sections. The FNW list is periodically amended to add, delete, or update names of species. Refer to the APHIS website (http://www.aphis.usda.gov) for the current list.

Currently, 55 FNWs have limited distribution in the US. Cooperative efforts by PPQ and state personnel are underway to eradicate or control infestations of the listed species. In addition, 44 regulated species do not exist within the US, and the Noxious Weed Program would be required to control them should infestations be confirmed. Some plants are not invasive in their native areas, but have become noxious weeds in the US. For example, tropical soda apple was added to the FNW list after it was detected in the southeastern US and determined to be invasive.

Newly Regulated Species

The newest weeds added to the FNW list are *Lygodium microphyllum* (Old World climbing fern) and *L. flexuosum* (maidenhair creeper). These species were regulated by the Federal Import Quarantine Order for Climbing Ferns, issued on 30 May 2008, with an interim rule later adding them to the to the FNW list (affirmed 3 May 2010).

Proposed Regulated Species

A regulation in progress, Docket APHIS–2007–0146, proposes to add several species to the FNW list. Completed PRAs are posted at: http://www.aphis.usda.gov/plant_health/plant_pest_info/weeds/riskassessments.shtml. In addition, this rule revises a number of provisions included in 7 CFR §360.

Summaries from Pest Risk Assessments

Acacia nilotica

Biology/damage: *Acacia nilotica* (thorny acacia) is a perennial, non-climbing shrub or tree. Seedlings and young trees are protected from grazing by thorns. It has long-distance dispersal mechanisms allowing uncontrolled spread, large seed production, and long-lived seeds. Young plants grow rapidly and are tolerant of grazing, drought, fire, and salinity. *A. nilotica* aggressively replaces grasslands with thorny thickets, and in northern sub-humid Australia it quickly became an invasive pest after introduction.

Distribution: *A. nilotica* is native to Africa, the Arabian Peninsula, western Asia, and the Indian subcontinent. It has naturalized in northern sub-humid Australia, is a serious weed in South Africa and Australia, and a major pest worldwide. It is said to occur in Puerto Rico, the US Virgin Islands, and perhaps Hawaii. *A. nilotica* may be cultivated in other states, as it has been offered for sale by at least three US nurseries. Its predicted range in the US is Hawaii, Florida, Texas, and California, as well as the coastal Southeast.

Rationale for listing: *A. nilotica* was evaluated as having a high likelihood of introduction, medium overall risk potential, and posing medium consequences. Potential pathways for introduction into the US include ornamental seed shipments, sale of seeds for medicinal purposes, and intentional importation in passenger baggage.

Ageratina riparia

Biology/damage: *Ageratina riparia* (mistflower) is an erect or sprawling herb to sub-shrub. Colonies increase in density and size by spreading horizontally and rooting at the nodes. The plant thrives in misty, upland pastures and mountainous areas with high rainfall. Leaf litter is allelopathic. It is an agricultural and environmental weed, competing with native plants and occupying disturbed areas.

Distribution: The center of origin is the mountainous coffee growing zone of Vera Cruz, Mexico. *A. riparia* is a serious weed in Africa, India, Indonesia, Papua New Guinea, Southeast Asia, Australia, New Zealand, Jamaica, Hawaii, and Madagascar. It is likely to establish in Florida, Texas, and other moist habitats within the warm Southeast. *A. riparia* was introduced to the US as an ornamental plant and by agricultural contamination. It is currently known to exist in Hawaii Volcanoes National Park.

Rationale for listing: *A. riparia* was evaluated as having a high likelihood of introduction, medium to high pest risk potential, and posing medium consequences. Likely pathways for introduction are as an ornamental plant and an agricultural contaminant. Of limited distribution in Hawaii, the state lists it as a noxious weed for eradication and control.

Arctotheca calendula

Biology/damage: *Arctotheca calendula* (capeweed) is a flat, stem-less or short-stemmed, spreading, rosette-forming annual (possibly perennial in areas with frost-free climate). A weed of disturbed, urban, and coastal habitats, it prefers sunny locations on sandy, well-drained soil. *A. calendula* is capable of infesting turf and pasture, competing with many kinds of crops, causing allergies and dermatitis in sensitive people, and negatively affecting stock production, with likely impacts to both agriculture and the environment. The sterile, vegetatively reproducing yellow-flowered perennial is now defined as a separate species, *Arctotheca prostrate*, sometimes sold in the nursery trade.

Distribution: The native range of *A. calendula* is South Africa and it is present in southern Australia. The plant can currently be found in the coastal prairies in the San Francisco Bay area and along California's northern coast; the species is of limited distribution and regulated in California.

Rationale for listing: *A. calendula* was evaluated as having a high likelihood of introduction, high overall risk potential, and posing high consequences. The annual species with purple-tinged flowers is present and regulated in California, which lists it as an eradication category weed.

Euphorbia terracina

Biology/damage: *Euphorbia terracina* (false caper) is a short-lived erect leafy perennial herb, resembling leafy spurge (*Euphorbia escula*). An aggressive plant, it forms dense stands that inhibit the growth of native plants, competes with crops and pasture plants, and is avoided by stock and can be toxic to animals.

Distribution: *E. terracina* is native to northern Africa, temperate Asia, and some areas of Europe. In western Australia, it is a serious weed of grazing land. The plant invaded disturbed coastal areas in southern California in the mid-1980s and spread rapidly after a series of fires dispersed the hardy seeds. *E. terracina* is of limited distribution and regulated in California.

Rationale for listing: *E. terracina* was evaluated as having a medium likelihood of introduction, medium to high pest risk potential, and posing high consequences of introduction. The species is present and of limited distribution in California, which regulates it as an eradication category weed pending permanent evaluation.

Inula britannica

Biology/damage: *Inula britannica* (British elecampane) is an erect biennial flowering herb, reproducing by seeds, short rhizomes, or by root fragments. It competes with surrounding nursery crops and has negative impacts on surrounding plants, which must be sacrificed if chemical control efforts are undertaken. Its rhizomes intertwine with the root systems of *Hosta* plants imported into the US. *I. britannica* prefers wet habitats, such as river and stream margins, marshes, ditches, wet grasslands, and wet woods.

Distribution: *I. britannica* is native to Europe and temperate Asia and known in Ontario and Quebec in Canada. In the US, the weed is known in Michigan; surveys made in Alabama, Connecticut, Kentucky, Maine, Minnesota, North Carolina, Ohio, Rhode Island, and South Carolina were negative.

Rationale for listing: *I. britannica* was evaluated as having a high likelihood of introduction, medium to high risk potential, and posing medium consequences of introduction. It is currently known only in Michigan.

Onopordum acaulon

Biology/damage: *Onopordum acaulon* (stemless thistle) is annual to biennial, nearly stem-less, and has stalks that rarely exceed four inches in length. A weed of roadsides, wastelands, cultivated land, and pastures, it reduces carrying capacity of pasture. Livestock eating the plant suffer impaction and liver damage. Seeds are long-lived in the soil.

Distribution: *O. acaulon* is believed to have originated in northern Africa and southwestern Europe. It was introduced to Australia as an ornamental and as an agricultural contaminant. Since then, it has naturalized. It is not currently known in the US, but is considered likely to establish in the southeastern US, as well as Texas, California, and Arizona.

Rationale for listing: *O. acaulon* was evaluated as having high likelihood of introduction, medium to high overall risk rating, and posing medium consequences of introduction. It is not known to occur in the US.

Onopordum illyricum

Biology/damage: *Onopordum illyricum* (Illyrian thistle) is a tall, erect annual or biennial herb. It is difficult to control and has the potential to infest pastures, reduce carrying capacity, and create physical barriers to stock and wildlife.

Distribution: *O. illyricum* is native to southeastern Europe and is naturalized in Australia. In California, it is found in natural areas, disturbed sites, roadsides, fields, and especially in sites with fertile soils. The species is regulated by the state and has the potential for introduction to other areas in US.

Rationale for listing: *O. illyricum* was evaluated as having a high likelihood of introduction, medium-high overall risk rating, and posing medium consequences of introduction. It is currently regulated as an eradication target within California.

Revisions and Updates to 7 CFR §360

- Add definitions for terms used in the regulations and replace references to the Federal Noxious Weed Act with references to the PPA;
- Provide additional detail about the requirements for permits to move noxious weeds in §360.300;
- Amend the 360 regulations to refer to required heat treatment for *Guizotia abyssinica* (niger) seed, currently required in §319.37–6;
- Add explanatory text to clarify the procedure for listing noxious weeds in §360.200 and add a section to provide information about the process for petitioning to add or remove a taxon from the noxious weed list;
- Update or correct the taxonomic designations for several currently listed noxious weeds: (1) *Caulerpa taxifolia*. The new entry would read: "*Caulerpa taxifolia* (Vahl) C. Agardh, Mediterranean strain (killer algae)," add the author's name and a common name to clarify that only the Mediterranean strain is regulated as a noxious weed; and remove the entry for *C. taxifolia* from the list of noxious weed seeds with no tolerances applicable to their introduction in §361.6(a)(1), as a marine alga would not be found in seed shipments, and *C. taxifolia* is not known to set spores; and (2) *Cuscuta* seeds. Revise the list of seeds of *Cuscuta* spp. allowed entry into the US for species native to or widespread in the US: Three of the species listed as exceptions under *Cuscuta* spp. have been determined to be synonyms of three other species listed as exceptions. Correct these listings: *C. jepsonii* = *C. indecora*; *C. occidentalis* = *C. californica*; and *C. nevadensis* = *C. veatchii*. *C. veatchii* is currently listed in the regulations as *C. vetchii*; and we would correct that error.
- The names listed in the regulations for two species listed as FNWs and seeds are not the currently accepted botanical names: replace the entry for *Digitaria scalarum* with *D. abyssinica*; replace the entry for *Mimosa invisa* with *M. diplotricha*; and replace the entry for *Setaria pallide-fusca* with *S. pumila* subsp. *pallidefusca*;
- Change a number of species authority citations;
- *Homeria* spp. The current listing is for the entire genus; however, several genera from the family *Iridaceae*, have been reclassified and transferred to the large genus *Moraea*. The PRA that we prepared to help evaluate *Homeria* spp. considered specific species within the genus *Homeria*. Replace the entry for *Homeria* spp. from both FNW and seed lists with entries for: *Moraea collina*, *M. flaccid*, *M. miniata*, *M. ochroleuca*, and *M. pallida*.

Revision and Validation of Plant Risk Assessment System

PPQ's Center for Plant Health Science and Technology has now completed assessments of nearly 200 species of known US non-invaders, minor-invaders, and major-invaders using our revised draft PRA system. Statistical analysis is underway. Comparing results to the Australian system (with Hawaii's secondary screening system) indicates that so far, this system is doing as well, if not slightly better than other tests of the Australian system in the world. Results from the APHIS model, which is similar to the Australian system, indicate that it continues to effectively separate major-invaders from non-invaders.

Other 2009–2010 Outreach

The FNW national program manager sponsored and supervised a student intern as a part of the Washington Internship for Native Students program at American University. The intern drafted 80 FNW factsheets in the summer of 2009. Additionally, the student intern attended various professional meetings with the FNW program manager. She has been hired as a student trainee under the Student Career Experience Program. Currently, the draft factsheets are in editorial review and will be posted on the APHIS weed website (http://www.aphis.usda.gov), along with PRAs, where available.

Overseas Pest Information Service

The APHIS Overseas Pest Information Service observes pest information outside the US. APHIS weed program personnel are evaluating and ranking a number of the FNWs not known to occur in the US and will provide factsheets for overseas personnel.

Propagative Materials Quarantine Revision

APHIS proposed to establish a new category of regulated articles governing the importation of nursery stock (also known as plants for planting), or Quarantine 37 (7 CFR §319.37). This new regulation will allow for the addition of a number of plants proposed for new importation, identified as having the potential to become invasive, to a proposed new category of plants for planting: Not Authorized for Importation Pending Pest Risk Assessment (NAPPRA). This was published as a proposed rule: Docket ID: APHIS–2006–0011; the comment period closed 21 October 2009 and the final rule is currently being drafted.

Criteria for Listing

In order to be included in the NAPPRA category, the taxa must undergo a brief assessment. Evidence is needed to show that: the taxon is a potential quarantine pest (or a potential host of a quarantine pest); that the taxon is botanically recognizable; and that some data is available identifying that the taxa has the potential to become invasive. Taxa to be added to the NAPPRA category will be published by notice (informal rulemaking).

Tie-in to Weed Program

The NAPPRA list will dramatically increase the number of plant taxa regulated as potentially invasive.

It is estimated that about 288 taxa will be added to NAPPRA in the first phase, and a further 110 in the second phase. This category will allow APHIS to regulate potential pest plants prior to full PRA and formal listing as FNWs. As a result, the demand for weed risk assessments will increase, and potentially, the demand for permits will increase.

More Eyes, Less Weeds: The Park County Volunteer Early Detection and Rapid Response Strike Team

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Abstract

Park County, Wyoming, on the eastern boundary of Yellowstone National Park, is known for its diverse landscape, rugged mountains, and millions of acres of public lands. Because of these features, a single agency such as the Park County Weed and Pest Control District (PCWP) is limited in the amount of surveying it can do. However, many local residents spend much of their leisure time on public lands, hiking trails, horseback riding, and driving recreational vehicles. Last year, the PCWP implemented an Early Detection and Rapid Response Strike Team program which uses trained volunteers to locate, identify, and map new infestations of noxious weeds in areas outside the normal travel routes of the PCWP staff.

Volunteers are provided with GPS devices and digital cameras, and then trained in weed identification and provided with a mapping protocol to collect data, which is later incorporated into the agency GIS program. Regular contact with volunteers during the summer allows the PCWP staff to suggest areas where volunteers have not toured in recent months. There are currently eight trained volunteers and several more who have expressed interest in being a part of the Strike Team. The team is taught that surveying where no noxious weeds are found is just as valuable as locating new infestations. Last year's volunteers provided over 1,000 data points of new or established weed infestations and represented hundreds of hours of volunteer survey work on remote areas of Park County.

The use of trained volunteers to survey and record remote areas helps prevent the establishment of noxious weeds on public and private lands within Park County.

Resumen

Condado de Park, Wyoming, en el límite oriental del Parque Nacional de Yellowstone, es conocida por su diversidad de paisajes, montañas escarpadas y millones de acres de tierras públicas. Debido a estas características, una sola agencia como Park County Weed and Pest Control District (PCWP) esta limitada en la cantidad de área que pueden cubrir. Sin embargo, muchos residentes locales gastan gran parte de su tiempo de ocio en terrenos públicos, excursionando senderos, paseos a caballo, y la conducción de vehículos de recreo. El año pasado, PCWP implemento el programa de detección temprana y respuesta rápida que utiliza voluntarios entrenados para localizar, identificar y cartografiar las nuevas infestaciones de malezas nocivas en zonas fuera de las rutas normales de viaje del personal del PCWP.

Los voluntarios cuentan con GPS, cámaras digitales, y son entrenados en la identificación de malezas y proporcionan un protocolo de mapeo para recopilar datos que se incorporan al programa de la agencia GIS. El contacto regular con los voluntarios durante el verano, le permite al personal de PCWP sugerir áreas donde los voluntarios no han recorrido en los últimos meses. Actualmente hay ocho voluntarios entrenados y muchos más que han expresado su interés en ser parte de un Ataque en Equipo. Al equipo se le enseña que las encuestas donde no se encuentran las malezas nocivas son tan

[1] Presenter.

valiosas como la localización de nuevas infestaciones. Los voluntarios del año pasado proporcionaron más de 1,000 puntos de datos de nuevas o ya establecidas infestaciones de malezas y representan cientos de horas de trabajo de investigación voluntario en zonas remotas del Condado de Park, Wyoming.

El uso de voluntarios capacitados para examinar y registrar las zonas remotas ayuda a prevenir el establecimiento de las malezas nocivas en tierras públicas y privadas dentro del Condado Park.

Introduction

Most weed control experts concur that treating small patches of noxious weeds before they have a chance to spread is by far the most effective and least expensive control method. In the mountainous western United States, large tracts of public and private lands and low human populations make it difficult to find those small patches before they become major infestations. In an effort to get more eyes looking for weeds, the Park County Weed and Pest Control District (PCWP) organized the Early Detection and Rapid Response Strike Team.

Figure 1. Strike Team volunteers.

Why Does Park County Need More Eyes?

Park County is located in the northwest corner of Wyoming. It borders Yellowstone National Park on the west and Montana on the north and encompasses 6,942 square miles or 4,442,880 acres. There are very few access roads on the public lands and 350,000 acres are designated as wilderness, which does not allow motorized or mechanized vehicles. Approximately 70 percent of Park County is public land (both federal and state) and of the 30 percent that is private, over half is range land.

With a total population of less than 28,000 people, much of the land in Park County is seldom seen by human eyes. Consider, also, that many of those people are not trained to recognized noxious weeds and see only pretty flowers.

Strike Team Becomes a Reality

The PCWP is aware of the importance of locating small weed infestations before they have a chance to expand and become serious problems. Under the direction of Mary McKinney, Assistant Supervisor and education coordinator for the PCWP, a noxious weed Strike Team was created. The original concept was to have a group of trained volunteers carry GPS units when engaging in their normal recreational activities and record any locations containing noxious weeds that they might come across. The goal of the Early Detection and Rapid Response Strike Team is "to defend our public lands and natural resources against 'noxious' weeds (non-native invasive species)…by developing and enhancing the capacity to identify, report, and effectively respond to newly discovered/localized invasive species."

An avid hiker, Mary knew that other individuals shared her passion for hiking in remote areas. She began organizing the Strike Team in the winter of 2008 and by the following spring, she had eight people interested in participating (Figure 1). With the help of PCWP staff and other qualified people in the area, the volunteers received over 24 hours of education. This training included weed identification, how to operate a GPS unit, map reading, safety training (including protection from grizzly bears), and an understanding of how the information they obtained fit into the overall program of the PCWP.

Funding is Secured

The PCWP obtained a grant from the Wyoming Wildlife and Natural Resource Trust to help initiate and support an Early Detection and Rapid Response (EDRR) program. With funds from this grant and from the general PCWP budget, each team member was provided with a GPS unit and a digital camera. In addition to these items, volunteers were encouraged to carry notebooks and pens to take notes if and when they located infestations.

Figure 2. 2010 spring training meeting.

Strike Team is Supplied with Materials and Direction

PCWP staff cooperated in developing an EDRR guidebook. Included in these guidelines are the goals and objectives of the Strike Team and an explanation of why we want to control invasive plants. The core of the guidebook is the list of protocols, which include site and plant information, how to document findings, what to do with a very small infestation, field safety, and use of equipment. Also included is a list of Wyoming's designated noxious weeds and other weeds of concern.

At the spring training meeting (Figure 2), members of the Strike Team were provided with maps of areas where little or no noxious weed data had been obtained. Because the team works on a volunteer basis, they were encouraged to consider hiking in the mapped areas. Not surprisingly, most of them agreed to focus on or at least include these areas in their hiking plans.

During the summer, the volunteers communicated with Mary and other team members to establish which areas had been covered and which had not.

Strike Team is Debriefed and Their Efforts Recognized

During the year, PCWP staff collect the GPS units and cameras from the volunteers and download the data into the district's computers (Figure 3). GPS points are incorporated into the district's GIS program for planning future treatment programs. New infestations of designated priority weed species are given the highest priority as part of the EDRR program and, depending on the situation, are dealt with immediately.

Photographs taken by the volunteers are indexed and saved to the PCWP network. These images are used for future educational programs and are valuable for identifying weed species; they are also dated so that they can be used in photo point monitoring.

As part of the continuing effort to let volunteers know how important they are to PCWP, the district hosts a fall get together. The gala event includes a barbeque, discussions about the progress made by the volunteers, and prizes for everyone.

Evaluating the Program

The district reviewed the information collected by the Strike Team after the first year. The team identified over 500 geographic points where invasive weeds were located. Although they found no weed species that were not already known to exist in Park County, they did locate many new infestations that had not been previously recorded. This information was valuable in determining the spread of noxious weeds in Park County.

The GPS units are set up so that they produce a track log when Strike Team volunteers are hiking. If no weeds are found, this provides the district with data about areas that are free of invasive species, which is pertinent when determining priority areas.

Future of the Program

Currently, there are 12 volunteers involved in the program. Although additional people have

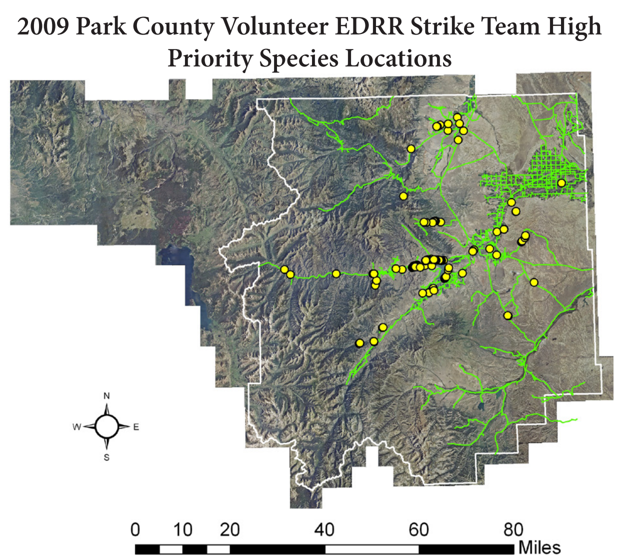

Figure 3. 2009 mapping data.

expressed interest in joining the Strike Team, the PCWP is hesitant to expand the program at this time due to the cost of equipment and the amount of staff time required to coordinate and train volunteers. The district is currently investigating additional funding sources so that the program may be expanded to include a coordinator position.

Everyone involved in this program agrees that it has been tremendously successful. Much effort is being dedicated to incorporating the Strike Team's work into PCWP's other programs. There is no doubt that more eyes are needed to locate and identify new invasive species. The PCWP Strike Team is a major contributor to this effort and has demonstrated a commitment to EDRR.

Early Detection of Invasive Species: A US National Park Service Approach

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Abstract

In 2008, the Eastern Rivers and Mountains Network (ERMN) and Northeast Temperate Network (NETN) of the US National Park Service (NPS) began early detection of invasive species surveillance monitoring throughout 20 parks in the Northeast Region. This monitoring effort is a component of the nationwide NPS Inventory and Monitoring Program. Early detection monitoring of incipient invasive plants, animals, and diseases was ranked among the top priorities in the ERMN and the NETN due to the known ecological impacts of invasive species on ecosystems, including loss of threatened and endangered species, altered community structure and composition of terrestrial and aquatic communities, and reduction in overall species diversity. While long-term changes associated with invasive species are being assessed through other monitoring protocols, it is also critical to detect new populations of invasive species early in their invasion of incipient and sensitive habitats. Only when invasions are caught early will the chance of eradication remain high. Early detection monitoring in the ERMN and NETN includes three main components: (1) creation of individual park early detection species lists; (2) opportunistic surveillance monitoring of invasive plant and forest pest species that focus on educating monitoring field crews, cooperators, volunteers, and resource managers on invasive species identification; and (3) development and maintenance of a coherent framework for reporting and disseminating information on potential infestations. These components allow park resource managers to assess each invasive species' early detection on an individual basis and target limited management resources and coordination toward the highest priority risks. During invasive species early detection surveillance monitoring in 2008 and 2009, a total of 20 new invasive plant and pest occurrences were documented at five parks in which data were collected. Of the 15 new plant occurrences, 10 consisted of single specimens and/or small populations that were successfully hand-pulled or chemically treated.

Resumen

En 2008, las redes de los ríos y las montañas del Este (ERMN) y templados del Nordeste (NETN) del Servicio de Parques Nacionales (NPS) comenzó la detección temprana de especies invasoras con la monitorización y vigilancia a lo largo de veinte parques de la región Nordeste. Este esfuerzo de monitoreo es un componente a través de la nación del Programa de Inventario y monitorea del NP.

[1] Presenter.

La detección temprana de incipientes plantas invasoras, animales y enfermedades se encuentra entre las principales prioridades en la ERMN y NETN debido a los conocidos impactos ecológicos de las especies invasoras en los ecosistemas, incluyendo la pérdida de especies amenazadas y en peligro de extinción, alterando la estructura de las comunidades y la composición de los sistemas terrestres y comunidades acuáticas, y la reducción de la diversidad de especies en general. Si bien los cambios a largo plazo asociados con las especies invasoras se están evaluando a través de otros protocolos de monitoreo, también es fundamental coger nuevas poblaciones de especies invasoras al comienzo de su invasión de nuevos y sensibles hábitats. Sólo cuando se detecta a tiempo las invasiones la posibilidad de la erradicación siguen siendo altas. La detección temprana en el ERMN y NETN incluye tres componentes principales: (1) creación de listas de parques individuales de detección temprana de especies; (2) vigilancia oportunista de plantas invasoras y especies forestales plaga que se centran en educar a los equipos de seguimiento en el campo, colaboradores, voluntarios y administradores de recursos sobre la identificación de especies invasoras; y (3) el desarrollo y mantenimiento de un marco coherente de información y difusión de información sobre infestaciones potenciales. Estos componentes permiten a los administradores de recursos del parque evaluar detección precoz de cada especie invasora de de forma individual y orientar los limitados recursos de manejo y coordinación hacia los riesgos más alta prioridad. Durante seguimiento, vigilancia y detección temprana de las especies invasoras en 2008 y 2009, un total de veinte nuevas casos de plantas y plagas invasoras fueron documentados en cinco parques en los que se obtuvieron datos. De los quince nuevos acontecimientos de plantas, diez consistieron en muestras individuales y/o poblaciones pequeñas y fueron exitosamente controladas a mano o tratados químicamente.

Background

During 2008, the Eastern Rivers and Mountains Network (ERMN) and Northeast Temperate Network (NETN) of the US National Park Service (NPS) began early detection of invasive species surveillance monitoring throughout 20 parks in the Northeast Region. This monitoring effort is a component of the ERMN and NETN Vital Signs monitoring program (Marshall and Piekielek 2007; Mitchell et al. 2006), which is part of the nationwide NPS Inventory and Monitoring Program (IMP) (Fancy et al. 2009). The following parks are included in the Early Detection of Invasive Species: Surveillance, Monitoring, and Rapid Response Protocol.

Eastern Rivers and Mountains Network

All ERMN parks (Figure 1): Allegheny Portage Railroad National Historic Site, Bluestone National Scenic River, Delaware Water Gap National Recreation Area, Fort Necessity National Battlefield, Friendship Hill National Historic Site, Gauley River National Recreation Area, Johnstown Flood National Memorial, New River Gorge National River, and Upper Delaware Scenic and Recreational River.

Northeast Temperate Network

All NETN parks (Figure 2): Acadia National Park, Appalachian National Scenic Trail, Boston Harbor Islands National Recreation Area, Marsh-Billings-Rockefeller National Historical Park, Minute Man National Historical Park, Morristown National Historical Park, Roosevelt-Vanderbilt National Historic Sites, Saint-Gaudens National Historic Site, Saugus Iron Works National Historic Site, Saratoga National Historical Park, and Weir Farm National Historic Site.

Introduction

An "invasive species" is an alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health (USPEO 1999). Early detection followed by rapid response can detect and eradicate incipient populations of invasive species before they have a chance to become widely established, eliminating the need for costly and resource-intensive control programs (Ashton and Mitchell 1989; OTA 1993; Atkinson 1997; Myers et al. 2000; Timmins and Braithwaite 2001; Harris et al. 2001; Rejmánek and Pitcairn 2002). Only when invasions are caught early will the chance of eradication remain

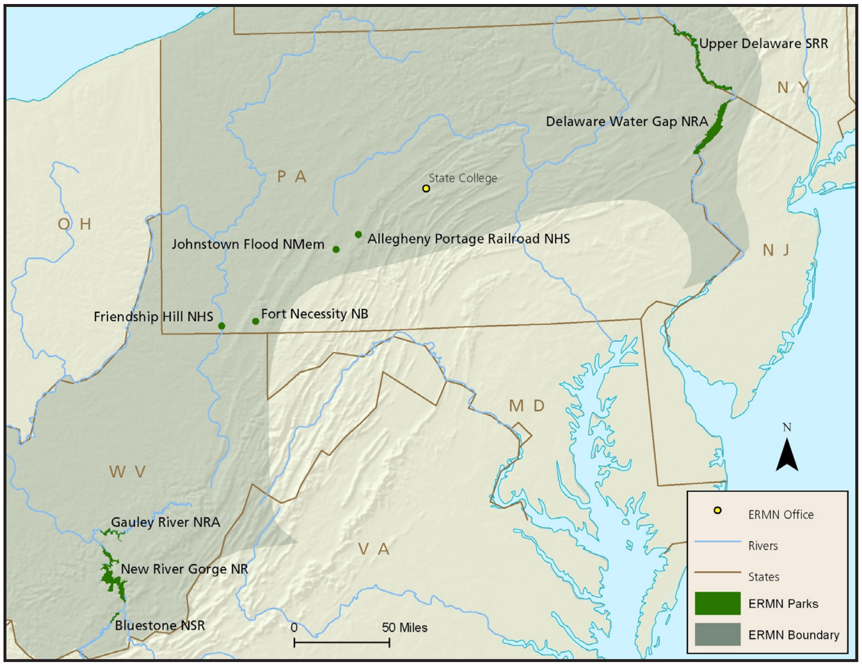

Figure 1. Location of parks in the Eastern Rivers and Mountains Network (ERMN).

high (Rozenfelds et al. 1999; NISC 2008). In addition to saving money, Early Detection and Rapid Response (EDRR) efforts minimize ecological damage by preventing habitat fragmentation and ecosystem degradation associated with large or widespread infestations of invasive species populations and related management activities (Smith et al. 1999; Timmins and Braithwaite 2001).

One of the most vital steps in confronting new invasive species problems is to know they exist (FICMNEW 2003). EDRR is one of five long-term strategic goals of the National Invasive Species Council's (NISC) Management Plan (NISC 2008). It is also a main element of the Federal Interagency Committee for the Management of Noxious and Exotic Weeds (FICMNEW) National EDRR System for Invasive Plants (FICMNEW 2003). Next to prevention, EDRR is a critical second defense against the establishment of invasive populations" (NISC 2008).

To understand the benefits of early detection, it is easier to calculate the costs of an invasion where early detection was not performed. Damages associated with alien invasive species effects and their control amount to approximately $120 billion per year (Pimentel et al. 2005). For example, the total cost of destruction by introduced rats on farms in the United States is more than $19 billion per year, while invasive weeds, pest insects, and plant pathogens cause several billion dollars worth of losses to crops, pastures, and forests annually in the US (Pimentel et al. 2005). The chestnut blight fungus (*Cryphonectria parasitica* (Murrill) ME Barr) and the virtual elimination of the American chestnut (*Castanea dentata* (Marsh) Borkh.) in the early 1900s (von Broembsen 1989) demonstrate the potentially devastating economic and ecological consequences of invading species.

Eradication of established invasive species is difficult, if not impossible in many cases, but early detection and associated management responses have proven effective in reducing, if not eliminating, the associated longer-term costs and consequences (MacDonald et al. 1989; Braithwaite 2000). EDRR success stories include

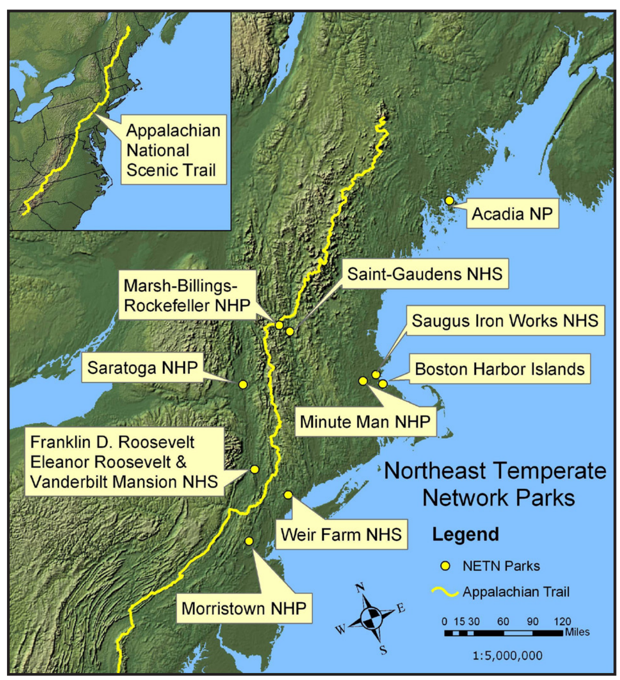

Figure 2. Location of parks in the Northeast Temperate Network (NETN).

restharrow (*Ononis alopecuroides* L.) in San Luis Obispo County, California (Tu 2002a); Egeria (*Egeria densa* Planch.) in the Connecticut River (Tu 2002b); and water hyacinth (*Eichhornia crassipes* (Mart.) Solms) and parrot-feather watermilfoil (*Myriophyllum aquaticum* (Vell.) Verdc.) in the Shawnee National Forest, Mississippi (Corey 2008).

Measurable Objectives

The goal of this protocol is to assist park managers in identifying high priority invasive species, quickly disseminating new occurrence information to all interested parties (NPS, public and private stakeholders, etc.), assessing the risk presented by incipient populations, and assisting with management of newly detected species.

The focus of early detection monitoring in the ERMN and NETN began with surveillance monitoring of invasive plant and forest pest species and focuses on educating all field crews and interested cooperators, resource managers, and volunteers on invasive species identification. The protocol also provides a coherent framework for reporting and disseminating information on potential infestations.

The primary monitoring objective is to detect incipient populations (that is, small or localized populations) and new introductions of target invasive species on each park's early detection list through opportunistic observations before the species become established.

To achieve the monitoring objective, this protocol includes the following components:

- Develop and maintain a list of target species that occur in localized areas of parks, are extremely rare, or are not currently present within a park, but have the potential to cause major ecological, cultural, or economic problems if they were to become established;
- Develop, maintain, and distribute appropriate target species identification information to all ERMN and NETN field crews and other interested cooperators, resource managers, and volunteers; and
- Develop and maintain an early detection reporting and tracking system that disseminates information on potential infestations in a timely and efficient manner.

These components will allow ERMN and NETN member park resource managers to assess each invasive species early detection on an individual basis and target limited management resources and coordination toward the highest priority risks.

Methods

Although a brief overview of the invasive species early detection (ISED) method is provided here, a detailed explanation of the background, rationale, and methods, in addition to Standard Operating Procedures, are provided in the Early Detection of Invasive Species: Surveillance Monitoring and Rapid Response Protocol (Keefer et al. 2010). Details regarding 2008–2009 early detection information and associated rapid responses are provided in the 2008–2009 annual summary report (Keefer 2010). Both reports are available online at: http://science.nature.nps.gov/im/units/ermn.

Selecting early detection species

The process for selecting a short list of invasive species for inclusion in the ISED program for each park in the ERMN consisted of four main steps: (1) review existing park datasets and literature and compile a list of all invasive plant and pest species known or thought to occur in the parks; (2) eliminate all common and well-established species as candidates for "early detection;" (3) consult relevant existing invasive species data sources from nearby parks, towns, counties, and states for incipient invasive species not yet present in the parks and add them to the candidate ISED list; and (4) conduct more extensive research on each candidate species and consult with park natural resource managers to narrow down and finalize each park ISED list (Keefer et al. 2010). At the conclusion of this process, each park's final ISED list generally consisted of between 10 and 20 species.

Opportunistic sampling

"Every person working or recreating in a national park has the potential to serve as an early detector" (Williams et al. 2007). Knowledgeable crew members provide an additional "set of eyes and ears" to detect invasive species occurrences

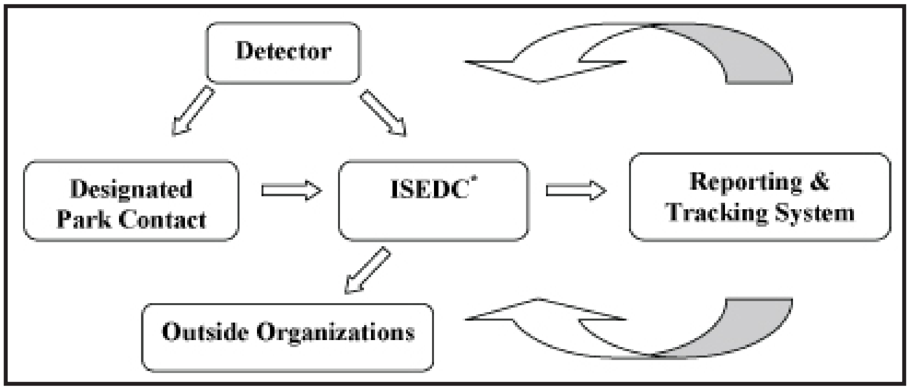

Figure 3. Early Detection of Invasive Species: Surveillance Monitoring and Rapid Response Protocol alert system. *Invasive Species Early Detection Coordinator (ISEDC).

while they are collecting data at monitoring sites, walking to and from monitoring sites, and driving along park roads. Invasive plants and pests present on each park's ISED list are sought during routine vegetation (Perles et al. 2010; Tierney et al. 2009), benthic macroinvertenrate (Tzilkowski et al. 2010) and water quality, and streamside bird (Mattsson and Marshall 2010) monitoring. Park natural resource managers, NPS Exotic Plant Management Teams (EPMTs), volunteers, and other NPS employees with scientific backgrounds also serve as early detectors during daily park activities.

Invasive Species Early Detection Field Guide

To assist with the identification of early detection species, ISED guides were provided to monitoring crews and interested parties. Hand-held, weather proof pocket guides (Invasive Plants Field and Reference Guide: An Ecological Perspective of Plant Invaders of Forests and Woodlands: http://www.treesearch.fs.fed.us/pubs/20715) were provided cost-free by the US Forest Service, in addition to a supplemental identification field guide developed by the ERMN, which were in combination used to distribute target species identification information. Production of the Early Detection of Invasive Species Surveillance Monitoring Field Guide and nine species cards was completed in summer 2009 and six new species cards were added in spring 2010. Each completed species card, as well as the entire field guide, are posted on the ERMN website and are available for download at: http://science.nature.nps.gov/im/units/ermn/monitoring/earlydetection.cfm.

Alert system

Data acquired from ISED is time sensitive and all new detections are immediately reported through the appropriate chain of command. Each observer or monitoring crew leader is responsible for alerting the designated park contact and Invasive Species Early Detection Coordinator (ISEDC) to all new species detections. In cases where noxious weeds or high-priority pests are detected, the coordinator will follow up with each designated park contact and may assist with alerting relevant outside agencies. The reporting and tracking system also serves as an alert system and enables anyone to sign-up to receive alerts when a new species is detected in user-chosen counties and/or states. Figure 3 depicts the Early Detection of Invasive Species: Surveillance Monitoring and Rapid Response Protocol alert system.

Reporting and tracking

The Early Detection and Distribution Mapping System (EDDMapS), in conjunction with the ERMN website, will provide a data entry port, alert system, and a one-stop resource for invasive species information, including links to other invasive species websites, photos, important contacts, and other pertinent information. To view the current ERMN website and EDDMapS, visit: http://science.nature.nps.gov/im/units/ermn/monitoring/EarlyDetection.cfm and http://www.eddmaps.org, respectively.

Rapid response

Rapid responses to invasions are effective and can prevent the spread and permanent establishment of invasive species. Coordinating and/or executing a rapid response is primarily the responsibility of the park resource manager(s) in which the infestation was detected. Rapid response should include positive species identification and management/eradication activities, and may involve coordination with the EPMTs, agencies such as the Bureau of Plant Industry and the Animal and Plant Health Inspection Service (APHIS) within the USDA, local weed management organizations, Network and park personnel, as well as park interns. Each response is based on the individual needs of the park and the resources available (Keefer et al. 2010).

Is the ISED Protocol Working?

During invasive species early detection surveillance monitoring in 2008 and 2009, 20 new invasive plant and pest occurrences were documented at five parks in the ERMN by the vegetation monitoring crew, Delaware Water Gap National Recreation Area Biologist, New River Gorge National River Biological Technician, and APHIS (Keefer 2010). New species occurrences included Japanese barberry (*Berberis thunbergii* DC.), narrowleaf bittercress (*Cardamine impatiens* L.), privet species (*Ligustrum* L.), gypsy moth (*Lymantria dispar* L.), Amur corktree (*Phellodendron amurense* Rupr.), Japanese knotweed (*Polygonum cuspidatum* Siebold and Zucc.), linden arrowwood (*Viburnum dilatatum* Thunb.), emerald ash borer (*Agrilus planipennis* Fairemaire), and viburnum leaf beetle (*Pyrrhalta viburni* Paykull) (Keefer 2010). Of the 15 new plant occurrences, 10 consisted of single specimens and/or small populations that were hand-pulled or chemically treated (Keefer 2010).

Conclusion and Future Directions

While discovering every new incipient invasive species is not probable, EDRR increases the chance of eradicating new species before they have a chance to become established and decreases the time and resources devoted to a generally uphill battle. In addition, recognizing and identifying organizational strengths and limited resources is crucial to developing a successful invasive species EDRR system. The four key components for this type of system are: (1) early detection species lists; (2) educational materials or a way to teach and present species identifying characteristics; (3) an alert system; and (4) a plan for rapid response. With these four components in place, it is possible for any organization, regardless of size and resources, to create a simple invasive species EDRR system to help cope with myriad future invaders.

If time and resources permit, Network staff will work closely with parks to educate the public on the importance of invasive species early detection. Visitor centers, campgrounds, and boat launch areas are examples of areas where informative posters or displays could be placed to make an impact regarding public invasive species awareness. Volunteers, park maintenance crews, and local organizations could also be trained to aid in the early detection effort. The more knowledgeable "eyes and ears" in our national parks, the better chance we have of discovering and eradicating future invaders.

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Invasive Plant Atlas of the United States, and Beyond?

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Abstract

The Invasive Plant Atlas of the United States is a collaborative project between the US National Park Service, the University of Georgia Center for Invasive Species and Ecosystem Health (CISEH), the Lady Bird Johnson Wildflower Center at the University of Texas at Austin, and the Invasive Plant Atlas of New England (IPANE). The purpose of the Atlas is to assist users with identification, early detection, prevention, and management of invasive plants. The focus is on non-native pest plant species impacting natural areas, excluding agricultural and other heavily developed and managed lands. Four main components of the project are species information, images, distribution maps, and early detection reporting procedures. The source of the invasive plant database portion of the Atlas website is the US National Park Service's WeedUS Database, which was developed to address the need for distribution of information on invasive alien plants affecting natural areas in the United States. Data was gathered from state, local and federal agencies, The Nature Conservancy, Exotic Pest Plant Councils, scientific journals, books, and other peer-reviewed sources.

In August 2009, the collaborators joined the WeedUS Database, IPANE, and CISEH's extensive image, mapping and data resources and launched the Invasive Plant Atlas of the United States (http://www.invasiveplantatlas.org). Each invasive plant species has a webpage featuring a descriptive paragraph, native range, images from CISEH's extensive image database, distribution maps from the Early Detection Distribution Mapping System, links to information resources on identification, biology and management, and native plant alternatives provided by the Lady Bird Johnson Wildflower Center. the Atlas currently includes 1,173 invasive plant species. Taxonomic information is automatically updated through coordination with the USDA Plants Database. The presentation will describe the current Atlas and open discussion for consideration of expanding the Atlas coverage to Canada and Mexico if there are sufficient interest and resources to support that.

Resumen

El Atlas de plantas invasoras de los Estados Unidos es un proyecto de colaboración entre el Servicio de Parques Nacionales, la Universidad de Georgia para las especies invasoras y la salud del ecosistema (CISEH), el Lady Bird Johnson Wildflower Center en la Universidad de Texas en Austin y Atlas de Plantas Invasoras de Nueva Inglaterra. El objetivo del Atlas es ayudar a los usuarios con la identificación, la detección temprana, la prevención y manejo de plantas invasoras. La atención se centra en las especies de plantas plagas no nativas que afectan las áreas naturales, con exclusión de la agricultura y otras muy desarrolladas y manejadas tierras. Cuatro componentes principales son la información sobre especies, imágenes, mapas de distribución, la detección temprana y procedimientos de reporte. La fuente de la base de datos de plantas invasoras es una parte de la base de datos National Park Service's WeedUS que fue desarrollada para hacer frente a la necesidad de información sobre la distribución de plantas exóticas invasoras que afectan a espacios naturales en los Estados Unidos. Se

[1] Presenter.

recopilaron datos de agencias estatales, locales y federales, The Nature Conservancy, Exotic Pest Plant Councils, revistas científicas, libros y otras fuentes publicadas.

En agosto de 2009 se unió a los colaboradores de la base de datos WeedUS, IPANE, y CISEH con amplia imagen, cartografía y los recursos de datos y presentó el Atlas de las Plantas Invasoras los EEUU (http://www.invasiveplantatlas.org). Cada especie tiene una página web con un párrafo descriptivo, área de origen, las imágenes de la extensa base de datos de imagen del Centro, los mapas de distribución proporcinados por Early Detection Distribution Mapping System (EDDMapS), enlaces a recursos de información sobre la identificación, la biología y manejo, y las alternativas de plantas nativas proporcionada por el Lady Bird Johnson Wildflower Center. El Atlas actualmente incluye 1,173 especies de plantas invasoras. La información taxonómica se actualiza automáticamente a través de la coordinación con la base de datos de plantas del USDA. La presentación describirá el actual Atlas y un debate abierto para la consideración de ampliación de la cobertura del Atlas a Canadá y México si hay interés suficiente y recursos para apoyarlo.

What is the Invasive Plant Atlas?

The Invasive Plant Atlas (Atlas) is a central website repository of information on the identification, distribution, and management of invasive plants affecting natural areas and native species. The focus is on non-native pest plant species impacting natural areas, excluding agricultural and other heavily developed and managed lands. The Atlas is the result of a collaborative effort between the US National Park Service, the University of Georgia Center for Invasive Species and Ecosystem Health (CISEH), the Lady Bird Johnson Wildflower Center at the University of Texas at Austin, and the Invasive Plant Atlas of New England. There are currently 1,173 plant species in the Atlas database fitting this description. Each species has a webpage with information including descriptive summaries, images, distribution maps, suggested alternative plants, links to guidance on control, and other resources to the Early Detection and Distribution Mapping System (EDDMapS) for reporting locations.

Why Was the Atlas Developed?

The Atlas was developed to assist a wide range of users with the information they need to identify, report, map, prevent, control, and track management of invasive plants as well as communicate with a vast invasive species network. The site is an easily accessible, consolidated place for finding and reporting information on invasive plants in order to foster information sharing and prevent spread and introduction. Land managers, conservationists, restorationists, researchers, the general public, citizen scientists, and many others use the Atlas. The Atlas:

- Provides a user-friendly format for reporting invasive plant occurrences using a high quality, easy-to-use Google-based mapping system;
- Provides a vehicle for reporting and notification of new invasive species introductions to allow for rapid response and eradication when needed;
- Fosters communication among a vast and expanding network of invasive species practitioners, educators, researchers, policy makers, regulators, horticulturists, students, citizen scientists, gardeners, and many others; and
- Increases sharing of invasive plant distribution information for this growing network.

What Information and Services Does the Atlas Provide?

The site provides a complete listing of all reported invasive plant species for the United States, along with reporting sources. The Atlas currently includes 1,173 invasive plant species. The following information is provided for each species:

- Individual species webpages with:
    - Identification information, biology and method of spread, ecological threat, and other relevant information;
    - Native origin;
    - Current taxonomy;
    - Images from the vast Bugwood image database (http://www.bugwood.org);

    - Maps depicting local, state, and national level distributions of each species;
    - Links to additional resources; and
    - Listing sources.
- National-level overview of invasive plants affecting natural ecosystems; and
- List of invasive plant species reported for 65 national parks.

Where Does Data Come From?

Sources of data include: the National Park Service's WeedUS Database, which provides state-level distribution data gathered from federal, state, and local agencies; the Nature Conservancy; Exotic Pest (Invasive) Plant Councils; scientific journals; books and other reputable sources; the USDA Plants Database; and the ever-expanding EDDMapS. Site-level data in EDDMapS comes from federal, state, and regional databases as well as from individual reports made by land managers, citizen scientists, and others. EDDMapS currently contains data from 531 sources and includes data imported from the USDA Plants Database and the Biota of North America Program. Taxonomic information is automatically updated through coordination with the USDA Plants Database. New information on species occurrences is continuously added to the Atlas and it is updated automatically as individual reports are submitted and verified, and as datasets are imported into the system by the Technical Director.

How is Quality Assured?

Data entered into EDDMapS and used by the Atlas are extremely important for making this system reliable and useful. Quality control is provided by requiring users to identify themselves and their level of expertise, along with requesting a herbarium specimen to be collected and the identification to be confirmed by a taxonomic expert if necessary. Submission of images is also requested to help provide visual clues and characters to help with species identification, until a voucher specimen can be obtained. In addition, a network of professional botanists and other users allows for review of the data entered. The Atlas produces summaries of species reported by individuals as well as all reports for a particular location or species. If an individual is found to have a large number of mistaken identities or otherwise problematic reports, their use of the system may be blocked until the problem is resolved.

What is EDDMapS and How Do You Use It?

EDDMapS is a very user-friendly system for reporting invasive species. The site is easy to understand for anyone with basic skills at maneuvering through webpages. Drop-down menus are provided to allow users to choose the species they are interested in reporting and locations can be identified quite precisely (to several meters accuracy), simply by drilling down through the provided Google maps. Images can also be downloaded into the system very easily. Each user must log-in to the system initially but once they are logged-in, they can reaccess the system easily. EDDMapS provides the mapping that helps us: manage and track invasive species; identify likely gaps in distributions of well-established species; identify threats of spread to new areas, in particular those with rare, threatened, and endangered species; and identify and announce introductions of new species so that rapid response can be initiated, if needed. EDDMapS can also be used to track releases and movements of biological control agents and species treatments and eradications.

Why Should the Atlas Be Expanded to North America?

Invasive species do not respect borders. Easy travel and trade between the US, Canada, and Mexico increases the likelihood of spreading invasive species from one country to another. The Atlas provides the types of information needed to help identify species that are highly invasive and have great potential to spread but are currently found in only a few locations, and to identify highly-susceptible areas that are most prone to invasion. This information is crucial for making rapid response a reality. Knowing the locations of widely established invasive species is also helpful in planning for containment and preventing spread to additional areas.

How Can This Expansion Be Achieved?

Expansion of the Atlas to Canada and Mexico can be accomplished simply, rapidly, and economically. Existing invasive species databases may be linked fairly easily so that information can be shared almost instantaneously between the Atlas, EDDMapS, and other databases. The newly established North American Invasive Species Network (http://www.naisn.org), a consortium that uses a coordinated network to advance science-based understanding of and effective response to non-native invasive species in North America, may be one vehicle to accomplish this. expansion The first step, however, is to identify what datasets and species lists already exist. Once these are identified, resources could be pooled and shared between countries to inexpensively expand the Atlas.

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Rapid Response: Putting Early Detection and Rapid Response (EDRR) into Practice

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Abstract

Early detection and rapid response implementation continues. In 2003, the Federal Interagency Committee for the Management of Noxious and Exotic Weeds (FICMNEW) issued a conceptual design for an early detection and rapid response (EDRR) system for invasive plants. This was the culmination of a stakeholder process initiated in 1998. The design identified gaps in existing response programs and proposed a template for a US national system to detect, assess, and respond to invasive species infestations in their early stages of establishment. One of the main EDRR objectives is to encourage management groups to promote EDRR as a preferred management option for new and emerging invasive species, and to assume a role in the development of a national EDRR system for invasive plants. Currently, attempts are underway to foster a regional approach to EDRR to connect local efforts to national regulatory and non-regulatory coordination groups.

Definitions: Invasive Species versus Noxious Weed

What is an invasive species?

Summarizing language from Executive Order 13112 (3 February 1999), which established the National Invasive Species Council, an invasive species is defined as follows: "Invasive species means an alien species…whose introduction does or is likely to cause economic or environmental harm or harm to human health. Note that this definition is with respect to a particular ecosystem and is not defined in regard to natural areas versus crop systems. We often think of invasive species in regard to individual plants or taxa; however, invasion can be thought of as an ecological process.

What is a noxious weed?

The definition of a Federal Noxious Weed (FNW), in contrast to an invasive species, is specifically defined in the Plant Protection Act (PPA; 7 USC §7702), the act (law) upon which the USDA Animal and Plant Health Inspection Service (APHIS) authority is based.

"The term 'noxious weed' means 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."

This law is implemented through APHIS regulations, found in the Code of Federal Regulations [(CFR); 7 CFR §300–399]. The Weed Regulations section is cited as 7 CFR §360, while the Seed Regulations are in 7 CFR §361. The broad PPA authority mandates 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. The primary focus of APHIS weed programs is on interdiction and eradication, and less on weed management. Eradication, of course, is management with a zero population endpoint.

Application of the Definitions: Authorities versus Regulations

The common thread between these definitions is harm or damage. The point of difference is that while FNWs are invasive species, not all invasive weeds are designated as FNWs. FNWs are those species that have been added to the federally regulated list designated in 7 CFR §360.200.

Note that states, tribes, and localities may also designate noxious weeds, many of which are not FNWs, but are state or local exclusion or management targets. There are 50 states in the US, plus its territories, (including American Samoa, the District of Columbia, Guam, Northern Marianas Islands, Puerto Rico, and the US Virgin Islands), as well as over 560 recognized tribes. Local rules apply within state (or equivalent) boundaries in the absence of a federal quarantine. For summaries of each state's laws, see the National Plant Board website: http://nationalplantboard.org/laws/index.html. Only a few states have no noxious weed law, although some states have very short regulated lists, or have no specific list even if they have a weed law.

There are several limitations; for example, not all FNWs are on all state regulated lists. (As of 2010, only Alabama, Georgia, North Carolina, South Carolina, and Vermont regulate all FNWs by reference). This means that APHIS actions within a state (or equivalent) boundaries may be limited, as states have authority over sales and movement within their boundaries in the absence of a federal quarantine which overrides state law. Usually, a federal action such as declaring quarantine, is done in response to a request from or with concurrence of a state or group of states. In addition, federal agencies, as well as most state agencies, are bound by the doctrine of "general applicability and future effect." For the federal government, this is laid out in the Administrative Procedures Act (5 USC §500 *et seq*.), which is discussed below. States usually have an equivalent procedures act. The doctrine of general applicability means that rules must apply to a class of persons or organizations, not only to an individual. Future effect means that the rule cannot be applied to events or things which have already occurred. Weeds on the ground, for example, cannot be seized if they existed before the rule went into effect, commonly referred to as being "grandfathered." It should be noted that a few states do recognize all FNWs in their state list. This is significant in cases where a FNW is detected in a state which already has authority for the taxa—the FNW cannot be grandfathered and can be legally seized or destroyed. The actual methods of establishing federal regulations are discussed below in the section entitled "Decisions and Regulations."

What Does EDRR Mean to You?

The Federal Interagency Committee for the Management of Noxious and Exotic Weeds (FICMNEW), a US federal interagency weed group, published a conceptual design for an Early Detection and Rapid Response (EDRR) system for invasive plants in 2003. USDA–APHIS, 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 national system to detect, assess, and respond to invasive species infestations in their early stages of establishment.

Currently, there are numerous local, state, and regional interagency groups involved with invasive plant management throughout the US, often in the form of Cooperative Weed Management Associations or Areas (CWMAs). One of the main objectives of FICMNEW's EDRR system is to encourage each group to promote EDRR as a preferred management option for new and emerging invasive species, and assume a role in the development of a national EDRR system for invasive plants.

Program Organization

Federal Incident Command System

In response to the events of 11 September 2001, Homeland Security Presidential Directive 5 was issued on 28 February 2003. The directive requires that all US federal departments and agencies adopt the National Incident Management System (NIMS) for 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 organization platform which provides a common framework within which individuals can work together effectively. Individuals may be drawn from multiple agencies that do not routinely work together and have varying organizational structures. ICS is designed to give standard response and operation procedures and was originally designed for fire response. ICS groups activities into domains that define the life-cycle of a domestic incident, including: Awareness, Prevention, Preparedness, Response, and Recovery. The framework is also used by many state and international groups. Training resources for NIMS are available online at: http://en.wikipedia.org/wiki/National_Incident_Management_System.

EDRR triggers

The decision making process for EDRR may be described within the five ICS domains (listed above); activities related to the categories recognized in the EDRR system (including pre-planning, detection and reporting, and identification and vouchering) exist within the Awareness, Prevention, and Preparedness domains. Drafting response plans prior to the detection of a new pest is an example of pre-planning. Setting up systems and plans for Detection and Reporting, and Identification and Vouchering may also fall within these domains. Once a new infestation is detected, the EDRR system should be activated; this corresponds with the Response domain block within ICS. Within the EDRR framework, the activities triggered are Detection and Reporting, Identification and Vouchering, and Rapid Assessment.

Determining What It Is: Pest Identification

Identification for program implementation

In order to initiate program response (including establishing an official quarantine or initiating enforcement action), an official identification must occur. For a federal action, this is done by APHIS–PPQ National Identification Services (NIS) or by an official authorized by NIS to make such identifications. APHIS identifiers are generally located at the APHIS Agriculture Quarantine Inspection Plant Material Centers at major ports and airports. These NIS identifiers also support actions initiated by the Department of Homeland Security, Customs and Border Protection (CBP). CBP assumed responsibility for luggage and cargo inspection after 11 September 2001, while APHIS Plant Material Centers primarily inspect shipments of nursery stock. APHIS–NIS personnel use modern technology, including the APHIS Remote Pest Identification Program and tests developed by the APHIS Molecular Diagnostics Laboratory. APHIS issues plant pest confirmation notifications internally and to states or other cooperators. In addition to identification of the detected plant, vouchering of a type specimen in a state or regional herbarium is encouraged, to allow verification of the species or type when later questions arise or taxonomic changes occur. Several identification resources used by NIS are listed below.

Identification aids and services

- USDA PLANTS Database: http://plants.usda.gov
- Germplasm Resources Information Network: http://www.ars-grin.gov
- Integrated Taxonomic Information System: http://www.itis.gov
- Federal Noxious Weed Disseminules of the US: http://keys.lucidcentral.org/keys/v3/FNWE2
- Biota of North America: http://www.bonap.org
- National Plant Diagnostic Network (mainly limited to entomology and plant pathology): http://www.npdn.org
- USDA–ARS Systematic Mycology and Microbiology Laboratory: http://www.ars.usda.gov

Program Decisions

After the identification

Various possible decisions may be made regarding program response. If the detection is determined to be a common weed, a decision would be made to either stop further planning or refer for a local response. This is what we might call a “dandelion report.” It should be noted that an exception might be a dandelion report in Alaska or the Yukon, where dandelions are not yet common. This would trigger, at least within the US, a state response not a federal one. If the plant is determined to be a current FNW, a decision would be made to determine whether a program for the weed already exists, or whether planning for such a program is needed. If the plant is not federally regulated, then the next step is to check for state regulations in the detection location; however, if the plant is already regulated by the state, program decision making may be shifted to the state program planning level.

New Pest Advisory Group

Once official identification is established, if the plant is not common and not currently regulated as a FNW, a brief needs assessment will be conducted by the risk assessment group of the PPQ Center for Plant Health Science and Technology to determine whether the detected plant is appropriate for listing as a FNW. If the taxa is determined to be a candidate for regulation, a New Pest Advisory Group (NPAG) many be assembled within APHIS–PPQ. (This is an ad hoc group led by an APHIS–NPAG core group.) An NPAG may draw from subject experts from various organizations, including APHIS, other federal agencies, various state organizations, including the Plant Board (the organization of state plant regulatory officials), universities, museums, and societies (such as the Weed Science Society of America).

The APHIS national program staff usually develops a Risk Management document to act as a summary of the issues considered in recommending a program, as well as appropriate follow-up steps. Possible recommendations include: develop a federal regulation; conduct 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 planning at the state level. If the state determines that no state response is warranted, the plant may still be referred for a possible local response.

Regulatory and/or program planning

Once it is determined that a state or federal response is warranted, the plant will enter regulatory planning and/or program planning, both often occurring in parallel (for example, a decision to conduct further survey work). This will trigger planning for a rapid response at the appropriate federal, state, or local level, or a combination of these. It should be obvious that rapid response may be preceded by a number of steps, which may consume considerable time. As such, “Rapid,” may be a relative term; however, many of the above steps take place concurrently, and do not always require considerable time.

Recovery

The Recovery phase added by the ICS, but not explicit in the EDRR framework, is often neglected, but should reflect revegetation planning or other post-treatment work, such as post-treatment monitoring to demonstrate success. Reporting program successes and costs prevented is useful when answering commonly heard questions such as, “Have you ever really eradicated any weeds?”

How Do We Do It Now?

Current EDRR organizational approach

Program umbrella groups are often centered upon individual taxa, for example the Regional Tropical Soda Apple Task Force. APHIS–PPQ, in cooperation with stakeholder coalitions, established a regional Memoranda of Understanding (MOU) for cooperative work on tropical soda apple, a FNW, in southeastern states. The tropical soda apple 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 tropical soda apple program is designed around concepts of integrated vegetation management and includes conventional survey and control efforts, as well as biological control. Similar approaches have been established by an MOU for giant hogweed in the northeastern US, an MOU for Alabama cogongrass with their state partners, and a Mississippi Cogongrass taskforce.

Developing EDRR organizational approach

Workgroups at a regional level for multiple weed species or even, in a few cases, all-taxa approaches, are a possible way forward from the single-taxa approach. Examples of regional approaches include the following groups: the Invasive Plant Atlas of New England; the Invasive Plant Atlas of the MidSouth; the Midwest Invasive Plant Network; the Center for Invasive Species and Ecosystem Health (and their Early Detection and Distribution Mapping System; and the Center for Invasive Plant Management.

Several of these groups are involved with organizing the North American Invasive Species Network, which will use a coordinated network to advance science-based understanding of, and effective response to, non-native invasive species in North America. For more information, see: http://www.naisn.org.

Regional and national plant boards, which are the organizations of state plant regulatory officials, are another example of all-taxa approaches to EDRR. The National Plant Board, for example, is an affiliate of the National Association of the State Departments of Agriculture.

Interagency coordination

The National Invasive Species Council (NISC) mentioned above, is the interdepartmental group responsible for federal interagency liaison on invasive species issues. NISC coordinates information regarding invasive species among 35 federal agencies whose efforts are authorized under approximately 39 federal laws. Council members include the Secretaries of the Interior, Agriculture, Commerce, State, Defense, Homeland Security, Treasury, Transportation, Health and Human Services, as well as the Administrators of the Environmental Protection Agency and the US Agency for International Development. The Council co-chairs are the Secretaries of the Interior, Agriculture, and Commerce. Day-to-day operations of NISC are coordinated by a council staff which meets regularly with invasive species liaisons from various member agencies and departments. One of the major coordination efforts of NISC is the development and updating of the National Management Plan. The plan provides a framework for a wide variety of stakeholders to come together and strategically solve problems caused by invasive species.

Interagency taxa groups

Council efforts are focused through three information sharing taxa groups, who meet regularly.

- FICMNEW: http://www.fs.fed.us/ficmnew
- Aquatic Nuisance Species Task Force: http://anstaskforce.gov
- Interagency Committee on Invasive Terrestrial Animals and Pathogens: http://www.itap.gov

Invasive Species Advisory Committee (ISAC)

ISAC is a group of non-federal experts and stakeholders established and mandated by Executive Order 13112 to advise the NISC on invasive species-related issues. The expertise of ISAC members represents a wide variety of interests from academia, industry, and the private sector. ISAC's (approximately) 29 members advise and make suggestions to assist NISC in its coordination and communications on invasive species issues.

APHIS activities to support EDRR

Early detection may provide the only opportunity to eradicate or contain invasive species. The intent of APHIS is to provide support for contributing to this activity. Examples of actions to which APHIS contributes include:

- Improve detection methods to speed up the EDRR process;
- Seek a flexible funding source for rapid response contingencies; and
- Establish rapid response guidelines and teams in cooperation with local and state organizations (see the NISC Invasive Species Plan described above), including:
  - Cooperative Agricultural Pest Survey (CAPS) Guidelines;
  - Weed Emergency Response Plan; and
  - Quadrilateral Scientific Collaboration in Plant Biosecurity Weed Toolbox (Australia, New Zealand, Canada, and the US).

Regulations

APHIS develops regulations to keep unwanted animal or plant diseases and pests from entering the country. Many regulations focus on domestic animals such as horses, cows and poultry, while APHIS plant regulations focus on soil, plants considered to be noxious weeds or plant pests (such as parasitic plants), and organisms that affect forestry and agricultural products. APHIS has limited authority over aquatic organisms and pet issues such as snakes, lizards, or mammals which may be considered invasive. APHIS does regulate animal welfare, but that is not related to invasiveness.

Pest risk analysis

APHIS conducts analysis of imported plant and animals to determine their likelihood of becoming invasive or causing damage. This supports decision making (discussed above), and rule making (discussed below).

Scientific support

APHIS provides laboratories and scientific support to Department of Homeland Security inspectors at ports of entry (as described above).

Survey

The second line of defense after ports is working with states to survey exotic invasive species that have entered the US through the import system or moved out of a regulated area. Much of this work is funded by APHIS through the CAPS program and a national survey priority list is maintained, although states have the option to use CAPS funding for state survey priorities.

Eradication

Often, if a very dangerous exotic invasive species is caught before it spreads, APHIS will undertake an eradication program for that species. Examples include gypsy moth *(Lymantria dispar)*, Asian gypsy moth *(Lymantria dispar asiatica)*, Asian longhorned beetle *(Anoplophora glabripennis)*, and light brown apple moth *(Epiphyas postvittana)* eradication programs.

Inspection

Most nursery stock, seeds, and plants are examined by USDA inspectors at one of 16 special stations for invasive pests and diseases.

Export certification

APHIS export inspection programs help protect other countries from plant or animal pests or diseases that are currently present in the US but might be invasive in those countries.

Levels of organization

Federal and state governmental groups fulfill various functions in invasive species management efforts. Federal agencies with regulatory or quasi-regulatory roles are USDA–APHIS, USDA Forest Service's State and Private Forestry organization, and the National Resource Conservation Service (NRCS). The Department of the Interior (DOI) agency with a regulatory role (endangered species) is the US Fish and Wildlife Service.

Federal land management responsibilities fall under the following agencies: USDA Forest Service and NRCS; and DOI Bureau of Land Management, Bureau of Reclamation, National Park Service, and Fish and Wildlife Service. There is some overlap between agencies with federal regulatory function and those with land management responsibility.

State Departments of Agriculture and/or Departments of Natural Resources usually contain the agencies with state regulatory authority; however, organization varies from state to state. Many states have organized non-regulatory groups usually called Invasive Species Councils (ISC) or Exotic Pest Plant Councils (EPPC). These state groups vary in structure; some have state charters while others do not. There are also various regional affiliations of both the regulatory and non-regulatory type: Regional Plant Boards, Regional Associations of State Departments of Agriculture, Regional ISC/EPPCs.

Funding for EDRR

A current need for EDRR is funding for implementation of rapid response plans when new incursions of invasive species are detected. In 2010, APHIS funded EDRR programs in 26 states, as well as several tribes. Many other sources exist for survey and program implementation at state and federal levels.

An additional potential funding source is authorized by the 2008 Farm Bill (Title X, Horticulture and Organic Agriculture, Section 10201, Plant Pest and Disease Management and Disaster Prevention). USDA Commodity Credit Corporation funds are authorized to implement the program. Details are posted on the APHIS–PPQ website: http://www.aphis.usda.gov/plant_health/plant_pest_info/pest_detection/farm_bill.shtml.

The implementation plan posted at the link above defines strategies to integrate and coordinate plant pest and disease management, and disaster prevention activities. Funding goals of particular interest to Weeds Across Borders participants include: (1) enhance plant pest/disease analysis and survey; (3) enhance and strengthen pest identification and technology; (5) conduct outreach and education to increase public understanding, acceptance, and support of plant pest and disease eradication and control efforts; and (6) enhance mitigation capabilities (management, revegetation, and EDRR).

Decisions and Regulations

Regulations vs. authorities

APHIS develops regulations to keep unwanted animal or plant diseases and pests from entering the country. As mentioned previously, this is supported by risk assessment. If the program decision regarding a new detection (or information is developed regarding a pest considered likely to enter the US) triggers a need for rule making, APHIS–PPQ national program staff prepare a regulatory work plan to initiate the process.

The general procedures for rule making in the federal government are described in the Administrative Procedures Act (5 USC §500 *et seq.*) as mentioned above. With minor variations, other national governments, US state and tribal governments, and many local governments follow similar methods. Under US law, a rule is any requirement of general applicability and future effect. It may be confusing, but the terms "rules" and "regulations" are just variant names for the same thing. An agency may issue rules only within the scope of its authorizing legislation, which for APHIS plant programs is the Plant Protection Act of 2000. A regulation is the way agencies put into practice the authorities listed in their implementing legislation. Regulatory agencies must conduct rulemaking whenever they wish to set up procedures to enforce a rule. New regulations require the following: (1) opportunity for congressional and judicial review; (2) opportunity for public comment (for example, publication in the US Federal Register); and (3) adherence to various laws and executive orders. The final rule publication is done with an explanation of any changes that the agency has made in response to the public comments.

Rule types

Several types of rulemaking exist for US federal agencies:

1. Informal or "notice and comment" rulemaking provides official notice to the public of a document's existence, location, and content. This process is extremely rapid, taking from just a few days to a few weeks.
2. Federal orders are effective immediately on announcement, and are later confirmed by interim rule. This process is extremely rapid, taking from just a few days to a few weeks.
3. Advance notice of proposed rule making (ANPR) is used to obtain preliminary information to support future rulemaking. An ANPR describes a rule under consideration and invites the public to comment and address specific questions. This process may take a month or more; an ANPR need not actually lead to a rule.
4. An interim rule goes into effect immediately on publication and is used to expedite rules expected to be non-controversial, or to announce minor changes to existing rules (for example, revisions to the boundaries of a federal quarantine area). This process usually takes a few weeks to a year to complete.
5. A proposed rule establishes the details of a rule and usually takes one or more years to complete.
6. A final rule announces the results of a comment period as well as any comments. This process may take several months to a year to complete, depending on the complications in the comments, and usually becomes final 30–60 days after publication.
7. An Affirmation of rule or final rule confirms that a rule is final with minor or no change.

Rulemaking steps

1. The need for a new rule is identified;
2. A risk analysis is prepared, if necessary;
3. A work plan is prepared, reviewed, and designated "not significant," "significant," or "economically significant" by the Office of Management and Budget (OMB);
4. The rule is drafted and all required analyses are completed;
5. The rule is reviewed by USDA attorneys and policy officials, as well as the OMB if the rule is designated "significant" or "economically significant";
6. (a) the proposed rule is published in the Federal Register with a 60–90 day comment period; (b) an interim rule is

published, effective upon publication prior to start of a comment period (usually 30 days);

7. Comments are received and, if necessary, public hearings are held;
8. Issues raised by comment makers are considered, and decisions about how to proceed are made. If major revisions are needed, the may be re-issued as a proposed rule rather than as a final rule;
9. A new work plan for final rule is prepared, reviewed, and designated;
10. The final rule (or affirmation in the case of an interim rule) is drafted;
11. The final rule is reviewed by USDA attorneys and policy officials, as well as the OMB if the rule is designated "significant" or "economically significant";
12. The final rule (or affirmation in the case of an interim rule) is published in the Federal Register; and
13. The final rule goes into effect, usually 30 days after publication. An affirmation is effective upon publication.

How long does rulemaking take?

The time elapsed for rulemaking depends on a number of factors. Some rules are relatively simple, while others are extremely complex. If the rulemaking process leads to a large number of comments, or if the comments are extremely negative in nature, either additional time will be needed for crafting revisions, or a completely new proposal will be drafted. The priority assigned by the agency dictates how quickly a rule will proceed through the approval process. (APHIS has an average of 150–200 rulemaking actions in progress at any given time). Additionally, rules are assigned a designation by the OMB; rules designated as "significant" or "economically significant" take longer because more analyses are required and those analyses are usually fairly detailed. Also, the clearance process takes longer because more levels of management must review the rule. Rules that are designated "not significant" normally require five levels of USDA clearance, a process that takes approximately one year, whereas rules that are designated "significant" or "economically significant" require 10–11 levels of USDA clearance and take approximately two to three years.

An Example of EDRR Shortfall

Pending regulation: wavyleaf basketgrass

Wavyleaf basketgrass was originally discovered in Maryland's Patapsco State Park in 1997. Dr. Paul Peterson, the grass curator at the National Museum of Natural History, identified the grass as Oplismenus hirtellus ssp. undulatifolius and published a note on the grass in 1999. Skip forward a few years to 2006, and wavyleaf basketgrass was reported as new to Maryland in Paint Branch Park. This was taken as an initiating event for APHIS, and PPQ weed manager Alan Tasker notified the NPAG of the find on 27 November 2006. The NPAG assessment was completed in July 2007, and recommended a Pest Risk Assessment (PRA). The PRA is currently on hold, pending a DNA study of the subspecies. A preliminary DNA study from 28 May 2010 indicated that wavyleaf basketgrass differs from both the native species and the known ornamental variety, thus the PRA process was restarted.

Problems

In an e-mail message on 16 October 2006, Charlie Davis noted to Mark Imlay that:

> "Peter Wieczorowski just sent me this photo for identification help as a follow up to a conversation that I had with him during the conference this weekend. He said it occurred near a Paint Branch Microstegium pull that you were overseeing.
> Did you take a sample of it? From the photo it looks like the highly invasive grass that Ed Uebel found up in Patapsco State Park in 1997, Oplismenus hirtellus ssp. undulatifolius. I'll identify/confirm it for you if you send me a sample."

Mark Imlay replied:

> "So we see there is a gap of six years between early detection by a native plant specialist and by an invasive plant manager. This demonstrates the need to fill in time gaps which may occur between field detections and the regulatory

process. Hopefully the regional data collection nodes will help to assure that information makes its way to the appropriate regulatory personnel more rapidly. Regulation does not kill weeds in the field, but lack of regulation may allow an invasive species more time to spread before program initiation. Such a delay may cause the loss of an opportunity to eradicate an invasive species."

Not Authorized for Importation Pending Pest Risk (NAPPRA): a proposed partial solution

As a partial solution, APHIS proposed the establishment of a new category of regulated articles governing the importation of nursery stock (also known as plants for planting), or Quarantine 37 (7 CFR §319.37). This new regulation will allow a number of plants proposed for new importation (identified as possessing the potential to become invasive) to be added to a proposed new category of plants for planting, NAPPRA. This was comment period for this proposed rule (docket ID: APHIS–2006–0011) closed on 21 October 2009, and the final rule is currently being drafted.

In order to be added to the NAPPRA category, the taxa must undergo a brief assessment and fulfill the following requirements: (1) the taxon must be a potential quarantine pest (or a potential host of a quarantine pest); (2) it must be botanically recognizable; and (3) data which identifies the taxon as having has the potential to become invasive must be available. Taxa to be added to the NAPPRA category will be published by notice (informal rulemaking).

Tie-in to weed program

The NAPPRA list will dramatically increase the number of plant taxa regulated as potentially invasive. Estimates indicate that approximately 288 taxa are in the first phase of NAPPRA assessment and 110 are in the second phase. This new category will allow APHIS to regulate potential pest plants prior to full PRA and formal listing as FNWs. As a result, the demand for WRAs will increase and, potentially, the demand for permits will increase. In addition, the issue of allowing states to petition APHIS to recognize state programs as having official control must be addressed. The PPA authorizes this; however, procedures to implement such official recognition remain under development.

I3N Risk Assessment and Pathway Analysis: Tools for the Prevention of Biological Invasions

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Abstract

Information on invasive alien species from published and unpublished accounts and databases is usually scattered in locations and formats that are not easily accessible. Customized informatics tools for collecting and organizing invasive species information can help resource managers better control biological invasions. The Invasives Information Network (I3N) of the Inter-American Biodiversity Information Network has created a distributed network of databases of invasive species profiles, subject matter experts, projects, and datasets hosted and published online by natural resource institutions throughout the Americas. Invasive species information is documented and published online in a standard format that can be searched by the public. Profiles and occurrence information on invaders can be documented using the I3N Database on Invasive Alien Species, published online using an easy-to-use template, and exchanged in standard formats. The I3N Risk Assessment and Pathway Analysis tools are designed to be used in conjunction with I3N Databases to assist decision-makers in setting priorities for containment. All these tools are freely available online at http://i3n.iabin.net. Coordinated by the United States Geological Survey National Biological Information Infrastructure, this network serves as an example of successful capacity building and regional collaboration on an issue of global significance.

Resumen

Información sobre especies exóticas invasoras (EEI) de fuentes publicadas y no formalmente publicadas y bases de datos relacionadas son normalmente dispersos en localidades y formatos poco accesibles. Herramientas hechas a la medida sobre la informática de EEI pueden ayudar a los encargados de recursos naturales en sus esfuerzos para controlar a las invasiones biológicas. La Red de Informática sobre Especies Exóticas Invasoras de la Red Inter-Americana de Información sobre la Biodiversidad (I3N por sus signos en inglés) ha creado una red distribuida de bases de datos que contienen perfiles sobre EEI, expertos en el tema, proyectos, y conjuntos de datos organizados y publicados en línea por instituciones de recursos naturales a través de las Américas. La información sobre EEI es documentada y publicada en línea en un formato estándar que el público puede examinar. Perfiles de especies e información sobre ocurrencias de EEI son documentados utilizando la base de datos I3N, publicados en línea en una plantilla de fácil uso, e intercambiados en formatos estándar. Las Herramientas de Prevención de Invasiones I3N fueron diseñadas para utilizarse en relación con las bases de datos I3N, para ayudar a los tomadores de decisiones con la priorización de acciones de contención. Todas las herramientas son disponibles gratuitamente en línea en el URL http://i3n.iabin.net. El I3N se coordina por la Infraestructura Nacional de Información Biológica de los EEUU, y esta Red sirve como un ejemplo exitoso de creación de capacidad y colaboración regional sobre un asunto de importancia global.

Introduction

Throughout the world, species information from published and unpublished accounts and databases is scattered in locations and formats that are not easily accessible. Customized informatics tools for collecting and organizing invasive species information can help countries to better manage biological invasions. As reported at Weeds Across Borders 2006 (Grosse et al. 2009), the Invasives Information Network (I3N) of the Inter-American Biodiversity Information Network (IABIN) has created a suite of tools and user manuals (available online in English, Portuguese, and Spanish at http://i3n.iabin.net/tools/web_tools.html) and a distributed network of databases of invasive species profiles, subject matter experts, projects, and datasets hosted and published online by natural resource institutions throughout the Americas (Figure 1). These providers manage their own information, but it is documented and posted in a standard, publicly-searchable format. This article provides an update on the I3N's development of two new tools for assessing and prioritizing biological invasions for improved response by decision-makers to invasive species. Designed to be used with the I3N databases, the Risk Assessment and Pathway Analysis tools are available in English and Spanish. These tools pose questions to the user about a species' biology or an introduction pathway's characteristics, providing quantitative results that can be compared across species and among pathways. Delivered as separate sheets in a single Microsoft Excel file format, these tools are the first in the I3N suite to deliver an interactive and analytical decision-making capability.

The IABIN Invasives Information Network

Since 2002, the I3N initiative has worked throughout the Americas to promote the organization and systematization of available information concerning invasive alien species and the adoption of common vocabularies and standards (Simpson et al. 2006). Currently, most countries in the region have established a national database (Figure 2), and the volume of information contained in these systems constitutes an enormous opportunity for information sharing and establishing management tools and models that permit the development of new strategies for preventing introductions, and containing the spread of invasive species already present (Ziller et al. 2007).

The I3N:

- Provides free internet hosting of invasive species records created by member countries;
- Freely distributes a trilingual (English, Portuguese, and Spanish) database template for creating invasive species records and web interface template for publishing those records on the internet; and
- Provides the search technology that indexes all of the records and resources on the I3N and member-country websites (Grosse et al. 2009).

I3N Risk Assessment

The I3N Risk Assessment is designed to evaluate the risk associated with the establishment and invasion of vascular plant species in any given area, allowing the direct application of information contained in national databases and other complementary information such as that found in A Toolkit of Best Prevention and Management Practices (Wittenberg et al. 2001) in establishing the levels of risk.

A large percentage of species introduced into the United States are imported intentionally (Pimentel et al. 2005). This is particularly true for plants, which are introduced for various purposes including, but not limited to, food crops, fodder, forestry, and horticulture (Reichard and White 2001). Only a small number of the species introduced into a country or region are known to become invasive (Lockwood et al. 2001). However, because the potential damage from invasive plant species can be devastating, it is important to compare and quantify the potential benefits and costs of importing a plant species before approving any new introduction. Therefore, the development of systems that reduce the uncertainty associated with the possible behavior of a species proposed for introduction is of high priority. These systems are known as "risk analyses" and they aim to inform the introduction of potentially dangerous species and to provide advice concerning the introduction of others of less risk.

This same evaluation method can also be used

Figure 1. I3N representatives Dr. Sergio Zalba, Grupo de Estudios en Conservación y Manejo (GEKKO), Universidad Nacional del Sur, Argentina *(second from left)* and Dr. Silvia Ziller, Instituto Hórus, Brazil *(center)*, provide hands-on training on the use of the I3N database, web template, and Risk Assessment and Pathway Analysis tools.

to establish priorities for the control and containment of non-native species already present in an area: The I3N Risk Assessment can be used to estimate the potential impact of existing invasive plant species, thereby enabling decision-makers to set priorities for their response to non-native plants in situations where funding and other resources are limited.

It has been clearly established that the introduction of a new species is often an irreversible event that always involves risks, and so must be carefully considered. The I3N Risk Assessment manual (http://i3n.iabin.net/documents/pdf/MANUAL_TOOLS_FOR_PREVENTION.pdf) states that an introduction should only be authorized when:

- Expected socio-environmental benefits are greater than possible damage;
- The species is not known to behave as invasive in similar habitats; and
- There are no native or introduced species that could fill the need for which the species is to be introduced.

How the I3N Risk Assessment Works

The main objective of the I3N Risk Assessment is to aid decision-makers when concerning the voluntary introduction of plant species by assigning a value of risk of invasion to the proposed species. To accomplish this objective, the tool considers 29 criteria grouped into three categories:

1. Risk of establishment and invasion
2. Potential impact
3. Difficulty of control or eradication in case the species manages to become invasive.

These criteria make use of information compiled in the national I3N databases and encourage the use of data held in systems of other countries in the region. If applicable, the I3N system also highlights key information that is missing—a rudimentary gap analysis—and so can identify areas where more research is needed. The completeness of invasive alien species data for risk assessment can be measured along three distinct parameters (Stohlgren and Schnase 2006): (1) taxonomic (how many occurrences of a species have been recorded?); (2) geographic (has the whole area been examined?); and (3) temporal (how often has an area been surveyed, and how long ago?). The data sharing model of the I3N is specifically designed to reduce the data collection burden for network participants, and by combining available I3N data, provide more completeness of invasive alien

Figure 2. The I3N has active participation by countries throughout the hemisphere.

species data for risk assessment and pathway analyses. It is also important to remember that "any assessment of risk requires a case-by-case study and is location-specific" (FAO 2003). The sum of points corresponding to each species' assessment results is a preliminary indication of the risk associated with its introduction. Uncertainties will remain about the species' actual rates of introduction (for example, at multiple sites and times), its spread (based on species demography, species interactions, and adaptations), and effects in new habitats (Stohlgren and Schnase 2006). Thus, an iterative approach to risk assessments is needed as new information becomes available.

The initial level of risk associated with the introduction of a species is calculated as a weighted average score of the I3N Risk Assessment questions (omitting those with insufficient information). The system also indicates the level of uncertainty associated with the analysis, calculated as the percentage of "insufficient information" answers. To minimize the variations caused by user bias and varied levels of expertise, it is suggested that assessments be performed by a single user, by group consensus, or by averaging individual results in a consistent way.

To establish acceptable thresholds of invasion for a specific area, a calculation is made of the levels of risk of introduction for a group of species that have been previously introduced into the region and become invasive (Table 1). The same analysis is also carried out for introduced species that are widely distributed but have not become invasive (over a suggested period of 50 years). The average scores of the risk index associated with each group will constitute the thresholds of high and low risk of invasion, respectively, for the area in question. Again, things change, so an iterative process is recommended.

I3N Pathway Analysis

For successful management of invasive alien species, high-risk pathways of spread must be identified and regulations put into place to inhibit populations from becoming established (Waugh 2009). The identification of high-risk pathways is best accomplished through robust data collection (Reaser and Waugh 2009), and the I3N Pathway Analysis tool enables pathway analyses in the Americas based on information collected and shared by the members of the Network.

The I3N Pathway Analysis tool is designed to optimize the monitoring of vectors and pathways associated with the introduction and spread of invasive species. Vectors include accidental or voluntary dispersal agents of a species and pathways are the routes by which vectors or species move between locations. This tool includes a detailed list of possible vectors and pathways and also groups of species most often associated with each one, and a system for evaluating the relative risk of introduction. Both natural and anthropogenic vectors are considered, specifically those corresponding to land, sea, river and air transportation, sale of live organisms or seeds, and other means of spread (for example, wind or bird). This evaluation system is based on the combined analysis of the probabilities of introduction, establishment, and dispersal, as well as the potential impact and chance of controlling a species if it becomes invasive.

How the I3N Pathway Analysis Works

The main objective of this analysis is to determine the risk of accidental and unauthorized introductions with a view to reducing them and to control possible dispersal of the species within the country, by identifying and evaluating vectors and pathways associated with different types of non-native organisms. The analysis is designed to provide decision-makers with the information needed to regulate or close high-risk pathways of invasion.

The vector and pathway variables considered are related to the following criteria:

- Presence and abundance of the species in the place of origin or in the pathway taken by the vector;
- Existence and effectiveness of mechanisms of detection and control at the point of origin and/or along pathways;
- Transport intensity or frequency of journeys (that is, how many possible introductions), and volume of organisms potentially transported during each journey; and
- Conditions of transport (temperature, humidity, and so on) and resulting in improved chances that organisms will arrive alive at the destination.

Table 1. Sample Risk Threshold Calculation: Scores of invasion risk (IR) calculated for species in Argentina, to determine risk thresholds (the mean scores for each group). The levels of associated uncertainty (NI) are in parentheses.

Invasive alien species in Argentina	IR (NI)	Non-invasive alien species in Argentina	IR (NI)
Arundo donax	7.9 (3.4)	*Abelia × grandiflora*	1.9 (10.3)
Ailanthus altissima	7.5 (0.0)	*Acanthus mollis*	2.9 (3.4)
Bromus hordeaceus	5.7 (0.0)	*Agapanthus africanus*	3.4 (6.9)
Centaurea solstitialis	6.9 (3.4)	*Beta vulgaris*	3.0 (6.9)
Chenopodium album	5.9 (0.0)	*Buxus sempervirens*	3.4 (13.8)
Chondrilla juncea	6.1 (13.8)	*Callistemon viminalis*	2.2 (13.8)
Cynodon dactylon	8.0 (3.4)	*Citrus limon*	3.4 (3.4)
Lactuca serriola	5.1 (10.3)	*Cordyline australis*	1.7 (13.8)
Lantana camara	7.6 (0.0)	*Eucalyptus cinera*	4.1 (17.2)
Ligustrum lucidum	8.5 (10.3)	*Ficus carica*	3.0 (3.5)
Lonicera japonica	6.2 (3.5)	*Hibiscus syriacus*	2.9 (10.3)
Marrubium vulgare	5.8 (10.3)	*Hydrangea macrophylla*	1.8 (10.3)
Melia azedarach	7.5 (0.0)	*Lagerstroemia indica*	2.3 (10.3)
Morus alba	5.9 (3.5)	*Lavandula angustifolia*	2.8 (10.3)
Potamogeton crispus	7.7 (6.9)	*Nephrolepis cordifolia*	3.2 (10.3)
Pyracantha coccinea	7.8 (10.3)	*Origanum vulgare*	3.8 (6.9)
Raphanus sativus	5.3 (6.9)	*Phormium tenax*	1.9 (3.5)
Silybum marianum	7.6 (6.9)	*Rosmarinus officinalis*	2.4 (3.5)
Taraxacum officinale	5.9 (10.3)	*Tropaeolum majus*	2.2 (6.9)
Vulpia myuros	6.5 (17.2)	*Viola tricolor*	2.6 (10.3)
Mean IR	**6.8**	**Mean IR**	**2.7**

There is often a lack of sufficient high quality information on species locations, abundance, and habitat requirements in native and introduced ranges. Likewise, many species have multiple pathways of spread, from shipping containers to railway cars to warehouses to trucks that travel in many different directions, before other natural vectors such as wind, birds, and small mammals take over to dominate local and regional distributions. The ability to accurately map the spread of many species is still several years in the future. In addition, the condition of transport changes as organisms grow from seeds to mature plants. Furthermore, the arrival and spread of species is dependent on more complex species-environment relationships that many "one-answer" questions cannot begin to analyze. However, these I3N tools can be seen as a humble beginning to gathering data, filling data gaps, and improving risk analysis approaches with time. There are few other alternatives currently available.

Summary

Since its inception in 2002, I3N has trained information managers in 16 countries on the issue of invasive alien species; how to collect and manage standardized invasive alien species information; and in the use of the I3N database and web templates, and risk assessment and pathway analysis tools (Simpson et al. 2009). It is understood that both risk assessments and pathway analyses require periodic revision. This is because variables may change over time (for example, the change in abundance of species of risk at sites where known vectors are present, or along pathways). It is also very important to justify the response to each evaluation criterion by citing information from databases, publications, and consultations with specialists and technicians. (The new I3N tools include a special section for including such information: Figure 4.) The main difference between the I3N Risk Assessment and Pathway Analysis tools is that the

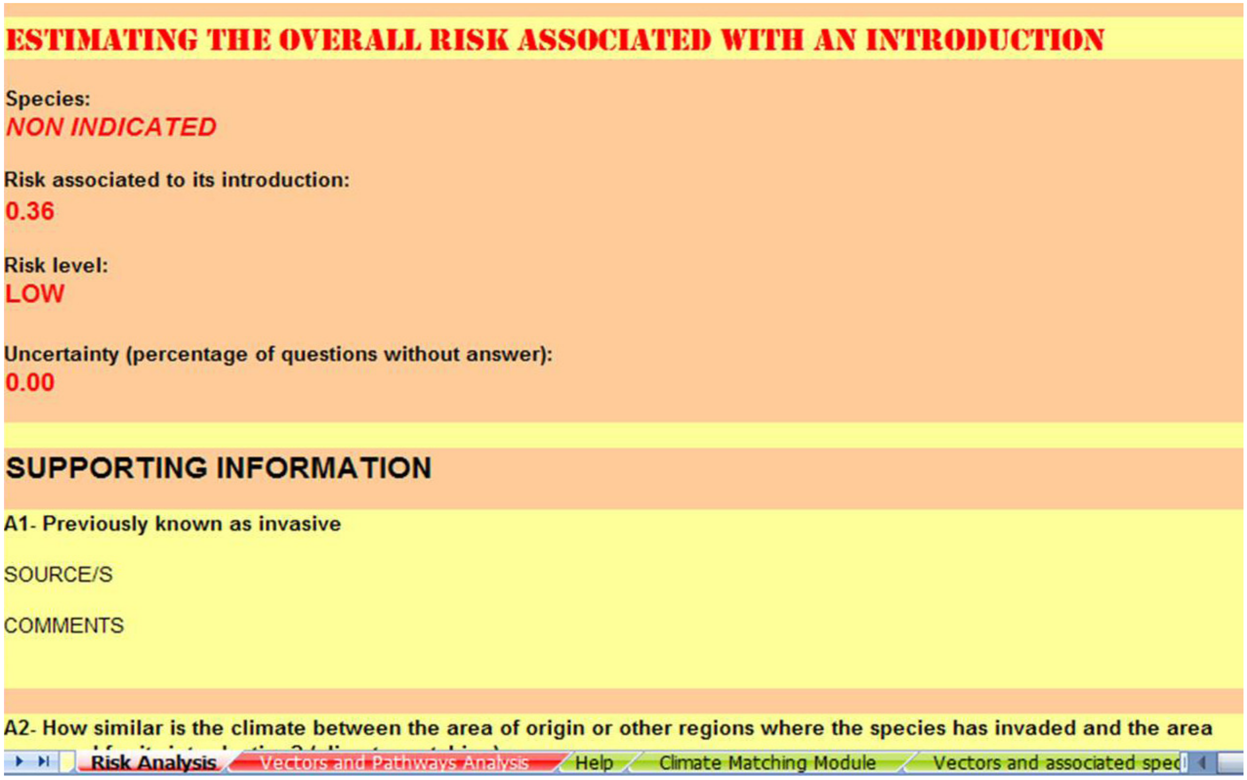

Figure 4. The I3N Risk Assessment and Pathway Analysis Tools are separate sheets in a single Microsoft Excel file format. When filling out the I3N Risk Assessment, do not select more than one answer per question or leave any questions blank. If there is not enough information available to answer a question, select "no data," and the system will display a question mark in the evaluation box. Documentation of the answers to the Risk Assessment questions is needed to support the decisions that are made based on the assessment. These tools are the first in the I3N suite to deliver an interactive and analytical decision-making capability for IAS managers.

Risk Assessment is designed for the evaluation of consequences associated with the voluntary introduction of species, whereas the Pathway Analysis evaluates the consequences associated with accidental or unauthorized introductions. There is also a module built into both tools that is designed to help the user to evaluate a preliminary, coarse-scale degree of climatic matching between a species' native distribution and where it might be introduced. These analyses are based on the Köppen-Geiger world climate classification (Kottek et al. 2006). Finer scale species-environmental matching models will be needed for local and regional management efforts (Jarnevich and Stohlgren 2009).

Acknowledgements

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ADDITIONAL CONFERENCE ABSTRACTS

Keynote Address

Aldo Leopold, Invasive Species, and the Land Health Concept

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Abstract

Aldo Leopold's great contribution to the growth of conservation thought and practice was to incorporate the emerging insights of ecology, evolutionary biology, and ethics into the various fields of natural resource management (forestry, wildlife management, range management, and so on). His experience across the first half of the 20th century led him to call for a "land ethic" that would regard land as "a community to which we belong" and would recognize our roles and responsibilities within that community. Closely connected to Leopold's land ethic was his concept of "land health," which he defined as "the land's capacity for self-renewal." The incidence of invasive species was among the key indicators of land health that Leopold identified and considered. In reviewing Leopold's maturing conservation thought, we can gain insights that inform our own efforts to build resilience into our coupled human and natural systems.

Resumen

La gran contribución del pensamiento y la práctica de conservación de Aldo Leopold fue la incorporación de las ideas emergentes de la ecología, la biología evolutiva, y la ética en los distintos ámbitos de manejo de los recursos naturales (forestales, manejo de vida silvestre, manejo de pastizales, et cetera). Su experiencia a través de la primera mitad del Siglo XX le llevó a requerir de una "ética de la tierra" lo que se refiere es a la tierra como "una comunidad a la que pertenecemos" y reconocería nuestros roles y responsabilidades dentro de esa comunidad. Estrechamente relacionado con ética de la tierra de Leopold era su concepto de "salud de la tierra," que él define como "la capacidad de la tierra para la auto-renovación." La incidencia de especies invasoras fue uno de los principales indicadores de salud de la tierra que Leopold identifico y considero. Al revisar el pensamiento la maduración de la conservación de Leopoldo, podemos adquirir una perspectiva que informa a nuestros propios esfuerzos para construir una resistencia en nuestros acoplados sistemas humanos y naturales.

National Invasive Species Council Perspective on Recent Invasive Species Developments in the United States

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Abstract

Over the past year, there have been many developments and changes that have important implications for invasive species and invasive plant management issues in the United States. This presentation will provide a broad overview of invasive species issues in the US.

The first part of the presentation will place invasive species and invasive plant management issues in the context of important recent developments including: the change in administration; climate change discussions and developments; energy issues, including biofuels; developments at the state level; and invasive species issues that are receiving the most interest and attention.

Secondly, this presentation will provide highlights of recent developments both for the National Invasive Species Council and in the areas of regulatory and legal domestic developments, and activities at the international level, including the Convention on Biological Diversity.

Resumen

Ha habido muchos acontecimientos y cambios en el último año que directamente tienen implicaciones importantes para las especies invasoras/

problemas de manejo de plantas invasoras en los Estados Unidos. La Sra. Williams dará una visión amplia de las especies invasoras en los EE.UU. y usted escuchara mucho más detalle más adelante en la Conferencia sobre cuestiones en particular.

La primera parte de la presentación colocara de especies invasoras/problemas del manejo de las plantas invasoras en el marco de importantes acontecimientos recientes tales como: el cambio de Administración; debates sobre el cambio climático y desarrollo, las cuestiones de energía, incluidos los biocombustibles, desarrollos a nivel estatal en los EE.UU., y especies invasoras que están recibiendo el mayor interés y atención.

En segundo lugar, la Sra. Williams ofrecerá aspectos más destacados de la evolución reciente tanto para el Consejo Nacional de Especies Invasoras y en las áreas de desarrollo interno de reglamentación y jurídicas así como las actividades a nivel internacional como la Convención sobre la Diversidad Biológica.

New Laws on Invasive Species in Mexico

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Abstract

On 6 April 2010, the government of Mexico modified its Wildlife Law *(Ley General de Vida Silvestre)* and its Environmental Law *(Ley General del Equilibrio Ecológico y la Protección al Ambiente)* to address the threat of exotic invasive species. The Wildlife Law established a definition of exotic invasive species and prohibited their importation and release into the wild. It also established an obligation to compile a list of exotic invasive species, as well as rules to manage, control, and eradicate these species. The Environmental Law established that the Environment Ministry, in cooperation with the Economic Ministry, will promote measures and restrictions for the import, export, and transportation of these species within Mexico.

Resumen

En abril 6 del 2010 México modificó la Ley General de Vida Silvestre (LGVS) y la Ley General del Equilibrio Ecológico y la Protección al Ambiente (LGEEPA) para enfrentar la amenaza de las especies exóticas invasoras. La LGVS establece la definición para una especie exótica invasora y prohíbe la importación y liberación al ambiente de dichas especies, incluyendo a las especies silvestres que son portadoras de especies exóticas invasoras. También establece la obligación de crear en normas oficiales mexicanas o acuerdos secretariales las listas de especies exóticas invasoras y las medidas de manejo, control o erradicación de dichas especies. La LGEEPA establece que la Secretaría de Medio Ambiente promoverá ante la Secretaría de Economía las medidas de regulación o restricción de la importación, exportación o transportación dentro del territorio mexicano de éstas especies.

Ornamental Plant Species that Threaten Biodiversity in Mexico

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Abstract

Following habitat destruction, the impact of invasive species has been identified as the main cause of global biodiversity loss. In the horticulture industry, many invasive plants are marketed for their adaptive advantages in new environments. The lack of knowledge about the biology of these species, coupled with high demand in the world market for variety and beauty, makes invasive ornamental plants a potentially dangerous source of habitat destruction and native biodiversity loss. To stop the flow of invasive ornamental plants, many countries have implemented strategies that involve producers and consumers through voluntary codes of conduct, which are ethical guidelines for the responsible management, reproduction, marketing, and enjoyment of ornamental plants. Mexico does not yet have such tools, and the Nature Conservancy, with support from state and municipal governments and the scientific community, has undertaken the task to promote and implement voluntary codes of conduct as a tool to prevent

[1] Presenter.

and control the introduction and spread of the invasive ornamental plants that are currently present in various Mexican ecosystems and, in some cases, have become serious threats to biodiversity and the national economy.

Resumen

Después de la destrucción del hábitat, el impacto por las especies invasoras ha sido identificado como uno de los principales causantes de la pérdida de biodiversidad a nivel global. En la industria de la horticultura se comercializan muchas plantas que tienen el carácter de invasoras por sus ventajas adaptativas. La falta de conocimiento sobre la biología de estas especies, aunado a la gran demanda que existe en el mercado mundial por su gran atractivo y belleza, hacen de las plantas ornamentales invasoras un potencial y peligroso foco de destrucción de los hábitat y su biodiversidad nativa. Para detener el flujo de plantas invasoras ornamentales, muchos países han implementado estrategias que involucran a productores y consumidores, mediante códigos voluntarios de conducta los cuales son lineamientos éticos para el manejo responsable, reproducción, comercialización y disfrute de las plantas de ornato. En México no contamos aún con este tipo de herramientas, por lo cual the Nature Conservancy con apoyo de los gobiernos estatales, municipales y de la comunidad científica, se han dado a la tarea de promover e implementar códigos voluntarios de conducta, como una herramienta para prevenir y controlar la introducción y propagación de plantas de ornato invasoras que actualmente están presentes en varios ecosistemas del país y que en algunos casos se han convertido en graves amenazas para la biodiversidad y para la economía nacional.

Invasive Weed Control and Ecosystem Restoration Using Integrated Vegetation Management

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Abstract

Integrated Vegetation Management (IVM) follows a process in which vegetation is inspected, action thresholds are determined, and control options are implemented to develop compatible plant communities. IVM Partners has developed vegetation management plans and documented plant community changes on electric and gas utility rights-of-way and wildlife refuges that have resulted from best practices at several case study sites throughout the United States. This presentation will discuss IVM methods that promote compatible plant communities; allow for utility safety, access, and reliability; improve wildlife and endangered species habitat; and lower costs and greenhouse gas emissions.

Resumen

El Manejo Integrado de Vegetación (MIV) sigue un proceso en el que la vegetación se inspecciona, se determina un umbral de acción y las opciones de control implementadas para desarrollar comunidades de plantas compatibles. Los socios del MIV han desarrollado planes de manejo de la vegetación y han documentado los cambios en la comunidad plantas en los refugios derechos de paso servicios públicos de electricidad y gas y de vida silvestre, que han resultado de las mejores prácticas en varios sitios de estudio de casos en todo Estados Unidos. Los mejores métodos de MIV se discuten que proporcionan a las comunidades vegetales compatibles que permiten la seguridad de servicios públicos, el acceso y la confianza al tiempo que mejora la vida silvestre y el hábitat de especies en peligro de extinción y reducir los costos y los gases de efecto invernadero.

Organic Noxious Weed Control on St. Regis Tribal Lands

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Abstract

The St. Regis Mohawk Tribe has begun a weed control and removal effort focused on *Phragmites australis* (common reed), a wetland plant that diminishes habitat for native birds and other wildlife. Research is being conducted to find a control method that does not utilize herbicide, as the widely used and accepted control methods for *Phragmites* are not in line with cultural and community values. Mechanical treatments, as well as

organic herbicides that do not negatively impact other vegetation, are being tested for effectiveness.

Resumen

En lo que respecta a las malezas invasoras ecológicas La Tribu Mohawk en St. Regis ha iniciado un control de malezas y se ha centrado en la remoción de *Phragmites australis* (common reed). Esta planta de humedales disminuye el hábitat de aves nativas y otros animales salvajes. Los ampliamente utilizados y aceptados métodos de control no están en consonancia con los valores de la comunidad entonces se lleva a cabo investigación en los métodos de control que no incluyen herbicidas. Se está probando la eficacia de tratamientos mecánicos, así como herbicidas orgánicos que no afecte negativamente otros tipos de vegetación.

US Customs and Border Protection Agriculture Specialists Protect the United States from Federal Noxious Weeds

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Abstract

As a result of cargo inspections at United States Customs and Border Protection (CBP) ports of entry, CBP Agriculture Specialists have intercepted Federal Noxious Weeds (FNW) 113 times from 25 different countries in the past 18 months. Analysis of these interceptions discovered that the grills on shipping container refrigeration units pose a significant risk of transporting FNW to the US. In response, CBP began conducting a special operation concentrating inspection resources on refrigerated containers.

Resumen

Como resultado de las inspecciones de carga en Aduanas y Protección Fronteriza (CBP) en los puertos de entrada y Aduanas y Especialistas en Protección Agricultura en las Fronteras han interceptado Malezas Nocivas Federales (FNW) 113 veces desde 25 países diferentes en los últimos 18 meses. El análisis de estas intercepciones descubrió que las rejillas de las unidades de refrigeración de los contenedores plantean un riesgo significativo de transportar FNW a los Estados Unidos. En respuesta, el CBP llevando a cabo un operativo especial concentrando los recursos de inspección en los contenedores refrigerados.

Alaska: Not as Isolated as You Might Think

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Abstract

When compared to the continental United States and the more populated Canadian provinces, Alaska has few people and comparatively little development. These factors, along with the state's spatial isolation and cold climate, mean that Alaska has comparatively few invasive species. Yet Alaska has more documented non-native plant species than our Canadian neighbor to the east, the Yukon; this is likely a function of more people and more numerous possible ports of entry in Alaska.

Alaska's most widespread invasive plants were brought to the state and dispersed intentionally for revegetation and forage production, and as ornamentals. Furthermore, it is believed that a few species were transported to Alaska accidentally, while pathways for other species remain obscure. In one case, seeds of a crop species grown historically in northwestern British Columbia are believed to have flowed down the Stikine River into Alaska to infest the floodplain's lower reaches, which ironically are part of a federally designated Wilderness Area. A number of different agencies are charged with managing invasive plant movement into Alaska, including US Customs and Border Protection, the US Department of Agriculture's Animal and Plant Health Inspection Service, and the Alaska Division of Agriculture. This presentation describes a new effort aimed at a mutual understanding of each agency's jurisdiction and role.

Resumen

Alaska tiene poca gente y el desarrollo relativamente poco. Estos factores, junto con el Estado, los oficiales administrativos de aislamiento espacial y clima frío, significa que Alaska tiene pocas especies invasoras en comparación con

los 48 estados y las provincias más pobladas de Canadá. Sin embargo, Alaska ha documentado más especies de plantas no nativas que nuestro vecino del este de Canadá, el Yukón, lo que es probablemente una función de mayor número de personas posible y los puertos de entrada más numerosos en Alaska. Alaska, el AM plantas invasoras más extendidas fueron traídos al estado y dispersa intencionalmente para la revegetación, para la producción de forraje y como planta ornamental. Unas pocas especies se cree que han sido transportados a Alaska por accidente, y la vía para algunas especies sigue siendo oscura. En un caso, las semillas de una especie de cultivo crecido históricamente en el noroeste de la Columbia Británica se cree que han fluido por el río Stikine en Alaska para infestar la llanura de inundación, el AM partes bajas, que, irónicamente, son parte de un Área Silvestre federal designada. Un número de diferentes organismos se encargan de la gestión de movimiento de plantas invasoras en Alaska, incluyendo EE.UU. Aduanas y Protección Fronteriza, el APHIS y la División de Agricultura de Alaska. Una nueva campaña dirigida a la comprensión mutua de cada organismo, la competencia y el papel de los oficiales administrativos se describe.

Using the National Invasive Species System as a Tool for Predicting Plant Invasions

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Abstract

The National Commission for Knowledge and Use of Biodiversity (CONABIO) is a permanent inter-ministerial commission that has the mandate to create and maintain the National Information System on Biodiversity (NISB). Among its activities, CONABIO advises other governmental bodies by providing science-based information for the decision making process. Awareness of the issue of Alien Invasive Species (AIS) in Mexico, through several high profile cases, has increased the need to establish different measures to face the problem, based on the best scientific information available and with the coordinated participation of different actors. In 2007, CONABIO began developing the National Invasive Species Information System (NISIS), a subcomponent of NISB, to compile information on the situation of AIS across the country. Although it is still a work in progress, the system is a specific tool to manage invasive species data and information. It holds a list of 358 invasive species, of which 50 percent are terrestrial or aquatic plants; 120 species information sheets; and over 93,000 records of occurrence across the country, including information about invasiveness in other regions, dispersion and pathways that can be related to other geographical layers, and to software on modeling habitat conditions where species might become established. Within the goals of the national strategy on AIS, access to information relevant to different stakeholders is essential to supporting the actions of other institutions to prevent, control, and eradicate species of major concern. Prevention is identified as one of the key strategic components and the information currently hosted by the NISIS can be used to predict probable areas of establishment for certain weeds, helping focus detection and monitoring efforts. This work provides examples of how the system can be used to predict risk to native flora and fauna by assessing weeds and plants of major concern.

Resumen

La Comisión Nacional para el Conocimiento y Uso de la Biodiversidad (CONABIO) es una comisión interministerial permanente que tiene el mandato de crear y mantener el Sistema Nacional de Información sobre Biodiversidad (NISB). Entre sus actividades CONABIO asesora a otros organismos públicos, proporcionando información basada en la ciencia para la toma de decisiones. El conocimiento de la cuestión de especies exóticas invasoras (AIS) en México, a través de varios casos de alto perfil se ha incrementado la necesidad de establecer diferentes medidas para hacer frente al problema, basado en la mejor información científica disponible y con la participación coordinada de los diferentes actores. En 2007, la CONABIO inició el desarrollo de la Nacional de Información sobre Especies Invasoras (Sistema NISIS), un subcomponente de NISB, que recopile información sobre la situación de los

[2] Presenter.

AIS en todo el país. Aunque todavía es un trabajo en progreso, el sistema es una herramienta específica para gestionar los datos de especies invasoras y la información. I, que contiene una lista de 358 especies invasoras, entre los cuales el 50 por ciento son terrestres o plantas acuáticas, 120 hojas de información sobre especies y más de 93,000 registros de ocurrencia en todo el país, incluyendo información sobre la capacidad de invasión de otras regiones, la dispersión y las vías que pueden estar relacionados a otras capas geográficas y al software de modelado de las condiciones del hábitat donde las especies pueden establecerse. Dentro de los objetivos de la estrategia nacional sobre las NIC, el acceso a la información necesarias en relación con las diferentes partes interesadas es esencial para apoyar las acciones de otras instituciones para prevenir, controlar y erradicar las especies de mayor interés. La prevención es identificado como uno de los componentes estratégicos clave y la información actualmente acogido por el NISIS puede ser utilizado para predecir probables áreas de establecimiento de ciertas malas hierbas, ayuda a detectar el enfoque y los esfuerzos de monitoreo. Este trabajo presenta algunos ejemplos de cómo el sistema puede ser utilizado para predecir el riesgo para la flora y la fauna mediante la evaluación de las malezas y plantas de gran preocupación.

Trade Secrets: A Potential Policy Barrier to Cooperation in Biosecurity Along Global Trade Pathways[3]

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Abstract

Effective border control requires a national biosecurity policy based upon quantitative analysis of species introductions and pathways. Such analysis is hindered whenever there is an absence of transparency and barriers to access to information by scientific and management authorities. Where international trade is the pathway for introduction, cooperation between the management authorities of trading partners is essential for meaningful early detection and rapid response measures. In the United States, conflicting federal policy and law has prevented effective data exchange between authorities with complementary responsibilities in invasive species management. While Executive Order 13112 of February 1999 requires federal agencies to prevent the introduction of invasive species, laws such as the Economic Espionage Act of 1996 (18 USC §1831–39) that aim to protect proprietary commercial information disclosed to government are cited as justification for restricting access to data concerning trade. A process for clarifying the law and providing appropriate guidance to and protection for federal agents in the execution of their duties is required, with a view towards optimizing protection of the public interest.

Resumen

Un control fronterizo eficaz requiere una política nacional de bioseguridad basado en el análisis cuantitativo de las introducciones de especies y sus rutas. Este análisis se ve obstaculizado cada vez que hay una falta de transparencia y barreras de acceso a la información por los científicos las autoridades administrativas. Cuando el comercio internacional es la vía para la introducción, la cooperación entre las autoridades administrativas de los socios comerciales es esencial para la detección temprana y las medidas rápidas de respuesta. En los Estados Unidos, entran en conflicto las políticas federales y las leyes y ha impedido el intercambio eficaz de datos entre las autoridades con responsabilidades complementarias en el control de especies invasoras. Mientras que la Orden Ejecutiva 13112 de febrero de 1999 requiere a las agencias federales para impedir la introducción de especies invasoras, leyes como la Ley de Espionaje Económico de 1996 (18 USC §1831–1839) cuyo objetivo es proteger la información comerciales divulgada al gobierno se cita como justificación para restringir acceso a los datos concernientes al comercio. Un proceso para aclarar la ley y proporcionar la orientación adecuada y protección a los agentes federales en ejercicio de sus funciones es necesario, con miras a optimizar la protección del interés público.

[3] Editor's note: The content of this presentation was combined with that of John Peter Thompson's and is published here under the title "Peeling Back the Onion: Conflicting Policy Objectives and Biosecurity in the United States Government Agencies."

Bio-economics of Invasive Species and the Horticulture Industry[4]

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Abstract

Biological invasions are linked to economic decisions, creating a wicked problem for both stakeholders and ecosystems. Wicked problems have multiple definitions, exist without ending points, and are non-linear, thus defying simple "either or" solutions. As a major pathway for the introduction of invasive species, the nursery, landscape, and gardening industry provides a complicated mix of cultural, environmental, and financial choices that are better informed by understanding how risk reductions are valued. The challenge of scale also affects valuation economic and ecological calculations. Equally important is the inclusion of uncertainty in ecological processes and the potential for fuzzy logic as a tool for decision making. This presentation will provide a very brief philosophic overview of the bio-economics of invasive species.

Resumen

Las invasiones biológicas están vinculadas a las decisiones económicas creando un perverso problema entre los interesados y los ecosistemas. Los problemas perversos tienen múltiples definiciones, existen puntos sin terminar y no son lineales, desafiando así simple "o cualquiera" soluciones. Las industrias de viveros, diseñadores de paisaje y la jardinería como principal vía para la introducción de especies invasoras, proporciona una mezcla complicada de factores culturales, ambientales, y opciones financieras que están mejor informados mediante la comprensión de cómo el riesgo de reducciones se valoran. El desafío de esta escala también afecta a los cálculos de valoración económica y ecológica. Igualmente importante es la inclusión de la incertidumbre en los procesos ecológicos y el potencial de la lógica difusa como herramienta para la toma de decisiones. La presentación tendrá una visión filosófica muy breve de la bioeconomía de las especies invasoras.

[4] Editor's note: The content of this presentation was combined with that of John Waugh's and is published here under the title "Peeling Back the Onion: Conflicting Policy Objectives and Biosecurity in the United States Government Agencies."

New Strategies for Early Detection and Rapid Response to Invasive Plants in Canada, Mexico, and the United States: the WAB 2010 International EDRR Train-the-Trainer Workshop[5]

Les Mehrhoff
Invasive Plant Atlas of New England

Randy Westbrooks
US Geological Survey

Abstract

Participants of the biennial Weeds Across Borders (WAB) conference have long recognized the need for sharing information about new and emerging invasive plants across North America. At WAB 2008 in Banff, Alberta, Canada, a plan was presented for the development of such an information sharing system—a North American Early Warning System for Invasive Plants. The first step in creating such a system is for each of the partner countries to develop a national Early Detection and Rapid Response (EDRR) system for invasive plants. In support of this ongoing effort, EDRR training workshops are being conducted by many WAB partner groups across Canada and the United States. The purpose of these workshops is to assist states and provinces in developing EDRR capacities through the establishment of state and provincial EDRR coordinating committees; volunteer early detection and reporting networks (patterned after the Invasive Plant Atlas of New England); and the establishment of Invasive Plant Task Forces and Cooperative Weed Management Areas (for rapid response), as appropriate. Topics typically covered in EDRR train-the-trainer and volunteer training workshops will be presented. With early warning and rapid response systems in place, Canada, Mexico, and the US will be better equipped to defend against future economic and environmental losses associated costs due to invasive plants out of place.

[5] The 2010 WAB International EDRR Train-the-Trainer Workshop was presented with financial assistance from Invasive Plant Control, Inc., based in Nashville, Tennessee. http://www.invasiveplantcontrol.com.

Resumen

Los participantes de la Conferencia bienal de Malezas sin Fronteras (WAB) han reconocido hace tiempo la necesidad de compartir información acerca de las nuevas y emergentes plantas invasoras en América del Norte. En el WAB 2008 en Banff, Alberta, Canadá, un plan fue presentado para el desarrollo de tal sistema de intercambio de información—un sistema de alerta temprana de plantas invasoras en América del Norte. El primer paso en la creación de tal sistema es que cada uno de los países socios desarrolle un Sistema Nacional de Detección Temprana y Sistema de Respuesta Rápida de las plantas invasoras. En apoyo de este esfuerzo continuo, EDRR talleres de capacitación se llevan a cabo por muchos grupos asociados WAB a través de los EE.UU. y Canadá. El objetivo de estos talleres es ayudar a los estados y provincias en el desarrollo de la capacidad de EDRR mediante el establecimiento de Comités Coordinadores EDRR Estatales y Provinciales, a través del desarrollo de redes de voluntarios de Detección Temprana y Reporte (el modelo del Atlas de Plantas Invasoras de Nueva Inglaterra), y el establecimiento Fuerzas de Tarea de Plantas Invasoras y Cooperativa de Manejo de Áreas de Malezas (de respuesta rápida), según corresponda. Los temas que generalmente son cubiertos en talleres de EDRR en la capacitación de instructores y de formación de voluntariado se presentará. Con la exclusión, de la alerta temprana, y los sistemas de respuesta rápida en el lugar, los EE.UU., Canadá, y México estará en mejores condiciones para defenderse de futuras pérdidas económicas y ambientales asociados costos debido a "plantas invasoras fuera de lugar."

Defending Favorite Places

Tim Richardson
Wildlife Forever

Abstract

Wildlife Forever is a national leader among hunting and fishing conservation groups in prioritizing the fight against invasive species. Whether people simply like to watch wildlife or like to hunt and fish, their favorite outdoor past-times are being threatened. Invasive species are destroying the habitat and food sources of North America's fish and wildlife. The Threat Campaign was launched by Wildlife Forever in 2006 with the goal of rapidly informing the public in general, and sportsmen and women in particular, that people are the first line of defense in stopping the spread of invasive species on land and in the water. Wildlife Forever's Threat Campaign utilizes mass marketing approaches to increasing awareness about invasive species as an efficient and effective public awareness and education outreach effort that has reached over 500 million impressions about invasives in the past four years. The Threat Campaign is designed to enlist the support of the public and encourage them to take action. The *Defending Favorite Places* DVD, to be aired at the WAB conference, was produced through collaboration with the US Forest Service, US Department of Agriculture, National Fish and Wildlife Foundation, US Fish and Wildlife Service, Center for Invasive Plant Management, and US Bureau of Land Management.

POSTER ABSTRACTS

Eight Prohibited Invasive Exotic Plants in Reston, Virginia

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Abstract

In May 2008, the Reston Association (RA) approved a resolution banning eight exotic invasive plants from being planted on homeowner property. The RA is the governing body of Reston, Virginia. Reston is a large planned community of 62,000 residents; it encompasses 11 square miles, and is located 25 miles from Washington, DC. An Environmental Advisory Committee advises the Reston Association Board of Directors. This committee worked with RA staff to develop a list of eight of the most commonly escaped ornamental landscape and yard species that overwhelm Reston's natural areas. It is these natural areas, which are spread throughout the community, that gave Reston its motto: "Living in Reston is like living in a park."

The eight species are:

- Flowering pear (*Pyrus calleryana* cultivars);
- Exotic bamboos (*Bambusa* species);
- Winged burning bush (*Euonymus alata*);
- Oriental bittersweet (*Celastrus orbiculatus*);
- Chinese and Japanese wisteria (*Wisteria sinensis*, *W. floribunda*);
- Bush honeysuckle (non-native *Lonicera* spp.);
- Japanese barberry (*Berberis thunbergii*); and
- English ivy (*Hedera helix*).

We chose these species because they decrease biodiversity and outcompete the native plants that wildlife depend on for food and shelter. Furthermore, these species were chosen because they are commonly sold in local nurseries and spread from neighboring properties. Many exotic invasive species overtake the native shrubs and trees that are a signature of the Reston community.

In an effort to enforce the resolution banning the planting of exotic invasive plants, landscape companies are required to inform homeowners of the RA's policy and are prohibited from planting any of the eight species. Because this resolution was only recently approved, we have had limited experience enforcing it and are aware that the challenging part lies ahead. However, we have seen an increase in the availability of native varieties in local nurseries.

Resumen

En mayo de 2008, la Asociación de Reston (RA) aprobó una resolución prohibiendo que ocho plantas exóticas invasoras sean plantadas en la propiedad de dueños de casa. La Asociación de Reston es el órgano rector de Reston, Virginia. Reston es una comunidad planificada grande de 62,000 habitantes y abarca 11 kilómetros cuadrados, situado a 25 millas de Washington, DC. La Comisión Consultiva Ambiental asesora a la Junta Directiva de la Asociación de Reston. Esta comisión trabajó con el personal de RA para elaborar una lista de ocho de las más comunes especies fugadas de jardines que superan los espacios naturales. Nuestras áreas naturales se extienden por todo Reston, de hecho, el lema de Reston es: "Vivir en Reston, es como vivir en un parque."

Las ocho especies son:

- Flowering pear (*Pyrus calleryana* cultivares);
- Exotic bamboos (*Bambusa* spp.);
- Winged burning bush (*Euonymus alata*);
- Oriental bittersweet (*Celastrus orbiculatus*);
- Chinese y Japanese wisteria (*Wisteria sinensis*, *W. floribunda*);
- Bush honeysuckle (no las especies nativas de *Lonicera*);
- Japanese barberry (*Berberis thunbergii*); y
- English ivy (*Hedera helix*).

Hemos elegido estas especies porque disminuyen la biodiversidad y causan daños a la vida silvestre que dependen de las plantas nativas para la alimentación y la vivienda. Fueron elegidas porque se venden comúnmente en los viveros y se dispersan desde la propiedad vecina. Muchas especies exóticas invasoras rebasan arbustos y árboles nativos que son la firma de la comunidad de Reston.

Debido a esta prohibición, cuando un dueño de casa trató de tener una de estas plantas instaladas, la empresa de jardineria le informó que a ellos no se les permite utilizar plantas prohibidas en el jardin. También hemos visto un aumento en la disponibilidad de las variedades nativas en viveros locales. Se trata de una reciente prohibición y hemos tenido una limitada experiencia en la aplicación de la esta resolución. La ejecución será un desafío.

An Update on the Invasive Plant Atlas of the Mid-South

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Abstract

The Invasive Plant Atlas of the Mid-South (IPAMS) is an integrated research and extension project to develop an invasive plant awareness program for the Mid-South states of Alabama, Arkansas, Louisiana, Mississippi, and Tennessee. This project aims to quantify relationships of weed distribution and spread with land use, then use that information directly in educating agriculture stakeholders, natural resources managers, and other interested parties on potential human-induced opportunities for invasive species spread. Research activities include conducting systematic regional vegetation surveys to assess the distribution of key invasive plants, developing models for predicting the occurrence of target species based on land use and cover, and evaluating the relative effectiveness of professional versus volunteer surveys. As part of these research activities, we have surveyed over 470 points throughout the state of Mississippi, providing data on more than 800 plant species, including more than 70 species that are not native to the region. Initial analyses of these data have demonstrated a strong correlation of land use and cover with the presence of exotic plant species, especially key invaders such as the grass *Imperata cylindrica* (cogongrass). Outreach and extension activities include developing training programs for volunteers to identify and report invasive species using IPAMS, developing an efficient Early Detection and Rapid Response (EDRR) system for invasive plants, developing best management information, and developing an online mapping system. To date, we have trained numerous individuals in identification of our target weed species, and we are in the process of developing management information for these species. Our website, http://www.gri.msstate.edu/ipams, is operational, with over 7,620 records entered for 134 species from 29 states and many more observations completed but not entered into the database.

Resumen

El Atlas de Plantas Invasoras del Medio Sur (IPAMS) es un proyecto integrado de investigación y extensión para desarrollar un programa de conocimiento de plantas invasoras para la los estados del medio sur Alabama, Arkansas, Louisiana, Mississippi y Tennessee. Este proyecto pretende cuantificar la relación de la distribución y propagación de malezas con el uso de la tierra, y luego utilizar esta información directamente en la educación de los interesados en la agricultura, administradores de recursos naturales, y otras partes interesadas en el potencial humano inducida por las oportunidades de propagación de especies invasoras. Las actividades de investigación incluyen la realización sistemática de encuestas de la vegetación regional para evaluar la distribución de las principales plantas invasoras, desarrollar modelos para predecir la ocurrencia de las especies objetivo basado en el uso y cobertura de la tierra, y la evaluación de la eficacia relativa de las encuestas de profesionales frente a las de voluntarios. Como parte de estas actividades de investigación, hemos examinado más de 470 puntos en todo el estado de Mississippi, proporcinando datos sobre más de 800 especies de plantas, incluyendo más de 70 especies que no son nativas de la región. Los primeros análisis de estos datos han demostrado una fuerte correlación del uso del suelo y la cubierta con la presencia de especies de plantas exóticas, especialmente los invasores claves como el pasto *Imperata cylindrica* (cogongrass). Difusión y extensión de las actividades incluyen el desarrollo de programas de formación de voluntarios para identificar y notificar las especies invasoras utilizando IPAMS, el desarrollo de un sistema eficaciente detección precoz y respuesta rápida (EDRR)

de las plantas invasoras, el desarrollo de la mejor información de manejo, y desarrollo de un sistema de mapas en línea. Hasta la fecha, hemos entrenado a numerosas personas en la identificación de nuestras especies de malezas objetivo, y estamos en el proceso de desarrollo de información de manejo de estas especies. Nuestra página web, http://www.gri.msstate.edu/ipams, está en funcionamiento, con más de 7,620 registros de entrada de 134 especies procedentes de 29 estados y muchas más observaciones completadas, pero no entradas en la base de datos.

The Florida Invasive Species Partnership: The Power of Partnerships

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Abstract

The Florida Invasive Species Partnership (FISP) is a multi-agency, organizational effort striving to improve the efficiency and effectiveness of preventing and controlling invasive non-native species. This is accomplished through partnering to increase communication, coordination, and use of shared resources in order to protect wildlife habitat, working agricultural and forest lands, natural communities, and biodiversity in Florida. FISP has three primary goals: (1) encourage voluntary partnerships to increase effectiveness and decrease costs of comprehensive invasive species management; (2) encourage the development, implementation and sharing of new and/or innovative approaches to address the threat of invasive species; and (3) provide tools and resources that enable the development of unified approaches, bridging the gap between private landowners' and land management agency invasive species efforts.

During 2006 and 2007, FISP developed the dynamic "Incentive Program Matrix" of existing federal, state and local funding sources, incentive programs and technical assistance for private landowners in Florida. The interactive matrix database, now available on the Florida Invasives website, http://www.floridainvasives.org, allows both private and public land managers to determine what current technical and financial assistance is available to best suit their specific needs and coordinate control efforts across boundaries. In 2007, FISP began promoting the concept of Cooperative Invasive Species Management Areas (CISMA) in Florida. The goal of this effort is to encourage development of local partnerships between federal, state, and local government agencies, tribes, individuals and various interested groups to manage noxious weeds or invasive plants in a defined area. To date, there are 15 CISMAs across Florida from the panhandle's Northwest Florida CISMA to the Florida Key's Invasive Task Force. The Incentive Program Matrix and locally led CISMAs allow us to expand invasive species management efforts across the landscape and build community awareness. Our strength is truly in the partnership, camaraderie and conservation ethic that is shared by our members.

Resumen

The Florida Invasive Species Partnership (FISP) es una multi-agencia y esfuerzo organizacional para tratar de mejorar la eficiencia y la eficacia de la prevención y control de especies invasoras no nativas a través de alianzas para incrementar la comunicación, la coordinación y el uso de los recursos compartidos, con el fin de proteger el hábitat de la vida silvestre, tierras agrícolas y forestales, comunidades naturales y la diversidad biológica en la Florida. FISP tiene tres objetivos principales: (1) Fomentar las asociaciones voluntarias para aumentar la eficacia y disminuir los costos de manejo global de especies invasoras; (2) Fomentar la desarrollo, aplicación y difusión de nuevos y/o innovadores enfoques para hacer frente a la amenaza de las especies invasoras; y (3) Proporcionar herramientas y recursos que permitan el desarrollo de enfoques unificados, reduciendo la brecha entre los propietarios privados y los esfuerzos de la agencia de manejo de especies invasoras.

Durante 2006 y 2007, FISP desarrollo la dinámica "Programa Matriz de Incentivos" de fuentes de financiación federal, estatal y local existentes, programas de incentivos y asistencia técnica para los propietarios privados en la Florida. La base de datos matriz interactiva, ahora disponible en el sitio web, http://www.floridainvasives.org, permite tanto a los administradores

de tierras públicas y privadas determinar qué tipo de asistencia técnica y financiera es actualmente disponible que mejor se adapta a sus necesidades específicas y coordinar los esfuerzos de control a través de las fronteras. En 2007, FISP comenzó a promover el concepto de la Manejo Cooperativo de Áreas de Especies Invasoras (CISMA) en el la Florida. El objetivo de esta iniciativa es fomentar el desarrollo de asociaciones entre federal, estatal y local organismos gubernamentales, tribus, individuos y diversos grupos interesados en el manejo de malezas nocivas o plantas invasoras en un área definida. Hasta la fecha, hay 15 CISMAs a través de la Florida desde el CISMA del noroeste de la zona del Panhandle de la Florida hasta Florida Key's Invasive Task Force. El Programa Matriz de Incentivos y localmente dirigidas CISMAs nos permitirá ampliar esfuerzos en el manejo de especies invasoras a través del paisaje y crear conciencia en la comunidad. Nuestra fuerza está verdaderamente en la cooperación, la camaradería y la ética de conservación que es compartido por nuestros miembros.

Use of Limestone Gravel on Forest Roads Increases Abundance of *Microstegium vimineum*

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Abstract

The disturbance and connectivity associated with forest roads can facilitate the spread of invasive plants. However, little is known about how soil changes caused by roads might influence plant community invasibility. Many unpaved forest roads in Pennsylvania are surfaced with limestone gravel, which raises pH of roadside soils. The annual grass *Microstegium vimineum* is invasive throughout the eastern US and is commonly found along forest roads. Previous studies have shown its presence to be correlated with elevated soil pH. We conducted a field survey and greenhouse experiment to investigate whether conditions created by the use of limestone gravel increase the abundance of *M. vimineum*. We selected four pairs of unpaved forest roads, consisting of one road with native shale surface and one with limestone. Along each road, we measured 1,000 meters with a rolling distance wheel, recording *M. vimineum* presence and abundance in five abundance classes. We measured the extent of *M. vimineum* away from the road at 25 points, and sampled soil pH along four transects across each road. Abundance of *M. vimineum* and its extent away from the road were significantly greater along limestone roads. Soil pH of undisturbed forest soils was 4.5 or lower; that of roadside plant communities ranged from 5.0 to 6.2 along shale roads, and between 6.8 and 8.2 along limestone roads. In the greenhouse, forest soils were amended with powdered limestone to create a range of pH levels. *M. vimineum* biomass accumulation was greatest in the pH 6.3 treatment, a soil pH considerably less acidic than native forest soils but within the range measured beside limestone-graveled roads. Our results suggest that use of limestone gravel facilitates invasion of roadside vegetation by *M. vimineum*.

Resumen

La alteración y la conectividad asociada a los caminos forestales pueden facilitar la propagación de plantas invasoras. Sin embargo, poco se sabe sobre cómo los cambios del suelo causados por las carreteras pueden influir en la invasibilidad de la comunidad de plantas. Muchos de los caminos forestales no pavimentados en Pennsylvania están recubiertos con grava caliza, lo que aumenta el pH de los suelos a los lados de la carretera. El pasto anual *Microstegium vimineum* es invasivo a través del oriente de los EE.UU., y se encuentra comúnmente a lo largo de los caminos forestales. Estudios anteriores han demostrado que su presencia se correlaciona con el elevado pH del suelo. Hemos realizado un estudio de campo y un experimento en invernadero para investigar si las condiciones creadas por el uso de grava de piedra caliza aumentan la abundancia de *M. vimineum*. Hemos seleccionado cuatro pares de carreteras forestales sin asfaltar, que consiste en una carretera con una superficie de pizarra natural y uno con piedra caliza. A lo largo de cada carretera, medimos 1,000 metros rodando una rueda medidora de distancias, registrando la presencia y abundancia de *M. vimineum* en cinco clases de abundancia. Se midió la extensión de *M. vimineum* lejos de la carretera en 25 puntos, y se midio el pH del suelo a lo largo

de cuatro transectos a través de cada carretera. La abundancia de *M. vimineum* y su extensión fuera de la carretera, fueron significativamente mayores a lo largo de las carreteras de piedra caliza. El pH del suelo de bosque no perturbado fue de 4.5 o inferior, el de las comunidades de plantas en carretera va desde 5.0 hasta 6.2 por carreteras de pizarra, y entre 6.8 y 8.2 por carreteras de piedra caliza. En el invernadero, los suelos forestales se han modificado con caliza en polvo para crear una gama de niveles de pH. La acumulación de biomasa de *M. vimineum* fue mayor en el tratamiento de pH 6.3, un pH del suelo considerablemente menos ácido que el suelo de los bosques nativos, pero dentro del rango de medida junto a las carreteras de grava de piedra caliza. Nuestros resultados sugieren que el uso de la grava caliza facilita la invasión de la vegetación del borde de la carretera por *M. vimineum*.

Invasive Species Information Management and Exchange: Risk Assessment/Pathways Analysis Tools and an Invasive Species Database/Web Template

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Abstract

Formed in 2004 to provide a platform for sharing invasive species information at a global level, the Global Invasive Species Information Network is a network of invasive species experts, researchers, information managers, and computer scientists sharing their knowledge and experience to improve access to information used to control the spread of invasive species.

Using biodiversity informatics to facilitate global information sharing is especially critical in invasive species science, because (1) the best indicator of the invasiveness of a species is whether it has been invasive somewhere else; and (2) natural history information (diet, predators, habitat requirements, reproduction, and so on) about a species where it occurs naturally, and information gathered from where it has been introduced (dispersal mechanisms, negative impacts, prevention and management strategies, and so on) is vital for effective responses to invasive species.

Working with Taxonomic Database Working Group–Biodiversity Information Standards, the Global Biodiversity Information Facility, the Group on Earth Observations, BioNET International, the Invasives Network of the Inter-American Biodiversity Information Network (I3N), and many other partners in the invasive species science community, the GISIN is developing a pilot web solution to cross search online invasive species information systems, and has proposed seven data models to facilitate data exchange. This poster explains the history of the GISIN, describes its mission, and portrays the developing network of data providers, consumers, and users.