PROCEEDINGS OF THE
6TH BIENNIAL WEEDS ACROSS BORDERS CONFERENCE
2012

Edited by WAB 2012 Coordinating Committee
Sponsors

COMISIÓN NACIONAL PARA EL CONOCIMIENTO Y USO DE LA BIODIVERSIDAD
COMISIÓN NACIONAL DE ÁREAS NATURALES PROTEGIDAS
INSTITUTO MEXICANO DE TECNOLOGÍA DEL AGUA
INSTITUTO NACIONAL DE ECOLOGÍA Y CAMBIO CLIMÁTICO
UNIVERSIDAD NACIONAL AUTÓNOMA DE MÉXICO
COLEGIO DE POSTGRADUADOS EN CIENCIAS AGRÍCOLAS
CENTER FOR INVASIVE PLANT MANAGEMENT
NATIONAL FISH AND WILDLIFE FOUNDATION /ANIMAL AND PLANT HEALTH INSPECTION SERVICE
USDOT FEDERAL HIGHWAY ADMINISTRATION
USDI BUREAU OF LAND MANAGEMENT
FEDERAL INTERAGENCY COMMITTEE FOR THE MANAGEMENT OF NOXIOUS AND EXOTIC WEEDS
US FISH AND WILDLIFE SERVICE
USDA ANIMAL AND PLANT HEALTH INSPECTION SERVICE
AGRICULTURE AND AGRI-FOOD CANADA
CANADIAN FOOD INSPECTION AGENCY
DOW AGROSCIENCES
INVASIVE PLANT CONTROL, INC.
Weeds Across Borders 2012 Coordinating Committee

Patricia Koleff
CONABIO

Isabel González
CONABIO

Yolanda Barrios
CONABIO

Georgia Born Schmidt
CONABIO

Elizabeth Galli-Noble
CENTER FOR INVASIVE PLANT MANAGEMENT

Emily Rindos
CENTER FOR INVASIVE PLANT MANAGEMENT

Jenny Ericson
US FISH AND WILDLIFE SERVICE

Mary Ann Rondinella
FEDERAL HIGHWAY ADMINISTRATION RESOURCE CENTER

Francisco Espinosa García
UNIVERSIDAD NACIONAL AUTÓNOMA DE MÉXICO

Gina Ramos
US BUREAU OF LAND MANAGEMENT

Peter Egan
ARMED FORCES PEST MANAGEMENT BOARD

Heike Vibrans
COLEGIO DE POSTGRADUADOS EN CIENCIAS AGRÍCOLAS

Stephen Darbyshire
AGRICULTURE AND AGRI-FOOD CANADA

Cory Lindgren
CANADIAN FOOD INSPECTION AGENCY
Acknowledgements

This conference would not have been possible without the support of the many people who participated in the different aspects of its preparation. First of all the staff from CONABIO particularly, Patricia Koleff, Ana Isabel Gonzalez, Yolanda Barrios, Georgia Born-Schmidt, Silvia de Jesús, Patricia Galindo, Gloria Espinosa, Mauricio Corona, and Sarah Sifuentes who took care of the many aspects related to the planning, logistics of this meeting ensuring everything and everyone arrived safely in Cancún and on time for the meeting, as well as of the translation and edition of this memoirs. The staff from CONANP especially Margarita García, Yadira Gómez Hernández, Rocío Bravo Xicoténcatl and Patricia Santos who funded and organized the field trips, CIPM’s Elizabeth Galli-Noble and Emily Rindos for assisting with logistics and obtaining additional sponsorship and to the rest of the Coordinating Committee for the brainstorming on the different aspects of the organization of the meeting and its contents. The meeting was sponsored by a number of organizations without whose help many of the participants would not have been able to attend.

Of course, our gratitude also goes out to all the presenters, moderators and participants who came from far and wide and who in spite of the beautiful Caribbean beach outside the conference room, were at the meeting everyday sharing their work and asking important questions. Their participation was key to the success of this meeting.

We hope this was a rewarding experience for everyone, that new links were created between the different organizations that participated and that the weeds across borders meetings translate into regional collaboration.
2012 Weeds Across Borders Participants
# Table of Contents

- **Conference Schedule**
- **Presentation Manuscripts**

## Session 2: Tri-national Partnerships

16. North American Weed Management Association (NAWMA): History and Future  
*Julie Kraft and Jennifer Grenz, NAWMA Board of Directors*

*Norma Alejandra Elizalde Jiménez, Subdirección de Armonización y Evaluación Internacional*

18. Strategy for the conservation of an area of binational interest Big-Bend Río Bravo  
*Carlos Alberto Sifuentes Lugo, Comisión Nacional de Áreas Naturales Protegidas*

19. North American Invasive Species Network (NAISN)  
*Pedro Antunes, Isabel González, and Alycia Crall, NAISN Board of Directors*

## Session 3: Policy Making, Regulation, and Border Control

21. Import of Allochthonous Banyans (*Moracea ficus*) in North America and Simultaneous Entry of *Ramphotyphlops braminus* (Reptilia: Typhlopidae) through a Shared Entry Route  
*Christian Amador Da Silva, Prospección de Campo A.C*

23. Weeds in the Rio Grande and Colorado River Basins  
*David Negrete, Comisión Internacional de Límites y Aguas (CILA)*

24. Revising Alberta’s Provincial Weeds List: Experiences and Lessons Learned  
*Alec McClay, McClay Ecoscience*

35. The Case for International Cooperation  
*Bonnie Harper-Lore, Private Consultant*

38. US Policy Developments in Preventing Introductions of New Weeds  
*Peter Jenkins, Center for Invasive Species Prevention*

## Session 4: Socio-cultural Topics: Education, Outreach, and Working with Tribes

48. Welcoming the Future by Respecting the Past, A Thirty-five Year Personal History of Local Weed (My journey from a “weed sprayer” to an “invasive species control manager”)  
*Bob Parsons, Park County (Wyoming) Weed and Pest Control District*
53 Social Media: The Post-brochure Era in Outreach
   Jennifer Grenz, Invasive Plant Council of Metro Vancouver

57 Implementing Noxious Weed Management in Tribal, County, State, and Federal Multi-jurisdictional Settings
   Virgil Dupuis, Salish Kootenai College

58 Canada: Organizing Nationally
   Barry Gibbs, Alberta Invasive Plants Council and Canadian Invasive Species Council

61 Positive Actions, Healthy Environments: Changing Behavior to Protect Our Resources from Invasive Species
   Barry Gibbs, Alberta Invasive Plants Council and Canadian Invasive Species Council

63 Keynote Address: Assessing the Impacts of Plant Invaders on Native Plant Species Diversity
   Dr. Marcel Rejmánek, University of California–Davis

70 Session 5: Invasive Species and Climate Change

70 Invertebrate-Invasive Plant Relationships Shifted by Global Change
   Gabriela Chavarria, US Fish and Wildlife Service

72 Invasive Species and Climate Change in the National Wildlife Refuge System
   John Schmerfeld, US Fish and Wildlife Service, National Wildlife Refuge System

83 Mapping Habitat and Potential Distributions of Invasive Plant Species on USFWS National Wildlife Refuges Under Current and Future Climate Change Conditions
   Nicholas Young, Colorado State University, Natural Resource Ecology Laboratory

91 Invasive Species Potential Niche Modeling Challenges in Current and Global Change Projected Conditions
   Enrique Martínez-Meyer, Instituto de Biología, Universidad Nacional Autónoma de México

92 Session 6: Early Detection and Rapid Response

92 History of Early Detection and Rapid Response in the United States
   Chuck Bargeron, Center for Invasive Species and Ecosystem Health

95 Early Detection and Rapid Response Efforts in Canada
   Cory Lindgren, Canadian Food Inspection Agency

96 Preliminary Results of Weed Distribution Models in Mexico
   Jesús Alarcón Guerrero, CONABIO

99 Developing Cost-effective Early Detection Networks for Regional Invasions
   Alycia Crall, Colorado State University

100 EDRR: From National Issues to On-the-ground Implementation
    Julie Kraft, Sublette County (Wyoming) Weed and Pest District
Session 7: Economic Impacts and Ecological Assessments of Invasive Plant Invasions

102 Effects of Cryptostegia grandiflora in Oasis Fauna in the Baja California Peninsula: Perspectives for Eradication
Ricardo Rodríguez-Estrella, Centro de Investigaciones Biológicas del Noroeste

103 Satisfying the Compact: A Look at the Economic Impact of Cleaning the Republican River
Jennifer Rittenhouse ten-Bensel, Southwest Nebraska RC&D

112 Economic Impacts of Invasive Species on Annette Island Reserve, Alaska
Gina Ramos on behalf of Genelle Winter, Metlakatla Indian Community

114 Tamarisk in Sonora: Are We Losing Biodiversity?
Ek Del Val, Centro de Investigaciones en Ecosistemas, Universidad Nacional Autónoma de México

115 IMPLAN’s Role in Invasive Plant Research and Management
Jennifer Thorvaldson, MIG, Inc.

123 Monitoring of the Defoliator Beetle (Diorhabda spp.) of Saltcedar (Tamarix spp.) in the Rio Grande and Conchos Rivers in the Chihuahuan Desert of Mexico
Pablo Zamorano, Instituto Nacional de Ecología

133 Preliminary project to modify the Official Mexican Norm NOM-043-FITO-1999. Specifications to prevent the introduction of quarantine weeds into Mexico
Gustavo Torres, SENASICA-SAGARPA.

139 Weeds Found in Transgenic Cotton (Gossypium hirsutum) Agrosystems in La Laguna, Durango
Cándido Márquez Hernández, Escuela Superior de Biología, Universidad Juárez del Estado de Durango

Poster Session

141 A Guide to the Identification and Control of Exotic Invasive Species in Hardwood Forests
Lisa Dericks, Invasive Species Research Institute

146 The Emergence of Parthenium (Parthenium hysterophorus) as a Trans-border Invasive Weed in the Caribbean
Puran Bridgemohan, University of Trinidad and Tobago

153 Conservation Implications of Lantana camara: Research in Progress
Christie Sampson, Clemson University

155 Weeds as disturbance indicators in the temperate forest of the Río Magdalena basin
Yuriana Martínez-Orea, Universidad Nacional Autónoma de México

163 The Plants of Canada Database
Karen Castro, Canadian Food Inspection Agency
167 Control of invasive Australian Pine \((Casuarina equisetifolia)\) in the Fauna and Flora Protection Area of Nichupté

\(Natalia \text{ Blancas, Comisión Nacional de Áreas Naturales Protegidas}\)

168 **Session 8: Invasive Plant Diversity, Floristics and Biogeography**

168 Are the Hotspots of the Floristic Richness of Mexico Also the Hotspots for the Synanthropic Richness?

José Luis Villaseñor, Instituto de Biología, Universidad Nacional Autónoma de México

176 Do Historical Disturbance Patterns Matter for Present-day Invasion Success?

Heike Vibrans, Colegio de Postgraduados en Ciencias Agrícolas

177 A Synopsis of the Native and Introduced Weedy Grasses of Mexico

Jorge Gabriel Sánchez Ken, Instituto de Biología, Universidad Nacional Autónoma de México

192 Condition of Invasive Weeds in Zacatecas

E. David Enríquez, Universidad Autónoma de Zacatecas

199 Mexican Aquatic Weeds: Distribution and Importance

Jaime Raúl Bonilla-Barbosa, Centro de Investigaciones Biológicas, Universidad Autónoma del Estado de Morelos

211 **Session 9: Invasion Ecology**

211 Two Strategies Are Better than One for a Successful Plant Invasion: Sexual Reproduction Versus Vegetative Propagation and the Invasive Common Reed \((Phragmites australis)\)

Arnaud Albert, Université de Montréal

212 Ecophysiological Traits of Invasive Plants: Are There Similarities Across Photosynthetic Pathways?

Erick de la Barrera Montpellier, Universidad Nacional Autónoma de México

213 Demography of Invasive Plant Species with Emphasis on Kalanchoe delagoensis

Jordan Golubov, Universidad Autónoma Metropolitana

214 Invasive Plant Spread Rate Estimation as a Risk Assessment Criterion for Naturalized Species

Francisco Espinosa García, Universidad Nacional Autónoma de México

215 Ecological and Anthropic Criteria for Mapping Invasive Plant Susceptibility in Mexico

Ek del Val, Centro de Investigaciones en Ecosistemas, Universidad Nacional Autónoma de México

217 **Session 10: Management and Control**

217 Actions of the National Commission for Natural Protected Areas \((CONANP)\) on Invasive Alien Species: Weeds in Natural Protected Areas

Margarita García Martínez, Comisión Nacional de Áreas Naturales Protegidas

218 Approaches to the Planning and Implementation of Large Scale Invasive Alien Plant Control Programs in Southern Africa

Andrew E.M. Brown, Independent Consultant
219 Managing Invasive Weed Species Using Integrated Vegetation Management Principles  
Richard Lee, USDI Bureau of Land Management

220 Problems and Management of Invasive Aquatic Weeds in Mexico  
Maricela Martinez, Instituto Mexicano de Tecnología del Agua

223 Understanding resistance to glyphosate inheritance in *Amaranthus palmeri*:  
recent advances and remaining conundrums  
Daniela Ribeiro, Mississippi State University

228 Slowing the Spread of Invasive Species through Pathway Management:  
The Don’t Move Firewood Campaign  
Leigh Greenwood, The Nature Conservancy

229 Casuarina in the Sian Ka’an Biosphere Reserve  
Yadira Gómez Hernández, Comisión Nacional de Áreas Naturales Protegidas

230 Control and Eradication of Giant Reed (*Arundo donax*)  
in the Cuatrociénegas Flora and Fauna Protection Area  
Martin Alfonso Carillo Lomas, Comisión Nacional de Áreas Naturales Protegidas

236 Team Arundo: A Partnership for Management and Control of Giant Reed (*Arundo donax*)  
and Restoration of Habitat in Southern California  
Nelroy Jackson, Monsanto (retired) and former ISAC Vice Chair

238 Field Trips
CONFERENCE SCHEDULE

TUESDAY, APRIL 24

8:30 Welcome
Isabel González, Comisión Nacional Para el Conocimiento y Uso de la Biodiversidad (CONABIO)

Session 1: Country Status Reports
Moderator: Isabel González, CONABIO

8:50 Mexico Update
Patricia Koleff, CONABIO

9:10 Canada Update
Cory Lindgren, Canadian Food Inspection Agency

9:30 US Update
Bonnie Harper-Lore, US Invasive Species Advisory Council

9:50 Break

Session 2: Tri-national Partnerships
Moderator: Pete Egan, US Department of Defense

10:20 North American Weed Management Association (NAWMA): History and Future
Julie Kraft and Jennifer Grenz, NAWMA Board of Directors

10:40 North American Plant Protection Organization (NAPPO)
Norma Alejandra Elizalde Jiménez, Subdirección de Armonización y Evaluación Internacional

11:00 Strategy for the conservation of an area of binational interest Big-Bend Río Bravo
Carlos Alberto Sifuentes Lugo, Comisión Nacional de Áreas Naturales Protegidas

11:20 North American Invasive Species Network (NAISN)
Pedro Antunes, Isabel González, and Alycia Crall, NAISN Board of Directors

11:40 Panel Discussion: NAWMA, NAPPO, NAISN, CONABIO, Federal Interagency Committee for the Management of Noxious and Exotic Weeds (FICMNEW), and Canadian Invasive Species Council

12:00 Lunch

Session 3: Policy Making, Regulation, and Border Control
Moderator: Gina Ramos, USDI Bureau of Land Management

1:00 Import of Allochthonous Banyans (Moracea ficus) in North America and Simultaneous Entry of Ramphotyphlops braminus (Reptilia tiphlopidae) through a Shared Entry Route
Christian Amador Da Silva, Prospección de Campo A.C.

1:20 Weeds in the Rio Grande and Colorado River Basins
David Negrete, Comisión Internacional de Límites y Aguas (CILA)

1:40 Revising Alberta’s Provincial Weeds List: Experiences and Lessons Learned
Alec McClay, McClay Ecoscience

2:00 The Case for International Cooperation
Bonnie Harper-Lore, Private Consultant

2:20 US Policy Developments in Preventing Introductions of New Weeds
Peter Jenkins, Center for Invasive Species Prevention

2:40 Break

Session 4: Socio-cultural Topics: Education, Outreach, and Working with Tribes
Moderator: Liz Galli-Noble, Center for Invasive Plant Management

3:00 Welcoming the Future by Respecting the Past, A Thirty-five Year Personal History of Local Weed Control in Park County, Wyoming (My journey from a “weed sprayer” to an “invasive species control manager”)Weed Management in the Western US: A Reflection on the Past 30 Years
Bob Parsons, Park County (Wyoming) Weed and Pest Control District

3:20 Social Media: The Post-brochure Era in Outreach
Jennifer Grenz, Invasive Plant Council of Metro Vancouver

3:40 Implementing Noxious Weed Management in Tribal, County, State, and Federal Multi-Jurisdictional Settings
Virgil Dupuis, Salish Kootenai College

4:00 Canada: Organizing Nationally
Barry Gibbs, Alberta Invasive Plants Council and Canadian Invasive Species Council
Positive Actions, Healthy Environments: Changing Behavior to Protect Our Resources from Invasive Species
Barry Gibbs, Alberta Invasive Plants Council and Canadian Invasive Species Council

Special Session

Tribute to Dr. Leslie J. Mehrhoff
Chuck Bargeron, Center for Invasive Species and Ecosystem Health
Note: Conference participants will have a chance to share their thoughts on Dr. Mehrhoff during this session.

Wednesday, April 25

Introduction to Keynote Speaker
Georgia Born-Schmidt, CONABIO

Keynote Address: Assessing the Impacts of Plant Invaders on Native Plant Species Diversity
Dr. Marcel Rejmánek, University of California–Davis

Session 5: Invasive Species and Climate Change
Moderator: Jenny Ericson, US Fish and Wildlife Service

Invertebrate-Invasive Plant Relationships Shifted by Global Change
Gabriela Chavarria, US Fish and Wildlife Service

Invasive Species and Climate Change in the National Wildlife Refuge System
John Schmerfeld, US Fish and Wildlife Service, National Wildlife Refuge System

Mapping Habitat and Potential Distributions of Invasive Plant Species on USFWS National Wildlife Refuges Under Current and Future Climate Change Conditions
Nicholas Young, Colorado State University, Natural Resource Ecology Laboratory

Invasive Species Potential Niche Modeling Challenges in Current and Global Change Projected Conditions
Enrique Martínez-Meyer, Instituto de Biología, Universidad Nacional Autónoma de México

Break

Session 6: Early Detection and Rapid Response
Moderator: Julie Kraft, Sublette County (Wyoming) Weed and Pest District

History of Early Detection and Rapid Response in the United States
Chuck Bargeron, Center for Invasive Species and Ecosystem Health

Early Detection and Rapid Response Efforts in Canada
Cory Lindgren, Canadian Food Inspection Agency

Preliminary Results of Weed Distribution Models in Mexico
Jesús Alarcón Guerrero, CONABIO

Developing Cost-effective Early Detection Networks for Regional Invasions
Alicia Crall, Colorado State University

EDRR: From National Issues to On-the-ground Implementation
Julie Kraft, Sublette County (Wyoming) Weed and Pest District

Lunch

Session 7: Economic Impacts and Ecological Assessments of Invasive Plant Invasions
Moderator: Cory Lindgren, Canadian Food Inspection Agency

Effects of Cryptostegia grandiflora in Oasis Fauna in the Baja California Peninsula: Perspectives for Eradication
Ricardo Rodríguez-Estrella, Centro de Investigaciones Biológicas del Noroeste

Satisfying the Compact: A Look at the Economic Impact of Cleaning the Republican River
Jennifer Rittenhouse ten-Bensel, Southwest Nebraska RC&D

Economic Impacts of Invasive Species on Annette Island Reserve, Alaska
Gina Ramos on behalf of Genelle Winter, Metlakatla Indian Community

Tamarisk in Sonora: Are We Losing Biodiversity?
Ek Del Val, Centro de Investigaciones en Ecosistemas, Universidad Nacional Autónoma de México
10:20 Ecophysiological Traits of Invasive Plants: Are There Similarities Across Photosynthetic Pathways?  
Erick de la Barrera Montpellier, Universidad Nacional Autónoma de México

10:40 Demography of Invasive Plant Species with Emphasis on Kalanchoe delagoensis  
Jordan Golubov, Universidad Autónoma Metropolitana

11:00 Invasive Plant Spread Rate Estimation as a Risk Assessment Criterion for Naturalized Species  
Francisco Espinosa García, Universidad Nacional Autónoma de México

11:20 Ecological and Anthropic Criterions for Mapping Invasive Plant Susceptibility in Mexico  
Ek del Val, Centro de Investigaciones en Ecosistemas, Universidad Nacional Autónoma de México

11:40 Lunch

Session 10: Management and Control  
Moderator: Nelroy Jackson, Monsanto (retired) and former ISAC Vice Chair

1:20 Actions of the National Commission for Natural Protected Areas (CONANP) on Invasive Alien Species: Weeds in Natural Protected Areas  
Margarita García Martínez, Comisión Nacional de Áreas Naturales Protegidas

1:40 Approaches to the Planning and Implementation of Large Scale Invasive Alien Plant Control Programs in Southern Africa  
Andrew E.M. Brown, Independent Consultant

2:00 Managing Invasive Weed Species Using Integrated Vegetation Management Principles  
Richard Lee, USDI Bureau of Land Management

2:20 Problems and Management of Invasive Aquatic Weeds in Mexico  
Maricela Martínez, Instituto Mexicano de Tecnología del Agua

2:40 Break

3:00 Understanding resistance to glyphosate inheritance in Amaranthus palmeri: recent advances and remaining conundrums  
Daniela Ribeiro, Mississipi State University

3:20 Slowing the Spread of Invasive Species through Pathway Management: The Don’t Move Firewood Campaign  
Leigh Greenwood, The Nature Conservancy

3:40 Casuarina in the Sian Ka’an Biosphere Reserve  
Yadira Gómez Hernández, Comisión Nacional de Áreas Naturales Protegidas

4:00 Control and Eradication of Giant Reed (Arundo donax) in the Cuatrocienegas Flora and Fauna Protection Area  
Martin Alfonso Carillo Lomas, Comisión Nacional de Áreas Naturales Protegidas

FRIDAY, APRIL 27

Field Trips
1. Sian Ka’an Biosphere Reserve
2. Isla Contoy National Park
La Asociación Norte Americana de Manejo de Malezas: Historia y Futuro

Julie Allen Kraft
Vice President/ Vice presidente
The North American Weed Management Association, nawma -Sublette County Weed and Pest District
PO box 729 Pinedale Wyoming 82941
jewelyjoe@hotmail.com

Other author/ Otro autor:
Jennifer Grenz
North American Weed Management Association
– Invasive Plant Council of Metro Vancouver
jgrenz@ipcmv.ca

Resumen
La Asociación Norte Americana de Manejo de Malezas es un grupo de profesionales en malezas interesados en educación, regulación, desarrollo profesional y concientización ambiental para conservar y proteger nuestros recursos naturales e infraestructura sobre los impactos negativos de malezas invasoras y nocivas. La NAWMA fue fundada por un pequeño grupo de encargados de malezas en el Oeste de Estados Unidos en 1992 y, desde entonces los comités de la organización han ayudado a coordinar estándares para mapeos, establecer lineamientos para forrajes libres de malezas y promover programas de detección temprana y respuesta rápida. La NAWMA enfrenta el desafío del futuro al completar un nuevo plan estratégico que ayudará a colocar a la organización a la vanguardia en cuestiones de manejo de malezas, al tiempo que proporciona coordinación, apoyo y educación para sus miembros actuales. Su objetivo es volverse una asociación verdaderamente norteamericana al atraer nuevos miembros de México, Canadá y el del Este de Estados Unidos.

Abstract
The North American Weed Management Association (NAWMA) is a group of professional weed managers who are interested in education, regulatory direction, professional development and environmental awareness to preserve and protect our natural resources and infrastructure from the degrading impacts of invasive and noxious weeds. NAWMA was founded by a small group of western weed managers in 1992 and since that time, committees from the organization have helped to coordinate mapping standards, set guidelines for weed free forage and promote early detection, rapid response programs. NAWMA is meeting the challenge or the future by completing a new strategic plan which will help to position the organization to stay on the cutting edge of weed management issues and provide coordination, support and education for its current members and to truly make it North American by attracting new members from Mexico, Canada and the eastern United States. Cooperation and coordination helps everyone be better weed managers!
Presentation Summary
The North American Weed Management Association was established in 1992 by a group of western weed managers. The group is formed of professional weed managers who are interested in education, regulatory direction, professional development and environmental awareness to preserve and protect our natural resources and infrastructure from the degrading impacts of invasive and noxious weeds. This association has grown but membership is still primarily in the west. In the twenty years since its inception NAWMA has provided great education, networking and standards for its members. However, the group of individuals that started NAWMA are now beginning to retire and we are not gaining new memberships.

Some say that NAWMA has become stagnant. The initial rush to get programs started, and standards set has slowed and members are not attending the annual conference. This decline has happened over the last few years. The 2012 board of directors are very concerned and have taken steps to revive NAWMA. While being respectful of the past but looking toward the future we have developed a New Name and New Direction.

In Early 2012 the board had a strategic planning session. We discussed the pros and cons of NAWMA and the direction that is needs to take in the future. The board agreed that NAWMA is great at networking amongst members and the weed free forage and mapping standards committees have great programs. We however, recognized that we are losing members because of retirements and new weed managers are not becoming members of the organization. The board had a long discussion about our bylaws, and have made several amendments to update and modernize them. Those amendments will be proposed to the membership at the annual meeting this fall. The Board is proposing a new name to the membership at our annual conference: The North American Invasive Species Management Association. The reason for the name change is to not exclude any invasive species manager or funding opportunity from joining our group. Many managers are responsible for multiple species and this just expands or networking and professional education opportunities to a multi-species field. However, the Board still understands that the focus of our group and been and will remain terrestrial plants.

With these changes the Board hopes to keep the Association on the cutting edge and provide education and networking for its members across North America.

www.nawma.org

North American Plant Protection Organization (NAPPO)
Organización Norteamericana de Protección a las Plantas (NAPPO)

Norma Alejandra Elizalde Jiménez
Sub-director of International Harmonization and Evaluation / Subdirectora de Armonización y Evaluación Internacional
General Division of Plant Health, Division of Phytosanitary Regulation, SENASICA / Dirección General de Sanidad Vegetal, Dirección de Regulación Fitosanitaria, SENASICA
Guillermo Pérez Valenzuela 127, México DF
alejandra.elizalde@senasica.gob.mx

Resumen
La Organización Norteamericana de Protección a las Plantas (NAPPO) es una Organización Regional la Protección de las Plantas creada bajo la autoridad del Artículo VIII de la Convención Internacional de Protección a las Plantas (IPPC) de la Organización de las Naciones Unidas para la Agricultura y la Alimentación (FAO), cuya Convención entró en vigor el 3 de abril de 1952, y fue enmendada posteriormente. NAPPO funciona en base a un Acuerdo Cooperativo suplementario al Acuerdo de Protección de las Plantas firmado por representantes de Canadá, los Estados Unidos de América, y México el 13 de octubre de 1976, con el fin de impulsar la cooperación en el campo de la protección de las plantas. En consecuencia, NAPPO es responde ante los Secretarios de Agricultura en los países miembros NAPPO.
El objetivo de esta presentación es proporcionar una introducción acerca de la NAPPO y abarca los siguientes puntos:
Quién somos y como somos organizados, con quién colaboramos, quién puede participar, qué hacemos, y por qué los estándares fitosanitarios son importantes.

**Abstract**

The North American Plant Protection Organization (NAPPO) is a Regional Plant Protection Organization created under the authority of Article VIII of the International Plant Protection Convention (IPPC) of the Food and Agriculture Organization (FAO) of the United Nations, whose Convention came into force on April 3 1952, and as subsequently amended. NAPPO operates according to a Cooperative Agreement supplementary to the Plant Protection Agreement signed by representatives of Canada, the United States of America, and Mexico on October 13, 1976 in order to encourage cooperation in the field of plant protection. Accordingly, NAPPO is accountable to the Minister/Secretary of Agriculture in NAPPO member countries.

The purpose of this presentation is to provide an introduction to what NAPPO is all about. It addresses: Who we are and how we are organized, who we collaborate with, who can participate, what we do, and why phytosanitary standards are important.

---

**Strategy for the conservation of an area of binational interest Big-Bend Río Bravo**

Estrategia para la conservación del área de interés binacional Big Bend – Río Bravo

Carlos Alberto Sifuentes Lugo

Director of Flora and Fauna Protection Area Maderas del Carmen / Director de a.P.F.F. Maderas del Carmen

CONANP- CEC/CCA

Bvd. Melchor Muzquiz Km. 2 Muzquiz, Coahuila 26340 México

cinthia_hdz2@hotmail.com

**Resumen**

La iniciativa de contar con un área de interés binacional para la conservación de los recursos naturales entre México y Estados Unidos, se remonta a la década de los 30’s, entre los presidentes Roosevelt y Ávila Camacho. Posteriormente ocurren diversas iniciativas impulsadas por los gobiernos de los estados de Coahuila y Chihuahua, pero no es sino hasta el año 2004 cuando se declaran las Áreas de Protección de Flora y Fauna Maderas del Carmen en Coahuila y Cañón de Santa Elena en Chihuahua, que se comienzan acciones coordinadas de conservación junto con el Parque Nacional Big Bend, mediante un memorandum de entendimiento firmado entre el Departamento del Interior de Estados Unidos y la Secretaría de Medio Ambiente Recursos Naturales y Pesca de México. En el año 2011 se reafirma la intención de colaboración mutua bajo un esquema denominado “Área de Interés Binacional para la Conservación Big Bend – Río Bravo”, en el que se adicionan dos Áreas Protegidas más a este complejo de cerca de 3 millones de hectáreas bajo un esquema binacional. Aquí se desarrollan mecanismos de colaboración conjunta y un cruce fronterizo que permita el desarrollo de actividades como recorridos de vigilancia por el Río Bravo, el desarrollo de planes para la atención de contingencias, monitoreo biológico e investigación y la restauración de zonas de interés como la erradicación de especies exóticas – invasoras en el corredor del Río Bravo.

La Comisión para la Cooperación Ambiental de Norteamérica ha decidido sumarse a los esfuerzos de esa iniciativa y se ha construido una estrategia para la conservación de los valores biológicos, escénicos y culturales de esta zona fronteriza, tomando como principal recurso el Río Bravo, en el que se llevan a cabo acciones bajo cuatro estrategias principales: difusión de información dirigida a propietarios, pobladores y público en general; capacitación y monitoreo de los principales factores geomorfológicos y ecológicos; restauración y manejo de áreas riparias; y la de Desarrollo comunitario y construcción de capacidades recreativas entre las comunidades rurales asentadas en las márgenes del Río Bravo.

**Abstract**

The initiative to have an area of bi-national interest for the conservation of the natural resources between Mexico and the United States goes back to the decade
of 30's, between the presidents Roosevelt and Avila Camacho. Afterwards diverse initiatives were initiated by the governments of the states of Coahuila and Chihuahua; but in was not until 2004, when the protection Areas of Flora and Fauna Maderas del Carmen in Coahuila and Cannon of Saint Helena in Chihuahua were declared, that coordinated actions of joint conservation began with the Big Bend National Park. These actions were based on a memorandum of understanding signed between the Department of the Interior of the United States and the Secretariat of Environment Natural resources and Fishing of Mexico. In the year 2011 the intention of mutual collaboration is reaffirmed under a so called “Area of Bi-national Interest for the Conservation Big Bend – Rio Bravo” scheme. Under this bi-national scheme two more protected areas were added to this complex of nearly 3 million hectares. Mechanisms of joint collaboration are developed and a frontier crossing is established to allow the improvement of activities such as surveillance for the Rio Bravo, the development of contingency plans, biological monitoring and research and the restoration of areas of interest as well as the eradication of exotic species, that are invading the Rio Bravo Corridor.

The Commission for the Environmental Cooperation of North America has decided to join the efforts of this initiative and a strategy for the conservation of the biological, scenic and cultural values of this frontier area was developed, taking as a main resource the Rio Bravo, in which actions are carried out under four main strategies: outreach efforts directed to owners, settlers and the general public; training and monitoring of the main geomorphologic and ecological factors; restoration and management of riparian areas; and Community development and construction of recreational capacities among the rural communities located in the margins of the Rio Bravo.

**North American Invasive Species Network (NAISN)**

*Red Norteamericana de Especies Invasoras (NAISN)*

Pedro M. Antunes  
*Associate professor and OMNR Research President / Profesor asociado y OMNR Presidente de Investigación*  
Department of Biology, Algoma University / Departamento de Biología, Universidad de Algoma  
1520 Queen St. E Sault Ste. Marie, ON P6A 2G4 Canada  
pantunes@gmail.com

Other authors / Otros autores:  
Isabel González Martínez  
Invasive Species program subcoordinator / Sub-coordinadora del Programa de Especies Invasoras CONABIO

Alycia W. Crall  
Postdoctoral fellow / Socio Postdoctoral  
Colorado State University / Universidad Estatal de Colorado

NAISN Board of Directors

**Resumen**

A lo largo del tiempo, se han establecido en Norteamérica varios centros de especies invasoras, institutos, laboratorios, y redes para ayudar a cumplir las necesidades de conservación de territorios federales de los manejadores de recursos acuáticos. Dos talleres se llevaron a cabo en 2010 (marzo y noviembre) para determinar cómo integrar estos centros, institutos, laboratorios, y redes en una Red Norteamericana de Especies Invasoras. Los científicos, tomadores de decisiones, encargados del manejo de recursos naturales, organizaciones no gubernamentales, educadores, y especialistas de información de Canadá, México, y los Estados Unidos asistieron a estos talleres junto con los directores o representantes de centros de especies invasoras, institutos, laboratorios, redes y otros. A consecuencia del taller de noviembre de 2010, siete centros de especies invasoras, institutos, y una red regional han acordado formar parte de la Red Norteamericana de Especies Invasoras (NAISN) como un centro o como un nodo. NAISN es una organización sin fin de lucro que une y conecta estos esfuerzos de especies invasoras existentes en una sola red, re-
sultando en una mejor comunicación, coordinación, colaboración, y cooperación en relación con los aspectos multi-jurisdiccionales de invasiones biológicas en Norteamérica. NAiSN sostendrá su tercer taller junto con la Conferencia “Malezas sin Fronteras de 2012” en Cancún, México en abril, organizado por CONABIO.

Abstract
A number of invasive species centers, institutes, labs, and networks have been established in North America over the years to help meet the needs of public conservation land and waterway resource managers. Two workshops were held in 2010 (March and November) to determine how to integrate these centers, institutes, labs, and networks into a North American Invasive Species Network. Scientists, policy makers, resource managers, NGO’s, educators, and information specialists from Canada, Mexico, and the U.S. attended these workshops along with the directors or representatives from invasive species centers, institutes, labs, networks and others. As a result of the November 2010 workshop, seven invasive species centers, institutes, and one regional network have agreed to become part of the North American Invasive Species Network (NAiSN) either as a hub or a node. NAiSN is a non-profit organization that unifies and connects these existing invasive species efforts into a single network resulting in better communications, coordination, collaboration, and cooperation in dealing with the multi-jurisdictional aspects of biological invasions in North America. NAiSN will hold its third workshop in conjunction with the 2012 Weeds Across Borders Conference in Cancun, Mexico in April, with the CONABIO hub hosting the event.
Import of Allochthonous Banyans (Moraceae Ficus) in North America and Simultaneous Entry of Ramphotyphlops braminus (Reptilia: Typhlopidae) through a Shared Entry Route

Christian Amador da Silva
Researcher-field explorer / Investigador-Explorador de campo
Prospección de Campo A.C
Ostia 2943 int.7 Col. Providencia cp. 44630 Guadalajara, Jalisco
amdach_2005@hotmail.com

Resumen
El comercio de plantas exóticas permite adquirir ejemplares vivos de zonas geográficamente distantes, para diferentes intereses sociales: decoración de jardines, colecciones botánicas o de uso ambiental. Contrariamente esta actividad puede causar afectaciones ecológicas y económicas locales por organismos que acompañan a las plantas exóticas. El género Ficus de la familia Morácea con 800 especies en las regiones tropicales y subtropicales del mundo son de interés comercial principalmente las especies asiáticas. El primer ejemplar asiático importado a México Ficus carica en el siglo xvi por clérigos españoles, las primeras décadas del siglo xx se importa en gran número Ficus microcarpa y Ficus benjamina para uso ornamental en áreas verdes de las ciudades en crecimiento. En la actualidad son arboles catalogados como invasores (Hawaii, Florida) o exóticos por su rápida dispersión: aves, murciélagos y avispas dispersan sus semillas así por reforestaciones mal planeadas. Ramphotyphlops braminus es un micro ofidio originario de India, hábitos subterráneos, partenogenético que depreda larvas de hormigas y termitas. El comercio de plantas distribuye al reptil accidentalmente por varios continentes, puede cubrir su ciclo biológico dentro de una maceta. El presente trabajo propone la ruta de introducción para banianos comerciales y el Typhlopido a Norteamérica, es una teoría basada en eventos históricos, origen geográfico compartido y los primeros reportes de Ramphotyphlops braminus donde anteriormente se importo F. microcarpa o F. benjamina como en California, Arizona, Hawaii y Florida en Estados Unidos. Baja california sur, Jalisco, Morelos y Quintana Roo en México. Se pone en duda el posible ingreso de la serpiente por el comercio a través de la nao de China entre las Filipinas y la nueva España (México) en los siglos XVI y XVIII y se propone el ingreso por el comercio e importación de Ficus a comienzos del siglo XX ante la demanda de estas especies con fines estéticos o donde otras especies no prosperan.

Abstract
The trade of exotic plants allows acquiring living specimen of geographically distant areas, for different social interests: decoration of gardens, botanical collections or environmental use. This activity can have local ecological and economic effects due to organisms introduced together with the exotic plants. The Asian species of the genre Ficus of the Moraceae family with 800 species in the tropical and subtropical regions of the world are mostly of commercial interest. The first Asian specimen imported into Mexico during the 16th century by Spanish clergymen was Ficus carica, during the first decades of the 20th century Ficus microcarpa and Ficus benjamina were imported in large numbers for ornamental use in green areas of growing cities. Currently these are trees catalogued as invasive (Hawaii, Florida) or exotic due to their rapid dispersion: birds, bats and wasps disperse its seeds because of badly planned reforestations. Ramphotyphlops braminus is a small blind parthenogenetic snake species from India that lives underground, and preys
on larvae of ants and termites. The trade of plants disperses the reptile incidentally to several continents, as the species can complete its biological cycle inside a flowerpot. The work presented here work proposes the pathway for introduction for commercial banana plants and the Typhloid to North America. This theory is based on historical events, shared geographical origin and the first reports of Ramphotyphlops braminus where F. microcarpa or F. benjamina were previously imported as in California, Arizona, Hawaii and Florida in the United States and Southern Baja California, Jalisco, Morelos and Quintana Roo in Mexico. We question the theory of the possible introduction of the snake through trade in vessels of China between the Philippines and Mexico during the 16th and 18th centuries and propose that its introduction was due to the trade and import of Ficus at the beginning of the 20th century given the demand of these species for ornamental purposes in places where other species do not prosper.

**Presentation Summary**

The exotic plant trade allows the acquisition of live individuals from geographically distant areas for different social interests: garden decoration, botanical or environmental collections. The interest to obtain exotic plants is several centuries old, especially during the discoveries of new continents by Europeans in several continents and islands and upon a growing biological science: botany. Sending live or prepared specimens to museums, gardens, private collections and universities was and is a common practice which can have ecological and economica affectations due to organisms of several phylum that accompany exotic plants. The genus Ficus of the Moracea family with approximately 800 species in tropical and subtropical regions of the world are of commercial interest, mostly Asian species for example: Ficus elastica (rubber fig) which was commercially introduced to Europe in 1815 as an ornamental plant. The first allochtonous banyan of Asian origin in northamerica: Ficus carica entered Mexico in the 16th century by Spanish clergymen for consumption of its false fruit (infrutescence) together with other successful species in the Mediterranean: Olive, Vid and almond. In the first decades of the 20th century urban growth would include green areas of several dimensions and thus begins the import of Ficus microcarpa and Ficus benjamina for aesthetic purposes as well as its rapid growth and adaptation to several soils; by 1912 F. microcarpa was already found in the state of Florida due to its popularity as a street tree and the geometric, zoomorphic and anthropomorphic figures that could be created through pruning. F. microcarpa can reach 15 meters in 20 years offering shade and in cities found in deserts where no trees are found or trees are short, using the adaptation advantage of several types of soils and climates adding them to the urban image in Phoenix Arizona, Hermosillo Sonora or in Los Cabos Baja California Sur. Ficus sp. is dispersed with the help of birds, bats and wasps (Agaonidae parapristina) that feed of the inflorescences and their seeds fall in structures where they grow rapidly, rocks, dead tree trunks, walls, roofs and palms or other trees where they begin an early epiphyte growth that ends in dendrocide action on its host by wrapping it with aerial roots that form new supporting structures in the growth of the banyan and its branches are posed on those of their supporting palm or tree or other species next to Ficus sp. in the race to reach sunlight. By being present since decades ago in cities and greenhouses of northamerica it is wrongly seen as a native species planted with ecological or aesthetic purposes (these are ever green trees and of rapid recovery to pruning) propagating more of these species and leaving native vegetation in a second plane or in the worst of cases permanently eradicating it by not controlling its number and growth its roots lift the pavement, break pipelines and block underground cables. The branches can cause problems to the aerial electrical or telecommunication cables especially during storms. It is generally catalogues as an exotic species at a continental level but in the usa it is considered an invasive species in Hawaii and Florida; these species can´t reach further north than the usa and Canada because of their natural dispersion. Its tropical origin stops it from moving into places where winters are characterized by the presence of snow and ice, only under artificially controlled environments and in the presence of bonsai will these Banyans be observed in cold climates of the continent. Currently the number of individuals of E. microcarpa and F. benjamina in urban and suburban environments is unknown, this includes the juvenile or bonsai individuals commercialized in Mexico and the US. Ramphotyphlops braminus (Daudin, 1803) is a snake native of the southeast of Asia. Daudin and other zoologists describe it in the herpetofauna of India, it is a parthenogenetic micro vertebrate of underground habits that feeds mostly off the larvae of ants and termites in different stages, has atrophiated
eyes that allow it to distinguish only light and darkness and it can be confused with an earthworm (*Annelida*) because of its size and because it is in gardens under flower pots. Only at night has it been seen on the surface, or during constant rain. The commercialization of exotic plants is the main distribution route of this species at a global level and it is catalogued as exotic since it doesn’t compete with native species for food. It is unknown if it is a vector for pathogens that place other species in risk. Since it is parthenogenetic it can start permanent populations in different ecosystems. Its introduction into the USA began at the start of the 20th century when plants were sent from Hawaii to Florida and later it would also be reported for California, Arizona, Texas and Alabama. It was probably introduced into Mexico 60 years ago, the states where it has been reported are Baja California sur, Durango, Guerrero, Jalisco, Michoacán, Morelos, Nuevo león, Oaxaca, Puebla, Querétaro, Sinaloa, Veracruz, Hidalgo, Puebla, Estado de México and Quintana Roo.

In spite of the fact that the previously mentioned Ficus species and Ramphotyphlops braminus are found in the southeast of Asia, the point of origin for the export of thousands of individuals of banyans is India and among the roots, the snake. It is true that these trees not only were imported from India but due to the amount commercialized and their frequent presence in urban vegetation this is the most likely pathway of accidental introduction.

Weeds in the Rio Grande and Colorado River Basins
Malezas en las Cuencas de los Ríos Bravo y Colorado

David Negrete
International Boundary and Water Commission / Comisión Internacional de Límites y Aguas (CILA)
15 de Junio Int. Puente Internacional I Nuevo Laredo, Tamaulipas
dnegrete@cila.gob.mx

Resumen

Se presenta un diagnóstico técnico y alternativas de control de especies acuáticas invasoras en los ríos Bravo y Colorado en la frontera México-Estados Unidos.

*Salvinia molesta*: se encontró en Mexicali en 1977 y en el río Colorado en el 2001. Se contrató a una empresa para realizar el diagnóstico de la situación y establecer líneas de acción. Los métodos de control son mecánicos, químicos y biológicos dependiendo del área afectada.

La especie *Dreissena rostriformis bugensis* se reportó en el Valle de Mexicali en el 2008, las acciones que se llevan a cabo para evitar su dispersión son: localizar a los adultos y su fuente, removerlos antes del mes de mayo para evitar su reproducción, pintar instalaciones con pintura antiaherente, colocar placas de fijación y monitoreo periódico.

*Hydrilla verticilata* se ha controlado biológicamente usando carpas esteriles de la especie *Ctenopharyngodon idella* lo cual ha dado buenos resultados en California. También se pueden usar químicos para lo cual se requiere coordinación internacional ya que la fuente de infestación estaba en California y se debe tratar la fuente también.

En cuanto al control de *Tamarix*, en 2007 las autoridades estadounidenses liberaron al escarabajo *Diorhabda* sp. en sitios ubicados en el lado estadounidense del Río Bravo y en 2009 se reportó que había cruzado hacia territorio mexicano causando problemas con las comunidades mexicanas quienes ven al pino salado como una especie que beneficia a la región. Se propone que debe informarse a la población, valorar los daños y establecer planes de monitoreo, reforestación, contingencias y un convenio internacional de responsabilidad por daños.

*Arundo donax*: en 2008 el gobierno estadounidense propuso un proyecto piloto para eliminar esta especie usando corte manual con aplicación de herbicidas, remoción mecánica y aspersión aérea de herbicidas, sin embargo la sección mexicana objetó el uso de herbicidas en sitios cercanos al Río Bravo por lo que se acordó eliminar la aspersión aérea sustituyéndolo por aplicación tópica de herbicidas.
Abstract
This presentation covers the technical diagnosis and control alternatives of invasive aquatic species in the Bravo (Grande) and Colorado rivers in the Mexico-US border.

Salvinia molesta: was found in Mexicali in 1977 and in the Colorado river in 2001. An external company was hired to perform the diagnosis of the situation and establish baseline actions. The control methods used are mechanical, chemical, and biological, depending on the affected area.

Dreissena rostriformis bugensis was reported in the Mexicali Valley in 2008, the following activities have been carried out to prevent dispersal: localization of adults and their source, removal to prevent their reproduction, painting installations with anti-stick paint, placing attachment plates, and monitoring.

Hydrilla verticilata has been biologically controlled using sterile carps of the species Ctenopharyngodon idella, this has yielded good results in California.

Resumen
En 2010 la Provincia de Alberta revisó su Regulación de Control de Malezas, que por su parte requirió la revisión de su lista de malezas reguladas. Alberta tomó esta oportunidad de desarrollar un proceso consistente y los criterios para clasificar especies de malezas en las categorías de “nocivo” y “nocivos prohibidos” según La Regulación I (Act I). Examinaré nuestras experiencias con este proceso, y hablaré de algunas cuestiones que surgieron que pueden ser de interés para otras instituciones que quieren actualizar sus listas de malezas. Las características principales de este enfoque incluyen un juego explícito de criterios para asignar especies a categorías reguladas; mayor atención a malezas de ambientes no agrícolas; la remoción de todas las especies nativas de categorías reguladas; y un proceso para revisión continua y revisión de las listas. Las dudas que surgieron durante el proceso incluyeron especies que son consideradas tanto como invasoras como benéficas en diferentes ambientes o regiones; complejidades taxonómicas y de nomenclatura; una carencia de la información sobre distribución de especies e impactos; la carencia de jurisdicción legal sobre especies acuáticas; la necesidad de educación y formación de los involucrados para dar cumplimiento a la legislación establecida; y el conflicto potencial entre el control biológico y el estatus nocivo y por lo tanto prohibido. Ilustraré estas cuestiones usando varias especies que se analizaron para incluirse en la lista de acuerdo a lo establecido en la legislación.
Abstract
In 2010 the Province of Alberta revised its Weed Control Act, which in turn required the revision of its list of regulated weeds. Alberta took this opportunity to develop a consistent process and criteria for assigning weed species to the “noxious” and “prohibited noxious” categories under Act. I will review experiences with this process, and discuss some issues that arose that may be of interest to other jurisdictions seeking to update their weed lists. The major features of this approach include an explicit set of criteria for assigning species to regulated categories; increased attention to weeds of non-agricultural environments; the removal of all native species from regulated categories; and a process for ongoing review and revision of the lists. Issues that emerged during the process included species that are seen as both invasive and beneficial in different environments or regions; taxonomic and nomenclatural complexities; a lack of information on species distribution and impacts; the lack of legal jurisdiction over aquatic species; the need for education and training of those involved in enforcing the Act; and potential conflicts between biological control and prohibited noxious status. I will illustrate these issues using a number of species that were considered for listing under the Act.

Presentation Summary
Weed legislation in Canada has a long history, dating back at least to the passage of the Canada Thistle Act of 1865 in Upper Canada (now the province of Ontario) (Evans, 2002). As European settlement brought agriculture to the prairies of western Canada, weed problems quickly followed, and the newly formed prairie provinces soon brought in legislation to attempt to enforce weed control practices. The province of Alberta, established in 1905, passed its first Noxious Weeds Act in 1907, setting out a list of weeds (Table 1) which owners and occupiers of land were required to destroy. The Act gave the province the power to appoint weed inspectors with power to enter land, inspect for weeds, and order them to be destroyed (including the ploughing under of crops). Penalties were prescribed for failure to comply with such orders. It is interesting, although somewhat discouraging, to note that only one species on this first noxious weeds list, Canada thistle (listed as Cnicus arvensis), is still a listed weed in Alberta, and that many of the other species are now so widespread that it is considered futile to regulate them.

Weed control legislation has been updated periodically over the last century in Alberta, the most recent version being the Weed Control Act of 2010 (Province of Alberta, 2010a). In recent Alberta legislation, the list of regulated weed species does not form part of the Act itself, but is established in a Weed Control Regulation made under the authority of the Act (Province of Alberta, 2010b). This allows the list to be modified and updated more readily than would be the case if the legislation itself had to be amended.

As the 2010 Weed Control Act was passed as a new piece of legislation, previous Weed Control Acts and their associated regulations were repealed, and new regulations to implement the Act had to be drafted. The Province of Alberta took this opportunity to update the process for listing weeds and the criteria by which plant species were assigned to the regulated categories. In this paper I will review the process and approach that were used in developing the new list, and discuss some issues that were encountered along the way.

The Weed Control Act
Although the 2010 Act was extensively rewritten from previous versions, the broad outlines of the law have remained similar over the last several decades. The Act is administered by the provincial Department of Agriculture and Rural Development. Briefly, it empowers the Minister of Agriculture to declare plant species to be “noxious weeds” or “prohibited noxious weeds”. The Act prohibits doing anything which would cause the spread of noxious or prohibited noxious weeds or their seeds. It also empowers the Minister to make rules governing the licensing of seed-cleaning plants. In addition to provincial declarations, the Regulation gives municipalities the power to make by-laws listing weeds as “noxious” or “prohibited noxious” within their jurisdictions; such declarations require the Minister’s assent and can only be used to promote species to a more serious category, not to reduce them.

Enforcement of the Act is the responsibility of weed inspectors, who are generally appointed and employed by municipalities, although the Minister may also appoint inspectors directly. Weed inspectors have broad powers to enter land and inspect personal property (such as vehicles) at any reasonable time, and it is an offence under the Act to obstruct or delay an inspector carrying out these duties. If an inspector
finds non-compliance with the Act, such as noxious weeds that have not been controlled, he or she can issue a notice requiring compliance. This can include controlling weeds, destroying crops, and limiting the use of the land in the following season. An appeal procedure is provided. If the owner or occupier does not take action as required by the notice, the inspector is empowered to take any necessary action to bring about compliance. This could include carrying out spraying or other weed control operations. The cost of these actions can be recovered from the owner or occupier, through property tax bills or as a debt to the municipality that can be enforced in court.

**Regulated weed lists in Alberta**

Under the previous Act there were three categories of regulated weeds in Alberta: “restricted”, “noxious”, and “nuisance”. In the 2010 Act, the “prohibited noxious” category is equivalent to the old “restricted”; and the “nuisance” category has been removed. Owners and occupiers of land are required to “control” noxious weeds (defined as “to inhibit [their] growth or spread”) and to “destroy” prohibited noxious weeds (defined as “to kill all growing parts, or render reproductive mechanisms non-viable”). Under previous legislation, owners and occupiers were required to prevent the spread of seed of nuisance weeds, but inspectors had no powers to enforce this requirement.

**Principles for listing weeds**

In preparation for the passage of the new Act, it was decided to adopt a more systematic and transparent approach to the listing of plant species under the Act, and to review the criteria by which species were selected for listing. The Act itself provides no guidance or criteria for listing plant species as “noxious” or “prohibited noxious”. Previously, species had been listed by an internal decision-making process that was not well documented or recorded, and the lists remained fairly static over time. It was necessary to update the lists to reflect the changing status and knowledge of weed problems in Alberta and beyond, and the broadening concern over invasive plants as a concern in non-agricultural areas.

With this in mind, a committee was formed in 2009 which became known as the Alberta Weed Regulatory Advisory Committee (AWRAC), with the task of advising the Minister on the listing of weeds and other issues related to weed regulation in Alberta. The committee includes representatives from urban and rural municipalities, the Alberta Invasive Plant Council (AIPC), Alberta Native Plant Council (ANPC), academia, industry, non-government organizations, the general public and both federal and provincial governments, all with a wide range of experience in studying and managing weeds and invasive plants in Alberta. The committee has two co-chairs: one appointed by the Department of Agriculture and Rural Development, and one appointed by the remainder of the Committee.

The committee agreed on several principles:
- The Weed Control Act and Regulation can best protect Alberta’s overall, long term interests by preventing the spread of unwelcome plants into unaffected areas.
- The Act should encourage and oblige landowners and managers to cooperate in prevention, containment and control.
- Protecting agricultural production is not the only reason for regulating problem plants. The Act must also protect natural areas and systems, non-agricultural industries, aesthetic values and public safety.
- The criteria for selecting regulated plants should be applied systematically and consistently to all non-native plants that are present in Alberta or that have the potential to spread into Alberta.

The Committee oversaw the development of the initial list of weeds incorporated in the Weed Control Regulation that was proclaimed simultaneously with the new Act (Province of Alberta, 2010b). It has since been approved as a continuing committee, with the role of keeping the Regulation under continual review and recommending further changes as needed. It has developed written protocols and procedures for reviewing species and for considering outside submissions.

The process of developing the new list flowed from several decisions. The basic philosophy is that there must be a public policy justification for listing a given species as noxious or prohibited noxious. This justification is not necessarily based simply on the severity of the losses or impacts due to a particular weed species, but on whether there is a public interest in compelling landowners to take control actions against it. In general the primary responsibility for controlling weeds rests with the landowner or occupier, and
in many situations owners or occupiers will control weeds because it is in their own interests to do so, for instance to improve crop yields and economic returns. However these market-based incentives for weed control do not always work. Such market failures occur when weed infestations spill over onto adjacent properties, when they threaten to cause widespread public harm, or when it is not economically feasible for the private sector to manage them (see discussion in Victoria Department of Primary Industries 2010).

Based on these principles, we developed criteria for assigning plant species to the “noxious” and “prohibited noxious” categories. Prohibited noxious weeds are species that do not currently occur in Alberta, or occur with very limited and local distribution, so that eradication is a realistic goal. These species have a significant risk of entry and establishment, and present significant economic, ecological, or social risks if allowed to establish and spread in the province. Prohibited noxious status supports the “prevention” and “early detection, rapid response” phases of invasive plant management (Wittenberg and Cock, 2001).

Noxious weeds are species that are sufficiently well established in Alberta that province-wide eradication is not a feasible goal. They can spread locally from existing infestations, and can cause economic problems or environmental impact on private or public land. The goal of listing species as noxious is to protect responsible owners and occupiers, and the public at large, from the further spread of established weed infestations. This status supports the “containment” phase of invasive plant management.

Two categories of plants were excluded from listing in either category under the Act. It was decided not to list any native species. This does not imply that native species cannot cause problems to farmers or other land users, but it is assumed that native species have in general already reached their full potential distribution in the province. Thus there is no scope to prevent further spread, and no public interest to be served by compelling landowners to control them. Introduced species were also excluded from listing if they were considered so common and widespread in the province that they already occur in virtually all suitable habitats: this is particularly applicable to species that occur primarily in disturbed or cultivated habitats. This category includes some agriculturally significant weeds, such as wild oats (Avena fatua L.) and false cleavers (Galium spurium L.). Thus, the list of weeds under the Regulation cannot be interpreted simply as a list of the “worst” weeds in the province.

Previous noxious weed lists in Alberta had been focused primarily on species of economic importance to agriculture. The new list is also intended to regulate species that are invasive in natural ecosystems and other non-agricultural habitats.

Weed listing process

The list was developed using a “blank slate” approach, rather than as an updating of the previous list. It was necessary, however, to limit the species considered for listing to those most likely to occur or be introduced into Alberta. An initial list of species for review was therefore developed by searching the USDA PLANTS database (usda-plants, 2012) for all introduced species occurring in Alberta and the neighbouring jurisdictions: British Columbia, Saskatchewan, Manitoba, Northwest Territories, and Montana (although not a neighbouring jurisdiction, Manitoba was included on the basis of similar habitats and likely movement along transportation corridors). This gave a list of 779 species (ignoring infraspecific taxa). This list was reduced to 387 species by flagging all plants listed as weedy or invasive in the Biology of Canadian Weeds series (Cavers et al., 2003), other provincial noxious weed lists, the ANPC Rogues Gallery (Alberta Native Plant Council, undated), the E-Flora of British Columbia (Perzoff, 2009), Weeds of the West (Whitson, 1991), Weeds of Nebraska and the Great Plains (Stubbendieck et al., 1994), the NatureServe invasive plant listings (NatureServe, 2011), and other literature sources.

This list was still too extensive to allow for a detailed risk assessment on each species. A subcommittee of AWRAC therefore went through the list and eliminated about half the species on the basis that they were either: (a) so common in Alberta that it would be futile to regulate them (b) unlikely to be adapted to Alberta’s climate (e.g. species found only on the west coast in British Columbia) (c) strictly aquatic species (outside the scope of the Act), or (d) species with low ecological or economic impact where they do occur. This resulted in a list of 152 species which were then circulated for review to the full committee. Committee members were asked to assign each species to one of four categories: Prohibited Noxious, Noxious, Do Not Regulate, or Don’t Know.
Species where the poll showed a clear consensus for one of the first three categories were assigned to the appropriate category. Species where there was uncertainty or disagreement were referred to a consultant (the author) for further review. This review was not a full risk assessment (e.g., Pheloung et al., 1999; Dahler et al., 2004), which would not have been feasible in the time available. Instead a brief summary was prepared for each species outlining its biology, distribution, likely impacts, and status in Alberta, with a recommended regulatory category. These were discussed by the committee, who followed these recommendations in some cases and made their own decision in others. Some species for which there was not sufficient information to justify a listing, but which nevertheless were thought to present potential future risks to Alberta, were placed on a watch list for periodic review as new information becomes available.

Since the initial list was promulgated as part of the Weed Control Regulation in 2010, the committee has continued to review further species for potential listing. Some of these are species for which the review could not be completed in time for the first issue of the Regulation, and other are species which raise some more difficult regulatory issues, such as those considered below. The intention is to keep the list under continual review, as invasive plant problems evolve and as new information becomes available. The Committee has also developed a process by which outside individuals or groups can propose species for listing under the Regulation and have these proposals assessed.

The Committee has also developed a more formal protocol for risk assessment of any species to be reviewed for possible listing in the future. This includes nomenclature and classification, current distribution in Alberta and elsewhere, regulatory status in North America and worldwide, ecology (life cycle, environmental tolerances, herbivory, symbiotic/parasitic relationships, distribution vectors), economic/social risks and benefits, ecological risks and benefits, risk mitigation, availability of control options (herbicides, biological control, other options), accessibility and ease of detection, acceptance and social perception.

**The lists**

Between 1980 and 2009 Alberta’s regulated weed list underwent relatively minor changes (Table 1); during this period two new species were listed as “restricted”, six new species were listed as “noxious”, one was promoted from “nuisance” to “noxious”, and one new species was listed as “nuisance”. The changes with the introduction of the new Act in 2010 were much more extensive (Table 1). The previous “nuisance” category was abolished, but two species on the old “nuisance” list were promoted to “noxious”, along with nine newly listed species. All species on the previous “restricted” list were classified as “prohibited noxious”, along with one species promoted from the previous “noxious” list and 36 newly listed species. The 2010 list contains 46 “prohibited noxious” species and 29 “noxious” species.

**Issues encountered**

**Regional variation in invasiveness**

To date, all listings of species under the Weed Control Regulation are effective Alberta-wide. However, not all species that could potentially be listed are equally invasive in all regions and environments across the province. An example is Russian olive, Elaeagnus angustifolia L.. This nitrogen-fixing shrub or small tree is a major invader of riparian habitats across the western USA (Katz and Shafroth, 2003; Friedman et al., 2005), and has been moving northwards in Montana, displacing native cottonwoods (Populus deltoides Marsh) (Pearce and Smith, 2001; Pearce and Smith, 2003). It is widely grown as an ornamental and shelterbelt tree throughout Alberta, and in recent years it has frequently been found naturalizing in southeastern Alberta (Medicine Hat area). In other areas of the province it has shown no tendency to naturalize. Listing of Russian olive as “noxious” would provide a tool to enforce control and protect riparian plant communities in southeastern Alberta, but would limit the use of a valuable and apparently harmless species elsewhere in the province. The Act, in section 30(a), does permit the Minister to designate a plant as a noxious weed or prohibited noxious weed “generally or in respect of any part of Alberta”. However, the power to make declarations applying only to a part of the province has not so far been used. An alternative possibility could be for municipalities in areas where Russian olive is a problem to elevate it locally to noxious status. A decision on the regulatory status of Russian olive has not yet been made.

**Invasive agronomic and horticultural species**

A number of species used or promoted as agronomic or horticultural species show invasive behaviour in
Alberta. Caraway (Carum carvi L.), is grown as a spice crop, with over 7,500 hectares seeded in western Canada in 2006 (Alberta Agriculture and Rural Development, 2008), but is now widespread as an invader in pastures and forested areas in western Alberta, and has been locally declared as a noxious weed by two municipalities. Sea buckthorn (Hippophae rhamnoides L.) is recommended in Alberta and other prairie provinces as a shelterbelt species and as a fruit crop with health benefits (Agriculture and Agri-Food Canada, 2008). It has been observed spreading from plantings in the City of Calgary and elsewhere (Alberta Native Plant Council, undated), and was ranked 15th in a prioritized list of invasive alien plants of natural habitats in Canada (Catling and Mitrow, 2005). Cicer milkvetch (Astragalus cicer L.) is a legume recommended as a high-quality forage for hay and pasture in western Canada (Acharya et al., 2006), but can be quite invasive in forests and grasslands in Alberta (Alberta Native Plant Council, undated).

Species with both invasive and beneficial aspects present a problem for regulation. In general the economic benefits of these species accrue to private individuals or businesses who grow them, while their impacts when they become invasive, and the costs of managing them, fall on other landowners and governments. The public policy question in regulating such species is how to balance private benefits with public and third-party costs. A decision to list these species as either “noxious” or “prohibited noxious” would effectively make their cultivation illegal under the Act, and would probably be controversial. No decisions have been made yet on how or whether to regulate such species in Alberta.

**Little-known species**

Some species that were reviewed for possible listing had characteristics that suggested they could be problematic invaders, but are not actually known as weeds elsewhere in North America. The clearest example of this was *Thesium arvense* Horv., a perennial root-parasitic herb native to southeastern Europe and Asia (Hendrych, 1968; Xia and Gilbert, 2003), which was found in a provincial park in Calgary in 2001 (Alberta Native Plant Council, undated) and has since spread to “hundreds of sites” within the park. *Thesium arvense* is only recorded from two other sites in North America (in Bozeman, Montana, and in North Dakota), and is not listed as a weed under any legislation in the USA or Canada. The available information on this species is very limited, but other species of *Thesium* are known as weeds in Mediterranean countries, Australia, and South Africa (Musselman, 1980; Anderson et al., 1987; Fer et al., 1993; Simier et al., 1993). *Thesium* species have a broad host-range and can parasitize plants in many different families, including wheat (Hendrych, 1972; Suetsugu et al., 2008; Dostálek and Münzbergová, 2010). I recommended that *T. arvense* should be listed as “prohibited noxious”, on the basis that it has a very limited distribution in Alberta, and that its biology suggested that it could be a threat to crops and native plants if it were to spread further. However, the committee decided not to list it at this time.

**Emerging weeds and unknown distributions**

A serious limitation in the assessment of potential weed species was the lack of detailed, comprehensive information on their distribution and occurrence in Alberta. To date the province has no centralized spatial database of weed or invasive plant distributions, so some assessments had to be based on informal and anecdotal information on distributions, which in some cases turned out to be significantly underestimated. Some species, such as Himalayan balsam (*Impatiens glandulifera* Royle), meadow hawkweed (*Hieracium caespitosum* Dumort.), and common buckthorn (*Rhamnus cathartica* L.) which were listed as “prohibited noxious”, have proven to be more abundant or widely distributed in the province than was realized when they were listed. Others, such as garlic mustard (*Alliaria petiolata* (M. Bieb.) Cavara & Grande) and hoary alyssum (*Berteroa incana* (L.) DC.), were detected for the first time in the province soon after they were listed. In these cases, the listing has probably been beneficial in drawing attention to these species and allowing for a rapid response. However, where species are found to be too widespread for eradication to be realistic, it may be eventually be necessary to move some of these species from the “prohibited noxious” to the “noxious” category.

**Biological control**

Purple loosestrife (*Lythrum salicaria* L.) a significant invasive species in wetlands elsewhere in North America, was listed as “prohibited noxious”. Alberta has very limited occurrence of purple loosestrife, and large areas of wetlands and riparian environments that would be susceptible to invasion by this species, so it fit the criteria for “prohibited noxious” status. The leaf beetles
Galerucella pusilla and Galerucella calmariensis, which have been effective biological control agents elsewhere in Canada (Lindgren et al., 2002), were released on one wetland population of purple loosestrife in central Alberta in 1998. In 2011 it was found that beetle populations are persisting at this site and appear to be exerting quite effective control (A. McClay and C. Saunders, unpublished observations). However, some discussion has arisen about whether biological control is an acceptable tactic for use in control of prohibited noxious species. Under the Act, landowners are required to “destroy” all prohibited noxious weeds, which is considered to imply that the goal is complete eradication. Typically, biological control is not expected to lead to complete eradication, suggesting that it is not a compatible method for prohibited noxious weeds. However, where effective biological control agents are available, it seems prudent to use them at least as a tool to help suppress population growth, making the eventual goal of eradication more feasible.

Ornamentals
A number of newly listed species are widely commercially available as ornamentals, despite the fact that they have shown invasive tendencies elsewhere. These include saltcedar (Tamarix spp.), yellow flag iris (Iris pseudacorus L.), and yellow clematis (Clematis tangutica (Maxim.) Korsh.). Yellow clematis is not widely known as an invasive species in North America, but in Alberta it has been spreading quite rapidly in the Bow Valley corridor, from Wheatland County through Calgary to Canmore. There has been some confusion about the implications of the Weed Control Act for commercial sales of these species, as the Act does not explicitly ban sale of regulated weeds. However it does provide that “a person shall not use or move any thing that, if used or moved, might spread a noxious weed or prohibited noxious weed”, which is broad enough language to implicitly prohibit commercial sale. The Department of Agriculture has been working with the nursery industry to improve awareness of the requirements of the Act, and cooperation has generally been good.

Aquatic weeds
Strictly speaking, the language of the Act does not authorize inspectors to enforce the control of fully aquatic invasive plants. Sections 2 and 3 require that owners and occupiers control or destroy noxious and prohibited noxious weeds, respectively, that are “on land the person owns or occupies”, and the Act defines land as “down to the low water mark of a stream, lake or other body of water”. One submerged aquatic species, Eurasian water milfoil (Myriophyllum spicatum L.), however, was listed as “prohibited noxious” under the Act. There is a gap in legislation in Alberta to regulate aquatic invasive species in general, and discussions are currently under way as to the best way to address this. Another major issue for aquatic species is the limited availability of control tools such as herbicides. It is not very productive to create a legal obligation to control a plant if landowners do not have effective methods of control at their disposition.

Discussion
The principles and criteria we have developed have put the selection of species for inclusion on the provincial weeds list on a more objective and consistent basis. Like any process, this one has had its limitations. With the resources and time available, it was not possible to do a full science-based risk assessment on every species that might have been considered for possible listing under the Act. The consensus process that was used reflects the extensive knowledge and experience of the members of the Committee in a wide range of positions dealing with invasive plants in Alberta. However, it also meant that there was a certain influence of tradition when dealing with species that have long been on the regulated list for the province. It could be argued, for instance, that Canada thistle (Cirsium arvense) is by now so widespread in Alberta that it already occupies virtually all suitable habitats, and that there was thus no public policy purpose to be served by listing it as “noxious”. Likewise, diffuse and spotted knapweed (Centaurea diffusa Lam. and Centaurea stoebe L. ssp. micranthos (Gugler) Hayek) have long been the subject of eradication efforts in Alberta and were on the “restricted” list under the previous Act. Although populations of these species are relatively low in Alberta compared to the extensive infestations in neighbouring British Columbia and Montana, it is open to question whether eradication is a realistic policy goal for them.

A major hurdle for assessing the appropriate regulatory status for weeds in Alberta has been the lack of detailed, accessible information on the distribution and abundance of invasive plant species in the province. Although many municipalities and some provincial government agencies collect such information for their own purposes, there is as yet no system in place to share it in a common format, such as Brit-
ish Columbia’s Invasive Alien Plant Program (British Columbia Ministry of Forests, Lands & Natural Resource Operations, 2012). Such a system for Alberta would be a valuable support for planning invasive plant management programs, as well as for making decisions about the regulatory status of invasive plant species. Some mapping initiatives are being developed in Alberta. The Pest Surveillance Branch of Alberta Agriculture and Rural Development has recently inaugurated a dedicated phone-in reporting system (310-APSS), which allows any member of the public to report a pest, including weeds. Reports from this system will be maintained and mapped in a centralized database compliant with Government standards for record keeping. The Branch is also developing distribution maps of regulated weeds in collaboration with managers of public lands (municipalities and provincial government departments, etc.). These maps are intended to inform the regulatory process, but will eventually be made available to the public. The Alberta Invasive Plants Council has also launched a pilot project using the EDDMAPS system to allow members of the public to report the locations of invasive plants (Alberta Invasive Plants Council, 2012).

Some gaps in Alberta’s legislative framework for invasive plants have become apparent. The lack of authority to regulate aquatic species has already been mentioned, as well as the failure to explicitly prohibit the sale of regulated species. The approach of the legislation is also very much focussed on enforcing the control of particular species by individual landowners, without any spatial, ecological or social context. Thus the legislation and regulations are silent on issues such as containment or exclusion zones, cooperative weed management areas, or pest management plans. No exemptions are provided for growing weeds for research purposes (thus making most weed science research technically an offence under the Act!) or for evaluating alternative measures such as biological control.

This process has produced a regulated weeds list for Alberta that better reflects our current knowledge of status and threats of invasive plants in the province, and reflects the increasing concern about plant invasions in non-agricultural habitats as well as for weed issues in agriculture. The establishment of the Alberta Weed Regulatory Advisory Committee, and the development of explicit criteria and processes for listing species in the “prohibited noxious” and “noxious” categories, will guide the further development of the list, and ensure that the reasons for decisions are documented for future reference. The process that has been developed, and the scientific input into the committee’s decisions, should ensure that over time the list becomes a more useful tool to support invasive plant management in Alberta. It should always be kept in mind, however, that the decision to regulate a particular plant species as a weed is ultimately a policy decision rather than a scientific one. This decision should be made after defining the policy goals for a particular species, and considering how or whether regulatory action can actually contribute to those goals.

Acknowledgments

I thank the members of the Alberta Weed Regulatory Advisory Committee, co-chaired by Gayah Sieushai (Alberta Agriculture) and Tim Dietzler (Rocky View County), and particularly Chris Neeser and Jim Broatch (Alberta Agriculture), James B. Posey (Alberta Native Plant Council), and Paul Watson (Alberta Invasive Plants Council). They participated in the development of the lists, and provided much welcome information and comments for this paper. My role in this process was as a consultant to the Alberta Weed Regulatory Advisory Committee, providing technical advice and recommendations on the biology and impacts of plant species that were considered for potential listing. The viewpoints and opinions offered here are my own, and do not necessarily reflect Government of Alberta policy.

References


Table 1. Regulated weed lists for Alberta. Species are listed under the names in use at the time the lists were enacted.

<table>
<thead>
<tr>
<th>1907</th>
<th>1980</th>
<th>2009</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Noxious (19 species)</strong></td>
<td><strong>Restricted (5 species)</strong></td>
<td><strong>Restricted (7 species)</strong></td>
<td><strong>Prohibited noxious (46 species)</strong></td>
</tr>
<tr>
<td>Agrostemma githago</td>
<td>Carduus nutans</td>
<td>Carduus nutans</td>
<td>Aegilops cylindrica</td>
</tr>
<tr>
<td>Amaranthus albus</td>
<td>Centaurea diffusa</td>
<td>Centaurea maculosa</td>
<td>Allaria petiolaris</td>
</tr>
<tr>
<td>Amaranthus retroflexus</td>
<td>Centaurea diffusa</td>
<td>Centaurea maculosa</td>
<td>Berberis vulgaris</td>
</tr>
<tr>
<td>Ambrosia trifida</td>
<td>Myriophyllum spicatum</td>
<td>Centaurea solstitialis</td>
<td>Cuscuta spp.</td>
</tr>
<tr>
<td>Avena fatua</td>
<td>Odontites serotina</td>
<td>Cuscuta spp.</td>
<td>Berteroa incana</td>
</tr>
<tr>
<td>Avena strigosa</td>
<td><strong>Noxious (16 species)</strong></td>
<td>Myriophyllum spicatum</td>
<td>Butomus umbellatus</td>
</tr>
<tr>
<td>Ayris amaranthoides</td>
<td>Cardaria spp.</td>
<td>Odontites serotina</td>
<td>Carduus acanthoides</td>
</tr>
<tr>
<td>Brassica sinapistrum</td>
<td>Centaurea repens</td>
<td><strong>Noxious (24 species)</strong></td>
<td>Carduus nutans</td>
</tr>
<tr>
<td>Camelina sativa</td>
<td>Cirsium arvense</td>
<td>Apocynum androsaemifolium</td>
<td>Centaurea × moncktonii</td>
</tr>
<tr>
<td>Capsella bursa-pastoris</td>
<td>Convolvulus arvensis</td>
<td>Cardaria spp.</td>
<td>Centaurea × psammogena</td>
</tr>
<tr>
<td>Cnicus arvensis</td>
<td>Erodium cicutarium</td>
<td>Centaurea repens</td>
<td>Centaurea diffusa</td>
</tr>
<tr>
<td>Conringia orientalis</td>
<td>Euphorbia cyprarissias</td>
<td>Chrysanthemum leucanthemum</td>
<td>Centaurea jacea</td>
</tr>
<tr>
<td>Echinospermum lappula</td>
<td>Euphorbia esula</td>
<td>Cirsium arvense</td>
<td>Centaurea macrocephala</td>
</tr>
<tr>
<td>Erysimum cheiranthoides</td>
<td>Galium aparine</td>
<td>Convolvulus arvensis</td>
<td>Centaurea nigra</td>
</tr>
<tr>
<td>Nesiia paniculata</td>
<td>Linaria vulgaris</td>
<td>Cynoglossum officinale</td>
<td>Centaurea nigrescens</td>
</tr>
<tr>
<td>Salvia kall v. tragus</td>
<td>Loliaceum persicum</td>
<td>Echium vulgare</td>
<td>Centaurea solstitialis</td>
</tr>
<tr>
<td>Sisymbrium altissimum</td>
<td>Lychnis alba</td>
<td>Erodium cicutarium</td>
<td>Centaurea stoebe ssp. micranthos</td>
</tr>
<tr>
<td>Sisymbrium incisum</td>
<td>Matricaria maritima</td>
<td>Euphorbia cyprarissias</td>
<td>Centaurea virgata ssp. squarrosa</td>
</tr>
<tr>
<td>Thlaspi arvense</td>
<td>Scleranthus annuus</td>
<td>Euphorbia esula</td>
<td>Chondrilla juncea</td>
</tr>
<tr>
<td>Silene cucubalus</td>
<td>Galium aparine</td>
<td>Cirsium palustre</td>
<td></td>
</tr>
<tr>
<td>Sonchus arvensis</td>
<td>Galium spurium</td>
<td>Crupina vulgaris</td>
<td></td>
</tr>
<tr>
<td>Tanacetum vulgare</td>
<td>Knautia arvensis</td>
<td>Cyperus esculentus</td>
<td></td>
</tr>
<tr>
<td><strong>Nuisance (36 species)</strong></td>
<td>Linaria vulgaris</td>
<td>Elaeagnus umbellata</td>
<td></td>
</tr>
<tr>
<td>Agropyron repens</td>
<td>Loliaceum persicum</td>
<td>Fallopia × bohemica</td>
<td></td>
</tr>
<tr>
<td>Amaranthus retroflexus</td>
<td>Lythrum salicaria</td>
<td>Fallopia japonica</td>
<td></td>
</tr>
<tr>
<td>Avena fatua</td>
<td>Matricaria perforata</td>
<td>Fallopia sachalinensis</td>
<td></td>
</tr>
<tr>
<td>Bromus tectorum</td>
<td>Ranunculus acris</td>
<td>Halogenet glomeratus</td>
<td></td>
</tr>
<tr>
<td>Campanula rapunculoides</td>
<td>Scleranthus annuus</td>
<td>Heracleum mantegazzianum</td>
<td></td>
</tr>
<tr>
<td>Capsella bursa-pastoris</td>
<td>Silene alba</td>
<td>Hieracium aurantiacum</td>
<td></td>
</tr>
<tr>
<td>Cerastium arvense</td>
<td>Silene cucubalus</td>
<td>Hieracium caespitosum</td>
<td></td>
</tr>
<tr>
<td>Cerastium vulgatum</td>
<td>Sonchus arvensis</td>
<td>Hieracium pilosella</td>
<td></td>
</tr>
<tr>
<td>Convolvulus sepium</td>
<td>Tanacetum vulgare</td>
<td>Hypericum perforatum</td>
<td></td>
</tr>
<tr>
<td>Year</td>
<td>1907</td>
<td>1980</td>
<td>2009</td>
</tr>
<tr>
<td>------</td>
<td>------</td>
<td>------</td>
<td>------</td>
</tr>
<tr>
<td><strong>Nuisance (36 species)</strong></td>
<td>Crepis tectorum</td>
<td>Impatiens glandulifera</td>
<td></td>
</tr>
<tr>
<td>Descurainia pinnata</td>
<td>Agropyron repens</td>
<td>Iris pseudacorus</td>
<td></td>
</tr>
<tr>
<td>Descurainia sophia</td>
<td>Amaranthus retroflexus</td>
<td>Isatis tinctoria</td>
<td></td>
</tr>
<tr>
<td>Echium vulgare</td>
<td>Avena fatua</td>
<td>Jacobaea vulgaris</td>
<td></td>
</tr>
<tr>
<td>Erucastrum gallicum</td>
<td>Bromus tectorum</td>
<td>Lythrum salicaria</td>
<td></td>
</tr>
<tr>
<td>Erysimum cheiranthoides</td>
<td>Capsella bursapastoris</td>
<td>Myriophyllum spicatum</td>
<td></td>
</tr>
<tr>
<td>Fagopyrum tataricum</td>
<td>Cerastium arvense</td>
<td>Odontites vernus</td>
<td></td>
</tr>
<tr>
<td>Galeopsis tetrahit</td>
<td>Cerastium vulgatum</td>
<td>Potentilla recta</td>
<td></td>
</tr>
<tr>
<td>Lappula echinata</td>
<td>Convolvulus epium</td>
<td>Rhamnus cathartica</td>
<td></td>
</tr>
<tr>
<td>Linaria dalmatica</td>
<td>Crepis tectorum</td>
<td>Raphonticum repens</td>
<td></td>
</tr>
<tr>
<td>Malva rotundifolia</td>
<td>Descurainia pinnata</td>
<td>Taeniatherum caput-medusae</td>
<td></td>
</tr>
<tr>
<td>Neslia paniculata</td>
<td>Descurainia sophia</td>
<td>Tamarix chinensis</td>
<td></td>
</tr>
<tr>
<td>Polygonum convolvulus</td>
<td>Erucastrum gallicum</td>
<td>Tamarix parviflora</td>
<td></td>
</tr>
<tr>
<td>Polygonum persicaria</td>
<td>Erysimum cheiranthoides</td>
<td>Tamarix ramosissima</td>
<td></td>
</tr>
<tr>
<td>Potentilla norvegica</td>
<td>Erucastrum cheiranthoides</td>
<td>Tribulus terrestris</td>
<td></td>
</tr>
<tr>
<td>Raphanus raphanistrum</td>
<td>Fagopyrum tataricum</td>
<td><strong>Noxious (29 species)</strong></td>
<td></td>
</tr>
<tr>
<td>Salsola pestifer</td>
<td>Galeopsis tetrahit</td>
<td>Arctium lappa</td>
<td></td>
</tr>
<tr>
<td>Saponaria vaccaria</td>
<td>Lamium amplexicaule</td>
<td>Arctium minus</td>
<td></td>
</tr>
<tr>
<td>Setaria viridis</td>
<td>Lappula echinata</td>
<td>Arctium tomentosum</td>
<td></td>
</tr>
<tr>
<td>Silene cserei</td>
<td>Linaria dalmatica</td>
<td>Bromus japonicus</td>
<td></td>
</tr>
<tr>
<td>Silene noctiflora</td>
<td>Malva rotundifolia</td>
<td>Bromus tectorum</td>
<td></td>
</tr>
<tr>
<td>Sinapis arvensis</td>
<td>Neslia paniculata</td>
<td>Campanula rapunculoides</td>
<td></td>
</tr>
<tr>
<td>Sonchus oleraceus</td>
<td>Polygonum convolvulus</td>
<td>Cirsium arvense</td>
<td></td>
</tr>
<tr>
<td>Spergula arvensis</td>
<td>Polygonum persicaria</td>
<td>Clematis tangutica</td>
<td></td>
</tr>
<tr>
<td>Stellaria media</td>
<td>Potentilla norvegica</td>
<td>Convolvulus arvensis</td>
<td></td>
</tr>
<tr>
<td>Taraxacum arvense</td>
<td>Raphanus raphanistrum</td>
<td>Cynoglossum officinale</td>
<td></td>
</tr>
<tr>
<td>Thlaspi arvense</td>
<td>Salsola pestifer</td>
<td>Echium vulgare</td>
<td></td>
</tr>
<tr>
<td>Saponaria vaccaria</td>
<td>Euphorbia esula</td>
<td>****</td>
<td></td>
</tr>
<tr>
<td>Setaria viridis</td>
<td>Gypsophila paniculata</td>
<td>****</td>
<td></td>
</tr>
<tr>
<td>Silene cserei</td>
<td>Hesperis matronalis</td>
<td>****</td>
<td></td>
</tr>
<tr>
<td>Silene noctiflora</td>
<td>Hyoscyamus niger</td>
<td>****</td>
<td></td>
</tr>
<tr>
<td>Sinapis arvensis</td>
<td>Knautia arvensis</td>
<td>****</td>
<td></td>
</tr>
<tr>
<td>Sonchus oleraceus</td>
<td>Lepidium appelianum</td>
<td>****</td>
<td></td>
</tr>
<tr>
<td>Spergula arvensis</td>
<td>Lepidium chalepense</td>
<td>****</td>
<td></td>
</tr>
<tr>
<td>Stellaria media</td>
<td>Lepidium draba</td>
<td>****</td>
<td></td>
</tr>
<tr>
<td>Taraxacum officinale</td>
<td>Lepidium latifolium</td>
<td>****</td>
<td></td>
</tr>
<tr>
<td>Thlaspi arvense</td>
<td>Leucanthemum vulgare</td>
<td>****</td>
<td></td>
</tr>
<tr>
<td>Linaria dalmatica</td>
<td>Linaria vulgaris</td>
<td>****</td>
<td></td>
</tr>
<tr>
<td>Linaria vulgaris</td>
<td>Ranunculus acris</td>
<td>****</td>
<td></td>
</tr>
<tr>
<td>Silene latifolia ssp. alba</td>
<td>Sonchus arvensis</td>
<td>****</td>
<td></td>
</tr>
<tr>
<td>Sonchus arvensis</td>
<td>Tanacetum vulgare</td>
<td>****</td>
<td></td>
</tr>
<tr>
<td>Tripleurospermum inodorum</td>
<td>Verbascum thapsus</td>
<td>****</td>
<td></td>
</tr>
</tbody>
</table>
Resumen
Las decisiones tienen consecuencias en tiempo y espacio en nuestro continente, en nuestro hemisferio y a través del mundo. Si no cooperamos en la misión de controlar a las plantas invasoras, las consecuencias del tiempo y las riquezas perdidas serán inmensas. Las pérdidas para la agricultura, el medio ambiente y la salud humana serán irreversibles. Nuestra decisión de escribir y firmar el Acuerdo de Banff en 2008 fue un primer paso. Sin embargo, el Acuerdo no tiene ninguna posición legal, ninguna influencia internacional y ninguna autoridad para ser reconocido por nuestras agencias/organizaciones. Aún hace falta algo para lograr un esfuerzo cooperativo. Las Malezas sin Fronteras juntaron a científicos, técnicos y políticos para compartir las informaciones mutuamente benéficas y buscar soluciones juntas. Ya deberíamos unir tecnologías de mapeo y bases de datos, compartiendo alertas de malezas, y acoplándolas para revisiones de campaña anuales a través de fronteras. Examinemos por qué el Acuerdo de Banff no basta y cuáles deberían ser nuestros siguientes pasos. Dado que los presupuestos para el manejo de malezas disminuyen; dado que el cambio climático amenaza ecosistemas; y dado que las necesidades humanas van ganando a las necesidades ambientales; este es el momento para la acción cooperativa.

Abstract
Decisions have consequences in time and space on our continent, in our hemisphere and across the world. If we do not cooperate on a mission to control invasive plants, the consequences of lost time and treasure will be immense. The loss to agricultural, environmental and human health will be irreversible. Our decision to write and sign the Banff Accord in 2008 was a first step. However, the Accord has no legal standing, no international clout, nor any authority for our agencies/organizations to recognize. Thus, the very thing we need for a cooperative effort is still missing. Weeds Across Borders gathered scientists, practitioners and policy-makers to share mutually beneficial information and together seek solutions. By now we should be connecting mapping technologies and databases, sharing weed alerts, and gathering for annual field reviews across borders. Let’s examine why the Banff Accord is not enough and what our next steps should be. Because weed management budgets are dwindling; because climate change is threatening ecosystems; and because human needs are preempting environmental needs; now is the time for cooperative action.

The Case for International Cooperation
El caso de la cooperación internacional

Bonnie Harper-Lore
Private Consultant / Consultora independiente
12505 Ridgemount Ave. W., Minnetonka, MN, USA
bonnielore@comcast.net

Presentation Summary
The Future of Continental Cooperation,
Is A Stronger Partnership Needed?
Weeds Across Borders (wab) was initiated by the Federal Interagency Committee for the Management of Noxious and Exotic Weeds (ficmnew) with its first international meeting in Tucson, Arizona in 2002. The idea of gathering researchers, policy-makers and practitioners from each North American country was based on the fact that invasive plants do not respect political boundaries. Due to the ecological and economic costs of spreading weeds, it was imperative to keep one another informed of progress in each country. An emphasis on inviting multi-level agencies led to federal, state, and local level participation. Importantly, natural resources and agriculture were represented.

The format for the conference was kept simple; a convenient and affordable location, alternating among the countries, with 100 invited papers for a strong agenda and easy networking. So that all attendees heard all the information, no concurrent sessions were held. Conferences included an early reception to introduce the participants to one another, plus a field trip in the middle of the two-day presentations to facilitate networking.

The intent was an intimate meeting leading to further exchanges of information long after each conference concluded. Thus far, WAB has visited: Tucson, Arizona; Minneapolis, Minnesota; Hermosillo, Sonora; Banff, Alberta; Shepherdstown, West Virginia; and Cancun, Quintana Roo. At the end of the 2004 Min-
neapolis meeting, an Ad Hoc Group discussed their lack of support from their own supervisors and countries for this kind of exchange.

We all knew invasive plants were not yet a high priority. I volunteered to find a trilateral mechanism to give us that support. Firstly, I talked to existing trilateral frameworks with the goal of associating with one. Neither the Commission for Environmental Cooperation, North American Plant Protection Organization, or the Fish and Wildlife Trilateral Committee saw invasive plants as a priority issue in 2004. Ultimately, I talked to the State Department who shared a precedent for an international Memorandum of Understanding which State would expedite in Washington DC.

The Memorandum of Understanding’s stated purpose was “to provide a framework for the exchange of scientific and technical knowledge between the U.S., Canada, and Mexico in the area of invasive plants.” Its simplicity would catch the attention of all three governments and lead to increased support for continental cooperation. Or so we thought. The carefully crafted MOU was introduced for discussion at the Banff 2008 WAB. A representative of NAPPO argued his organization already did this work. Although we proved that not to be true, the momentum was broken. At the end of the Weeds Across Borders meeting, attendees signed the “Banff Accord”, supporting the need for support.

Following this surprise ending, the conference organizers selected two members from each country to review and revise, if necessary, the Memorandum of Understanding. The MOU committee did not have the time to bring the MOU back for discussion by 2010. So in 2012, I thought an explanation of this simple document should be offered at the WAB conference for further consideration. This time, I explained the details of the MOU.

For example, “Each party may... with consent of the other parties: invite scientists, technical experts, government agencies, and institutions to participate in activities like field reviews, research studies, a continental work plan, cooperative projects, workshops, and or conferences”. In other words, the MOU supports further information exchange beyond Weeds Across Borders.

All “cooperative activities” would be defined by a designated representatives from each nation who would meet annually to review activities and develop proposals for future joint activities. Activities are based on the 1994 FICMNWEW objectives and 2004 WAB additions to include:
- early detection and rapid response cooperation,
- inventory database coordination and prediction,
- weed warnings based on investigations,
- weed control technology transfer,
- restoration and long-term monitoring, and
- public awareness and related education.

This paper represents the will and logic behind a stronger international partnership to support the work and information exchange of North American scientists, land managers and policy makers aimed at stopping the spread of weeds across borders. Our choices remain: 1.) do nothing to increase support, 2.) review, revise and sign the Memorandum of Understanding, or 3.) find a new way to strengthen support for continental activities to stop the spread of weeds. Part of the response to this paper suggested the National Invasive Species Council of the United States advance the MOU for signature.

MEMORANDUM OF UNDERSTANDING BETWEEN THE DEPARTMENT OF OF THE GOVERNMENT OF THE UNITED STATES OF AMERICA AND THE MINISTRIES OF GOVERNMENT OF CANADA / MEXICO CONCERNING SCIENTIFIC AND TECHNICAL COOPERATION IN PREVENTION AND CONTROL OF INVASIVE PLANTS

ARTICLE I. SCOPE AND OBJECTIVES

1. hereby agree to pursue scientific and technical cooperation in the prevention and control of invasive plants in accordance with this Memorandum of Understanding (hereinafter “Memorandum”).

2. The purpose of this Memorandum is to provide a framework for the exchange of scientific and technical knowledge between the United States, Canada, and Mexico in the area of invasive plants.

3. The Parties shall encourage and facilitate, where appropriate, the development of direct contracts and cooperation among government agencies, universities, research centers, institutions, private sector companies, and other entities of the three Parties.
4. Each Party may, with the consent of the other Parties and to the extent permitted by laws and policies to which they are subject, invite other government entities or agencies of the United States, Canada, and Mexico, including scientists, technical experts, governmental agencies, and institutions of third countries or international organizations, to participate in activities undertaken pursuant to this Memorandum, subject to such terms and conditions as the parties may specify.

ARTICLE II. COOPERATIVE ACTIVITIES

1. Forms of cooperation under this Memorandum may consist of exchanges of technical information, visits, participation in training courses, conferences and symposia; the exchange of professional scientists in areas of mutual interest; and any other cooperative research consistent with programs of the Parties. Specific areas of cooperation may include, but are not limited to, such areas of mutual interest as:
   A. Early detection and rapid response cooperation.
   B. Vegetation inventory databases coordination and prediction.
   C. Weed Alert postings based on investigations.
   D. Weed control technology transfer.
   E. Restoration and long term monitoring.
   F. Public awareness and related education.

2. Activities under this Memorandum shall be undertaken in accordance with the laws, regulations, and procedures of each country.

ARTICLE III. AVAILABILITY OF RESOURCES

Cooperative activities under this Memorandum shall be subject to the availability of personnel, resources, and appropriated funds. This memorandum shall not be construed to obligate any particular expenditure or commitment of resources or personnel. The Parties shall agree in accordance with Article VII below upon specific Project Annexes in writing before the commencement of any activity pursuant to this Memorandum.

ARTICLE IV. FEE AND TAX EXEMPTION

In accordance with the laws and regulations to which it is subject, each Party shall work toward obtaining, on behalf of the other Party, relief from taxes, fees, customs duties, and other charges (excluding fees for specific services rendered) levied with respect to:

A. All transfer, ownership, construction, renovation, or maintenance of facilities or property by or on behalf of the other Party to implement this Memorandum.
B. The import, purchase, ownership, use, or disposition (including export) of goods and services by or on behalf of the other Party in support of activities under this Memorandum; and
C. Personal property of personnel of the other Party or entities of such other Party implementing provisions of this Memorandum.

The Parties do not foresee the provision of foreign assistance under this Agreement. If the Parties decide otherwise with respect to a particular activity, or other relevant implementing arrangement would need to be consistent with the requirements of applicable laws and regulations of the United States, Canada, and Mexico that regulate activities related to foreign assistance.

ARTICLE V. INTELLECTUAL PROPERTY AND SECURITY OBLIGATIONS

The protection and distribution of intellectual property created or furnished in the course of cooperative activities under this Memorandum shall be governed by Annex I of this Memorandum. Provisions for the protection of classified information and unclassified export-controlled information and equipment are set forth in Annex II of this Memorandum. Annex I and II are integral parts of this Memorandum.

ARTICLE VI. DISCLAIMER

Information transmitted by one Party to the other Party under this Memorandum shall be accurate to the best knowledge and belief of the transmitting Party, but the transmitting Party does not warrant the suitability of the information transmitted for any particular use or application by the receiving Party or by any third party.

ARTICLE VII. PLANNING AND REVIEW OF ACTIVITIES

Each Party shall designate a principal representative who, annually or as appropriate as are mutually agreed upon by the Parties, shall meet to review the activities under this Memorandum and develop proposals for future activities.

ARTICLE VIII. PROJECT ANNEXES

Any activity carried out under this Memorandum shall be agreed upon in advance by the Parties in writing. Whenever more than the exchange of technical information or visits of individuals is contemplated, such activity shall be described in an agreed Project Annex to this Memorandum, which shall set forth, in terms appropriate to the activity, a work plan, staffing requirements, cost estimates, funding sources, and other undertakings, obligations, or conditions not included in this Memorandum. In case of any inconsistency between the terms of this Memorandum and the terms of a Project Annex, the terms of this Memorandum shall control.

ARTICLE IX. ENTRY INTO FORCE, AMENDMENT, AND TERMINATION

This Memorandum shall enter into force upon the signature of all parties and shall remain in force until terminated at any time by any Party upon at least ninety (90) days prior written notice to the other Parties, unless otherwise agreed, the termination of this Memorandum shall not affect the validity or duration of projects under this memorandum that are initiated prior to such termination. This Memorandum may only be amended by written agreement of all Parties.

DONE at Reston, Virginia, and ______ in duplicate, in the English language.

FOR THE U.S. DEPARTMENT OF:
Signature _______________________________________
Name __________________________________________
Title __________________________________________
Date ______________

FOR THE MINISTRY OF:
Signature _______________________________________
Name __________________________________________
Title __________________________________________
Date ______________

ANNEX I. INTELLECTUAL PROPERTY RIGHTS

I. General Obligation
II. Scope
III. Allocation of Rights
IV. Business Confidential Information

ANNEX II. SECURITY OBLIGATIONS

I. Protection of Sensitive Technology
II. Technology Transfer
US Policy Developments in Preventing Introductions of New Weeds
Desarrollo de políticas en los USA para prevenir introducciones de nuevas malezas

Peter Jenkins
Executive Director / Director Ejecutivo
Center for Invasive Species Prevention / Centro de Prevención de Especies Invasoras
PO Box 42241. Washington, DC 20015 USA
jenkinsbiopolicy@gmail.com

Abstract
After 7 years of planning, in June 2011 the U.S. Department of Agriculture issued a final regulation for imports of all nursery plants that dramatically enhances the agency’s ability to take precautionary steps to prohibit invasive plants (as well as plant pests). This is known as the Quarantine 37 revision, which created a new regulatory category called Not Authorized Pending Plant Risk Assessment (NAPPRa). USDA took the major first step in implementing this new law in the fall of 2011 by proposing the first round of 41 NAPPRA weed species. The presentation will cover the contours and status of NAPPRA and discuss it as an innovative policy concept, but one whose effectiveness will depend on the knowledge and commitment applied by USDA in its implementation. The opportunities for outside party’s to influence NAPPRA’s development will also be covered.

Presentation Summary
USDA’s New “Not Authorized Pending Pest Risk Analysis” Noxious Weed Regulation Program

Background
U.S. Federal regulators gained expanded power to move “much more quickly” to halt imports of plants suspected of being invasive species or carrying noxious pests under a new Department of Agriculture (USDA) regulation announced on May 27, 2011. The regulation allows USDA’s Animal and Plant Health Inspection Service (APHIS) to prohibit imports of risky plants without needing to do a full-blown weed risk assessment. This was done under the APHIS regulation that applies to nursery plant imports, known as Quarantine 37 (Q-37) and it created the precautionary regulatory category known as “not authorized pending pest risk analysis” (NAPPRa). Additionally, on July 26, 2011, USDA published a “Notice of Availability of Data Sheets for Taxa of Plants for Planting That Are Quarantine Pests or Hosts of Quarantine Pests”.

This sought public comment (by Sept. 26) on the agency’s proposal to designate 41 taxa of plants for planting as quarantine pests and 107 taxa of plants for planting as hosts of 13 quarantine pests, which therefore should be added to the list of plants for planting whose importation is prohibited due to being placed in this new NAPPPRA category.

Numerous stakeholders commented on the invasive plant issues in that first NAPPPRA proposal. Continuing opportunities for input to the NAPPPRA process are anticipated in the future. The NAPPPRA concept likely is the most important policy innovation in the invasive species prevention arena in the last ten years, but its usefulness will depend on how energetically APHIS implements it and how APHIS interprets key terms. The NAPPPRA concept encompasses several limitations on the categories of plants APHIS will consider for a new listing. The agency’s interpretations of those limits are based on the key authorizing statutes: the Plant Protection Act (PPA) and Federal Noxious Weed Act (FNWA), as well as the over-riding treaty, the International Plant Protection Convention (IPPC).

For interested parties to engage in future implementation of this policy innovation, they need a good grasp of its scope, limits, processes, timing and the opportunities for public input into future NAPPPRA designations. Clarifying those aspects of NAPPPRA is the purpose of this paper.

**How the USDA APHIS NAPPPRA process will work for potentially invasive plants**

The full explanation of how the new NAPPPRA process is intended to work covers 39 pages in the Federal Register. The explanation is very detailed and responds to a large number of comments from the public and stakeholders based on the earlier Q-37 NAPPPRA “Proposed Rule” that APHIS issued in 2009. This paper addresses the Final Rule’s major points and is informed by APHIS’s first implementation attempt to date.4

This excerpt summarizes the NAPPPRA process (Final Rule, p. 31172):

> If scientific evidence indicates that a taxon of plants for planting is a quarantine pest or a host of a quarantine pest, we will publish a notice [in the Federal Register] that will announce our determination that the taxon is a quarantine pest or a host of a quarantine pest, cite the scientific evidence we considered in making this determination, and give the public an opportunity to comment on our determination. If we receive no comments that change our determination, the taxon will subsequently be added to the new category. We will allow any person to petition for a pest risk analysis to be conducted to consider whether to remove a taxon that has been added to the new category. After the pest risk analysis is completed, we will remove the taxon from the category and allow its importation subject to general requirements, allow its importation subject to specific restrictions, or prohibit its importation.

Here is an explanation of how the agency intends to address the crucial challenge of the higher level of uncertainty that could be associated with this quicker, more precautionary, regulatory process as species are proposed for NAPPPRA without first preparing a full pest risk assessment (PRA) (p. 31174):

We agree that there is uncertainty about the risk associated with any imported plants for planting when those plants have not been thoroughly studied. Our process for placing restrictions on the importation of a taxon of plants for planting has typically involved the preparation of a comprehensive PRA. This approach required us to evaluate the uncertainty regarding all aspects of the risk associated with the importation of the taxon before any action could be taken. The NAPPPRA category that we are adding to the plants for planting regulations in this final rule gives us a streamlined, transparent means to respond to new scientific evidence indicating that a taxon of plants for planting is a quarantine pest or a host of a quarantine pest, thus directly addressing risk while giving us the necessary time to evaluate uncertainty. We will make every effort to respond to scientific evidence as it becomes available.

---

4 Through April 2012.
With respect to the timing and deadlines for APHIS to take actions during the various procedural steps, they are:

- **Future proposals:** APHIS has not indicated any hard timeframe expected between NAPPRa proposals or how many species are likely to be proposed each time, but APHIS has indicated that as of April 2012 it had two more sets of proposals in preparation.

- **Public comment period on NAPPRa proposals:** 60 days, but APHIS can extend that if requested (typically by 30 days).

- **APHIS’s decisionmaking period:** No hard and fast deadline and APHIS has stated no informal guidance or goals for how long its decisions will take after the end of the comment period.

- **Effective date of import restriction after APHIS’s decision:** 15 days notice period after the NAPPRa list is announced before the import ban takes legal effect (according to APHIS staff); this will, for example, allow importers to complete any ongoing transactions in the banned species.

If APHIS, after considering the comments, decides a taxa should stay on the NAPPRa list and the effective date of the decision has passed, thereafter the species can be called: “a taxa prohibited from importation through NAPPRa.” Anyone then can petition at any time for APHIS to do a PRA on a species prohibited through NAPPRa in order to remove it from that list. However, the bare fact of asking for the PRA does not guarantee APHIS will agree a PRA is warranted and the information threshold APHIS requires petitioners to meet is fairly restrictive (see Final Rule pp. 31195-31197). There are no stated deadlines or guidelines for how long APHIS will take to do such a PRA.

**How Does this Differ from the Prior Regulatory Approach?**

In response to a public comment that the NAPPRa approach is redundant when considering the prior regulatory approach and APHIS’s pre-existing authority to summarily block imports of high risk species with “emergency orders,” APHIS explained the difference in terms of how NAPPRa allows regulators to avoid lengthy PRAs and administrative rulemaking processes (p. 31201):

> In situations that we judge to pose an emergency, we can take action immediately to stop the importation into the United States of a taxon whose importation poses a risk of introducing a quarantine pest. However, in the past, we have relied on the comprehensive PRa and rulemaking processes for reviewing the scientific literature and inviting the public to comment on restrictions we are contemplating for specific taxa of plants for planting. The NAPPRa category allows us to be transparent and engage the public by publishing notices, making available the scientific justification for our decisions, and requesting comments, while avoiding the burden of conducting a comprehensive PRA and completing rulemaking before putting restrictions in place, which previously had been our common practice. The NAPPRa category thus does not duplicate current efforts but provides us with a way to more efficiently utilize our limited resources, to employ transparent processes in reaching and communicating our decisions, and to allow for public participation in the process.

**When Will APHIS Initiate a New NAPPRa Proposal?**

Initiation events are as follows (p. 31183):

> We would initiate an evaluation of a taxon of plants for planting for addition to the NAPPRa category whenever we become aware of a quarantine pest risk associated with the importation of a taxon of plants for planting. This could include interceptions of imported plants for planting that are infested with quarantine pests, literature reviews and scientific references, and results from scientific screening systems and predictive models. We would not automatically initiate an evaluation upon receiving a request for an import permit or upon becoming aware that plant explorers want to import small quantities of a taxon.

**What Risk Screening and Assessment System will APHIS Use for NAPPRa Proposals?**

At p. 31188, APHIS states: “We plan to use the information from the WSSA screening system to identify taxa for evaluation as quarantine pests.” The WSSA point-based ranking system is laid out in: Parker, C., Caton, B.P., & Fowler, L. 2007. Ranking Nonindigenous Weed Species by Their Potential to Invade the United States. Weed Science 55:386-397.
In practice, that paper was cited in the data sheets for 24 of the 41 species APHIS proposed as prohibited “pest plants” in the first round of NAPPPRA. However, none of those 24 data sheets reiterates the plant’s ranking or points given under their model. While Parker et al., provides the preliminary screening tool, for further risk evaluation, APHIS also states (p. 31188):

*We are developing a new WRA [Weed Risk Assessment] methodology. The new methodology is based on the style and general approach of the [Australian] WRA, but the structure of the assessment and the means used to evaluate risk are not based on those in the AWRA. The new methodology also takes into account lessons learned from other systems like the one in use in New Zealand and the Hawaii-Pacific Weed Risk Assessment tool mentioned earlier..... When we have finished our development work on this new WRA methodology, we plan to have the methodology published in a peer reviewed journal, taking into account the opinions of the peer reviewers. We will make the methodology available to interested parties as well.*

**Other Key APHIS Statements in the NAPPPRA Rule**

**On listing non-native plants that are being “conserved” in the U.S. (p. 31176):**
A taxon requiring conservation is unlikely to be added to the NAPPPRA lists as a quarantine pest, since any plant that has difficulty surviving in field conditions is likely incapable of reproducing enough to cause potentially economically important damage to agricultural or environmental resources. For that reason, a taxon that could not survive outside a greenhouse would also be unlikely to be added to the NAPPPRA lists.

**On listing non-native plants that are “in cultivation” in the U.S. (p. 31180):**
When determining whether a taxon of plants for planting is a quarantine pest, we consider whether the taxon is present in the United States, regardless of whether it is in cultivation or in the wild. However, we agree with the commenters that the fact that a taxon died out in cultivation would be useful evidence in evaluating whether that taxon could qualify as a quarantine pest. Every time we make a determination that a taxon of plants for planting is a quarantine pest, we will publish a notice in the Federal Register informing the public of our determination and requesting public comments. Commenters will have an opportunity to provide information indicating that the taxon is in cultivation, which would indicate that the taxon is present in the United States and thus not eligible for addition to the NAPPPRA category unless it is under official control. If commenters indicate that the taxon was at one point in cultivation but died out, that would indicate that the taxon would be unlikely to cause economically significant damage, and we would consider that to be evidence against adding the taxon to the NAPPPRA category.

**On listing whole genera (p. 31183):**
We would only add taxa higher than the species level to the NAPPPRA category as quarantine pests if most of the species in a genus had been shown to be quarantine pests;

**On whether APHIS has articulated a general level of protection or precautionary standard it is seeking to achieve (p. 31190):**
The ultimate standard by which we will evaluate taxa for addition to the NAPPPRA category is whether they are quarantine pests or hosts of quarantine pests, based on the definition of quarantine pest that we are adding to the regulations. We will evaluate each individual taxon that comes to our attention to determine whether it meets this criterion. The unique biological characteristics of each evaluated taxon and, if applicable, the quarantine pests associated with it will inform our decisions. Therefore, it is not possible for us to specify an overall level of protection or general criteria that would apply to all our decisionmaking.

In short, APHIS declined to state anything about its decision criteria beyond a case-by-case determination, thus leaving the agency maximum discretion and leeway.

**On what this new program costs the Federal government (p. 31201):**
There are no direct costs associated with the implementation of the rule. Initially, we will use current resources to inspect shipments of taxa to determine
whether any NAPPR-A-listed plant for planting are present and to conduct PRAS and WRAS.

This is vital information. With predicted agency budget cuts and an anti-regulatory agenda among many in the U.S. Congress, the assertion that this program does not require any additional appropriations likely will be critical to defend it against cost-cutting arguments in the future.

**Limitations on the scope of plants the agency will consider for NAPPR-A**

The fundamental limiting definition in the Final Rule (p. 31208), which a taxon must meet in order to be eligible for a NAPPR-A listing, is:

**Quarantine Pest:** A plant pest or noxious weed of potential economic importance to the United States and not yet present in the United States [first prong], or present but not widely distributed and being officially controlled [second prong].

The key undefined word in both prongs of this definition is “present.” Much of the scope of this policy innovation will turn on how APHIS defines that in practice. In the first round of NAPPR-A proposals, there were three species proposed that were not indicated to be under “official control,” (thus did not fall under the second prong of the definition) and for which APHIS appeared aware of their likely occurrence in the United States, but still was not treating them as “present” under the first prong of the definition of “quarantine pest.” Those three and as many as 13 other species caused a fair amount of controversy in the public comments on the initial NAPPR-A round, as commenters disagreed with APHIS’s determination on its data sheets that the species were not present under the first prong. Again, if they are present and are not under official control, then they do not qualify for NAPPR-A and would have to be dropped from the final list.

Most observers would agree that occurrence of a few specimens in one private greenhouse collection in the country does not equal “present,” but APHIS has yet to articulate a clear threshold for what constitutes that term (See Box 1.). The Final Rule is ambiguous and even contradictory in some respects on the issue. The first round of NAPPR-A listing proposals, when APHIS finalizes it in the Federal Register and responds to public comments, will shed light on this based on the outcomes of the dozen or so species for which the commenters asserted APHIS incorrectly determined their status. APHIS’S response to the comments in the public docket regarding what amounts to “present” very likely will resolve the issue more clearly for purposes of future NAPPR-A proposals. Readers are advised to refer to that Federal Register notice when published.

---

**Box. 1 – Issues and Scenarios Related to When a Taxon is “Present” in the United States.**

APHIS has indicated its intent to follow the IPPC in implementing NAPPR-A. However, APHIS’s definition of “quarantine pest,” above, deviates from the IPPC Glossary (International Standard for Phytosanitary Measure, ISPM, 5) definition. The IPPC Glossary defines:

“**Quarantine pest** - A pest of potential economic importance to the area endangered thereby and not yet present there, or present but not widely distributed and being officially controlled.”

And the key term within that definition is defined:

“**endangered area** - An area where ecological factors favour the establishment of a pest whose presence in the area will result in economically important loss.”

---

5 IPPC ISPMs are online at: http://www.ippc.int/index.php?id=ispms.
APHIS has stricken the IPPC phrase “the area endangered thereby” and replaced it with “the United States.” This change suggests APHIS’s view is a pest plant anywhere within the entire United States is “present,” but this goes against the IPPC’s indication that presence is to be judged by whether the taxon occurs in a location where it is likely to become established and cause economic harm, i.e., “where ecological factors favour establishment.” Plainly, for any given pest plant, all areas in the United States are not going to provide the ecological factors that are favorable for establishment that would cause “economically important loss”.

Below are examples of different levels of cultivation where the question of a taxon being “present in the United States” under the first prong of “quarantine pest” appears unclear.

a) it has been sold by one nursery for a very short time and is not known to have spread beyond cultivation.

b) it has been imported by a few private individuals and is grown only in greenhouses.

c) it was imported very recently by several companies, but has not yet been sold or planted anywhere beyond nursery or greenhouse cultivation.

d) it has been offered for general sale and shipping to the United States on a website, but no indication exists of the extent of any actual sales or whether it is in cultivation.

e) it was sold in small quantities many years earlier and was cultivated, but is not still being sold and is not known to still be in cultivation or to have spread beyond cultivation.

IPPC ISPM 8 (Determination of Pest Status) does include some further sub-classifications of “present” and “transient” taxa in a given area, but it aims at plant pests, rather than at pest plants, and does not provide clear resolution of whether the above scenarios should or should not be considered “present” under the U.S. definition.

Moving on to the second prong of APHIS’s “quarantine pest” definition, certain actions by the agency in the first NAPPPRA round raise the question of what constitutes “being officially controlled”? At p. 31208, the Final Rule provides:

**Official Control:** The active enforcement of mandatory phytosanitary regulations and the application of mandatory phytosanitary procedures with the objective of eradication or containment of quarantine pests.

Among the 41 pest plant NAPPPRA proposals, several species were described as present and not widely distributed, thus they would have to fall under the second prong of the “quarantine pest” definition. However, each of their data sheets stated only that they were being “considered for official control”. The data sheets did not say they were actually or actively “being officially controlled”. Official control according to APHIS appears to encompass taxa that are in the planning or proposal stage to be officially controlled. The response APHIS makes on the first round of its NAPPPRA proposals and any determinations it makes to strike or add species under the second prong of the definition will provide guidance on the agency’s interpretation of present and official control going forward.
The relationship between NAPPPRA and the Federal Noxious Weed Listing Process

NAPPPRA has the potential to be a significant improvement over the agency's own Federal Noxious Weed (FNW) Program. In one “fell swoop” of its first NAPPPRA proposal for 41 species, APHIS could effectively increase the list of pest plants prohibited from importation by almost 40% beyond what the FNW program has accomplished in listing about 110 noxious weeds over the last several decades. Of course, the final numbers will depend on the comments on the proposals and which species APHIS decides to keep on the final prohibited NAPPPRA list.

The question arises: don’t the new NAPPPRA species also need to be added to the FNW list? There is one major difference between the NAPPPRA list and the FNW list: species on the former are only prohibited from importation, while species on the latter are prohibited from both importation and interstate commerce. Interstate transportation and commerce in those new NAPPPRA species logically should also be prohibited. Considering just the subset of NAPPPRA species that are present in the country and under official control, one cannot assume that official control for a given NAPPPRA-listed weed necessarily includes any actual restrictions on interstate commerce that would protect non-invaded States from that weed.

Ideally, to protect such States from any NAPPPRA-listed weed that already is in commerce in the country, but that lacks effective interstate import or export restrictions under State laws, the FNW program should list the weed species to protect those non-invaded States under Federal law.

This issue of FNW listings for NAPPPRA species was raised to APHIS, as is reflected in its response to public comments on the Final Rule (p. 31201). APHIS declined to commit to listing NAPPPRA species as FNWS and did not address the interstate commerce threat mentioned above.

Consider this scenario: a prized ornamental plant is present in widespread cultivation in 2/3rds of the country where it cannot survive beyond cultivation, but it could become a serious weed beyond cultivation in the other 1/3rd of the country, but it is not there yet. It likely will fall to States to cope with this plant in the form of import bans or other restrictions, because it is not a NAPPPRA candidate (again, NAPPPRA does not regulate interstate commerce) and would not qualify as a FNW due to being “widely distributed” under the “quarantine pest” definition. “Widely distributed” is another subjective term APHIS could clarify for the benefit of both the NAPPPRA and FNW processes, that is, by indicating what are appropriate distribution thresholds that constitute “widely”. The term is not defined by the IPPC or under APHIS guidance.6

Public information and opportunities for input to the nappra process

The Q-37 NAPPPRA rule contains several online information sources and mailing lists for which the public can sign up. Basic information and the NAPPPRA species lists are at:


One can also access APHIS’s “Plants for Planting Manual,” (formerly known as the “Nursery Stock Manual”) which summarizes all of APHIS’ prohibitions and restrictions on the importation of plants for planting:

www.aphis.usda.gov/import_export/plants/manuals/online_manuals.shtml

APHIS suggests that anyone interested in receiving notifications on NAPPPRA-related issues join the PPQ Stakeholder Registry:

https://web01.aphis.usda.gov/PPQStakeWeb2.nsf

People who sign up for the Stakeholder Registry and select the category “PI—Plants” will receive email notifications whenever APHIS publishes a notice adding a taxon to the NAPPPRA category. There is good indication in the Final Rule that non-government groups can play a key role (p. 31186, emphasis added):

We will certainly take into account information from State and local invasive species councils and from native plant organizations about the damage caused by various taxa. At the same time, given such information, we would likely seek to corroborate it with other scientific evi-

6 IPPC ISPM 8 provides some guidance, at: www.ippc.int/file_uploaded/1146658133679_ISPM8.pdf
dence describing the damage the taxon causes before adding it to the NAPPR A category. (It is also worth noting that many taxa of concern for those groups may not be under official control and thus would not be considered quarantine pests.)

Anyone can submit NAPPR A proposals; APHIS has provided Guidelines to do so (Box 2).

**Box 2. APHIS’ Guidelines for Submitting NAPPR A Proposals:**

The below excerpt from the final NAPPR A rule explains the process for the public to submit NAPPR A proposals (p. 31183):

“Several commenters stated that members of the public should be allowed to suggest that species be added to the NAPPR A category. Some commenters asked that we accept recommendations from specific groups of people, including ecologists who study invasive plant species, scientists in general, and local natural resource managers. One commenter stated that we should allow the public to suggest species to add to the NAPPR A category in the absence of an immediate importation request, since local weed management areas and invasive plant councils may elect to prevent movement of species that they expect will be problematic into their areas.

We agree with these commenters that the public should be allowed to suggest species to be evaluated for addition to the NAPPR A category. To facilitate public input, we have established an email drop box on our plants for planting Web site: www.aphis.usda.gov/import_export/plants/plant_imports/Q37_nappra.shtml that will allow the public to submit taxa for evaluation. We will also accept suggestions that are mailed to APHIS at Risk Management and Plants for Planting Policy, ATTN: NAPPR A List Candidates, RPM, PPQ, APHIS, 4700 River Road Unit 133, Riverdale, MD 20737–1236. (This address will also be available on the plants for planting Web site.)

The Web site also recommends that members of the public who suggest taxa to be evaluated for addition to the NAPPR A category include certain information, if available, with their suggestion, to facilitate evaluation of the taxon. The basic information we would need to evaluate a taxon is the taxon’s scientific name and author and its common name(s). If the taxon was to be evaluated to determine whether it is a host of a quarantine pest, the scientific name and author and the common name(s) of the pest would also be necessary.

Beyond that, helpful information for a taxon to be evaluated as a quarantine pest plant would include:

- Whether the taxon is present in the United States, and if so, where;
- If the taxon is present in the United States, information regarding any official control efforts,
- The taxon’s habitat suitability in the United States (predicted ecological range);
- Dispersal potential (biological characteristics associated with invasiveness);
- Potential economic impacts (e.g., potential to reduce crop yields, lower commodity values, or cause loss of markets for U.S. goods);
- Potential environmental impacts (e.g., impacts on ecosystem processes, natural
community composition or structure, human health, recreation patterns, property values, or use of chemicals to control the taxon);
- Potential pathways for the taxon's movement into and within the United States; and
- The likelihood of survival and spread of the taxon within each pathway.
Helpful information for a taxon to be evaluated as a host of a quarantine pest would include:
- If the pest is a pathogen, whether it could be introduced and established in the United States through the importation of seed or other types of propagative material;
- The pest's habitat suitability in the United States (predicted ecological range);
- Whether the pest is present in the United States, and if so, where;
- If the pest is present in the United States, information regarding any official control efforts,
- Means by which the pest infests plants;
- The host range of the pest;
- The plant parts the pest infests;
- Potential economic impacts (e.g., potential to reduce crop yields, lower commodity values, or cause loss of markets for U.S. goods);
- Potential environmental impacts (e.g., impacts on ecosystem processes, natural community composition or structure, human health, recreation patterns, property values, or use of chemicals to control the pest);
- Other potential pathways for the pest's movement into and within the United States; and
- The likelihood of survival and spread of the pest within each pathway.

For each type of suggestion, we would need references to support any information supplied, and the contact information of the person who made the suggestion, so we could follow up if necessary.”

**The role of state agencies**
State and local agencies are well-placed to designate existing invaders as under official control. **APHIS**’s Final Rule includes statements relevant to this point (p. 31179):

We agree that State and local governments are invaluable partners in identifying and responding to new pests. We work closely with State and local governments to share information about pest problems, develop phytosanitary controls, and enforce restrictions on the intra- and interstate movement of plants for planting. We are developing a process by which a State will be able to request that **APHIS** recognize its regulations and procedures as official control for the purposes of Federal regulation; we will grant recognition if an evaluation of the regulations and procedures indicates that they are effective and justified based on the economic importance of the pest. Such regulations and procedures could include both control and eradication programs and designation of a plant taxon as subject to movement restrictions. We plan to publish a notice in the **Federal Register** to provide information about this process once its development is complete. 

If we discover an introduction of a taxon of plants for planting that may be a quarantine pest, we will evaluate it. If the taxon is under official control and is of economic importance, we will publish a notice proposing to add the taxon to the **NAFFRA** lists. If the taxon is not under official control, we will further evaluate whether the taxon should be under official control; if the taxon is of sufficient economic importance, we
will take appropriate regulatory action, which would normally be adding it to the list of noxious weeds in 7 CFR part 360. We will also recognize State and local official control programs, if they exist, in considering whether to list a pest plant in the NAPPA category.

It is not clear whether a State noxious weed listing, or perhaps a weed listing by a State’s Exotic Pest Plant Council (EPPC), might be enough to constitute official control? Or if a State or local agency is putting funds toward management of an EPPC-listed species, does that constitute official control? APHIS’ first round of NAPPA proposals identified several species as under “official control,” but it did not elaborate on what type of control was involved, thus APHIS so far has not answered those questions.

**Concerns of industry and other stakeholders**

The public comment file for the July, 2009, Proposed Rule that formally initiated the NAPPA concept contains 263 comments, of which it appears dozens are from industry or other stakeholders expressing concerns.7 This Guide does not provide a comprehensive catalog of those concerns. APHIS spent a great amount of time and effort summarizing and responding them throughout the 35 pages of the Federal Register that are preamble to its May, 2011, Final Rule. The detailed concerns with the most pertinence to NAPPA’s future development boil down to several themes:

- More species will be restricted without justification which will harm various interests.
- The new system will result in unnecessary delays.
- APHIS lacks the resources, personnel and funding needed to do a good job.
- NAPPA shifts the burden of proof for NAPPA-listed species to importers to show they are safe.
- The key term “present” in the quarantine pest” definition includes ambiguity such that NAPPA might apply to various taxa that had been imported previously.

Stakeholders also weighed in with public comments on the first NAPPA proposals of July, 2011. APHIS’s resolution of the concerns raised when the agency responds to the comments and decides which of its proposed species should stay on the final NAPPA list will shed significant light on how this policy innovation will proceed. Stakeholders on all sides have an interest in APHIS doing high quality background research as it prepares data sheets and regulates species in the international trade.

---

7 Online at: www.regulations.gov/#!docketDetail;id=PS;ppp=10;pe=0;D=APHIS-2006-0011
Bob Parsons
Supervisor / Supervisor
Park County Weed and Pest Control District
PO Box 626 Powell, WY 82435
pcwp@wir.net

of an area in excess of 6,900 square miles (4.4 million acres), Bob has learned that effective weed control is a product of cooperation of management working towards one common goal of an environment of fewer invasive species. Therefore, the real dilemma should be how do we get there from here?

But before we can map where we are going, it is helpful to remember from where we came.

Presentation Summary

Introduction
In February of 1977, I left the stressful world of teaching vocational agriculture at the high school level and moved into what I thought was the tranquility of a county government job. It didn’t seem that being a weed and pest “supervisor” for a department of one could be too much of an issue. And starting a job of weed control in February with six inches of snow on the ground seemed a guarantee that I had hit easy street. I was soon to learn that there is no such thing as an easy job when it comes to working with the public.

Wyoming weed and pest districts are required by Wyoming Statutes 11-5-101. The district boundaries are the same as the county’s and comprise all lands whether federal, state, private or municipal. Each district is governed by either a five or seven person board
of directors who are appointed by the county commissioners. Each district is also required to hire a supervisor who is required to meet minimum qualification requirements.

Funding for Wyoming weed and pest districts is unique in that they do not have to compete with other county departments for funding from the county commissioners. Although the county commissioners have final approval of the weed and pest district budgets; approved funding is provided by a separate mill levy that cannot be transferred to another entity. Each county can assess up to one mil of the assessed valuation of all state, private, and municipal lands. Districts can also apply for an additional mil by forming a special management district. The only disadvantage of this funding method is that weed and pest districts do not receive any portion of federal Payments in Lieu of Taxes (pilt) funds. There is also a lot of inconsistency in the valuation between the 23 counties due mainly to mineral values. For example, one mil generates as little as $80,000 in Niobrara County to over $5,425,000 in Campbell County. There is currently no method in place that allows this disparity to be equalized across the districts since each weed and pest district is autonomous from all other districts because we are funded by the county taxpayers.

**Personal Background**
I was hired as the Park County Weed and Pest supervisor in the spring of 1977. I had received my degree in vocational agriculture education in the fall of 1974 from the University of Wyoming. I began teaching at the Powell High School that fall and taught secondary education for three years. In January of 1977, I decided that teaching was not my chosen profession, and started looking for another line of work.

When the position of county weed and pest supervisor became available at that time due to the death of the previous supervisor, I decided to apply. I had not had much experience in working with weed and pest districts so I was not sure what would be expected of me. I was hired in February of 1977 and began what was to be my lifelong profession. It is a decision that I have never regretted.

Although the supervisor who was my immediate predecessor had died unexpectedly, the individual who had held the position before him was still in the area and was hired to help train me. He had been the weed and pest supervisor for over 10 years and therefore I felt I had a definite advantage many new employees by having such a qualified teacher.

**Situation of Park County Weed and Pest 1977**
When I took over the program in 1977, I was the only full time employee of the district. Our equipment consisted of a 2-wheel drive pickup and a hand cart. Our facility was a 2800 square foot warehouse/garage/office building sitting on half a city block in the industrial area of town. Because of the building’s design, the offices smelled just like the inside of the spray trucks that our contractor parked in bays. These bays were available as garages only during the winter months because in the summer, they were full of pesticides for resale.

Park County was unique even at that time, because we did not own or operate any of our own spray equipment. We had a contract with a private applicator who did all of the weed control contracts for the district. The district had federal contracts with the U.S. Forest Service, Bureau of Land Management, and Bureau of Reclamation. They also contracted with the Wyoming Highway Department and the Wyoming State Parks to control weeds along the state highways and Buffalo Bill Reservoir. All of these agencies reimbursed the weed and pest district for managing their weed control program which generated $14,000 help cover the cost of our contractor. The district was also responsible for vegetation maintenance within the county road right-of-way; since in the 1960’s, the county commissioners and the district board members had agreed that the weed and pest district would pay for treatment along the county roads since “there was plenty of money available in the district’s budget to cover that expense.”

Although a full mil would have generated over $300,000, my board at that time believed that we could run an adequate program on 40% of that amount. Although this was a great “bragging point” as public servants, it did stymie our program for almost 20 years (I always used to say that my board tried to control the national financial inflation by limiting my $24,000 salary).

As a supervisor, my general job description was to work with the local farmers and ranchers to make sure that they controlled the noxious weeds on their prop-
erty. At that time, 90% of the private land was farmed or ranched by about 300 landowners. There were very few subdivisions and since they did not produce any crops, I was not expected to work with them. I was basically an Ag Advisor or a specialized County Agent.

During the winter months I spent a lot of my office time generating reports (this was before computers). In the spring I would attend farm auctions and grower’s meetings to establish relationships with the local agriculture producers. In April we would purchase pesticides for resale to the local growers in June through August.

Most of the summer was spent in the field. My duties included coordinating with the contract sprayer to establish treatment areas on public lands, offering application recommendations to local farmers and ranchers, administering all the finances, preparing for and attending monthly board meetings, and “anything else that needed to be done.”

Come fall, it was time to put together all the spraying reports and billing for the contract labor (again remembering that this was before computers, so every report had to be generated from scratch.) October would find me attending a couple of state meetings (usually Wyoming and Montana) followed by a welcome time of recuperating over the holidays to start all over again planning for the next year.

Between 1977 and 2000, not a whole lot changed. We did start hiring an “assistant supervisor” but they were only expected to work regular hours from May through September. For the most part they were either hired only during those months or else were paid minimal annual salaries that resulted in them being profoundly underpaid in the summer and therefore not required to put in many, if any, hours during the off-season.

Life as a “Supervisor” was pretty static for about the first 15 to 20 years. Although there were occupational changes, most changes were related to the types of pesticides we had available to us. In the late 1970’s, 2,4-D was the product of choice for most growers. The area farmers purchased 2,4-D and Banvel® (dicamba) from us to spray malting barley and corn for noxious and annual weeds. They also purchased a few other products from local business to treat annual weeds in sugar beets. Ranchers and cattle producers were excited about a new product called Tordon® (picloram). Since one of the major rangeland weed species was Musk thistle, Tordon was a great alternative compared to 2, 4-D.

Ultimately, it was the change in demographics that resulted in changes within the weed and pest district. During the 1990’s, many of the non-agricultural population started moving out of town and purchasing small rural acreages ranging from 1 to 10 acres. Most of these areas were unregulated and the people purchasing them had little if any farming experience. Something comparable to the Johnson County Range War (between cattlemen and sheepherders) was brewing. However, this battle was between the active agriculture producers or farmers and the subdividers. From the farmer’s view, the small acreage people did not control their weeds and those spread onto the adjacent farm ground. The Subdividers argued that farmers were spraying everything and the chemical drift was killing their gardens and poisoning their families. Throw in a few gates left open, dogs being run-over or shot, misuse or mismanagement of irrigation water and you have the makings of a major conflict. The amazing thing was that weeds were often used in the arguments on both sides as to justifications as to why there was conflict, but neither side was willing to take the initiative to clean up their problem first.

The weed and pest board began to realize that where before I could visit with one landowner (a traditional farmer) for 30 minutes and have consulted about weeds on 200 or more acres of farm ground. Now I would have to have discussions with 20 or more small acreage landowners to strategize about weed control on that same 200 acres of subdivision. Also, the people who lived on the small acreages usually had daytime jobs that made them inaccessible during normal working hours. As a result, the number of complaints about weed issues in the farming areas was becoming more numerous. Because so much of my time was being used to resolve those problems, weed issues in the large tracts of rangeland were going unheeded which caused conflicts between the ranchers and the federal land managers.

By the spring of 2000, it was obvious that the weed and pest district could not continue with “business as usual.” Things had to change.
2000-2011, the Decade of Change

The first thing the Park County Weed and Pest board recognized was that one full time person could not handle all the weed problems in a county of 4.4 million acres. So in the spring of 2000, the board hired a full time assistant supervisor. Normally this would have offered immediate relief to the distribution of jobs, but unfortunately I ended up having surgery that summer and was unable to help out very much from May through August. We were blessed to have hired a young man that was very willing to take on the responsibilities and kept us afloat during that year.

During the next five years 2001 through 2005, we were able to gain back some of the ground we had lost during the 1990’s. However, the number of small acreage landowners in the county continued to increase and we recognized that we needed to create a program to educate both non-agricultural and production agricultural people. So in 2005 the board hired another assistant supervisor to focus on education and public relations.

The increase in field personnel and the increase in the amount of paperwork being required by all government agencies resulted in us having to hire a fulltime administrative assistant/warehouse manager. With four fulltime staff, it was obvious that we needed more office space. The board was also beginning to consider hiring their own spray crews which would require more year round garage space. So plans were drawn up, land purchased and a new 9600 square foot building was built on 6.5 acres. Although the plans for a new facility were already underway, a major pesticide spill (while unloading a 250 gallon shuttle) at our old facility confirmed that our decision to move out of town was the right choice. Fortunately we had a very effective emergency response plan in place so the spill did not get into the drainage system or contaminate the surface water. In May of 2009, Park County Weed and Pest moved into their new facility.

As future plans to take over their own spray crews became more plausible, the board hired a third assistant supervisor in 2010. Working closely with the rest of the staff and the board of directors, the district began making plans to begin taking over some of the $400,000 worth of right-of-way and public land spraying that we had been contracting out during the past 35 years. During the winter of 2011, the district began what hopes to be smooth transition in taking over the bulk of the county and state road spraying and the contract for treatment of public lands.

Current Situation of Park County Weed and Pest

So what does Park County Weed and Pest look like today as compared to 35 years ago? First of all, the supervisor is a lot older, hopefully a lot wiser and definitely a lot slower.

Today we work out of a very modern and attractive building of over 9600 square feet. About 4000 square feet of that is for offices and meeting rooms. There are four separate offices for the supervisor and assistants. A lot of planning was put into the design of these offices to meet the needs of an “electronic world” with plenty of electrical plug-ins and intranet connections in each office. The balance of the facility is warehouse storage for pesticides that are for resale to the general public and for district use in their treatment programs. During the winter months, the area is used for garaging all the equipment the district now owns. The two halves of the facility are separated with a design practically eliminates the possibility of odors contaminating the offices. The facility is surrounded by 6.5 acres to insure that we do not become bordered by private residences or business that might object to the activities that we currently conduct.

Our staff numbers have changed dramatically over the past 35 years also. We have gone from one fulltime employee to five fulltime employees. We also hired eight seasonal employees last year. In addition, we have contracts with four individuals and two companies. Three of the individuals are responsible for our Early Detection/Rapid Response program and coordinate our four weed management areas. We also hire one person to conduct our county-wide quarantine release program. Our contract spraying companies are responsible for most of our government agency contracts. One of the companies runs six ATV’s and two boardjetting trucks. The other company operates a unique horse-pack spraying service with five individuals and at least 10 horses. They are responsible for weed treatment in the “back country” and wilderness areas.

Since 1977, we have increased our vehicle fleet from one 2-wheel drive pickup for the supervisor’s official use to the following:
• Four trucks/suv for use by the supervisor and assistants.
• Two trucks for use by the individual contractors
• Three trucks for use by our summer temporary crews.
• Two Utility Vehicles (utv) with computerized GPS and spray monitoring systems.
• Four ATV units mounted with 40 gallon spray units.
• Four utility trailers ranging from 10 feet long to one over 30 feet long.
• One small (3,000#) forklift.

Needless to say, all this equipment requires a lot more maintenance and therefore a lot more tools. In addition to the shelves of hand tools, we also have a welder, plasma cutter, and air compressor.

Park County Weed and Pest still administer many government contracts. All of these have increased in amounts over the past 35 years. The contract with the U.S. Forest Service has increased from $5,000 per year to $250,000 last year. Bureau of Land Management (BLM) has grown from $2,500 to $45,000 for noxious weed control plus and additional $25,000 for a cooperative program with the city of Cody for control of Russian olives along the Shoshone River. The Bureau of Reclamation increased from $2,500 to $40,000 for control of noxious weeds around Buffalo Bill Reservoir after the construction to raise the dam an additional 25 feet in the 1980’s. The contract with Wyoming Department of Transportation for noxious weed control has steadily increased to $30,000 for the 250 miles of highway in Park County, plus an additional $22,000 for annual weed treatment to reduce cost of manual maintenance such as mowing and hand cutting by their staff. The Wyoming Game and Fish provides $4,000 a year for weed control on game winter ranges plus an additional $25,000 for a cooperative program with the city of Cody for control of Russian olives along the Shoshone River. We also have a number of smaller contracts with municipalities. These include the City of Cody ($30,000) and the City of Powell ($3,000).

The downside of all this is that the spraying that we do for the County Road and Bridge along the 700 miles of county roads has also increased. Last year these costs exceeded $100,000 and those funds have to come out of the weed and pest budget. However, in exchange the county commissioners have been generous in working with the district by provide in-kind services such as an office in the courthouse for use by one of our assistant supervisors, access to their water stations to fill our spray trucks, and other miscellaneous situations that have come up over the years.

As a Wyoming weed and pest district, we are allowed to sell pesticides for the control of noxious weeds and pests. Over the years, we increased our “arsenal” to include not only 2, 4-D, dicamba, and picloram, but many new products that have become available. These include Roundup®, Escort®, Telar®, Milestone®, Chaparral®, and Perspective®. Although this broad choice of pesticides confuses our cooperators, it does allow us to make recommendations that can be used on specific weed species under many conditions.

Due to inflation and increased evaluation over the past years, the amount of funding available for the weed and pest has increased dramatically. A mil in 1977 would generate about $300,000 for the district. In 2010, a single mil provided $1.02 million dollars for the weed and pest. This windfall of tax income helped finance a large portion of our new building. With current increases in the value of oil, Park County could expect similar revenues in the next few years. The current board recognizes that we offer a major service to the Park County residents and therefore have changed their cost share programs over the past 35 years to provide more direct benefit to all taxpayers and not just the agricultural producers. The board currently has programs to reduce the herbicide costs on several different weeds and pests. These include 25% on grasshoppers, 50% on Russian olive, salt cedar, and whitetop, and 100% on high risk weeds such as Dalmatian toadflax, spotted knapweed, leafy spurge, and a number of other noxious weeds that are very limited in Park County.

My general job description has changed over the years also. Although the basic accountability is still to the Park County Weed and Pest Board of Directors, I now have responsibility of supervising people and overseeing programs. The amount of bookkeeping required in 1977 was minimal, so I have always taken on that responsibility which included not only oversight of the budget, but also writing checks and other bookkeeping jobs. Although that is a lot more time involved in those activities today, it is something that I have not been willing to reassign to anyone else. However, I
suspect that with my upcoming retirement that this is a job that will be either hired out to a second firm or else someone hired part-time to fulfill these duties. Because of the time involved with general supervisory responsibilities and bookkeeping duties, my position has become mostly a desk job. I do see this changing in the near future as my position is replaced with another supervisor. Over the years, our field work has increased with the addition of new programs and increased numbers of taxpayers utilizing our services. These responsibilities for these activities have been passed on to assistant supervisors over the years. This has resulted in better quality programs because they can narrow their focus and expertise in fewer areas and not be required to be a “Jack of all trades.”

The biggest change in the Park County Weed and Pest program over the past 35 years has been the number and background of the clientele we work with. In 1977 there were about 30 subdivided areas and these were usually adjacent to one of the urban communities which were often incorporated into the municipality. These were general small lots that were easily manageable by the landowner using traditional lawn care equipment. Over the years, more and more people want their “little house on the prairie.” Their dream is to own a place in the country with a modest house and barn and a few acres on which to run their horses. Many end up purchasing about 2 to 3 acres about 5 miles from town. Unfortunately this is too small an acreage to raise two horses and too small to justify purchasing farm equipment to manage the land properly. It is also too large to care for as a weekend hobby using typical lawn care equipment. So many of these acreages become a burden to landowners who feel they paid too much and got less than they thought they were getting. However, this does not seem to discourage more and more individuals from moving to the country. As stated before, instead of having 200 landowners to work with each year, we now have over two thousand. The location of our new facility has also given us more visibility and therefore more people “drop-by” to ask questions or purchase pesticides. A third factor has been the success of our increased public relations program. Media advertisements of the services we provide are well published now and people are anxious to take advantage of them, and thankfully we now have personnel available to do the programs justice.

So how do I summarize 35 years of experience? Obviously we would expect things to change. But it takes sitting down and looking at the whole picture to see those changes. Since so many of them happened one item at a time, you have to look at the whole picture to truly see what has taken place. I think if you were to ask local residents what changes they have seen with the Park County Weed and Pest Control District over the last 35 years, you would get one of two responses—either “The what???” or else “I don’t think they’ve been around for 35 years.” My response would be that we have changed our philosophy. I believe that we were a small government agency who was funded by the Park County taxpayers and provided services for the local farmers and ranchers. Now we are a public agency that provides services to Park County residents who want to control their noxious weeds and pests and can expect that service because they too pay their taxes.

With all the changes that have taken place in the past 35 years, who knows what the next 35 years will bring?

---

Social Media: The Post-brochure Era in Outreach
Medios sociales: La era post-folleto en la concientización

Jennifer Grenz
Invasive Plant Council of Metro Vancouver / Consejo de Plantas Invasoras de Metro Vancouver
NAWMA Treasurer / Tesorera de NAWMA
13480 Blundell Rd. Richmond, BC, Canada V6W 1B5
jgrenz@iscmv.ca

Resumen
Las herramientas para “alcanzar” a la gente en relación a diferentes causas o campañas han cambiado considerablemente en un período corto de tiempo. En la última década hemos pasado de folletos, sitios web estáticos simples, y los anuncios de periódico a los materiales de difusión sin papel por Twitter, Facebook, blogs, y
páginas Web dinámicas. El auditorio para nuestros mensajes ha cambiado también. Los “alcanzados” ya no están satisfechos con un folleto periódico y un boletín de noticias anual; para involucrarse ellos necesitan la información al día, hábilmente presentada y personalizada. Mientras que muchas organizaciones no gubernamentales y las organizaciones del gobierno reconocen estas tendencias, ellos no saben donde comenzar, ni saben si realmente vale la pena unirse al vagón de la última moda en comunicación social. Pero sí lo vale. Jennifer Grenz nos guiará a través de los medios de difusión electrónica disponibles y nos mostrará el increíble potencial que, al utilizarlo, puede alcanzar hasta la organización más pequeña. La difusión electrónica nos saca de nuestras pequeñas esquinas del mundo y puede darnos una voz que puede tener un gran impacto en la política y presión social. ¿Sabía usted que está a sólo un tweet del presidente? Aprenda como identificar los instrumentos de difusión apropiados para su audiencia; y al hacer esto, usted no sólo puede crear un programa de difusión eficaz sino también mejorar su capacidad de obtener y reforzar fondos.

Abstract

How we “reach” people about causes of any type has changed significantly in a short period of time. Within the last decade we have gone from brochures, simple static websites, and newspaper ads to paperless outreach materials through Twitter, Facebook, blogging, and dynamic web pages. The audience for our messages has changed too. The “reached” are no longer happy with a periodic brochure and an annual newsletter; to be engaged, they need up-to-the-minute, slickly-presented, personalized information. While many non profit and government organizations recognize these trends, they don’t know where to begin, nor do they know if there really is value in jumping on the latest social media bandwagon. There is. Jennifer Grenz will guide you through the available electronic outreach mediums and shows you the potential of the unbridled power that even the smallest organization can create through their use. Electronic outreach takes us out of our small corners of the world and can give us a voice that can have a major impact on social pressure and policy. Did you know that you are only one Tweet away from the President? Learn how to identify the appropriate outreach tools for your target audiences; and how doing so, you can not only create an effective outreach program but also improve your ability to raise and leverage funds.

Presentation Summary

Social Media, the post-brochure era in outreach Understanding the Context

The Invasive Species Council of Metro Vancouver (iscmv) is a not for profit organization located in Vancouver, British Columbia Canada. iscmv was established in 2006 and has a mandate to “improve invasive species management in Metro Vancouver”. The activities of the organization include education, outreach, research, inventory, control, mapping, collaboration, and information sharing. Our partners include all levels of government (federal, provincial, regional, municipal and First Nations), non profit organizations, academic institutions, and concerned members of the public.

iscmv’s management area is in the Metro Vancouver regional district of British Columbia, Canada. The organization is one of 16 other such invasive species organizations in the province. The entire province of British Columbia covered by an invasive species organization. iscmv’s management area is the smallest geographically however more than half of the population of the province resides within it. Current estimations of the area’s population is 2.5 million people. This region is also unique in that within it are 22 municipalities which makes invasive species management challenging as invasive species do not respect boundaries and the region has often been referred to as a “jurisdictional puzzle”. Each of these municipalities have different invasive species management programs and some of them do not manage invasive species.

Primary species of concern in the region are Giant Hogweed (Heracleum mantegazzianum) and Knotweed species. Giant Hogweed poses significant public safety risks as the plant can cause serious burns from touching it. These burns cause photosensitization that can last up to a decade. The toxic sap from the plant can also cause blindness if it gets into a person’s eyes. In addition to its public safety risks it also causes significant ecological damage in riparian areas. The plant is quick to establish and displaces native vegetation. It has no wildlife value.

Knotweed species pose significant risks to infrastructure and the environment. Considered one of the most invasive plants in the world, the Metro Vancou-
ver region is seeing the plant growing through roads, out of the bottom of bridge footings, through retaining walls and driveways. In some riparian areas we are seeing changes to the hydrology of streams as the plant forms islands in creeks and has also completely displaced native vegetation. There is evidence of erosion and turbidity issues as a result.

Given the health and safety concerns of these species, it is critical in a region so highly populated in a small geographic area that we are able to effectively communicate to the public and to politicians about the potential impacts of these species. In an era where the brochure is becoming passé, we needed to look at other mediums to get important information out to the public and focus our efforts on those that will effectively take advantage of information sharing methods quickly. Further to that, conducting this type of work in a highly populated area, effective and efficient outreach is vital as one organization will not be able to answer all public inquiries or do enough public presentation to reach the entire population.

While most organizations are making use of websites, Twitter, facebook, and blogs, we found that many opportunities are being lost as these avenues of communication are not being used effectively or being used to leverage funding and support for their cause.

Understanding what each of the new communication avenues can do to spread the word about invasive species is critical as each serves a very different function. Organizations must ask themselves who their target audiences are for each type of outreach. Who will be looking at your website? Who will be reading your blog? Who will follow you on Twitter? Who will check you out on facebook? The audiences for each of these are often very different but all very important.

**Branding is everything**

Before diving into any of the above mentioned social media outlets, creating brand recognition around a high-profile looking brand is one of the most important investments an organization can make. A simple, home-made look will not effectively position an organization to attract financial support or general support for the organization's mission. **Funders want to invest money where it looks like there is already money.** The public and funders like and trust a “high capacity” appearance. First impressions are everything.

**More Than a Web Presence**

While an organization's branding is its outreach cornerstone, its website is its outreach foundation. First impressions are important and this is often the first impression of the organization.

An effective website is one that provides multiple outreach opportunities. It is not merely a web presence but provides multiple avenues to provide information to all of the organization's audiences in an attractive, engaging way. Examples from the Invasive Species Council of Metro Vancouver include a blog that is used to engage the public in what on-the-ground activities the organization is working on and also engages funders on a daily basis. Feedback from funders is that they really like the blog section of the website as they can check in to see how money is being spent and share the link with others from the funding agency. Making funders feel good and showing the public that you are out working on the issue are very important to strengthening those relationships.

The bottom line is that a website must be dynamic. Having merely a web presence is no longer sufficient. Mechanisms must be built into the site so that every time someone returns to the site, something is different. This can be as simple as rotating videos or pictures or even having your latest Tweets appear on the home page. Keeping it fresh keeps people coming back. Keeping it fresh relays the message that you are relevant and leaders on the issue.

**Website Analytics**

Proper analytics of your website is what will help you to continue to make your website a wealth of relevant information to your target audiences. Website analytics, such as Google Analytics, allows you to track all of information pertaining to your website. You can see who is visiting your site, where they come from, what pages they are looking at, how they got to your site, what search words they might of used to end up at your site etc. This is very important information as it allows you to see who the main audiences for your website are and what kind of information they are seeking. This then allows you to build the parts of your website that are most popular and helps you to prioritize where to spend the time, energy and funding on it.

**The Outreach Gateway**

Physical outreach materials no longer have to be an
end in them selves. Physical outreach materials such as signs, brochures and postcards are now a gateway to providing your audiences with further information. QR codes, short for Quick Response Code, is a type of barcode that allows a person to use an App on their Smartphone to scan the code and immediately be redirected to a webpage. Having one of these codes on these types of materials increases the efficacy of your outreach tenfold. Your audience is able to get more information right away which often results in a greater amount of awareness or commitment to your cause from your audience. As an example, the Invasive Species Council of Metro Vancouver uses QR Codes on their herbicide signage. All herbicide treatment sites require signage and given the extreme sensitivity by most of the public in our region about any pesticide use, it was important to the survival of our treatment program that we be able to be as transparent as possible about our treatment sites, why we are using chemicals and what the species are that we are treating. Through Google Analytics (mentioned above), we can track how many people are using the QR code and where they are located which gives us valuable information about the members of the public and the relative level of concern in the different areas of the region where we conduct control activities.

**The Facebook and Twitter ‘Thing’**

I often hear references by organizations to the different social media outlets that, “we should be using that facebook thing”, or I guess we should be “tweeting” and then these organizations have a student sign them up without them understanding the power of these “things”. Social media outlets change quickly and while it may not be possible to spend the time and energy learning about them and staying in touch with the latest and greatest, every organization needs to have someone that does. This “someone” not only needs to know social media tools work, they need to know to use them to leverage funding, get media attention on your cause, and have your organization’s name be recognized by all levels of politicians. This “someone” also needs to recognize that the different social media outlets, namely Facebook and Twitter, have two very distinct roles to play in electronic outreach.

Facebook really is an extension of your website. It gives anyone interested in your organization a deeper look into your daily activities, special projects, things that you are working on. You can easily post additional photos or links to other resources. By posting these additional materials, those who “like” your Facebook page, can then share them with their friends. This greatly increases your reach and you may then have access to audiences you wouldn’t normally.

Twitter for the invasive species world is really less about who is following you and more about who you are following. While it is beneficial to have lots of followers on Twitter, its real power for our purposes is to use it to raise awareness about our cause to politicians of all levels and to the media. Twitter is so powerful because it gives you a new type of access to politicians. While politicians may not directly handle their Twitter account (many do), you have an easier access to them and their staff than ever before. By sending a message to a politician, suddenly you have gone around many layers of bureaucracy and been able to put your cause forward to that person. In the past, you would have written a letter perhaps and it would slowly funnel its way through the chain of command likely never landing on the desk of the politician.

As an example, if your organization is trying to lobby support from an Environment Minister, you can Tweet something about your issue and name the Minister (if they have a Twitter account). What you have to realize is that the media and many members of the public follow these important people on Twitter. They may see your Tweet if they are following mentions of that particular person. This has worked successfully a number of times for the Invasive Species Council of Metro Vancouver where the media has ended up picking up a story because we Tweeted about an important story in our region and how the issue had not been enough of a priority by local politicians.

**The Power of Images**

As the cliché goes, “a picture is worth a thousand words”. In our line of business, collecting evidence of damages caused by invasive species is crucial to helping those outside of our field to understand the importance of the issue. The collection of high quality images and videos should be a high priority for any organization. As an example, the Invasive Species Council of Metro Vancouver crew is equipped with their own iPad and the images they have collected have been an integral part of very important presentations to politicians and were instrumental in leveraging funds. Presentations that compel people are not ones where slides are full
A recent presentation I gave only had pictures and resulted in a funding opportunity and a media frenzy. Have good quality gear out in the field whenever possible and photograph everything. It is so much easier to pitch your cause when you have images that are from your own part of the world. This makes the issues tangible, understandable and can hopefully be used to leverage funding and or support for your cause.

**Breaking Away from the Brochure**

In a short time, outreach has transformed from a rather static piece of information to a portal of fast paced possibilities. The resulting transformation is a breaking down of barriers to access people of influence including politicians, policy makers, funders and the media. This transformation is also resulting in a greater hunger from the public for high quality materials to learn more about our cause. A better informed public can help to reduce the spread of invasive species and help to pressure politicians to recognize that this is a high priority issue. Effective reach in this “post brochure era” demands that organizations stay on top of available social media outlets and outreach technology and I can’t wait to see what we can use next!

---

**Implementing Noxious Weed Management in Tribal, County, State, and Federal Multi-jurisdictional Settings**

Implementando el manejo de malezas nocivas a nivel comunitario, municipal, estatal y federal bajo contextos jurisdiccionales múltiples

Virgil Dupuis

*Extension Director / Director de Extensión*

Salish Kootenai College / Colegio Salish Kootenai

PO Box 70 Pablo, MT 59855

virgil_dupuis@skc.edu

**Resumen**

El manejo eficaz de malezas nocivas dentro de propiedades y jurisdicciones múltiples incluyendo a comunidades indígenas, municipios y entidades estatales, agencias federales, intereses internacionales, e individuos requiere de capacidades de comunicación específicas y un entendimiento de las diferentes capacidades, prioridades, y procesos que cada actor ostenta. Las comunidades indígenas tienen papeles múltiples como terratenientes, implementadores de normas ambientales de comunidades indígenas y federales, protectores de recursos sociales y culturales, y son la fuente de la mayor parte de la actividad económica en las reservas. Las cuestiones de salud pública siempre se levantan cuando se usan pesticidas como herramienta de manejo. La tenencia complicada y el uso de tierra en comunidades indígenas y el entremezclado con la tierra estatal, federal, y privada crea problemas adicionales de coordinación. Las comunidades nativas a menudo carecen del personal y recursos para planear y poner en práctica programas y coordinarse con entidades exteriores en esfuerzos regionales de planificación.

Las comunidades indígenas se involucran cada vez más en el manejo de especies invasoras, desarrollando programas, regulaciones de plantas y pesticidas, y participando en proyectos cooperativos de manejo de malezas nocivas. Es necesario de informar y coordinarse con las autoridades tribales, los profesionales de recursos tribales, y las sociedades tribales de las comunidades indígenas sobre oportunidades de manejo de malezas cooperativas, en particular en la formulación de procedimientos de respuesta rápida. Las comunidades indígenas son más eficaces cuando ellos pueden liderar el manejo de sus infestaciones con malezas nocivas, coordinando con terratenientes circundantes, y trabajando con varias jurisdicciones gubernamentales en el manejo cooperativo y esfuerzos de prevención.

**Abstract**

Effective noxious weed management within multiple ownerships and jurisdictions involving tribal governments, county and state entities, federal agencies, international interests, and individuals requires special communications and understanding of the differing capacities, priorities, and processes each party possess. Tribes have multiple roles as landowner, enforcer of tribal and federal environmental regulations, protector of social and cultural resources, and are the source
of most of the economic activity on the reservation. Public health issues always arise when pesticides are used as a management tool. A complicated Tribal land ownership and use pattern intermixed with state, federal, and private land creates extra coordination issues. Tribes often lack the personnel and resources to plan and implement programs and coordinate with outside entities on regional planning efforts.

Increasingly tribes are becoming more involved in managing invasive species, developing programs, plant and pesticide regulations, and participating in cooperative projects to manage noxious weeds. There is a need to inform and coordinate with tribal leadership, tribal resource professionals, and the tribal membership about cooperative weed management opportunities, particularly in formulating rapid response procedures. Tribes are more effective when they can take the lead in managing their noxious weed infestations, coordinate with surrounding landowners, and working with various governmental jurisdictions in cooperative management and prevention efforts.

Canada: Organizing Nationally
Canadá: organización a nivel nacional

Barry Gibbs
Executive Director / Director Ejecutivo
Alberta Invasive Plants Council & Canadian Invasive Plant Council, Invasive Species Council of BC
Suite 104- North 2nd Avenue Williams Lake, BC
aipc.executivedirector@gmail.com

Resumen
Las especies invasoras no reconocen ningunos límites y con frecuencia se dispersan a través de tierras públicas y privadas y fronteras nacionales e internacionales. Columbia Británica no es ninguna excepción ya que las especies invasoras se introducen y se disper san entre la provincia y nuestros vecinos, incluyendo a Alberta, Washington e Idaho, a través de actividades sociales (viajes, canotaje, pesca, excursionismo a pie, y horticultura), actividades económicas (importación y exportación de bienes), y actividades culturales.

Abstract
Invasive species know no boundaries and frequently spread across public and private lands and national and international borders- Canada is no exception to this. Canada is working towards enhancing invasive species management across the country through increasing collaboration, networking, and creating novel and readily available management techniques.

One of the more recent endeavours that invasive species organizations across the country are investigating focuses on one of the key pathways of invasive species introduction and spread- social activities. Organizations are working towards finding out how social activities, for example, boating, fishing, hiking and gardening, contribute to the introduction and spread of invasive species and how associated pathways of introduction and vectors of spread can be effectively managed.

Currently in British Columbia, efforts are being to reduce the spread of invasive species within the province and across borders. Through partnership with regional invasive species committees, the Invasive Species Council of BC is implementing a provincial “Clean, Drain, Dry” program. This program is based on community based social marketing principals that are designed to develop activities aimed at changing or maintaining people’s behaviour for their benefit. The primary goal of this program is to change the behaviour of freshwater boaters to reduce the introduction and spread of aquatic invasive species both within British Columbia and beyond. The program encourages boaters to ‘Clean, Drain, and Dry’ their boats after leaving one water body and entering another, preventing the introduction and spread of aquatic invasive species.

The outcome of the Clean, Drain, Dry program will provide the foundation for a provincial social behaviour change plan. The goal of the plan is to measure tangible changes in behaviour that reduce the spread of invasive species. The social behaviour change plan will define specific behaviours that can be monitored.
and evaluated over time. The plan will be made available to everyone working to prevent and manage invasive species in British Columbia.

**Presentation Summary**

**The Canadian Invasive Species Council**

Invasive plant and animal species groups are now working in partnership to build upon the lessons learned in each province or territory to improve public awareness of invasive alien species. Detecting emerging invasive species early is integral to prevention, as once established, they spread rapidly, causing damage to the environment, economy, and/or human health. Accordingly, invasive species councils, committees, and coalitions representing the majority of provinces and territories in Canada have formed a National Invasive Species Council to work together to reduce the impact of invasive species across the country. The Council works collaboratively across jurisdictional boundaries to support actions and provide information that can help reduce the threat and impacts of invasive species. The Council was formed as a result of a joint meeting early in 2009 where 10 provinces and two territories voiced the desire to share knowledge across Canadian borders, as invasive species ‘know no boundaries’. Together, members agreed that a national working group would help build bridges across Canada to work together in the battle against invasive species. As of 2012, the Council’s is composed of the following organizations:

1. **Invasive Species Council of BC (iscbc):** is a registered charity that aims to improve the coordinated management of invasive species across the province and beyond borders. The Council works with agencies and residents collaboratively to minimize the environmental, economic, and social impacts of invasive species. The Council works through building collaboration on mutual priorities determined by its diverse membership from private organizations, governments and individuals. The Council’s representative Board of Directors implements members’ key priorities in collaboration with Regional Committees and other partners.

2. **Alberta Invasive Plant Council (aipc):** is a registered non-profit society that provides leadership and expertise to engage, enable, and empower Albertans to take action on invasive plant issues. Council members share an interest in understanding invasive plant issues and fostering viable prevention and management strategies. The **aipc** works to increase awareness of the impacts of invasive plants in collaboration with stakeholders.

3. **Saskatchewan Invasive Species Council (sisc):** is a not-for-profit association of professionals from federal, provincial, municipal governments, industry and non-government organizations. Council members are knowledgeable on invasive species or their management. The **sisc** was formed in 2008 to address the lack of coordination and understanding associated with invasive species within the province of Saskatchewan and across Canada. Their vision is to work together to ensure Saskatchewan’s environment, economy and social interests are protected through permanent control and eradication of invasive alien species.

4. **Invasive Species Council of Manitoba (iscm):** is a non-profit organization providing a centralized and coordinated province-wide leadership body adopting a collaborative approach to the prevention, early detection, management and potential eradication of invasive species in Manitoba. The **iscm** was formed out the demand for collaboration among stakeholders in December of 2006, and continues to grow and gain momentum. Their vision is to maintain a healthy, bio-diverse landscape through the prevention, early detection, and education and awareness of invasive alien species management practices in order to eradicate or limit further spread.

5. **Ontario Invasive Plant Council (oipc):** is a non-profit, multi-agency organization founded in April 2007 by a group of individuals and organizational representatives who saw the need for a coordinated provincial response to the growing threat of invasive plants. The **oipc** is currently housed within the Ontario Federation of Anglers and Hunters, a non-profit, charitable organization providing the **oipc** with administrative support and office space in its initial stages. Their purpose is 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.

6. **Québec Interdepartmental Committee on Invasive Species:** is an inter-ministry committee that facilitates networking between government ministries and agencies to develop a priority invasive species list, outreach materials, promote research,
and a rapid response plan to fight against invasive species. Its purpose is to share information, network, and develop a common vision on invasive species.

7. **Memorial University of Newfoundland Botanical Garden Inc:** as part of the University’s inclusive community, is a non-profit corporation that creates and inspires understanding, appreciation, and conservation of plants in gardens and natural areas to further the Memorial’s mission of research, education, and outreach. They also provide information and resources on invasive alien species impacting Newfoundland.

8. **New Brunswick Invasive Species Council (nbisc):** is a collaborative initiative involving a number of agencies formed to address the lack of coordination and understanding associated with invasive species within the province of New Brunswick and across Canada. Their vision is to work together to ensure New Brunswick’s environment, economy, and social interests are protected through the prevention, early detection, and education and awareness of invasive alien species. They fulfill this vision through best management practices in order to control and eradicate invasive alien species.

9. **Prince Edward Island Invasive Alien Species Working Group:** is led by the P.E.I. Nature Trust, a non-profit organization dedicated to the protection and management of rural areas on Prince Edward Island. Their objectives are to acquire and hold lands and waters in order to ensure the proper use of plants and animals.

10. **Invasive Species Alliance of Nova Scotia (IsANS):** is a non-profit group of individuals and organizations focused on improved communication and information sharing to better address the threat of invasive alien species at the provincial level. IsANS is hosted by the Acadia Centre for Estuarine Research (acER) at Acadia University, centrally located within the province.

11. **Yukon Invasive Species Council (YISC):** is a registered non-profit society formed to prevent the introduction and manage the spread of invasive species in the Yukon. This is accomplished by educating and advising the public and professional about invasive species and their risk to ecosystems and economies; actively collaborating with other jurisdictions; and encouraging, promoting, and supporting research on invasive species.

12. **Government of the Northwest Territories, Department of Environment and Natural Resources:** promotes and supports the management and sustainable use of renewable resources, the protection and conservation of the environment and wildlife in the Northwest Territories, including the management of invasive alien species.

Currently, the Canadian Invasive Species Council’s key areas of focus include:

1. Sharing inventory data across the country- this is being done by sharing information on data tracking systems.
2. Partnering with the horticulture industry and promoting Grow Me Instead- the goal here is to encourage garden enthusiasts to identify invasive plants used in garden practices and provide them with suitable native alternatives to plant instead.
3. Sharing and linking existing Spotter’s Program across Canada- The premise of this program is to increase the number of eyes on the ground, looking for and reporting invasive species across the country.
4. Hosting bi-annual national invasive species forums.

**The Invasive Species Council of BC and Community Based Social Marketing**

Through province-wide cooperation and coordination, the Invasive Species Council of BC (ISCBC) is working to minimize the negative ecological, social, and economic impacts caused by the introduction, establishment, and spread of invasive species. The ISCBC is a registered charity whose members are involved in all aspects of invasive species management. The key goals of the ISCBC are to:

- To educate the public and professionals about invasive species and their risk to ecosystems and economies;
- To coordinate and fund research relating to invasive species and make this available to the public; and
- To undertake and support actions that improve the health of BC’s natural ecosystems

Traditionally, the Council’s programs and project deliverables were based largely on the number of brochures created, number of people in attendance at education/outreach events, number of book marks delivered, workshops participants, etc. The problem
with measuring success by events and paper resources is there is no way to qualify or quantify their impact on people's behaviours. Accordingly, the Council is shifting towards adopting the principals of Community Based Social Marketing (CBSM) as a key tool used to promote changing the behaviour of BC citizens towards invasive species. By applying CBSM principles, the Council is enabled to both quantitatively and qualitatively measure program impacts and outcomes. There are 6 key principals involved in CBSM, as outlined below:

1. Identify a specific behaviour that needs to be changed to help reach your project goal
2. Identify target group that needs to adopt the behaviour change (research/observation)
3. Identify existing barriers that prevent the desired behaviour from occurring
4. Remove or address these barriers
5. Gain personal commitments from target group to adopt new behaviour
6. Measure the behaviour change

In 2012, the ISCBC initiated its first behaviour change program, titled Take Action. This is a two year program, funded by the provincial government, which is designed to change the behaviour of citizens as way to help to stop the introduction and spread of invasive species in BC. The initial focus was on the behaviour “Clean, Drain, Dry”. By using CBSM principles and methods, this project has been designed to reduce the spread of aquatic invasive species by changing boater behaviour so that they clean, drain and dry their boats and boat trailers before entering or leaving a body of water. This behaviour was chosen after baseline data was collected on the primary pathways for invasion - the results of data collected indicated that boating was identified as a key pathway. This behaviour was also chosen as similar programs had been carried out successfully in New Zealand, Idaho and other areas, allowing the council to “borrow” ideas and resources for the development of the Council’s program. The Clean Drain Dry program will roll out over the summer months of 2012, with preliminary results expected by fall 2012.

The second desired change will focus on a behavior linked to horticulture, likely the disposal of garden waste. The ISCBC is currently working on developing this portion of the program and implement it across the province in 2013.

The outcome of the Take Action program will provide the foundation for a provincial social behaviour change plan. The goal of the plan is to measure tangible changes in behaviour that reduce the spread of invasive species. The social behaviour change plan will define specific behaviours that can be monitored and evaluated over time. The plan will be made available to everyone working to prevent and manage invasive species in British Columbia.

Positive Actions, Healthy Environments: Changing Behavior to Protect Our Resources from Invasive Species

Acciones positivas, ambientes sanos: Cambiando nuestro comportamiento para proteger a nuestros recursos de las especies invasoras

Barry Gibbs
Executive Director / Director Ejecutivo
Alberta Invasive Plants Council & Canadian Invasive Plant Council, Invasive Species Council of BC
Suite 104- North 2nd Avenue Williams Lake, BC
aicp.executivedirector@gmail.com

Resumen
Se están realizando esfuerzos para reducir la dispersión de las especies invasoras dentro de Columbia Británica y a lo largo de sus fronteras mediante un programa provincial que se llama “Limpiar, Drenar, y Secar”. Este programa está basado en principios de mercadotecnia social de comunidades, diseñados para desarrollar actividades dirigidas a cambiar o mantener el comportamiento de la gente para su propio beneficio. El objetivo principal de este programa es cambiar el comportamiento de usuarios de embarcaciones, en cuerpos de agua dulce, para reducir la introducción y la dispersión de especies invasoras.
acuáticas tanto dentro de Columbia Británica como fuera de ella. El programa anima a usuarios de botes a “Limpiar, Drenar, y Secar” sus botes después de salir de un cuerpo de agua y antes de entrar en otro, previniendo la introducción y la dispersión de especies invasoras acuáticas.

El resultado del programa “Limpiar, Drenar, y Secar” proporcionará la base para un plan provincial de cambio de comportamiento social. El objetivo del plan es medir cambios tangibles del comportamiento que reducen la dispersión de especies invasoras. El plan de cambio de comportamiento social definirá comportamientos específicos que pueden ser monitoreados y evaluados con el tiempo. El plan estará disponible para todos los que trabajan en la prevención y manejo de especies invasoras en Columbia Británica.

**Abstract**

Efforts are being made to reduce the spread of invasive species within British Columbia and across borders through a provincial “Clean, Drain, Dry” program. This program is based on community based social marketing principals that are designed to develop activities aimed at changing or maintaining people’s behavior for their benefit. The primary goal of this program is to change the behavior of freshwater boaters to reduce the introduction and spread of aquatic invasive species both within British Columbia and beyond. The program encourages boaters to ‘Clean, Drain, and Dry’ their boats after leaving one water body and entering another, preventing the introduction and spread of aquatic invasive species.

The outcome of the Clean, Drain, Dry program will provide the foundation for a provincial social behavior change plan. The goal of the plan is to measure tangible changes in behavior that reduce the spread of invasive species. The social behavior change plan will define specific behaviors that can be monitored and evaluated over time. The plan will be made available to everyone working to prevent and manage invasive species in British Columbia.
Resumen

Aunque ha habido un progreso sustancial en la comprensión de los atributos de las plantas responsables, o al menos de aquellos atributos correlacionados con, la reproducción exitosa y dispersión de especies de plantas invasoras, nuestra habilidad para predecir sus impactos o incluso medir sus impactos utilizando métodos estandarizados es aún muy rudimentaria. Recientemente se han publicado diversos meta-análisis basados en datos publicados sobre los impactos ecológicos de plantas invasoras. En general, concluyen que muchas plantas exóticas tienen efectos negativos estadísticamente significativos sobre la abundancia, adaptabilidad y diversidad de plantas nativas. Al menos 80% de más de 1000 estudios de campo incluidos en dichos meta-análisis se basaron en un enfoque de “sustitución de espacio por tiempo”. Sin embargo sin datos sobre el estado de pre-invasión de los sitios invadidos y los no invadidos, las conclusiones pueden ser engañosas y no se puede concluir con seguridad si las especies no nativas realmente tenían un impacto negativo sobre la diversidad de las especies nativas. Aunque el enfoque de tiempo (comparaciones de parcelas permanentes en situaciones de pre y post invasión) aparentemente es la única opción para resolver las limitaciones anteriores y cumple el propósito de medir el impacto real de especies no-nativas, puede generar conclusiones erróneas también. Sin datos sobre hábitats equivalentes no-invadidos en situaciones de pre y post invasión no es posible estimar la dirección de los efectos de especies no nativas ni sus magnitudes. Los experimentos de competencia que generalmente están limitados solamente a pares de especies pueden ser una opción. Las respuestas a invasores en comunidades de multi-especies pueden ser evaluadas en experimentos de adición de invasores, experimentos de remoción de invasores y experimentos en los que se analiza la colonización pasiva de monocultivos de invasores. Preferentemente, en todas las situaciones se deben prever y evaluar sistemáticamente los mecanismos múltiples de impactos de especies invasoras. Los modelos demográficos de matriz son un método cada vez más estándar para la evaluación cuantitativa de los impactos de los invasores sobre las especies de plantas amenazadas.

Abstract

While there has been substantial progress in understanding plant attributes responsible for or, at least, correlated with successful reproduction and spread of invasive plant species, our ability to predict their impacts, or even measure their impact using standardized methods, is still very rudimentary. Several meta-analyses of published data on ecological impacts of invasive plant species have been published recently. In general, they conclude that many alien plants have a statistically significant negative effect on native plant abundance, fitness, and diversity. At least 80% of over 1000 field studies included in these meta-analyses were based on a ‘space-for-time-substitution’ approach. However, without pre-invasion data from the invaded and non-invaded sites, conclusions may be misleading and one cannot conclusively determine whether non-native species really had a negative impact on diversity of native species. Although the time approach (comparisons of permanent plots in pre- and post-invasion situations) is apparently the only option for resolving the above limitations and serves the purpose of measuring the real impact of non-native species, it can nonetheless produce mistaken conclusions as well. Without data from equivalent non-invaded habitats in pre- and post-invasion situations, one may not estimate the direction of the effects of non-native species, nor their magnitudes. Competition experiments that are usually limited just to pairs
of species represent one option. Responses to invaders in multispecies communities can be evaluated in invader addition experiments, invader removal experiments, and experiments where passive colonization of invader monocultures is analyzed. Preferably, in all situations multiple mechanisms of impacts of invasive species should be anticipated and systematically tested. Demographic matrix models are an increasingly standard method for quantitative evaluation of invader's impacts on endangered plant species.

Presentation Summary

How to assess impacts of plant invaders on native plant species diversity?

Seedlings and young plants of Rhododendron ponticum are occasionally found at a considerable distance from the nearest adult shrub, but most of the woods away from the plantations of the shrub are still free from it. It seems likely, however, that the invasion is progressive. If the replacement of Ilex aquifolium by Rhododendron is really progressive it is an interesting example of an apparently rare phenomenon – the successful invasion of an undisturbed community by an exotic species.

Tansley, 1939, p. 339

The above quotation from Tansley’s magnum opus is educational in many ways. First, Tansley was asking several basic questions that are still highly relevant for current invasion biology: Is invasion ongoing, or even accelerating? How far does the species disperse? What is the ecological impact? What is the role of disturbance? How often are undisturbed plant communities invaded? Importantly, however, there is not much more about invasive plants in Tansley’s book besides the few lines quoted above. Tansley’s book was rather typical in terms of the limited appreciation of the importance of invasive plants at that time. The situation changed rather rapidly from about middle of the last century, after Elton’s (1958) The Ecology of Invasions by Animals and Plants, but particularly after the first SCOPE International Program on Biological Invasions (Drake et al., 1989). Currently, several books on biological invasions are published every year and the number of papers in journals is increasing exponentially.

Most human-introduced plant species stay in disturbed areas or are incorporated into resident plant communities and have no noticeable or measurable impact. Plant invasions are very often just symptoms of human-created changes in our environment rather than causes of those changes (Farnsworth, 2004; Maskell et al., 2006; Mills et al., 2009; Cratford et al., 2012). I other words, they are more often “passengers” than “drivers” of environmental change (MacDougall & Turkington, 2005; Wilson & Pinno, 2012). In fact, some non-native plants species may have even positive environmental effects in some situations (Shapiro, 2002; Fisher et al., 2009; Lescano & Farji-Brener, 2011). However, a small percentage of introduced plants do have substantial environmental and/or economic impacts (Richardson et al., 2000; Williams et al., 2010; Ehrenfeld, 2011; Simberloff, 2011; DiTomaso & Barney, 2012; Grant & Paschke, 2012). This is the main reason for the explosion of research interest in biological invasions. There are three perennial questions of plant invasion biology:

1. What kind of plants are the most successful invaders and under what circumstances?
   In other words: What makes some plant taxa more invasive (reproducing and spreading in areas where they are not native)?

2. What kind of ecosystems are more (or less) likely to be invaded by alien plants? In other words: What makes particular ecosystems more invasible?

3. What is the impact of plant invaders? This includes environmental impacts, economic impacts, impacts on human health and on landscape aesthetics.

Over last 30 years, we made substantial progress in answering the first two questions. We understand much better which plant attributes are responsible for, or, at least, correlated with successful reproduction and spread of invasive plant species (e.g., van Kleunen et al., 2010; Barrett, 2011; Rejmánek, 2011; Dawson et al., 2012). Similarly, invasibility of plant communities is no longer just a black box (e.g., Levine et al., 2004; Fridley et al., 2007; Fridley, 2011; Rejmánek et al., 2012). However, our ability to predict impacts of invasive plant species, or even measure their impact using standardized methods, is still very rudimentary.

There are several cases where the impacts of invasive plant species on whole ecosystems are obvious. Examples of such so called “transformer species” or “transformers” are fire-promoting grasses (e.g., Andropogon gayanus, Bromus tectorum, Melinis minutiflora), fast-growing vines (Cryptostegia grandiflora, Lygodium peltatum, Melastoma malabathricum), and fire-promoting shrubs (e.g., Elaeagnus angustifolia, Lantana camara, Rhus aromatica).
spp., *Pueraria montana* var. *lobata*), donors of limiting resources (nitrogen: *Acacia* spp., *Morella faya*, *Robinia pseudoacacia*; phosphorus: *Buddleja davidii*, *Centaurea maculosa*, *Solidago gigantea*), colonizers of intertidal mudflats (*Spartina* spp., *Rhizophora* spp.), and aquatic plants with vigorous vegetative propagation (*Eichhornia crassipes*, *Salvinia molesta*). However, for majority of invasive (non-native and spreading) plant species we are just guessing what their impacts may be. Unfortunately, the shortage of hard data is often substituted by premature alarming statements about harmfulness of non-native species (Theodoropoulos, 2003). Among the most often discussed environmental impacts are the impacts of plant invaders on diversity of native plant species. The rest of this review will concentrate on this topic.

It is important to stress that the impacts of invasive plants on biodiversity are generally less dramatic than the impacts of non-native pathogens (Fisher et al., 2012), herbivores (Spear & Chown, 2009), or predators (Fritts & Rodda, 1998). Elimination of such key-stone invaders like goats or feral pigs should be always the priority. There are at least 3000 naturalized plant species in North America and more than 1000 of them are invasive. However, not a single native plant species is known to have been driven to extinction due to interactions with alien plants alone. Even on islands, where numbers of non-native plant species are often increasing exponentially, extinctions of native plant species cannot be attributed to plant invasions per se (Sax et al., 2002). Also, the often reported positive correlation between numbers of native and non-native plant species on the landscape scale (Stohlgren et al., 2006) can be interpreted as a lack of mechanisms for competitive exclusion of native plants by non-native ones. Nevertheless, we should be careful with conclusions – many invasions are quite recent and extinction takes a long time.

Several meta-analyses of published data on ecological impacts of invasive plant species have been published recently (Gaertner et al., 2009; Powel et al., 2011; Vilà et al., 2011). In general, they conclude that many alien plants have a statistically significant negative effect on native plant abundance, fitness, and diversity. At least 80% of over 1000 field studies included in these meta-analyses were based on a ‘space-for-time-substitution’ approach. However, without pre-invasion data from the invaded and non-invaded sites, conclusions may be misleading and one cannot conclusively determine whether non-native species really had a negative impact on diversity of native species (Fig. A). Although the time sequence approach (comparisons of permanent plots in pre- and post-invasion situations) is apparently the only option for resolving the above limitations and serves the purpose of measuring the real impact of non-native species, it can nonetheless produce erroneous conclusions as well (Fig. A). Without data from equivalent non-invaded habitats in pre- and post-invasion situations, one may not estimate the direction of the effects of non-native species, nor their magnitudes (Clarke et al., 2005; Rooney & Rogers, 2011). Finally, for the sake of simplicity, only two points in time are used in Fig. A. This should not create an impression that relationships between invasions in time and species diversity changes are linear. Probably most often, they are not (Rejmánek & Rosén, 1992; Thiele et al., 2010, 2011). For example, invasive species may initially facilitate establishment of some native species. Later, however, when the invasive's density or cover increases, competition and elimination of native species may prevail. This has apparently been the case for some mobile Californian coastal dunes stabilized by introduced “phalanx” European beach grass (*Ammophilla arenaria*).

Greenhouse and garden competition experiments represent one option how to assess potential impact of invasive plant species (Nernberg & Dale, 1997; Rejmánek et al., 1989; Gibson et al., 1999; Call & Nielsen, 2005; Garcia-Serrano et al., 2007; Meyer et al., 2010; Mangla et al., 2011). Such experiments are usually limited just to pairs of species and most commonly performed as simultaneous cultivation of seedlings of invasive and native species in mixtures. However, in nature, the most common situation is that seedlings of invasive species are competing with already established native plants. In general, outcomes of interspecific competition depend on the life-cycle stage at which the interaction occurs (Barrat-Segetain, 2005; Lamb & Cahill, 2006; Gómez-González et al., 2009). Moreover, realistic spatial aggregation of competing populations can change outcomes of competition as well (Rejmánek, 2002). Also, it is important to realize that declines in species richness associated with exotic plant invasions may result from negative effects on local recolonization by natives and not from competitive displacement of established individuals of native species (Yurkonis & Meiners, 2004). Many different field experiments on competition between
native and introduced plant species have been gaining momentum in recent years (Caldwell et al., 1985; Gaudet & Keddy, 1988; Kueffer et al., 2007; Maron & Marler, 2008). An ongoing discussion about differences between intensity and importance of competition (Freckleton et al., 2009; Kikvidze et al., 2011) is extremely relevant in this context.

Responses to invaders in multispecies plant communities can be evaluated in invader addition experiments (Maron & Marler, 2008b; Meffin et al., 2010). Perhaps, mainly for ethical reasons, such experiments are very rare. The paper by Meffin et al. (2010) could serve as a model study showing how properly designed experiments of this kind should be conducted. Differences in species richness between original native vegetation and planted exotic monocultures (Richardson & van Wilgen, 1986) may be used to represent the worst possible impacts of severe invasions by alien trees. Invader removal experiments are much more common (McCarthy, 1997; Alvarez & Cushman, 2002; Schutzenhofer & Valone, 2006; Castro et al., 2010). However, there are many problems associated with this kind of experiments. First, it is very difficult to remove mechanically particular species populations without creating some disturbance of soil surface. Usually, we do not have species-specific herbicides. Exceptional situations are created by efficient species-specific biocontrol agents (Rayamajhi et al., 2009). Second, the obvious question arises: would removal of some dominant native species have the same effect? Third, effects of an invader removal are not necessarily a mirror image of invasion process.

Figure A.
(a) A hypothetical example in which species diversity of non-invaded sites (open circles) remains constant and the native diversity in the invaded sites (black circles) increases over time (trajectory 1), remains constant (trajectory 2) or decreases (3 and 4) over time. Trajectory 1 indicates that non-native species increased the diversity of invaded sites, while trajectory 2 indicates that non-native species had no effects on native diversity, conclusions that are opposite to the one reached by the space-for-time substitution approach, i.e., using post-invasion data only. Trajectories 3 and 4 are in accordance with the finding that non-native species negatively affected native species diversity using the space-for-time approach, but this approach overestimates (trajectory 3) or underestimate (trajectory 4) invasion impact.

(b) A hypothetical example in which diversity of both invaded and non-invaded sites decrease over time. Contrary to what would be suggested by the space-for-time approach, trajectory 1 indicates that the decrease in native diversity was higher in non-invaded than in invaded sites. Trajectory 2 indicates that non-native species had no effect on natives, because the decrease in diversity was the same in both invaded and non-invaded sites (see e.g., Rooney & Rogers, 2011). However, using the space-for-time approach, the real negative impact would be underestimated if temporary changes of diversity followed trajectories 3 or 4, because native diversity decreased more in invaded than in non-invaded sites (see e.g., Flory & Clay, 2010). Modified from Thomaz et al. (2012).
A completely different category of studies on plant invasion impacts are assessments focused on individual native plant species that are assumed to be endangered by exotic plants (Miller & Duncan, 2004; Maroney et al., 2011). Demographic matrix models (Thomson, 2005; Williams & Crone, 2006; Dangremond et al., 2010).

Obviously, there is no one “silver bullet” for evaluation of invasive plant species impacts. There is not, and probably newer will be, a “How to” book for invasive plant impact studies. Proper approaches will depend on life forms of involved species, conservation and/or economic priorities, and available resources. Preferably, in all situations multiple mechanisms of impacts of invasive species should be anticipated and systematically tested (Bennett et al., 2011). Consistent results obtained by application of several different methods will be always more convincing.

References


Invertebrate-Invasive Plant Relationships Shifted by Global Change
Cambios en las relaciones entre invertebrados y plantas invasoras debido al cambio climático

Gabriela Chavarria
Science Advisor / Asesor científico
US Fish and Wildlife Service
1849 C Street, NW Washington, DC 20240
gabriela_chavarria@fws.gov

Other authors / Otros autores:
Jenny Ericson & John Schmerfeld
US Fish and Wildlife Service

Presentation Summary
The relationship between invertebrates and plants is complex and fundamental to the functional health of ecosystems worldwide. Through evolutionary time, most invertebrates have co-evolved with their plant communities and have adapted to the niches created by plant diversity (Tallamy, 2007). As a result, these relationships are quite susceptible to forces that also affect diversity. Ecosystem transformers, such as the introduction of invasive plants and climate changes are two such forces that are now having significant impacts on invertebrate (hereafter, insect) populations. Because interactions between insects and their host plants often vary throughout the ranges of individual insect species, it is important to consider this in the context of range shifts under climate change.

Insect populations are particularly responsive to climate change because much of their life history is influenced by temperature. They are also strongly affected by the quality and availability of plants as food resources. Many insect species can be generally considered to be opportunistic in nature. As such, we are beginning to see that some insect species which are not native to a particular area can become harmful in that area and that other species can become beneficial. Because insects and plants disperse at different rates, geographic range shifts during periods of climate change could differ substantially. We are starting to see how changes in phenology can impact insect populations. For example, native bees such as bumble bees leave hibernation in early spring. However, if the plants they visit at that time have already flowered or are late to flower, bees will not be able to extract the pollen they need to survive and bee populations will be negatively impacted as a result.

In recent years, shifts have occurred in the geographic distribution of some insect species in response to regional changes in the climate. These range shifts are expected to continue into the future. Distributional shifts occur as habitats at pole-ward latitudes and higher elevations become more suitable and individuals disperse and establish in new locales. Studies, such as those done by Parmesan et al. (1999), that focus on butterfly species have shown that some species of non-migratory butterflies have recently shifted their distributions pole-ward or to higher elevations, namely 240 km over 30 years, while the expected average rate that trees can track a changing climate is 20-40 km over 100 years. The disruption of synchronous range shifts between insects and their plant hosts will yield unknown consequences and likely a few surprises. There will be winners and losers.

Geographic turnover in host plants (invasive and native) suitability and availability often results in populations of herbivorous insects that are locally adapted to different host plants throughout the species geographic range, creating a geographic mosaic of host plant specialization. And, in many cases, native in-
sects are adapting to invasive plant species. Hellman et al. (2007) show how certain butterflies in the United States are successfully feeding on new host plants, some are adapting, but others are not. Other studies have shown that some native lepidopterans do not distinguish introduced plants from native plants when depositing eggs even though an introduced plant may be toxic or even lethal to their offspring (Tewksbury et al., 2002). Observations such as this one have given rise to the theory that introduced plants may become evolutionary traps for some invertebrate species (Battin, 2004). In contrast, some invertebrates, such as the native soapberry bug (*Jadera haematoloma*) have successfully adapted to evolutionarily novel host plants (Carroll et al., 1997, 1998), which would represent an evolutionary release versus an evolutionary trap (Schlaepfer et al., 2005).

Insect-plant interactions must be considered when predicting the impacts of climate change given that local adaptation to host plants has been demonstrated in a variety of insect species throughout their geographic ranges.

Finally, it is important to consider how invasive plant control and management strategies are impacting invertebrate species. For example, every year honey bees in the United States are transported across the country to meet the needs of industrial agriculture, which tends to grow crops in monocultures. The bees are transported because of the lack of available food in given areas throughout the year. Transportation is synchronized with the flowering season of plants so that as transportation takes place the trucks carrying the hives stop along the way to enable the bees to feed in large areas of flowering plants. Unfortunately these areas are often populated by large infestations of invasive plants. And, in some cases, the plants have been treated with pesticides exposing the bees to toxins that, in some cases, may constitute unlabeled chemicals.

**References**


Invasive Species and Climate Change in the National Wildlife Refuge System
Especies invasoras y cambio climático en el Sistema Nacional de Refugios para Vida Silvestre

John Schmerfeld
Climate Change Coordinator / Coordinador de Cambio Climático
National Wildlife Refuge System, USFWS
4401 N Fairfax Dr. Arlington, VA 22203 USA
schermfeld@fws.gov

Other authors / Otros autores:
Collette Thogerson & Jenny Ericson

Resumen
Brindar una panorámica de la estructura y organización del Sistema Nacional de refugios para la Vida Silvestre del USFWS, así como de sus iniciativas de planeación estratégica para el cambio climático. El autor discutirá la visión del sistema de refugios en el contexto de evaluación de su vulnerabilidad ante el cambio climático y la planeación adaptativa y relacionará estos esfuerzos con casos específicos de manejo de especies invasoras en diversos refugios.

Abstract
Provide an overview of the USFWS National Wildlife Refuge System structure and organization and its climate change strategic planning initiatives. The author will discuss Refuge System vision within the context of climate change vulnerability assessment and adaptation planning and will relate these efforts to invasive species management with specific examples from several refuges.

Presentation Summary
The National Wildlife Refuge System (NWRS) is managed by the U.S. Fish and Wildlife Service (Service) and is one of the world's premier systems of public lands and waters established to conserve fish, wildlife and plants in the United States. Climate change has and will continue to facilitate the spread of invasive species through the NWRS. In turn, invasive species increase the vulnerability of ecosystem resilience to other climate-related stressors. Using an ecosystem-based adaptation approach can help to reduce pressures of climate change by preventing the expansion of new invasive species and eradicating or controlling existing ones.

Background
The Service's NWRS is one of the world's premier systems of public lands and waters established to conserve fish, wildlife and plants in the United States. Over the past 105 years, the NWRS has grown to more than 150 million acres, and includes 556 NWRS units and numerous wetland management districts. The Service also collaborates with partners to manage four marine national monuments in the Pacific Ocean. These marine monuments cover an additional 214 million acres and are composed of small islands, atolls, coral reefs, submerged lands, and deep waters.

General Climate Change Impacts
Climate is the aggregated pattern of weather. A human construct, the concept of “climate” encompasses averages and trends of weather phenomena over a 20 to 30 year period. This includes the timing and spatial distribution of phenomena such as temperature, precipitation, snowfall, snowpack, snow melt, extreme weather event patterns such as blizzards, tornadoes and typhoons, and sea level rise; all strong forces that shape and guide ecological processes. However, most downscaling efforts focus on temperature, and to a lesser extent, precipitation.

The rate at which temperature changes are occurring on a global level suggests that many, if not most, wild species will experience climate change as a stressor that reduces survival and/or reproduction, and thus has strong potential to lead to native population declines and extinction. The most recent Intergovernmental Panel on Climate Change (IPCC) report (2007), which represents the consensus view of a team of hundreds of scientists from across the globe, suggests that 15-40 percent of species will be at increasingly high risk of extinction as global mean temperatures reach 2 to 3°C above pre-industrial (or 1.2 to 2.2°C above current) levels (Field et al., 2007, based on work in Thomas et al., 2004).

Impacts of climate change have been well-documented for terrestrial, aquatic, and marine ecosystems.
Well publicized impacts of climate change include sea level rise, ocean acidification, insect outbreaks, coral reef bleaching, and melting of sea ice and permafrost. Less obvious ecological impacts on ecosystems across the globe include changes in the length of the growing season and stratification period in lakes, in the timing of seasonal events (phenology), in patterns of primary production, and in species distributions and diversity (Péñuelas and Filella, 2001; Walther et al., 2002; Parmesan and Yohe, 2003; Root et al., 2003; Austin and Coleman, 2007; Field et al., 2007). Mismatched changes in seasonal timing of interacting species have been documented in terrestrial, aquatic, and marine ecosystems (Winder and Schindler, 2004; Thackery et al., 2010), and have serious implications for the life cycles and competitive abilities of numerous species. Similarly, as species vary widely in their abilities to shift location in response to climate change, we can expect impacts from disruptions in key species interactions, and additional stress on species from both native and non-native species, and disease vectors that shift into new locations. Researchers have begun to explore the implications of these changes for the provisions of ecosystem services (Millennium Ecosystem Assessment, 2005). Many of the deleterious impacts on biodiversity will not be direct, but will come as a result of altered species interactions (Pounds et al., 2006). Examples of different ecological effects in Europe and North America include shifts in spring events such as budburst, floral abundance, egg laying, bird migration, and the hatching of caterpillars occurring earlier over the course of the last 30 years (Menzel et al., 2006; Schwartz et al., 2006; Van Asch and Visser, 2007; Inouye et al., 2000). Evidence from two comprehensive analyses and a synthesis on a broad array of species and ecosystems suggests that there is a significant impact of recent climatic warming in the form of long-term, large-scale alteration of animal and plant populations (Parmesan and Yohe, 2003; Root et al., 2003, Parmesan, 2006).

Direct Consequences of Climate Change on Invasive Species

Climate change and invasive species present two of the greatest threats to biodiversity and the provision of valuable ecosystem services. The estimated damage from invasive species worldwide totals in many billions of dollars annually with impacts across a wide range of sectors including agriculture, forestry, aquaculture, transportation, trade, power generation and recreation (Pimentel et al., 2001; TNC, 2011). In environmental terms, islands, by example, with their unique and varied biodiversity have suffered disproportionately from invasive species, which are responsible for half to two-thirds of all species extinctions (Donlan and Wilcox, 2008; IUCN, 2009).

In comparison, economic projections of global climate change-induced losses may range from 1-20% of gross domestic product (GDP), which is equally about 5% of GDP annually (Stern, 2006). Combined, the complexity of the interaction of these two global drivers – climate change and invasive species – increases dramatically, and evidence is rapidly growing on how climate change is compounding the already devastating effects of invasive species. Climate change impacts, such as warming temperatures and changes in CO₂ concentrations, are likely to increase opportunities for invasive species because of their adaptability to disturbance and to a broader range of biogeographic conditions and environmental controls. The impacts of those invasive species may be more severe as they increase both in numbers and extent, and as they compete for diminishing resources such as water. Warmer air and water temperatures may also facilitate movement of species along previously inaccessible pathways of spread, both natural and human-made (Burgiel and Muir, 2010).

Invasive species are generally viewed as having a broader range of tolerances (i.e., a bigger bioclimatic envelope) than natives, thereby providing invaders with a wider array of suitable habitats (Walther et al., 2009). A shift in temperature, for example, might then have significant impacts on a native species, but little impact on an introduced species, thereby altering the competitive dynamic between them. In some cases temperature alone may not be a determining factor. For example, with invasive plants, changes in precipitation patterns, elevated CO₂ levels and increased nitrogen deposition may play a greater role (Richardson et al., 2000). It is therefore necessary to look at the full suite of variables relevant to a particular species’ bioclimatic envelope, as well as its broader symbiotic relationships and trophic webs. Changes in competitive dynamics will not be uniform globally, particularly when considering changes across tropical vs. temperate systems or low vs. high altitude systems. Higher latitudes and altitudes will probably see a shifting range of species as temperatures increase and “new” species migrate.
from adjacent, previously warmer climates (Parmesan, 2006). As tropical systems warm they will not face the same threat as there is no pool of species coming from even warmer climes. However, changes in precipitation and other climatic variables may still stress such ecosystems, thereby increasing their vulnerability to invasive species. In addition to range expansion, there may also be range contraction or diminished impacts of invasive species pending the influence of climatic and other variables (Hellman et al., 2008; Richardson et al., 2000; Burgiel and Muir, 2010).

**Indirect consequences of Climate Change**

Changes in soil composition, flood and drought cycles, fire regimes, glacial extent and warming permafrost may all provide fertile ground for invasive species. Interactions may have compounded effects on broader ecosystem services such as groundwater retention and filtering, pollination, disease suppression and carbon sequestration. The damage caused by storms will increase disturbance in habitats providing opportunities for the establishment and/or spread of already extant invasive species (Burgiel and Muir, 2010). For example, after the major tsunami in southeast Asia in 2004, Sri Lanka witnessed a significant expansion of prickly pear cactus (*Opuntia dillenii*), mesquite (*Prosopis juliflora*), lantana (*Lantana camara*) and Siam weed (*Chromolaena odorata*) in degraded coastal areas, as well as of water hyacinth (*Eichhornia crassipes*) and cattails (*Typha angustifolia*) in lagoons and estuaries (Bambardeniya et al., 2006; Burgiel and Muir, 2010). Native forests are being strangled on the Cook Islands in the South Pacific from invasive balloon vine (*Cardiospermum grandiflorum*) and mile-a-minute vine (*Mikania micrantha*), presumably caused by seed dispersal from ornamental introductions being spread by Cyclone Solly in 1987 (Burgiel and Muir, 2010).

New pathways for invasion and “unforeseen” consequences of management actions have the potential to exacerbate effects of climate change. For example, warmer temperatures will allow for more arctic exploration and open new areas to invasive species by human transport. Receding ice formation in the Arctic is already opening a northwest passage for ships to move cargo and is creating new opportunities for the exploitation of oil, gas and other natural resources. This will significantly increase the exposure of these relatively pristine areas to invasive species introduced through ships’ ballast water, as well as hull fouling, drilling platforms and other equipment. Increased water temperatures will allow species to live longer in ballast water of ships and will have more potential to invade new areas (Frank and Olden, 2008).

At a global scale, changing trade patterns and routes will also increase the potential for the introduction of non-native species into new environments. Higher temperatures and changes in precipitation will have significant impacts on agricultural productivity, and consequently will result in shifts in production. Changes in the trade of agricultural commodities will have impacts on the transport networks used to move such goods and the inherent invasive species risks associated with vectors like ballast water, hull fouling, aviation and ground transport. Depleted water supplies, land degradation and sea level rise will likely lead to the mass movement of peoples and even climate refugees. Population migrations, increases in density, as well as poor sanitary conditions may create vectors for the spread of disease, a phenomenon that will likely be compounded by expanded ranges of diseases like malaria, dengue and yellow fever under warming climate scenarios (Reiter, 2001). Migrants often bring desirable crops, domestic animals, and ornamental species to their new homes, potentially speeding dispersal of new non-native species. Managing invasive species necessitates the use of management tools such as biocontrol agents, which can sometimes affect native species as well as target non-native species. For example, *Rhinocyllus conicus*, a Eurasian weevil was initially introduced to control invasive thistles (Musk and Canadian), but is now impacting 22 native North American thistles (Louda and O’Brien, 2002), which are essential to various native insects.

**How is the NWRS considering climate change in invasive species management?**

**Ecosystem-based adaptation**

Ecosystem based adaptation uses a variety of opportunities for the sustainable management, conservation, and restoration of ecosystems to provide services that enable people to adapt to the impacts of climate change. It aims to maintain and increase resiliency and reduce the vulnerability of ecosystems in the face of the adverse effects of climate change. Healthy ecosystems provide a wide range of ecosystem services that serve as the background and backbone for the production of necessities like food and fiber, building materials and potable water.
Early Detection
The need for early detection and monitoring for invasive species is greater in a changing climate. Most invasive species are well equipped to take advantage of a changing environment. They lack the biological control interaction which keeps them in check in their native ranges. They propagate quickly and can often take advantage of natural or artificial disturbances. Future invasive species may already be present but in a non-invasive state and consequently not considered noxious. However, the potential for a “sleeper” exotic species to become invasive could be triggered by a change in climate. Early detection of these species needs to be incorporated in an Early Detection Rapid Response (edrr) program. Having invasive species integrated into landscape modeling or other predictive models would be a useful tool for predicting spread of invasive species.

Early detection requires the ability to identify a species during the introduction phase, and should be followed by a rapid eradication response before the species has a chance to become established and colonize the area. This is a difficult task to accomplish. It requires reliable inventory and monitoring efforts. It also requires identification of potential routes of invasion and regular monitoring of those routes for new invasions. And, it requires having the necessary financial resources on hand to remove an invasive species as soon as it has been identified rather than waiting for funding to be allocated at a later time. Costs can increase exponentially if a newly identified invasive species is not controlled or eradicated promptly (usfws 2009).

Application of Herbicides and Pesticides
In a changing climate, the application of pesticides to control invasive species has added challenges. Increasing precipitation or flooding and volatilization of pesticides due to increasing temperatures may enhance the movement of pesticides to off-target locations and may affect pesticide efficacy. Windows of opportunity for proper application of pesticides in conformance with labels may become narrower with changes in climatic factors. Decreased “windows of opportunity” may adversely impact the ability to successfully control both new and established invasive species because the targeted species may not be susceptible to certain management techniques at that particular time, i.e., chemical, biological, or mechanical control, or cultural practices such as prescribed fire.

Climatic effects may alter the physiology of plant tissue cells and even nurture a resistance to herbicides. These changes, as well as other stresses which are placed on the invasive and native species may alter the effectiveness (both increasing and decreasing) of herbicides. Increased CO₂ levels are shown to have a direct effect on the cellular structure of plants, increasing rigidity and thus the effectiveness of chemical control. Increasing CO₂ has been shown to reduce herbicide efficacy of glyphosate of field weeds (Ziska et al., 2004). Monitoring pesticide and herbicide applications for effectiveness on target species as well as adverse impacts to native species and the ecological system is an important consideration of NWRS invasive species monitoring efforts (usfws 2009).

Biological Control
Biological control focuses on the specific relationship of the target species with the control agent. As an invasive species range shifts, so should the range of the biological control agent because it is tied to the host for shelter, development or reproduction. The relationship between the bio-control-agent and its host is a population control (herbivore/plant, parasite/host, etc.) relationship rather than a competitive relationship where a limited resource (light, nutrient, etc) is the overarching control mechanism.

Changes in climatic factors may alter the inter-specific interactions between the host and the agent (Stacey and Fellowes, 2002; van Asch and Visser, 2007). Increased plant growth due to rising CO₂ may actually lead to the agents feeding more and having higher reproductive rates, or conversely may impact the digestibility of an invasive species. In addition, plants grown in CO₂ enriched environments may outgrow their herbivores and the agent population cannot keep up with that of the host.

Restoration of Habitats
Restoration of natural habitats in a changing climate will challenge previously implemented goals and objectives for ecosystem restoration to a historical state. Climate change may preclude the restoration of a habitat to what it was 100 or even 50 years ago (usfws, 2009). When restoring habitats; land managers must plan for the future rather than look to the past for design implementation. Seed sources for restoration may need to come from stocks which are located within habitats that are likely to withstand increasing temperatures.
and periods of drought. For instance, in restoring an oak forest on the mid-Texas Coast, seedlings from acorns gathered in dryer and better drained soils may be better able to survive long term than those gathered from seed sources in the wetter and cooler edges of its range (USFWS, 2009).

Climate change will provide opportunities for restoration when an area at risk becomes climatically unsuitable for an invasive species (Bradley and Wilcove, 2009). NWRS managers can take advantage of these opportunities by restoring native species grown from local, genetically-appropriate native seed and or implementing management options to provide a healthy and diverse ecosystem (USFWS, 2009).

Three Climate Change Invasive Species Management Case Studies From the previous discussion, the challenges of managing invasive species on NWRS lands in the face of climate change are daunting. Examples of important work accomplished by other researchers and managers on separate climate change-related invasive species challenges at three far-flung management areas are highlighted below:

Kenai NWR - Invasive Plant Bioclimatic Modeling Efforts (adapted from Bella, 2009)

Sustainable management efforts are limited by a lack of basic information about species behavior in a changing climate. An understanding of how invasive plant species are likely to behave in a changing climate allows NWRS managers with limited time and budgets to make better-informed decisions about what type of management may be appropriate for a particular species, a suite of species, or a specific land area. Invasive plants are thought to have the potential to disrupt ecosystem function on a widespread scale in Alaska (Carlson et al., 2008). Maps created from models provide land managers with a visual tool for quickly assessing an invasive species’ potential range in today’s climate and under future climate scenarios. Current potential range maps can direct scouting, research, and planning efforts to areas most likely to be subject to invasion and can aid in hypothesis testing. Future range predictions provide insight on which species are likely to spread rapidly, allowing managers with limited budgets to focus prevention, detection, and rapid response efforts on key species in focal areas today to avoid future large-scale problems. Comparison of current and future range maps will also indicate locations of potential change in the vicinity of planned construction, restoration, or visitation activities and associated nearby wildlife habitats. This will allow managers to incorporate adaptability into long-term operational planning under climate change. Mapping output can guide decision-making for actions that maximize NWRS accountability for its operations. At the same time, using these predictions will help the NWRS maintain critical ecosystem services and the social and cultural structure of Alaskan communities that depend on native fish and wildlife resources.

In this Case Study, current (Figure 1) and future (Figure 2) range map scenarios were created for sixteen invasive plant species in Alaska. Selected species represent primarily aquatic, riparian, or wetland habitats and have a high to extremely high invasion potential. Selected species either occur in Alaska (11 species) or are currently absent (5 species). All modeled species showed a potential invasion range within the state of Alaska in current and in future predicted scenarios. An example highlighting potential cheatgrass range shifts is provided below. Known current populations indicate that species are not yet filling their current predicted potential range. However, some known occurrences already extend beyond the predicted range for that species in the current climate (Bella, 2009).
Figure 1. Current potential range of *Bromus tectorum*

Figure 2. Future predicted range for *Bromus tectorum*
Tamarisk - Natural Resource Management in the Southwest

In the Case Study of tamarisk (*Tamarix* spp.) in the Southwest United States, climate-related impacts may facilitate this species’ continued biological invasion and associated management challenges without necessarily being the direct source of its introduction. Disturbance event impacts occurring within Southwestern ecosystems are primary drivers that shift species composition and influence trophic chain responses. Disturbance phenomena can be linked to broader regional processes that increase ecosystems’ vulnerability to the establishment and spread of invasive species (Campbell et al., 2009). As previously mentioned, climate change brings a host of impacts including the increased intensity of severe weather events. As a general rule of thumb, experts suggest that wet regions will likely get wetter and dry regions will likely get dryer (although more precise modeling exists for many areas). This is likely to amplify both flooding and drought particularly if rains are concentrated either seasonally or within individual storms. Both of these processes will stress local ecosystems and provide a foothold for species such as tamarisk that are more tolerant to such extreme conditions or able to thrive with these disturbances (Burgiel and Muir, 2010).

Originating in central Asia, tamarisk has an extensive root system that grows deep into the soil. This allows tamarisk to grow further back from the river, occupy a large area, and use more water across the floodplain than native plants. It is well suited to hot, arid climates and the alkaline soils common in the western U.S. These adaptations have allowed it to effectively exploit many of the degraded areas along southwestern river systems today. By the 1900’s tamarisk stands dominated many low-elevation river, lake, and stream banks across the west, and today cover an estimated 1.5 million acres of land in the western U.S. Tamarisk reproduces primarily through wind and water-borne seeds and requires a wet, open surface to establish itself. In the presence of established native vegetation, tamarisk seedlings are not as competitive. However, when native vegetation is suppressed by conditions like late flooding, fire, drought, and animals eating native saplings, tamarisk is better able to invade. Once established, tamarisk grows so densely that it pushes out native vegetation. Tamarisk also has a higher tolerance for fire, drought, and salinity than native plants and can actually increase fire frequency and intensity, drought, and soil salinity. It is probably no surprise that tamarisk continues to pose a significant management challenge to NWRS managers across the Southwest. Because tamarisk brings fire into fire-intolerant ecosystems, the NWRS annually expends significant financial resources in the Southwest region for the fuels management (prescribed burning), suppression, and rehabilitation of burned areas. Large-scale tamarisk eradication and control efforts are underway at the Cibola, Bosque del Apache and Bitter Lake NWMRS units. At the Lower Rio Grande NWR in South Texas, AmeriCorps crews have treated over 400 acres and have removed nearly 50,000 trees. Additionally, the NWRS has established Invasive Species Strike Teams (ISSST) in New Mexico and Arizona (among others). ISSST crews address priority work requested from NWRS units as well as adjacent federal, state and tribal land managers in both states. In 2011, the New Mexico ISSST worked on, or near, six NWRS units treating over 600 acres in 5040 person hours. In 2011, the Arizona ISSST provided nine Arizona NWRS units and adjacent lands with almost 13,000 person hours of invasive species control/eradication effort, treated nearly 800 refuge acres to improve or restore native wildlife habitat, and provided over 100 young professionals with conservation experience. The scale of these efforts is massive and has required significant outlays of person hours, equipment and funding. The payoff is equally significant and is measured in the enhancement of functional native systems that are crucial to the survival of imperiled species including: the Pecos assiminea snail, the Roswell spring snail, the Noel’s amphipod, the Pecos gambusia, the Pecos sunflower, the Pecos bluntnose shiner, the Rio Grande silvery minnow, the southwestern willow flycatcher, the yellow-billed cuckoo, the Yuma clapper rail, the black rail, and the New Mexico meadow jumping mouse.

**The Nature Conservancy (TNC) Delaware Bayshores Program - Phragmites’ Role in Marsh Migration (adapted from Allen and Smith, 2012)**

Coastal plant communities are dynamic by nature but sea level rise resulting from climate change has the potential to dramatically alter the pace and trajectory of this change. On many Mid-Atlantic NWRS units these habitats, moving from sea to land, transition from open water and tidal flats to salt tolerant marsh plant
communities (low marsh dominated by *Spartina alterniflora* and high marsh dominated by *Spartina patens*), and eventually to forest (Adams, 1963). At the transition between high marsh and forest there can often be fringing band of *Phragmites australis* (Minchinton & Bertness, 2003). The introduction of a non-native genotype of *Phragmites* in the early 20th century transformed this species from a minor component of this transitional community to a dominant species in many wetland habitats, particularly in disturbed areas (Saltonstall, 2002). One example of such a disturbance is when forest fringing the coast is killed by encroaching sea levels (Hussein, 2009; Williams et al., 1999). In this process which is repeating itself along many units of the NWRs along the Atlantic seaboard, the majority of tree species are killed. This loss creates an opportunity for colonization of these vacant areas by species like *Phragmites* which are better adapted to the resulting brackish conditions. In much of the Mid-Atlantic, there has been a steady pace of relative sea-level rise that gradually overtakes forested uplands and wetlands due in large part to post-glacial subsidence (Engelhart et al., 2009). Over time these areas become part of the salt marsh (Brinson et al., 1995). Reports of significant losses to the land base from eyewitness accounts date at least as far back as the mid-19th century (Kitchell, 1857). These past losses of terrestrial habitats to sea level rise present an opportunity to examine how the change from forest to marsh proceeds over time so that future changes can be better anticipated. Little is known about the plant communities that develop during the transition period after trees die but before salt marsh has overtaken the area. Anecdotal evidence from the Delaware Bay suggests that as trees succumb to sea-level rise, they are often replaced by a vegetation community dominated by *Phragmites*. Little is understood regarding the pace of transition from forest to marsh and how it compares to the pace of the eventual transition from *Phragmites* to native salt marsh as sea level rise proceeds. There may be differences in how habitats respond to sea level rise because each type could have a different level of resistance to change (Brinson et al., 1995). Resistance to change is composed of the breadth of tolerance for changing conditions inherent to a plant community, along with that community’s capacity to respond to change.

The results of TNC’s work in this Case Study indicate that habitat change driven by sea-level rise has occurred throughout the 20th century. Given that global sea level is predicted to rise, the rate of habitat change can be expected to further accelerate (Wu et al., 2009). A clear understanding of the relative pace of change for different habitat types can yield important insights into how the habitat composition of coastal landscapes will change in the coming years as sea level rise accelerates. Habitats have different levels of resistance to change as a result of their tolerance and ability to respond to dynamic conditions (Brinson et al., 1995). Wetland habitats respond to sea-level rise by accelerating their vertical accretion rate which affords them a measure of resistance to change (Kearney et al., 1994). Different wetland types can accrete at different rates (Nydict et al., 1995). Findings from previous work indicate that *Phragmites* accretes at significantly greater rates than both the low marsh dominated by *Spartina alterniflora* (Rooth et al., 2003) as well as the high marsh dominated by *Spartina patens* (Windham, 2001). Since forest has a low tolerance to salinity (Williams et al., 1998), it can make no such response to rising sea levels and as a result may be less resistant to change than all three of the marsh types. TNC’s finding that the pace of *Phragmites* movement inland is significantly slower than the pace of forest movement supports this pattern. Given that *Phragmites* is more resistant to changes induced by sea level rise than the native marsh and forest habitats (Rooth et al., 2003; Windham, 2001), TNC predicts that the difference in change rates will result in increasing coverage of *Phragmites* over time at the expense of the forest it replaces. High marsh habitat may also be under threat because the transition zone between marsh and forest that this habitat often occupies will be quickly colonized by *Phragmites*. The increased resistance to change of *Phragmites* may also prevent existing high marsh from moving inland. It is possible that *Phragmites* may persist until salinity and tidal conditions reach a threshold where only low marsh habitat can displace *Phragmites*, precluding an intermediate transition to high marsh. More observational and experimental studies are needed to test such a possibility (Allen and Smith, 2012).

**Conclusions**

The breadth and intensity of invasive species management within the NWRs will continue to expand under the influence of climate change. With this in mind, the NWRs is working to integrate climate change considerations into its invasive species management approach. The following considerations encompass areas of specific focus. Incorporating climate change in
all new and revised versions of Comprehensive Conservation Plans (CCPs), step-down plans - including habitat management plan, fire management plans, integrated pest management plans, and invasive species management plans:

Incorporating the results of vulnerability assessments into NWRS planning;

Outlining the need for broad landscape-based conservation planning and implementation, and examine refuges’ role in increasingly complex ecological systems;

Integrating invasive species management considerations into the Landscape Conservation Cooperatives (LCCSs) by working with other Federal, State and partner organizations to develop, test, and implement conservation strategies responsive to dynamic landscape changes resulting from accelerating climate change;

Fully implementing an early detection network across the NWRS to improve chances of eradication during the early 'introduction' phase of invasions;

Fully implementing adaptive management strategies keeping in mind the implications under a changing climate. Most land use practices, ecological restoration and engineering practices are based on historic climatic conditions. Adaptive response to climate change will require plans for defining potential change, monitoring change and developing dynamic management practices;

Shifting management focus from costly management of established infestations with little to no chance of eradication to prevention, Early Detection, Rapid Response and maintenance of pristine areas;

Managing pristine and previously treated areas first, incorporating actions to limit pathways for invasion; Increasing restoration efforts after invasive species control actions and prescribed burning through use of genetically appropriate native seed capable of establishing and being maintained to ensure long-term success; and

Enhancing inventory, monitoring and data sharing capabilities through new and existing channels including but not limited to the Pesticide Use Proposal’s database, peer-reviewed journals, and a national inventory and monitoring network. Data sharing capability includes geospatial, empirical and qualitative information regarding the detection, adaptation, management, results of treatment, and inter-specific relationships the invasive has with trust resources.

References


Windham, L. (2001). Comparison of biomass production and decomposition between Phragmites australis (common reed) and Spartina patens (salt hay grass) in brackish tidal marshes of New Jersey, USA. Wetlands 21:179–188.


Mapeando el hábitat y distribución potenciales de especies de plantas invasoras en Refugios de Vida Silvestre del USFWS bajo condiciones de cambio climático actual y a futuro

Nicholas Young  
Postgraduate Student / Estudiante de posgrado  
Natural Resource Ecology Laboratory, Colorado State University / Laboratorio de Ecología de los Recursos Naturales, Universidad del Estado de Colorado  
Fort Collins, Colorado 80523-1499 USA  
nicholas.Young@colostate.edu

Other authors / Otros autores:  
Paul Evangelista  
Lane A. Carter  
Natural Resource Ecology Laboratory, Colorado State University

Jenny Erickson  
Invasive Species Program, National Wildlife Refuge System

Resumen
Las acciones de respuesta rápida requieren de herramientas de detección temprana y de predicción ecológica de especies invasoras, que son de alta prioridad para los manejadores de recursos. Los modelos de nicho ecológico (también llamados modelos de distribución de especies y modelos de hábitat) se utilizan cada vez más para modelar y mapear distribuciones de especies invasoras. Estos modelos pueden utilizarse en conjunto con modelos climáticos para obtener predicciones de riesgo bajo proyecciones de cambio climático. Utilizamos el modelo de entropía máxima (maxent) para obtener riesgos actuales y futuros de cinco especies invasoras en tres Cooperativas de Conservación de Paisaje (LCCS) a lo largo de los Estados Unidos. Utilizamos 19 variables bioclimáticas derivadas del Centro Canadiense para el Modelado y Análisis Climáticos (CCCMa) para predecir riesgos futuros. Los modelos actuales funcionaron bien y revelaron áreas puntuales para enfocar acciones de detección y respuesta tempranas. Los modelos de riesgo bajo escenarios de cambio climático mostraron, para algunas especies, cambios significativos de rango e incremento en el riesgo comparados con las condiciones actuales, mientras que en otras el riesgo parece disminuir. Un análisis de coincidencias de los mapas de riesgo actual y futuro identificó áreas con niveles de riesgo estable, áreas donde el riesgo incrementa y áreas donde se reduce. Las contribuciones de las variables hacia la distribución de especies varían entre especies y entre áreas (LCCS) destacando la importancia del manejo caso por caso de ambas. Nuestros resultados son el producto de un esfuerzo más grande para proveer a determinados Refugios de Vida Silvestre y a socios del sector público y privado, con información sobre especies invasoras de alta prioridad, al cimentar nuevas evaluaciones en campo sobre bases de datos existentes y utilizar estos datos para alimentar modelos de distribución de especies. Estos mapas predictivos a escala de LCCS pueden apoyar a los manejadores de recursos para la toma de decisiones para establecer prioridades en términos de especies, espacios y tiempos, y para acciones de manejo basadas en el incremento/disminución de riesgo de cada especie en base a las proyecciones de cambio climático.

Abstract
Early detection and ecological forecasting of invasive species are urgently needed for rapid response and remains a high priority for resource managers. Ecological niche models (also called species distribution models and habitat suitability models) are increasingly being used to model and map invasive species distributions. These models can be used in conjunction with climate models to provide risk forecasts of invasive species in light of projected climate change. We used maximum entropy (Maxent) to model current and future risk for three invasive species in three Landscape Conservation Cooperatives (LCCS) across the United States. We used the 19 bioclimatic variables derived from Hadley Centre Couple atmosphere-ocean general circulation Model (HadCM3) along with topological and hydrological variables to model future risk. Current condition models performed well and revealed areas to target early detection and re-
sponse actions. Risk models under projected climate change showed significant range shifts and increases in predicted risk area compared to current conditions in some species while other species showed a decrease in predicted risk. The highest contributing variables to invasive species distribution varied among species and among LCCs highlighting the importance of species and place-based management. Our results are the product of a larger effort to provide high priority invasive species information to selected U.S. National Wildlife Refuges (NWR) and public/private partners by building on existing datasets with new field surveys and using these data to inform species distribution models. These forecast maps at the LCC scale can provide a decision support for refuge managers to prioritize, in terms of species, space and time, management actions based on each species increase/decrease of predicted risk in light of projected climate change.

Presentation summary

Cost of Invasive species

Many scientists recognize invasive species as the number one environmental threat of the 21st Century (Stohlgren and Schnase, 2006). Invasive species pose threats to global ecosystems, including processes, functions, and the life they sustain (Mack et al., 2000). The invasion of non-native plants, animals and pathogens has escalated dramatically over the last few decades with the increase of trade, transportation and other elements of globalization, often negatively affecting state, regional, national, and global ecosystems, economies, and human health. The overall economic costs associated with invasive species in the United States are estimated to exceed $120 billion per year in terms of control costs, lost productivity, reduced water salvage, and reductions in rangeland quality and property values (Pimentel et al., 2000, 2005). The global economic costs of invasive species are estimated at $1.4 trillion annually, representing five percent of the global economy (Keller et al., 2007). With a high cost of control, it is no wonder that a recent study found risk assessment of invasive species to be a net economic benefit (Keller et al., 2007).

Climate Change and Invasive Species

Climate change is also expected to be a major environmental and economic threat. Only until recently have scientists studied the impact climate change may have on invasive species distributions (Smith et al., 2012). Some of the likely consequences are shifts in geographic distributions which also may include range expansion, and an increase or decrease in the currently understood rate of invasion. In addition, as the climate changes, human behavior is likely to be altered which may also impact invasive species distributions. For example, as the northern seas warm, the northwest passageway may be more navigable for longer periods of time; opening the area to new invaders on transportation vessels.

Project background

The results discussed in this study build upon a pilot program organized by the National Invasive Species Program within the broader National Wildlife Refuge System of U.S. Fish & Wildlife Service. This project was aimed at improving early detection and rapid response by building on existing datasets and new field surveys for select refuges across the United States.

Part of this task was to take priority invasive species for each refuge and provide models/maps of the potential distribution and risk of particularly problematic invaders at two scales: (1) the extent of the participating NWR, and (2) the associated Landscape Conservation Cooperative (LCC). This paper builds on this project by aggregating the data collected during this program with other data sources to predict distributions for the priority species under future climate change projections at a landscape scale.

Use of species distribution models and the modeling process

One of the best tools to predict invasive species under climate change is species distribution models; also called ecological niche models or environmental matching models. Species distribution models relate species response data (either occurrence or abundance) with environmental characteristics (Elith & Leathwick, 2009). These models have met many management objectives including identifying previously unknown populations of endangered species (Evan-gelista et al., 2008), predicting vulnerable habitats to species invasions (Stohlgren et al., 2002), estimating species richness (Graham & Hijmans, 2006), and many others (Elith & Leathwick, 2009).

In terms of invasive species and climate change, (Smith et al., 2012) stated “These models can be used to anticipate where pests might spread in the future, so that early detection and rapid response efforts are targeted...
to specific geographic regions, and scarce... management resources are used efficiently.” This highlights the importance of species distribution models as a tool to predict invasive species’ response to climate change. Using our understanding of the species distribution under current conditions based on recoded occurrences and environmental variables in a geographic information system framework, these models can be used to evaluate the sensitivity of invasive species to future climate change which can then help guide management (Figure 3).

Methods
Study area and Priority Species
The study areas for this project included three Landscape Conservation Cooperatives (LCC) in the united States (Figure 4). Each LCC is based on ecological boundaries without adhering to political boundaries. While developed models for multiple species per refuge and associated LCC, this discussion only highlights one example from each Landscape Conservation Cooperative. Tamarisk (Tamarisk sp.) is an invasive large shrub that our group is very familiar with. This riparian invader to the sw United States is forms dense stands and can decrease water tables and out-compete native species. Native to South America Alligator weed (Alternanthera philoxeroides) is perennial forb in the South Eastern United states. It can survive in fresh and mild brackish waters. It forms dense mats, both on shore and in shallow waters that overwhelming native species and has cause impacts to water recreation. Introduced to Tennessee in 1919, Japanese stiltgrass (Microstegium vimineum) in an annual grass also forms dense stands along riparian corridors, often invading areas that were previously disturbed, like flood plains and trails.
Spatial Analysis- Maxent

We selected the maximum entropy model (Maxent) to conduct all analyses for three primary reasons. First, multiple studies have found that Maxent regularly performs better, or as well, as other ecological niche models for invasive species (Evangelista, 2008; Kumar, 2009). Secondly, Maxent is designed to handle the types of survey data collected for the study; specifically point data collected with a GPS (as opposed to plot data and percent cover) and presence-only (as opposed to presence-absence data). Third, Maxent has several built-in features that are of particular importance to refuge managers, including performance evaluations.

The Maxent model was designed as a general-purpose predictive model that can be applied to incomplete data sets (Phillips et al., 2004; Phillips et al., 2006). The Maxent model is freely distributed on the web (www.cs.princeton.edu/~schapire/maxent/). Maxent operates on the principle of maximum entropy, making inferences from available data while avoiding unfounded constraints from the unknown (Phillips et al., 2006). Entropy is the measure of uncertainty associated with a random variable. Adhering to these concepts, Maxent uses presence-only points of occurrence, avoiding absence data and evading assumptions on the range of a given species.

The validation of model outputs from Maxent is accomplished in several ways. First, the user has the option of defining a percentage of the data that: (1) plots testing and training omissions against threshold; (2) plots predicted area against threshold; and (3) calculates the receiver operating curve (ROC). The area under the curve (AUC) is calculated for each. Second, a jackknife option allows the estimation of the bias and standard error in the statistics and the test of variable importance. Finally, Maxent will generate response curves for each predictor variable. Maxent has also been found to perform well in case of small sample sizes as low as four (Pearson et al., 2007).

Analyses consisted of twenty replicate models. Each model used 80% of the presence points to train the model for each targeted invasive species and used the remaining 20% for model validation. Additional model replicates used the same method; however, new training and validation points were randomly selected for each replicate using cross-validation subsampling. We used the 19 bioclimatic variables (Hijmans et al., 2005) derived from Hadley Centre Couple atmosphere-ocean general circulation Model (HadCM3) along with topological and hydrological variables to model future risk (Table 2). To help ac-
count for sampling bias, we trained the models on counties that contained occurrence points and then projected the model to current and future environmental variables at the study area extent (Phillips et al., 2009). The twenty model iterations for each species were averaged in a single output and included average area under the curve (AUC) value, and average percent variable contributions.

**Table 2.** Environmental variables used to develop models.

<table>
<thead>
<tr>
<th>Environmental Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual Mean Temperature</td>
</tr>
<tr>
<td>Mean Diurnal Range (Mean of monthly (max temp - min temp))</td>
</tr>
<tr>
<td>Isothermality</td>
</tr>
<tr>
<td>Temperature Seasonality (standard deviation *100)</td>
</tr>
<tr>
<td>Max Temperature of Warmest Month</td>
</tr>
<tr>
<td>Min Temperature of Coldest Month</td>
</tr>
<tr>
<td>Temperature Annual Range</td>
</tr>
<tr>
<td>Mean Temperature of Wettest Quarter</td>
</tr>
<tr>
<td>Mean Temperature of Driest Quarter</td>
</tr>
<tr>
<td>Mean Temperature of Warmest Quarter</td>
</tr>
<tr>
<td>Mean Temperature of Coldest Quarter</td>
</tr>
<tr>
<td>Annual Precipitation</td>
</tr>
<tr>
<td>Precipitation of Wettest Month</td>
</tr>
<tr>
<td>Precipitation of Driest Month</td>
</tr>
<tr>
<td>Precipitation Seasonality (Coefficient of Variation)</td>
</tr>
<tr>
<td>Precipitation of Wettest Quarter</td>
</tr>
<tr>
<td>Precipitation of Driest Quarter</td>
</tr>
<tr>
<td>Precipitation of Warmest Quarter</td>
</tr>
<tr>
<td>Precipitation of Coldest Quarter</td>
</tr>
<tr>
<td>Distance to Water</td>
</tr>
<tr>
<td>Elevation</td>
</tr>
<tr>
<td>Geology</td>
</tr>
<tr>
<td>Slope</td>
</tr>
</tbody>
</table>

**Results**

**Central Plains LCC – Tamarisk**

The model for tamarisk at the Central plains LCC has the most complete dataset. The model performed well with a Test AUC of 0.85 (Table 3). The high risk predictions are mostly found in the riparian areas (Figure 4). The amount predicted risk appears to increase in future climate conditions especially in the south. Distance to water was the highest contributing factor at over 50% (Table 4), indicating that hydrological factors are a more important driver than climate for Tamarisk at this scale and extent.
South Atlantic LCC - Alligator Weed

The South Atlantic alligator weed model performed the best out of the three models with a test AUC of 0.89 (Table 3). Notice that the current prediction model has very little area that is a novel environment (Figure 4) indicating that the training points used to develop the model had good environmental coverage. However, predictions in the future show that the environmental conditions quickly extend beyond the range used to develop the model as the amount of novel area increase significantly in 2020 and almost completely covers the study areas in 2050 (Figure 4). Overall, the Alligator weed model appears to change relatively little in future conditions. The top five predictor variables were all climate variables with annual mean temperature contributing the most to Alligator weed distributions (Table 5).

North Atlantic LCC - Japanese Stiltgrass

Japanese stiltgrass in the North Atlantic performed the poorest with a test AUC of 0.73 (Table 3). This is likely due to the limited amount of occurrence points used to develop the model. Similar to the South Atlantic study area, the climate changes in the North Atlantic beyond the range used to develop the model, showing a large area of novel environments in 2020 and 2050 (Figure 5). While distance to water was an important predictor for this model, for this region and scale, climate variables accounted for most of the contribution (Table 6) indicating that this species will likely change its distribution as climate conditions change in the future.

Table 3. Training and Test AUC for each Landscape Conservation Cooperative (LCC) – priority species model.

<table>
<thead>
<tr>
<th>Study Area - Species</th>
<th>Train AUC</th>
<th>Test AUC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central Plains LCC - Tamarisk</td>
<td>0.86</td>
<td>0.85</td>
</tr>
<tr>
<td>South Atlantic LCC - Alligator Weed</td>
<td>0.92</td>
<td>0.89</td>
</tr>
<tr>
<td>North Atlantic LCC - Japanese Stiltgrass</td>
<td>0.85</td>
<td>0.73</td>
</tr>
</tbody>
</table>

Table 4. Top five contributing environmental variables for tamarisk at the Central Plains LCC.

<table>
<thead>
<tr>
<th>Environmental Variable</th>
<th>Percent contribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance to Water</td>
<td>50.4</td>
</tr>
<tr>
<td>Precipitation of Wettest Month</td>
<td>24.7</td>
</tr>
<tr>
<td>Geology</td>
<td>7.4</td>
</tr>
<tr>
<td>Maximum temperature of Warmest Month</td>
<td>3.5</td>
</tr>
<tr>
<td>Precipitation of Warmest Quarter</td>
<td>3.3</td>
</tr>
</tbody>
</table>

Table 5. Top five contributing environmental variables for alligator weed at the South Atlantic LCC.

<table>
<thead>
<tr>
<th>Environmental Variable</th>
<th>Percent contribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual Mean Temperature</td>
<td>21.1</td>
</tr>
<tr>
<td>Precipitation of Wettest quarter</td>
<td>12.3</td>
</tr>
<tr>
<td>Precipitation of Wettest quarter</td>
<td>10.1</td>
</tr>
<tr>
<td>Mean Temperature of Warmest Quarter</td>
<td>9.9</td>
</tr>
<tr>
<td>Minimum temperature of Coldest Month</td>
<td>6.9</td>
</tr>
</tbody>
</table>
Conclusions
While climate change and invasive species are both ecological and economical threats, there needs to be more targeted research at investigating climate change and invasive species concurrently as highlighted by Smith et al. (2012). Species distributions models provide a practical tool for this investigation. These models can help identify whether an invasive species distribution is driven primarily by topological and hydrological environmental variables, such as the case with Tamarisk in the Central Plains, or if it’s driven more by climate variables, such as Alligator weed in the South Atlantic. This information can help

Table 6. Top five contributing environmental variables for Japanese stiltgrass at the North Atlantic LCC.

<table>
<thead>
<tr>
<th>Environmental Variable</th>
<th>Percent contribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precipitation of Driest Quarter</td>
<td>17</td>
</tr>
<tr>
<td>Minimum Temperature of Coldest Month</td>
<td>12.5</td>
</tr>
<tr>
<td>Geology</td>
<td>12.3</td>
</tr>
<tr>
<td>Precipitation Seasonality</td>
<td>8.4</td>
</tr>
<tr>
<td>Distance to Water</td>
<td>7.9</td>
</tr>
</tbody>
</table>

Figure 5. Habitat suitability/ predicted risk for three priority species at three LCC under current, 2020, and 2050 climate conditions. Warmer colors represent higher habitat suitability or higher risk. Areas covered by the transparent grey color represent novel environments.
guide management decisions. This study also revealed that, given projected climate change, climate in the north and east will change significantly from current condition. The full impact of this on invasive species distribution is difficult to determine. To improve future risk predictions, additional data collection is warranted. Specifically, focus should be to collect those occurrence locations in the most novel areas to gain. As with all species distribution modeling, this is an iterative process. As new data area available, both in terms of occurrence points, and environmental variables, these models need to be updated to inform adaptive management for invasive species across borders.

References


Resumen
El cambio climático y a las especies invasoras se han identificado como las dos amenazas a la biodiversidad en la actualidad y a futuro. Estos dos factores, tanto de manera aislada como combinada, tienen el potencial de producir cambios profundos en la estructura y funcionamiento de los ecosistemas al alterar la composición de las comunidades. El modelado de nicho ecológico se ha vuelto un enfoque popular para analizar y anticipar los fenómenos de distribución en este contexto: por un lado el potencial invasor de especies exóticas y, por el otro, alteraciones en las distribuciones de la biodiversidad causados por el cambio climático. Sin embargo estudios recientes acerca de la capacidad de estos modelos para atender estas problemáticas de manera adecuada han levantado opiniones encontradas. La transferibilidad de los modelos de nicho en tiempo y espacio (p. ej. Su proyección en escenarios geográficos o temporales diferentes), y por ende su posibilidad de predecir exitosamente la respuesta geográfica de las especies ante escenarios nuevos depende, por lo menos, de cinco factores críticos, (1) nuestra capacidad de caracterizar adecuadamente el nicho ecológico de la especie blanco que, a su vez depende de lo completo del muestreo del nicho ecológico, frecuentemente constreñido por factores geográficos; (2) el grado de conservación/plasticidad del nicho de la especie; (3) las condiciones abióticas de los ambientes nuevos; (4) el contexto biótico; y (5) la capacidad de dispersión. El atender cada uno de estos puntos adecuadamente no es una tarea fácil, tanto conceptual como prácticamente, pero el no hacerlo frecuentemente lleva a obtener resultados inadecuados.

Abstract
Climate Change and invasive species have been identified as the two main emergent threats to biodiversity nowadays and in the years to come. These two factors, in isolation and combined, have the potential to produce profound changes in ecosystem structure and function by altering community composition. Ecological niche modeling has become a popular approach to analyze and anticipate distributional phenomena in this context: invasive potential of alien species on one hand, and distributional shifts of biodiversity due to climatic changes, on the other. However, recent studies on the capacity of niche modeling to address these issues adequately have raised counter-opinions. Transferability of niche models in time and/or space (i.e., their projection to a different temporal or geographic scenario), and thus the possibility of successfully predicting the geographic response of species to novel scenarios depends, at least, on five critical factors, namely: (1) our capacity to characterize adequately the ecological niche of the target species, which, in turn, depends on the sampling completeness of the ecological niche, frequently constrained by the geographical setting; (2) the degree of niche conservatism/plasticity of species; (3) the abiotic conditions of novel environments; (4) the biotic context; and (5) dispersal capacity. Addressing each one of these issues sufficiently is not an easy task, both conceptually and practically, but not doing so frequently yields poor predictive results.
History of Early Detection and Rapid Response in the United States
Historia de la detección temprana y respuesta rápida en Estados Unidos

Chuck Bargeron
Technology Director / Director de Tecnología
Center for Invasive Species and Ecosystem Health / Centro para Especies Invasoras y Salud del Ecosistema
University of Georgia 2360 Rainwater Road Tifton, GA
cbargero@uga.edu

Other authors / Otros autores:
Randy Westbrooks
Invasive Species Prevention Specialist / Invasive Plant Control, Inc

Abstract
Over the past 50 years, there has been rising concern about invasive plants in managed and natural areas of the U.S. New and emerging species are often addressed through single agency-led federal/state weed eradication programs or interagency task forces. Widespread species such as leafy spurge (Euphorbia esula) are often managed through cooperative weed management areas (CWMAS). In the 1980s, a lack of funding interfered with efforts to address large infestations of Federal Noxious Weeds such as goatsrue (Galega officinalis) in Utah. This led to efforts to detect and eradicate new species much earlier. The eradication of Asian common rice (Oryza sativa) in the Florida Everglades in the mid-1990s is an example of this new trend in invasive plant management through early detection and rapid response.
response (EDRR). One important dynamic that has impacted these efforts over the years is the ever changing priorities of federal administrators and the needs of industry stakeholders. In the mid-1990s, departmental leaders took note of successful CWMAS in the western states and began to encourage interagency partnering across the country. This provided an important boost to EDRR projects and encouraged the development of CWMAS across the country. Today the Federal government has a focus on other high priority issues (e.g., national security and energy). As a result, it is more important than ever for invasive species managers to have a clear vision of the invasive species challenges that face our nation. State invasive species councils, interagency task forces, and CWMAS provide a forum where impacted and potential stakeholders can collaborate in addressing invasive species. Such groups can also help to educate the public about this problem. Today, smartphones are revolutionizing EDRR again, because we now have millions of potential early detectors with a camera, GPS and Internet connected device in their pockets.

Presentation Summary

Introduction
Throughout recorded history, as people colonized the Earth, they have taken cultivated plants and domesticated animals along with them. Since European settlement of North America began in the 1500s, over different 50,000 types of plants and animals have been introduced to this continent. While most of these species provide great benefits to human society, a small percentage of them have escaped and pose a threat to food and fiber production, and/or natural ecosystems. To date, about 4,200 species of introduced plants, or about 8.4% of total introductions, have escaped from cultivation and established free-living populations in the United States alone.

Several years ago, scientists at Cornell University estimated that losses to the American economy due to introduced invasive species are now over $138 billion per year. Of this total, costs and losses due to invasive plants are now at least $50 billion per year. Unlike chemical pollutants that can be eliminated from use and will eventually break down in the environment, invasive species can reproduce and spread, causing ever increasing harm. Our biggest challenge is to control established invasive species faster than they can reproduce and spread. But, everyone will agree – we don't need any new ones to have to manage.

Since only about 2% of the U.S. population are now engaged in agriculture or land management, there is much less awareness of this issue than in generations past. So, clearly, land owners and managers, gardeners and horticulturalists, and others who have a strong connection to the land, have a major role to play in ongoing efforts to deal with this ‘silent ecological explosion’.

Currently, there are numerous agencies as well as interagency groups that are involved with invasive plant management across the United States and Canada – including State/Regional and Provincial Invasive Species Councils (e.g., the Southeast Exotic Pest Plant Council), Invasive Plant Task Forces (e.g., the Beach Vitex Task Force), and Cooperative Weed Management Areas (e.g., the South Fork wma in Wyoming). Such agencies and groups routinely employ a number of strategies to manage widespread invasive plants through prevention, control, and public outreach. However, it is always a challenge to address new invasive plants - even though Early Detection and Rapid Response (EDRR) is clearly the preferred management strategy for preventing the establishment and spread of new and emerging species.

Implementation of the principles and practices of EDRR for new invasive plants on a single land unit is a rather straightforward process that aims to protect biodiversity and/or the production capacity of the land. This is accomplished by taking steps to contain an infestation, to stop further seed production, and to exhaust the seed reserve in the soil. However, efforts to address new invasive species that occur on multiple land units, and across multiple jurisdictions, typically require the cooperation of numerous agencies, as well as impacted and potential stakeholders, to be effective. Our experience in providing science and technical support to single agency-led federal/state weed eradication programs and projects in the 1980s and early 1990s showed that a cooperative, systematic approach to weed prevention and eradication is needed.

Development of a National EDRR Framework.
Development of a U.S. National EDRR System for invasive plants was first discussed as a long term goal by
the Federal Interagency Committee for the Management of Noxious and Exotic Weeds (FICMNEW) at its first bi-annual program planning retreat in Shepherdstown, WV, in 1998. Since that time, there has been an ongoing effort to develop EDRR capacity at the state and local level across the country.

Conceptually, a National EDRR System is a coordinated framework of state and provincial interagency partner groups that are working together to increase EDRR capacity through:

- **Interagency Coordination** (by State and Provincial Invasive Species Councils and EDRR Committees);
- **Early Detection and Reporting** of suspected new plants to state officials (by trained volunteers and agency field personnel);
- **ID and Vouchering** of suspected new plants (by cooperating botanists and herbaria);
- **Archival** of new plant records in online regional and national plant databases - e.g., the University of Georgia’s Early Detection & Distribution Mapping System (EDDMapS);
- **Rapid Assessment** of new plant species for invasiveness (by cooperating scientists); and,
- **Rapid Response** to confirmed new invaders by Single Agency-led Weed Eradication Programs (e.g., the USDA-Carolinas Witchweed Eradication Program), by Invasive Plant Task Forces (eradication of specific new weeds; e.g., the Beach Vitex Task Force); or by Cooperative Weed Management Areas (eradication of weeds within a defined geographic area).

Once fully developed in the United States, Canada and Mexico, the proposed **National EDRR Systems for Invasive Plants** will provide an important second line of defense against invasive plants across North America. They will also complement federal efforts to prevent unwanted introductions at U.S. and Canadian ports of entry. With both prevention and early detection systems in place, America will be better able to manage “plants out of place”.

**The Role of Land Managers and the Public in Addressing New Invasive Plants.**

Land managers and the public can greatly assist in the effort to prevent the introduction and spread of exotic invasive plants. Here’s how.

1. **Help Prevent the Problem**...... Use native or non-invasive exotic plants for landscaping and restoration projects.
2. **Take Action**...... Eradicate new invasive plants on lands that you own or manage.
3. **Get Involved**...... Report unknown plants to state and federal officials.
4. **Volunteer**...... Help remove invasive species from area parks and public lands.
5. **Tell Somebody**...... Help raise awareness of the problem.

**EDDMapS - Early Detection and Distribution Mapping System**

- Real time tracking of invasive species occurrences
- Local and national distribution maps
- Electronic early detection reporting tools
- Library of identification and management information

EDDMapS is a web-based mapping system for documenting invasive species distribution. It is fast, easy to use and doesn’t require Geographic Information Systems experience. Launched in 2005 by the Center for Invasive Species and Ecosystem Health at the University of Georgia, it was originally designed as a tool for state Exotic Pest Plant Councils to develop more complete distribution data of invasive species.

EDDMapS goal is to maximize the effectiveness and accessibility of the immense numbers of invasive species observations recorded each year. As of May 2012, EDDMapS has over 1.8 million records.

EDDMapS combines data from other databases and organizations as well as volunteer observations to create a national network of invasive species distribution data that is shared with educators, land managers, conservation biologists, and beyond. This data will become the foundation for a better understanding of invasive species distribution around the world.

EDDMapS documents the presence of invasive species. A simple, interactive Web interface engages participants to submit their observations or view results through interactive queries into the EDDMapS database. EDDMapS encourages users to participate by providing Internet tools that maintain their personal records and enable them to visualize data with interactive maps.
Users simply enter information from their observations into the standardized on-line data form, which allows specific information about the infestation and images to be added. Data entered is immediately loaded to the Website, allowing real time tracking of species. Being able to see the current data of a species as it moves into a new area helps to facilitate Early Detection and Rapid Response programs (EDRR). EDRR programs help stop or control an invasive species before it becomes an unmanageable problem.

All data is reviewed by state verifiers to ensure all data is accurate. The data is made freely available to scientists, researchers, land managers, land owners, educators, conservationists, ecologists, farmers, foresters, state and national parks.

**EDDMapS Smartphone Apps**
The University of Georgia’s Center for Invasive Species and Ecosystem Health has also developed a scaled-down version of EDDMapS for smartphones. These smartphone apps allow users of both iPhone and Android-based smartphones to submit reports with images directly from their phones. The first application, funded by the National Park Service’s Everglades National Park, allows reporting of invasive animals and plants in Florida and features an interactive field guide. The second application, funded by the U.S. Forest Service’s Southern Research Station, converted a regional field guide (see Miller et al., 2010) into an interactive iPhone application. These frameworks have been expanded to other regions of the country and apps for the Missouri River Watershed Coalition, Mid-Atlantic Early Detection Network, Southeast Early Detection Network and an App for reporting invasive insects in Massachusetts entitled Outsmart Invasive Species. Each of these apps are available on both iPhones and Androids. Apps are currently under development for the Invasive Plant Atlas of New England and the Great Lakes Early Detection Network.

---

**Early Detection and Rapid Response Efforts in Canada**

*Esfuerzos de detección temprana y respuesta rápida en Canadá*

**Cory Lindgren**  
Senior Program Specialist, Invasive Plants / Especialista, Plantas Invasoras  
Canadian Food Inspection Agency  
613-269 Main St. Winnipeg, MB R3C 1B2 Canada  
cory.lindgren@inspection.gc.ca

**Resumen**
Canadá se ha comprometido a la atención de las malezas invasoras a través de un enfoque jerárquico que prioriza la prevención, detección temprana y respuesta rápida, seguidos del manejo. Los programas de Detección Temprana y respuesta Rápida (DTRR) son la segunda línea de defensa después de que los esfuerzos para prevenir a las especies exóticas invasoras (EEI) han fallado. Esta presentación sintetiza algunos de los esfuerzos de nacionales de DTRR que se están llevando a cabo actualmente en Canadá. Para responder al reto de las malezas invasoras los actores federales y de las provincias se han asociado con la Agencia Canadiense de Inspección de los Alimentos para desarrollar un plan de DTRR para malezas invasoras. Los socios y actores involucrados participan en foros mensuales de DTRR a nivel nacional para discutir cómo utilizar las diferentes herramientas para responder a las malezas invasoras en Canadá. Existen muchas otras actividades complementarias de DTRR lideradas por agencias como Parques de Canadá y la rama de servicios de agricultura y medio ambiente de Agri-Food Canadá. Estas actividades complementan y apoyan el esfuerzo nacional e DTRR.

**Abstract**
Canada has committed to responding to invasive weeds through a hierarchical approach that prioritizes prevention, early detection, and rapid response followed by management. Early detection and rapid response (EDRR) programs are the second line of defense after IAS prevention efforts have failed. This presentation summarizes some of the national EDRR efforts currently being employed in Canada. In responding to invasive weeds, federal and provincial stakeholders have partnered with the Canadian Food Inspection Agency in developing an EDRR plan for invasive weeds. Part-
ners and stakeholders participate in monthly National EDRR Forum meetings to discuss issues such as how to use EDRR tools in responding to invasive weeds in Canada. There are many other ongoing complimentary EDRR activities, led by agencies such as Parks Canada and the Agri-Environment Services Branch of Agriculture and Agri-Food Canada. These EDRR activities complement and support the national EDRR effort.

**Preliminary Results of Weed Distribution Models in Mexico**

Resultados preliminares de modelaciones de distribuciones de malezas en México

Jesús Alarcón  
*Spatial Biodiversity Information Analyst / Especialista de Información Espacial de Biodiversidad*  
CONABIO  
Liga Periférico - Insurgentes Sur, Núm. 4903, Col. Parques del Pedregal, Delegación Tlalpan, 14010, México, D.F.  
jalarcon@conabio.gob.mx

Other authors / Otros autores:  
A. Isabel González, Yolanda Barrios, G. Born-Schmidt, Silvia de Jesús  
CONABIO

**Presentation Summary**

Globalization and the growth of commercial and tourist activities together with the emphasis given to free trade offer opportunities for the dispersal of exotic and invasive alien species which can damage ecosystems causing ecological unbalances among native populations such as changes in the composition of species and trophic structure, native species displacement, loss of biodiversity, reduction of genetic diversity and disease transmission. In Mexico, the presence of invasive alien species is one of the factors of greater impact on terrestrial ecosystems after habitat transformation and resource overexploitation.

As part of CONABIO’s role, to promote, coordinate, support and undertake activities geared towards increasing the knowledge on biological diversity as well as its conservation and sustainable use for the benefit of society. The Invasive species program in CONABIO aims to

- Update alien and invasive species listings
- Design a subsistem for the capture and management of information on invasive species
- Develop risk analysis for Mexico and the main routes of introduction
- Support projects that generate information on invasive species in Mexico
- Follow up on the agreements that arise from the National Strategy to Prevent, Control and Erradicate Invasive Species in Mexico.

CONABIO has over 50,000 current and historical records of occurrences of invasive species, 57% of which are of angiosperms. With the objective of identifying areas that might be more susceptible to the presence of these invasive plants, we developed several Potential Distribution Models (PDM) using records from 1985 to this 2012. With these criteria, 222 species out of 266 were selected (9,757 occurrence records). PDM are tools that help us recognize patterns of climate, physiographic and biological similitude and the necessary conditions that a species needs to maintain a viable population. In this sense there are many algorithms that offer PDM with different approaches.

There are three main points that have to be taken into account when preparing a PDM (Figure 6):

a) The correct identification of the species  
b) The correct geographic coordinates  
c) The right choice of coverture and scales

The resulting maps were added onto one single map (Figure 7) which shows a sampling bias towards temperate areas and also that the distribution of invasive plants is closely related to areas of human activity.
Consultation of different information systems (REMIB, SNIB, WEB)

Validate coordinates

Is there a Minimum number of points

End of the process

Site coordinates

Environmental covertures

Scale or resolution

Input variables

Model generation

Model selection

Model adjustment

Final model

Expert

Figure 6. PDM process

Figure 7. Invasive species richness in Mexico
The map with the sum of the potential distribution maps was also compared to:
- Ecorregions: geographic units that encompass a group characteristic of natural communities
- Protected areas
- Prioritary terrestrial sites: determined with over 1200 objects of conservations
- Terrestrial GAP: That identifies three priority levels according to the species found in them taking into account endemism, rarity, protection categories, among other characteristics.

Based on these analyses, and the overlap with the PDM models, certain species were identified as being particularly vulnerable to the impact of invasive species (Table 7).

**Table 7.** Priority species vulnerable to the impact of invasive species

<table>
<thead>
<tr>
<th>GROUP</th>
<th>NAME</th>
<th>ENDEMIC</th>
<th>NOM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agaves</td>
<td>Agave polianthiflora</td>
<td>yes</td>
<td>Threatened</td>
</tr>
<tr>
<td>Birds</td>
<td>Campephilus imperialis</td>
<td>yes</td>
<td>Probably extinct in the wild</td>
</tr>
<tr>
<td>Reptiles</td>
<td>Crotalus exsul</td>
<td>yes</td>
<td>Threatened</td>
</tr>
<tr>
<td>Trees</td>
<td>Cupressus guadalupensis</td>
<td>yes</td>
<td>Endangered</td>
</tr>
<tr>
<td>Plants</td>
<td>Dioon edule</td>
<td>yes</td>
<td>Threatened</td>
</tr>
<tr>
<td>Birds</td>
<td>Euptilotis neoxenus</td>
<td>yes</td>
<td>Threatened</td>
</tr>
<tr>
<td>Reptiles</td>
<td>Gerrhonotus lugoi</td>
<td>yes</td>
<td>Threatened</td>
</tr>
<tr>
<td>Reptiles</td>
<td>Gopherus flavomarginatus</td>
<td>yes</td>
<td>Endangered</td>
</tr>
<tr>
<td>Agaves</td>
<td>Manfreda brunnea</td>
<td>yes</td>
<td>Threatened</td>
</tr>
<tr>
<td>Reptiles</td>
<td>Phrynosoma orbiculare</td>
<td>yes</td>
<td>Threatened</td>
</tr>
<tr>
<td>Birds</td>
<td>Rhynchopsitta pachyrhynch</td>
<td>yes</td>
<td>Endangered</td>
</tr>
<tr>
<td>Plants</td>
<td>Stenocereus eruca</td>
<td>yes</td>
<td>Threatened</td>
</tr>
<tr>
<td>Plants</td>
<td>Amoreuxia wrightii</td>
<td>no</td>
<td>Endangered</td>
</tr>
<tr>
<td>Birds</td>
<td>Aquila chrysaetos</td>
<td>no</td>
<td>Threatened</td>
</tr>
<tr>
<td>Reptiles</td>
<td>Coluber constrictor</td>
<td>no</td>
<td>Threatened</td>
</tr>
<tr>
<td>Reptiles</td>
<td>Cophosaurus texanus</td>
<td>no</td>
<td>Threatened</td>
</tr>
<tr>
<td>Reptiles</td>
<td>Crotaphytus collaris</td>
<td>no</td>
<td>Threatened</td>
</tr>
<tr>
<td>Birds</td>
<td>Falco mexicanus</td>
<td>no</td>
<td>Threatened</td>
</tr>
<tr>
<td>Reptiles</td>
<td>Gopherus berlandieri</td>
<td>no</td>
<td>Threatened</td>
</tr>
<tr>
<td>Trees</td>
<td>Juglans major</td>
<td>no</td>
<td>Threatened</td>
</tr>
<tr>
<td>Trees</td>
<td>Litsea glaucescens</td>
<td>no</td>
<td>Endangered</td>
</tr>
<tr>
<td>Birds</td>
<td>Strix occidentalis</td>
<td>no</td>
<td>Threatened</td>
</tr>
<tr>
<td>Reptiles</td>
<td>Thamnophis cyrtopsis</td>
<td>no</td>
<td>Threatened</td>
</tr>
<tr>
<td>Reptiles</td>
<td>Thamnophis eques</td>
<td>no</td>
<td>Threatened</td>
</tr>
<tr>
<td>Reptiles</td>
<td>Thamnophis marcianus</td>
<td>no</td>
<td>Threatened</td>
</tr>
<tr>
<td>Reptiles</td>
<td>Thamnophis proximus</td>
<td>no</td>
<td>Threatened</td>
</tr>
<tr>
<td>Plants</td>
<td>Thelocactus bicolor</td>
<td>no</td>
<td>Threatened</td>
</tr>
</tbody>
</table>
The models gave us a first overview of the potential areas of concern regarding the distribution of non-native plants, as well as their location in relation of our Natural Protected Areas Network, the areas that need to be observed within each ecorregion, and some of the Mexican species that could be affected by their presence. The next steps are now to upload the models to the data portal so they can be reviewed and validated by specialists, to develop and prioritize management, monitoring, control and eradication strategies at different levels and to fund project geared towards obtaining and validating the information in the field.

**Developing Cost-effective Early Detection Networks for Regional Invasions**

**Desarrollo de redes regionales económicamente viables de detección temprana**

**Alycia Crall**

*NIISS Citizen Science Program Coordinator / Coordinadora del Programa de Ciencia Ciudadana de NIISS*

Colorado State University
Fort Collins, Colorado 80523-1499
alycia.crall@colostate.edu

Other authors / Otros autores:
Mark Renz, Brendon J. Panke, Gregory Newman, Carmen Chapin, Jim Graham & Chuck Barger

**Resumen**

La Detección Temprana y Respuesta rápida (DTRR) busca controlar o erradicar nuevas invasiones para prevenir nuevas dispersiones, sin embargo una **DTRR** efectiva permanece elusiva debido a problemas de manejo y financieros. Como parte de la Red de Detección Temprana de los Grandes Lagos, solicitamos a los diferentes actores que señalaran sus necesidades para una herramienta de comunicación de **DTRR** efectiva. Nuestros resultados llevaron al desarrollo de un sitio web con cinco secciones principales: 1) la habilidad para que observadores casuales reporten una detección; 2) una red de profesionales que verifiquen nuevas observaciones; 3) alertas por correo de nuevas detecciones, incluyendo información de todas las bases de datos de la región; 4) mapas de distribución de especies de todos los proveedores de datos; y 5) canales de comunicación accesibles entre los diferentes actores. Utilizando los resultados de nuestras discusiones con los usuarios, proporcionamos un marco rentable para redes electrónicas de **EDRR** que integran información y desarrollan capital social a través de una comunidad virtual. Este marco busca proveer información en tiempo real sobre distribuciones actuales de especies y mejorar la colaboración entre diferentes jurisdicciones disminuyendo descuidos.

**Abstract**

Early detection and rapid response (**EDRR**) seek to control or eradicate new invasions to prevent their spread, but effective **EDRR** remains elusive due to financial and managerial constraints. As part of the Great Lakes Early Detection Network, we asked stakeholders to indicate their needs for an effective **EDRR** communication tool. Our results led to the development of a website with five primary features: 1) the ability for casual observers to report a sighting; 2) a network of professionals to verify new sightings; 3) email alerts of new sightings, including data from all data providers across the region; 4) maps of species distributions across data providers; and 5) easy communication channels among stakeholders. Using results from our stakeholder discussions, we provide a cost-effective framework for online **EDRR** networks that integrate data and develop social capital through a virtual community. This framework seeks to provide real-time data on current species distributions and improve across jurisdictional collaboration with limited oversight.
Resumen
La Detección Temprana y Respuesta rápida (DTRR) puede ser la práctica más importante que un administrador implemente dentro de un programa de manejo de malezas. Los programas de DTRR se inician en todos los niveles del manejo de malezas: Internacional, Federal, Estatal y Municipal, y dentro de Áreas de Cooperación para el Manejo de Malezas. Quisiera compartir con ustedes como Sublette County Weed and Pest en Wyoming utiliza la información que obtenemos mediante nuestras redes para implementar estos programas en el campo. Existen muchas maneras de implementar la DTRR, afortunadamente en Wyoming nuestros programas de malezas se coordinan a través de un consejo estatal pero se manejan y financian a nivel municipal. Esta flexibilidad nos permite iniciar un programa acerca de una especie nueva al exponerla a través de una declaración de emergencia e inmediatamente desarrollar un protocolo de manejo para salir a combatir la maleza. Esta respuesta rápida, combinada con la educación sobre detección temprana que recibimos a través de nuestras redes permite a los responsables controlar y hasta erradicar una maleza. Al combinar políticas, coordinación e implementación obtenemos un programa exitoso de DTRR.

Abstract
Early Detection and Rapid Response (EDRR) may be the single most important practice that a manager can implement into their weed program. EDRR programs are initiated at all levels of weed management: International, Federal, State, County and within cooperative weed management areas. I would like to share with you how Sublette County Weed and Pest in Wyoming takes the information that we gain through our networks to implement these programs on the ground. There are many ways to implement EDRR, in Wyoming our weed programs are fortunate to be coordinated through our state council but run and funded as county government. This flexibility allows us to initiate a program on a newly found weed species by declaring it with emergency declaration and immediately develop a management protocol to go out and treat that weed. This rapid response combined with the education that we receive through our networks in early detection allow managers to actually manage or possible even eradicate a weed. Combining policy, coordination and implementation creates a success EDRR weed program.

Presentation summary
Early Detection and Rapid Response is based on the management principle of finding new populations when they are small and to immediately implement management strategies to eradicate that population. This principle is not new but is still not widely implemented. Most managers understand that EDRR is the best principle after prevention. Prioritizing EDRR in an overall management program is often a challenge. Weed managers are pulled in many directions and funding limitations often prioritize our programs for us.

There are many steps in EDRR and all must come together to make a successful program. Managers must be educated on potential invaders. This requires plant identification skills and the ability to determine invasive weeds from native plants that appear similar. To find new weed populations managers must prioritize surveys. These surveys often mean pulling resources from treatments. Surveys need to be conducted in high priority areas and along corridors and vectors. Once an infestation is found managers must research the best management tools to control and hopefully eradicate that weed. Often those tools are limited by more than just science. The ability to employ the best tool to get the job done can be limited by funding and policy. In the US, particularly in the West, federal land dominates our landscapes. Each agency has an approved herbicide list and techniques that can be implemented. This often limits the manager’s tools.

In Wyoming, we deal with these challenges. In Sublette County in 2006 Austrian fieldcress or Rorippa
austrica was found. The identification was confirmed by the University of Wyoming and research on control of this plant was initiated. There are many challenges with fieldcress and the habitat that it invades. In order to manage this invasive weed in Sublette County with mill levy funding, our board had to write a resolution declaring fieldcress as a Sublette County Declared noxious weed. Our new law allows for this to happen in the current field season but before 2011 this process took at least a year. Now we can achieve rapid response legally. We have an EDRR species list that we look for but most of this species are not declared or designated species. Once a species acquires emergency declaration then it is put on the noxious weed list for the future. The challenge is that you never know what you are going to find.

Most states have a watch list of potential invaders. We learn these species from maps, networking or education efforts. In the west summer is a flurry of activity to try and get management practices on the ground. If a new species is found and species confirmation or management is delayed then the process stalls and infestation increase. Survey may be expensive but as population size increases so does the cost and success in successful treatment. Large infestations cost more to treat, have limited success, use more herbicides, may require continued maintenance and continue to invade.

There are many challenges to federal, state or local EDRR programs. Shrinking budgets limit travel that provides education to field personnel on potential invaders, while also decreasing on-the-ground management. Most agency budgets and fiscal programs do not account for estimated acres protected and we must report in our records acres treated. By reporting only acres treated there is no way to account for all lands that were surveyed and where no weeds were found or the land that was protected. This is the most valuable information.

Last summer we initiated a taskforce focused on finding out the distribution and abundance of cheatgrass in Sublette County. We obtained grant funding and initiated a survey to find where and how much cheatgrass was in sensitive or core sage grouse habitat. We designated 5 areas as high priority based on sage grouse yearlong use and surveyed all two track roads (approx. 650 miles) in these areas for cheatgrass presence. We found several locations that total less than 24 acres of cheatgrass. The taskforce then took rapid response to treat all known locations in the area. This year we are treating known locations and corridors and vectors, surveying additional areas and have developed a hold the line along the east side of our county. East of that line we are implementing large scale control programs. Even in my county different weeds have different priorities based on location.

There are many ways to start EDRR programs but I think education and survey are the most important. This can be done at any scale. It is important to set priority areas, make a plan, set aside funding and time. Record areas surveyed, especially when weeds are not found. When infestations are found implement rapid response.

Surveys can be done at any level. You can hire a contractor to survey the land by air, ground or water. With each landowner contact I make I try to implement some type if survey whether while inspecting a hay meadow for the weed free forage program or out looking in a yard for sick trees. As you all know, once you know your weeds you are always looking and finding them. In Sublette County we survey our major and minor waterways by helicopter. It is amazing what species you can see from the air: Tamarix, Lepidium, Euphorbia and Centaurea.

In the west we have many remote lands both public and private. These lands are valuable for natural resources both in rangeland forage and energy minerals below the surface. If we can survey to find new populations in these areas it is money well spent. These are areas that support our fresh water, tourism and western way of life. These lands are too important to allow invasions and the cost of doing nothing is too high. I became interested in plants at a young age, because I saw the damage that yellow toadflax had on the wilderness that I love and grew up exploring. I will not let this happen to other pristine areas on my watch!
Effects of Cryptostegia grandiflora in Oasis Fauna in the Baja California Peninsula: Perspectives for Eradication

Efectos de Cryptostegia grandiflora en la fauna de oasis de la Península de Baja California: Perspectivas para su erradicación

Ricardo Rodríguez-Estrella
Researcher / Investigador
Northwestern Center of Biological Research / Centro de Investigaciones Biológicas del Noroeste
Mar Bermejo 195, Col. Playa Palo Santa Rita La Paz 23060. México
estrella@cibnor.mx

Other authors / Otros autores:
Alma A. Sánchez Velasco & José Juan Pérez Navarro

Abstract
Cryptostegia grandiflora (Asclepiadaceae, Periplocoideae) is a perennial climbing woody bush, which has been recognized as an invasive in the oasis of the Baja California Peninsula. The species comes from Madagascar and was introduced in the South of the Peninsula in the early 1900’s as an ornamental. It is currently found in over 25% of the approximately 80 oasis from Southern Baja California, and has been dispersing more or less successfully. With the hypothesis that Cryptostegia grandiflora could have a negative impact similar to what has been reported for Australia, we studied the use of its flowers and different structures by different species or vertebrates and invertebrates in 3 oasis, where the species has a good coverage. What we found in this isolated and delicate systems, surrounded by desert, is in sharp contrast with the Australian findings, due to the great number of species that consume its nectar and polen, or that use the plant as a refuge or for foraging around the oasis. We discuss the implications of these findings. We also present a proposal for the eradication of the plant from the oasis in Southern Baja California, that has been recently proposed and its perspectives of success through the involvement of local communities.

Resumen
Cryptostegia grandiflora (Asclepiadaceae, Periplocoideae) es un arbusto perenne trepador de contextura leñosa, que se reconoce como planta invasora en oasis de la península de Baja California. Es una especie originaria de Madagascar que fue introducida en el sur de la península a principios del siglo pasado como planta de ornato. Actualmente se encuentra en más de 25% de los más de 80 oasis que existen en Baja California Sur, dispersándose de manera más o menos exitosa. Con la hipótesis de que Cryptostegia grandiflora tendría un efecto negativo similar al reportado en Australia, estudiamos el uso que invertebrados y vertebrados hacen de los flores y estructuras de esta planta en 3 oasis donde la especie tiene una buena cobertura. Lo encontrado en este sistema frágil y aislado rodeado por desierto contrasta completamente con lo reportado para Australia, por el gran número de especies que consumen néctar y polen o que lo usan como refugio o para realizar actividades de forrajeo en los oasis. Se discuten las implicaciones de estos hallazgos. Asimismo, se presenta el plan de erradicación de esta especie exótica de los oasis de Baja California Sur que hemos propuesto e iniciado recientemente y las perspectivas de éxito mediante el involucramiento de la gente local en la erradicación.
Satisfying the Compact: A Look at the Economic Impact of Cleaning the Republican River
Una mirada a los impactos económicos de la limpieza del Río Republicano

Jennifer Rittenhouse ten-Bensel
Executive Administrator / Administrador ejecutivo
Southwest Nebraska RC&D
PO Box 433 Indianola, NE 69034 USA
jennifer@swrcd.org

Other authors / Otros autores:
Mary Rittenhouse
Center for Economics Education, University of Nebraska at Kearney

Resumen
El agua es un recurso valorado en todo el planeta, y el estado de Nebraska no constituye ninguna excepción a esta regla. Es difícil explicar el valor económico del agua o determinar quién es el dueño del agua que fluye en los arroyos, pero los estados han hecho precisamente eso. Es por esto que el Acuerdo Republicano de la Cuenca, firmado el 31 de diciembre de 1942, se acordó entre los estados de Nebraska, Kansas y Colorado. Este acuerdo establece la cantidad de agua del Río Republicano que cada estado puede utilizar.

Actualmente, el uso del agua del Río republicano está regido por un decreto de 2003 de la Suprema Corte de los Estados Unidos, que aprobó un acuerdo entre Colorado, Kansas y Nebraska a raíz de una demanda que interpuso Kansas en 1998. En 2007, el Estado de Kansas amenazó nuevamente con demandar a Nebraska por excederse en la cantidad de agua utilizada en 2005 y 2006. Como respuesta a esta acción legal, Nebraska comenzó a buscar soluciones para la problemática del Río Republicano.

Este trabajo examina la respuesta de Nebraska a estos litigios y las contribuciones socio-económicas al estado a raíz de las soluciones propuestas. Una solución fue revisar el flujo de arroyos del Río Republicano y buscar maneras de incrementar el flujo de agua hacia Kansas para satisfacer el acuerdo. El proyecto de Ley 701 atendió el problema mediante la asignación de recursos a Áreas de Manejo de Malezas a lo largo de la cuenca del Río Republicano, para remover a las especies invasoras en el canal y en las planicies de flujo del río. Se pensaba que estas plantas indeseables estaban utilizando grandes cantidades de agua y acabando con el recurso antes de que este llegara a Kansas. Al limpiar el río de vegetación indeseada más se liberaría más agua para cumplir con el acuerdo.

El Área de Manejo de Malezas del Sureste, un proyecto de Southwest Nebraska RC&D, ha recibido más de $2.9 millones desde el 2007, para la remoción de especies invasoras del Río republicano en los condados de Furnas, Red Willow, Hitchcock y Dundy. Este trabajo revisa los resultados de la remoción de especies invasoras del Río Republicano en el Área de Manejo de Malezas del Sureste. Compara la cantidad invertida en estos cuatro condados de Nebraska con los acres de trabajo completado. También examina la información sobre el flujo de arroyos proporcionada por el United States Geological Survey y determina si los recursos gastados por el Estado se han incrementado. Finalmente, se habla de los acres utilizables a raíz del trabajo que se llevó a cabo en el Río.

Abstract
Water is a valued resource all over the world, and the State of Nebraska is no exception to rule. It is difficult to explain the economic value of water or determine who owns water flowing in streams, but states have done just that. That is why the Republican Basin Compact signed on December 31, 1942 was put in place between Nebraska, Kansas and Colorado. This compact outlines the amount of water each state is entitled to from the Republican River.

Today, water use from the Republican River is governed by a 2003 decree from the United States Supreme Court, which approved a settlement among Colorado, Kansas and Nebraska of a lawsuit that Kansas filed in 1998. In 2007, The State of Kansas again threatened to sue the State of Nebraska for exceeding the amount of water used in 2005 and 2006. As response to this legal action, Nebraska started looking for solutions to the Republican River water problems. This paper looks at Nebraska’s response to this litigation and the socioeconomic contributions to the
state from the proposed solutions. One solution was to look at stream flow from the Republican River and figure out ways to get more water into Kansas to satisfy the compact. Legislative Bill 701 addressed this problem by allocating money to Weed Management Areas located in the Republican River Basin to remove invasive species in the channel and floodplain of the river. These undesirable plants were thought to use excessive amounts of water and were using the water before it got to Kansas. By clearing the river of unwanted vegetation more water would be freed to meet the compact.

Southwest Weed Management Area, a project of Southwest Nebraska RC&D has received more than $2.9 million since 2007 for the removal of invasive species in the Republican River in the Nebraska Counties of Furnas, Red Willow, Hitchcock and Dundy. This paper looks at the findings from the removal of invasive species on the Republican River in the Southwest Weed Management Area. It will compare the money spent in these four Nebraska Counties to the acres of work completed. This paper will also look at the stream flow data provided by the United States Geological Survey and determine if the dollars spent by the State has increased. This paper also addresses the useable acres now available from the work on the river.

Presentation Summary

History of the compact

On December 31, 1942 the States of Nebraska, Kansas and Colorado entered into a compact regarding the waters of the Republican River Basin. One purpose of this compact was to provide the most efficient use of the waters equally between states. The compact outlined the specific allocations made to each State. Since the 1950s the Compact has been administered by the Republican River Compact Administration. Today, water use from the Republican River is governed by a 2003 decree from the United States Supreme Court, which approved a settlement among Colorado, Kansas and Nebraska.

In 2007, The State of Kansas again threatened to sue the State of Nebraska for exceeding the amount of water used in 2005 and 2006. In May of 1998 the State of Kansas filed a complaint with the U.S. Supreme Court alleging that Nebraska was in violation of the Republican River Basin Compact. As response to this legal action, Nebraska started looking for solutions to the Republican River water problems.

Nebraska’s response

In 2006, Nebraska Senator Tom Carlson began addressing water issues that have a considerable economic impact on his district and the state. As a result of his findings, Senator Carlson submitted Legislative Bill 458 as his priority bill to the Nebraska State Legislature. The bill was amended and combined with Legislative Bill 701 to create a comprehensive bill on state water policy. Part of this bill recognized the importance of controlling noxious and invasive vegetation as part of the answer to Nebraska’s water problems. Invasive and native vegetation occupied much of the Republican River bed, inhibiting stream flow by consumptive water use and excessive sedimentation.

One solution was to study the stream flow from the Republican River and determine alternative ways to satisfy the compact. Legislative Bill 701 addressed this problem by allocating money to Weed Management Areas located in the Republican River Basin to remove invasive species in the channel and floodplain of the river. These undesirable plants were thought to use excessive amounts of water and were using the water before it got to Kansas. By clearing the river of unwanted vegetation more water would be freed to meet the compact.

Legislative Bill 701 provided $2 million to begin a vegetation removal program in Nebraska. This bill gave bonding authority to Natural Resource Districts (NRD’s) to provide funding needed to meet consumptive use targets through 2012. The bonds would be paid off through fees or taxes levied by local NRD’s.

The State of Nebraska felt this Legislative Bill would help provide the necessary steps to fixing the looming water problem. Senator March Christensen, of Imperial, NE was the original author of Legislative Bill 701. “By ensuring that our state has the funding necessary to devote to programs that will better manage our water supply, all those involved in supporting this legislation have put the best interests of our state first. This is vital legislation that will help us to become better stewards of our state’s most valuable natural resource.” (Hein, 2007).

Work completed

Southwest Weed Management Area, a project of Southwest Nebraska RC&D has received more than
$2.9 million from grants since 2007 for the removal of invasive species in the Republican River in the Nebraska Counties of Furnas, Red Willow, Hitchcock and Dundy. Southwest Weed Management Area was formed in 2006 and includes as members: county weed superintendents, Southwest Nebraska RC&D Inc., the Upper and Middle Republican NRDS, NRCS field office personnel, and other agencies and private land owners. The group coordinates and assists efforts to identify and control noxious weeds and invasive plants. The primary targets of this project are saltcedar (*Tamaricaceae*) and Phragmites (*Phragmites australis*) within the river channel and Eastern red cedar and Russian olive (*Elaeagnus angustifolia*) within the 100 foot corridor on the stream banks up to the high flood plain.

In 2007, Southwest Weed Management Area was awarded a grant in the amount of $814,617.00 for the Western Republican River Riparian Improvement Project. This grant was funded with monies set aside by Legislative Bill 701 and was administered by the Nebraska Department of Agriculture. The purpose of this grant was to facilitate the removal of invasive species from the Republican River corridor in Southwest Nebraska. This began the work completed by Southwest Weed Management has continued to receive money from different grant sources each year through 2010 for invasive species removal on the Republican River. In 2008 Southwest Weed Management Area received a second grant from the Nebraska Department of Agriculture in the amount of $764,700. Funding from LB 701 ended after the second year and other grant sources were sought.

In 2009 Southwest Weed Management Area applied for and received a grant in the amount of $300,000 from the Nebraska Environmental Trust. Additional years were awarded in 2010 for $494,988 and in 2011 for $604,610 (Figure 8).

![Figure 8. Dollars Received each year](image)

Mechanical Tree Removal has been the primary source of the removal of invasive species on the Republican River for Southwest Weed Management Area. Mechanical Tree removal is exactly what the name implies. It is simply the use of a machine to remove a tree. During the performance of region wide vegetation control operations, trees that are too large or are geographically located in such a way as to be unmanageable by other control methods (i.e. chemical treatment, controlled burn, etc.) are frequently encountered. The only viable way to deal with these larger trees is through the process of mechanical removal. This is basically a three step process.

First the tree must be cut. This can be accomplished in several ways. Anything from chainsaws for smaller projects up to commercial forestry Hydro axes can be used. Due to the large scale of the project, Southwest Weed Management Area opted to use skid steer loaders
with large rotary saws or scissor type shears affixed to the front ends for the majority of the operations. These machines are highly mobile and are able to cut large volumes of work in a short time. An added benefit of skid steer based tree saws is their comparative lower cost to purchase and operate as opposed to large commercial sized equipment. This lower cost point enabled smaller local operators and contractors to bid on tree removal jobs which greatly increased Southwest Weed Management’s options as far as the number of contractors used to work on the project. This greater number of available contractors contributed to a much more competitive bidding process and certainly lowered costs for Southwest Weed Management considerably.

Second, depending on the species of tree being cut, the stump must be treated with a suitable herbicide in order to prevent regrowth. Certain species of trees, primarily the conifers will not regenerate from a cut stump and thus require no chemical treatment. However two of the species of trees that Southwest Weed Management was dealing with, Russian olive and salt cedar are aggressive re-sprouters. The stumps of these two species must be chemically treated after cutting. This chemical application could either be performed by sprayers mounted on the skid steer or manually by personnel with small hand held sprayers. The preferred treatment formulation was a mixture of Garlon 4 Ultra and Stalker. These two agents were mixed with JLB oil as a carrier. This mixture was then applied to the cambium layer of the cut stump. The success of this part of the operation was most dependent on the skill of the operator and care had to be taken to properly apply the chemical. This treatment was most effective when performed within 15 minutes of the actual cutting.

Finally, the tree must be removed. Due to the large scale of the project and the economic realities of our geographic location, the only viable option for Southwest Weed Management at this time is to gather the cut trees and place them in large piles. Disposal of these piles has been left to the landowner. Many of these piles have been burned or simply left for wildlife habitat. An economically viable use for these piles is being considered and studies at this time.

Herbicide treatment has also been used on the invasive species. This treatment can be applied by airboat, helicopter or with ground crews using all-terrain vehicles. This is not efficient on the large trees in the channel, but very effective on the re-growth and smaller trees. Herbicide treatment is also used on Phragmites.

The initial program only removed invasive species within 100 foot of the center of the river. In 2009, the boundary was extended to include the flood plain, increasing the amount of area needing treatment.

During the first year of treatment, Southwest Weed Management focused most of their efforts on mechanical removal in the channel and within the 100 foot. 1,064 acres were cleared of undesirable species (Figure 9).

Figure 9. Acres of Invasive Removal Per Year. Source: Southwest Weed Management Area.
A limited amount of spraying was done during the first year. Phragmites had been located in Furnas, Red Willow and Hitchcock Counties. These areas were found and treated along the river by using an airboat.

The results—socioeconomic benefits
The most common way to determine if water flow has increased in a river is to look at stream flow measurements. The United States Geological Survey has this information available on rivers and streams in Nebraska through September, 2010. Measurements were taken from six locations on the Republican River in the Southwest Weed Management Area. These locations were near Haigler, Benkelman, Palisade, Culbertson, McCook and Cambridge (Figure 10).

The Stream flow measurements taken from six locations on the Republican River do not necessarily support the initial opinions regarding the use of water by invasive species in the Republican River. By initial reasoning, removing the invasive species would free up water consumption and therefore more water should be flowing in the river. Each year, the stream flow would continue to increase while invasive were being removed, if this is the case. However by looking at the six measurement sites, this is not necessarily true (Table 8: Appendix A).

Looking at each site individually also does not provide conclusive evidence that removing trees has provided more water for the Republican River Basin. By organizing the stream flow data into monthly comparisons, a more accurate portrayal of water flow each season can be viewed. As shown on the Figure 11, this is not necessarily true either (Data provided in Table 9: Appendix B). The six sites do not indicate a regular increase in stream flow as invasive trees were removed from the river channel.
Figure 11. Stream Flow comparisons by month. *Source: U.S. Geological Survey*
Palisade, NE Stream Flow Comparison by month

Red Willow CO, NE Stream flow Comparisons by month

Cambridge, NE Stream flow comparisons by month
There are other measurements that indicate positive results of the invasive species removal. One of these is looking at the channel of the river itself. Before the river was cleared, there was nowhere for the water to flow during high water events. During these events, water that would normally flow down the channel of the river often flooded the land around the river bed. This caused flooding of crops resulting in loss of income for agricultural producers. Valuable pasture land that provides grazing for cattle along the river was also lost during times of flooding.

Another important economic benefit from the removal of invasive species is the number of jobs created for this project. Since 2007, more than 20 contractors have been involved with the project in these four counties. Most of these were tree removal companies located in the Southwest Weed Management Area or in the state of Nebraska. There have also been several ground crews hired for spraying, an airboat crew and a helicopter crew. This project has provided employment for nearly 100 people at some point during the project, including one full time coordinator for Southwest Weed Management Area.

Before the clearing of the river, much of the land in the riparian area was not able to be used for other uses. It had too many trees to farm, or even use as pasture for livestock. By mechanically clearing nearly 5,000 acres (Figure 9) this land can be utilized for other uses. Some agriculture produces have opted to put some of this land back into production for farming. With very high commodity prices, this land provides more income on the farm. Other producers have been able to graze these acres, making those acres economically viable again. Grazing the river has an added benefit for controlling grasses and other vegetation.

The benefits to wildlife should not be discounted. In a state that is recognized for water fowl hunting, open rivers allow a place for geese to land and lay their eggs. Many have been using the open islands on the river as habitat.

Eco-tourism benefits of birding and wildlife watching is also becoming popular on the Republican River and in the state of Nebraska. With waterways open for landing, birds have found their way back home and are able to nest again in the Republican River Valley. Clearing excess trees open up the possibility of tours on the river for birdwatchers from other states.

Another possible economical benefit is the biomass left from the trees cut and piled. Southwest Weed Management has been working with Nebraska Forestry and Nebraska College of Technical Agriculture in Curtis, NE to find a feasible way to chip these trees and use them as a fuel source at the college.

**Conclusion**

After looking at the numbers provided by the stream flow data, one might decide this project has not met the initial goals. Did the cost outweigh the benefits of clearing invasive species on the Republican River? Other indicators show the positive results of the Western Republican River Improvement Project.

The Socioeconomic benefits of the invasive removal are many. The invasive species living in the river bed choked out the channel leaving nowhere for the water to flow. By cleaning this up, the water is able to stay in the river and reduce the amount of farm and pasture land to flooding during high water events. The vegetation also slowed the flow of water moving in the channel, meaning it took longer to arrive at Kansas for measurement to meet the compact.

Jobs were created throughout the project, bringing additional income to the four counties in the Southwest Weed Management Area and vicinity. There is also the possibility of new economic ventures with the biomass being used to heat broiler systems being installed in local colleges.

Finally, the benefit for wildlife is valuable also. The removal of trees in the channel area aids in hunting and also eco-tourism activities such as birding and wildlife watching on the Republican River.

The data does not indicate that removing these invasive species directly put water back into the river to send to Kansas. The benefits for the river and the people who use it, are continuous.
### Table 8. Appendix A-Stream Flow Measurements

Stream Flows are measured in Cubic Feet per Second

<table>
<thead>
<tr>
<th>Date</th>
<th>Haigler, NE</th>
<th>Benkelman, NE</th>
<th>Palisade, NE</th>
<th>Culbertson, NE</th>
<th>Red Willow, CO, NE</th>
<th>Cambridge, NE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mar. 2007</td>
<td>0.26</td>
<td>0</td>
<td>30.83</td>
<td>52.37</td>
<td>6.27</td>
<td>71.86</td>
</tr>
<tr>
<td>Jun. 2007</td>
<td>6.01</td>
<td>3.75</td>
<td>41.37</td>
<td>115.03</td>
<td>17.2</td>
<td>358.7</td>
</tr>
<tr>
<td>Sept. 2007</td>
<td>0.71</td>
<td>0</td>
<td>19.23</td>
<td>39.38</td>
<td>6.18</td>
<td>132.07</td>
</tr>
<tr>
<td>Dec. 2007</td>
<td>0.21</td>
<td>0</td>
<td>22.10</td>
<td>41.37</td>
<td>6.09</td>
<td>56.67</td>
</tr>
<tr>
<td>Mar. 2008</td>
<td>0.16</td>
<td>0</td>
<td>24.13</td>
<td>51.07</td>
<td>6.87</td>
<td>111.2</td>
</tr>
<tr>
<td>Jun. 2008</td>
<td>4.04</td>
<td>0</td>
<td>30.00</td>
<td>62.43</td>
<td>41.99</td>
<td>376.87</td>
</tr>
<tr>
<td>Sept. 2008</td>
<td>4.17</td>
<td>1.19</td>
<td>14.03</td>
<td>37.97</td>
<td>10.68</td>
<td>149.37</td>
</tr>
<tr>
<td>Dec. 2008</td>
<td>0.23</td>
<td>6.48</td>
<td>20.73</td>
<td>37.57</td>
<td>8.31</td>
<td>103.5</td>
</tr>
<tr>
<td>Mar. 2009</td>
<td>0.42</td>
<td>9.23</td>
<td>24.90</td>
<td>50.43</td>
<td>8.47</td>
<td>127.93</td>
</tr>
<tr>
<td>Jun. 2009</td>
<td>1.79</td>
<td>22.13</td>
<td>29.40</td>
<td>35.60</td>
<td>8.97</td>
<td>109.33</td>
</tr>
<tr>
<td>Sept. 2009</td>
<td>1.17</td>
<td>2.68</td>
<td>26.23</td>
<td>17.49</td>
<td>9.83</td>
<td>105.83</td>
</tr>
<tr>
<td>Dec. 2009</td>
<td>0.92</td>
<td>12.47</td>
<td>27.43</td>
<td>49.00</td>
<td>122.04</td>
<td>207.03</td>
</tr>
<tr>
<td>Mar. 2010</td>
<td>3.24</td>
<td>26.13</td>
<td>31.53</td>
<td>59.80</td>
<td>46.53</td>
<td>256.87</td>
</tr>
<tr>
<td>Jun. 2010</td>
<td>7.4</td>
<td>19.93</td>
<td>34.40</td>
<td>59.70</td>
<td>50.53</td>
<td>23.53</td>
</tr>
<tr>
<td>Sept. 2010</td>
<td>2.07</td>
<td>18.95</td>
<td>18.53</td>
<td>25.03</td>
<td>20.5</td>
<td>144.9</td>
</tr>
</tbody>
</table>

Source: U.S. Geological Survey

### Table 9. Appendix B-Stream Flow Measurements by Site (Monthly Comparison)

Stream Flow is measured in Cubic Feet per Second

<table>
<thead>
<tr>
<th>Date</th>
<th>Haigler, NE</th>
<th>Benkelman, NE</th>
<th>Palisade, NE</th>
<th>Culbertson, NE</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007</td>
<td>0.26</td>
<td>0</td>
<td>30.83</td>
<td>52.37</td>
</tr>
<tr>
<td>2008</td>
<td>6.01</td>
<td>3.75</td>
<td>41.37</td>
<td>115.03</td>
</tr>
<tr>
<td>2009</td>
<td>0.71</td>
<td>0</td>
<td>19.23</td>
<td>39.38</td>
</tr>
<tr>
<td>2010</td>
<td>0.21</td>
<td>0</td>
<td>22.10</td>
<td>41.37</td>
</tr>
</tbody>
</table>

### Benkelman, NE

<table>
<thead>
<tr>
<th>Date</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mar.</td>
<td>0.26</td>
<td>0.16</td>
<td>0.42</td>
<td>3.24</td>
</tr>
<tr>
<td>Jun.</td>
<td>6.01</td>
<td>4.04</td>
<td>1.79</td>
<td>7.4</td>
</tr>
<tr>
<td>Sept.</td>
<td>0.71</td>
<td>4.17</td>
<td>1.17</td>
<td>2.07</td>
</tr>
<tr>
<td>Dec.</td>
<td>0.21</td>
<td>0.23</td>
<td>0.92</td>
<td>N/A</td>
</tr>
</tbody>
</table>

### Palisade, NE

<table>
<thead>
<tr>
<th>Date</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mar.</td>
<td>30.83</td>
<td>24.13</td>
<td>24.90</td>
<td>31.53</td>
</tr>
<tr>
<td>Jun.</td>
<td>41.37</td>
<td>30.00</td>
<td>29.40</td>
<td>34.40</td>
</tr>
<tr>
<td>Sept.</td>
<td>19.23</td>
<td>14.03</td>
<td>26.23</td>
<td>18.53</td>
</tr>
<tr>
<td>Dec.</td>
<td>22.10</td>
<td>20.73</td>
<td>27.43</td>
<td>N/A</td>
</tr>
</tbody>
</table>

### Culbertson, NE

<table>
<thead>
<tr>
<th>Date</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mar.</td>
<td>52.37</td>
<td>51.07</td>
<td>50.43</td>
<td>59.80</td>
</tr>
<tr>
<td>Jun.</td>
<td>115.03</td>
<td>62.43</td>
<td>35.60</td>
<td>59.70</td>
</tr>
<tr>
<td>Sept.</td>
<td>39.38</td>
<td>37.97</td>
<td>17.49</td>
<td>25.03</td>
</tr>
<tr>
<td>Dec.</td>
<td>41.37</td>
<td>37.57</td>
<td>49.00</td>
<td>N/A</td>
</tr>
</tbody>
</table>
Economic Impacts of Invasive Species on Annette Island Reserve, Alaska
Impactos económicos de las especies invasoras en la Reserva Isla Annette, Alaska

Gina Ramos on behalf of Genelle Winter
Metlakatla Indian Community

Presentation Summary
Annette Islands Reserve (AIR) is the southernmost community in Alaska and the only Native Reserve in the State of Alaska. The Metlakatla Indian Community (MIC) is the population center and governing body of AIR. There are approximately 1450 people living on this 130 square mile island, some 83,200 acres of land. Of these 12,472 acres have been surveyed for invasive species and to date, we have 339.25 acres of known invasive weeds. This is just under 3 acres, less than previous years, thanks to the efforts of our Metlakatla Landscape and Maintenance crew (MLM), who have removed hundreds of pounds of weeds in the last six years!

The weeds of concern that have been found are:
• *Cirsium vulgar* - Bull Thistle
• *Cirsium arvense* - Canada Thistle
• *Sonchus arven* - Sow Thistle
• *Persicaria wallichii / Polygonum polystachyum* - Himalayan Knotweed
• *Polygonum cuspidatum* - Japanese Knotweed
• *Senecio jacobaea* - Tansy Ragwort
• *Hieracium aurantiacum* - Orange Hawkweed
• *Phalaris arundinacea* - Reed Canary Grass

To date, the MLM of MIC has spent over 13,000 combined hours and just under $100,000 each year treating, surveying and performing inventory on invasive plants on AIR. We expect to maintain a consistent level of funding in the on-going fight to prevent and control invasive species on Annette Islands Reserve.

References


Source: U.S. Geological Survey
As we observe changes in our climate, our responses to the presence of invasive species must change as well.

Economic impacts to traditional foods from invasive species cannot be under emphasized and yet it is very difficult to put into hard numbers. Local subsistence foods include, but are not limited to the following low and high bush cultivars: blueberry, huckleberry, salmonberry, thimbleberry.

Example of potential economic factors:
A jar of raspberry jam (comparable to salmonberry preserves) costs $6.69 for an 18 oz jar

A bag of frozen blueberries costs $6.29 for a 16 oz bag

These items are commonly supplemented by harvesting, freezing or preserving wild berries instead of purchasing them. If these wild berries were to be eradicated by invasive species such as Himalayan Knotweed (*Persicaria wallichii* or *Polygonum polystachyum*) or Reed Canary Grass (*Phalaris arundinacea*) it would cause a financial hardship on many families.

Our family for example, harvests a minimum of 4 gallons of berries each season. If we had to purchase those fruits it would cost our family over $200.00 for the blueberries alone.

**Medicinal and Cultural plants**
Pressure from invasive plants also affects traditionally harvested medicinal and culturally significant plants some examples are:

- Devils Club (*Oplopanax horridus*) - used for medicinal tea, salves, poultices and many other uses
- Yew Wood (*Taxus brevifolia*) - used for its beautiful, tough, durable wood for a variety of uses as well as tea from the bark thought to be good for cancer and other diseases
- Labrador Tea (*Ledum groenlandicum*) makes a tasty tea full of antioxidants
- Cedar bark, and maidenhair fern (*Adiantum pedatum*) are used for weaving baskets and regalia
- Both Red Cedar (*Thuja plicata*) and Yellow Cedar (*Chamaecyparis nootkatensis*) and Alder (*Alnus rubra*) are used for carving
- Alder (*Alnus rubra*) is the most versatile for carving, the art of carving is still taught to the youth in Metlakatla, carrying on this art form for future generations. And is the most common wood to smoke fish with

Another example of an economic impact is the income from salmon. A can of Pink Salmon at the local store costs $6.69 which means that a case of 12 costs $80.28 for pink salmon. The average family harvests 10 cases, approximately $802.80 per family in addition to the amount processed for their own consumption. Allowing spawning beds to be impacted negatively in any way would cause financial hardship for these families that harvest and process subsistence gathered salmon.

Other subsistence foods at risk are Dungeness Crab, Shellfish such as butter clams and cockles, seaweed and sea asparagus. A 6 oz can of crab at the market costs $3.59, a 6.5 oz can of clams at the market costs $2.25. These foods are at risk from aquatic invaders like Tunicates and Botryloids, Zebra and Quagga mussels, European Green Crab and Atlantic Salmon invading their feeding grounds, degrading their spawning grounds and changing the ecosystem in ways we still don’t know or can’t predict.

On the Annette Island Reserve, approximately $2 million flow into the local economy from commercial salmon fishing alone. Any risk to this sustainable and responsibly managed harvest would be unacceptable.

As a result, we are aggressively researching all we can about the potential threats to these important food and commercial revenue sources. One of weeds of great concern is a newly identified Reed Canary Grass (*rcg*) and material has been published to communicate that it is a plant that spreads aggressively, reproduces by seed or rhizomes, and can be dispersed from one wetland to another. The experience in SE AK is that *rcg* starts growing much sooner than in other areas in the State and due to its aggressive propagation habit this weed is our #1 invader to watch for and to treat outside of the established areas in the city limits. We have surveyed and identified 5 acres to date, but we know there is more that hasn’t been documented yet. We estimate the number is closer to 20 acres.

A major vector of introduction that we are putting great effort into education and manual prevention is the Alaska Marine Highway System (*amhs*). Our isolated island can only be accessed by vehicle via the *amhs* or by
Barge. To prevent spread and introduction of weed seed and plant particles we are working with the AMHS to install a vehicle wash system at the vehicle exit on our new, currently weed free Walden Point Road. The goal is to prevent this pristine road from being impacted by serious invaders from other parts of Alaska and British Columbia given that we are the southernmost community in SE AK, and only a six hour ferry ride from Prince Rupert BC and a 36 hour ride from Bellingham WA.

Thus we must carefully monitor the entry vectors to the island, the AMHS, the Barge system, commercial fishing vessels and recreational boaters and campers. Installing the vehicle wash system will help prevent species such as Giant Hogweed, Bohemian Knotweed, Scotch Broom and others from becoming established on our island. If we do not apply Early Detection and Rapid Response (EDRR) the impacts could become very costly, both economically and environmentally.

In Conclusion, the costs to our subsistence foods is difficult to quantify but to say the least, it would be a tragic end to a rich cultural heritage that should be preserved and respected.

Acknowledgements and Thanks
The Metlakatla Indian Community
The Bureau of Indian Affairs, FICMNEW
And the people of the community of Metlakatla, Alaska.

Reference material was taken from Invasive Plants of Alaska, produced in cooperation with the U.S. Department of the Interior; the U.S. Department of Agriculture; the Alaska Soils and Water Conservation District; the University of Alaska Fairbanks Cooperative Extension Service and the Alaska Natural Heritage Program.

Tamarisk in Sonora: Are We Losing Biodiversity?
Tamarisco en Sonora: ¿Estamos perdiendo biodiversidad?

Ek Del Val
Researcher / Investigadora
Ecosystems Research Center, UNAM / Centro de Investigaciones en Ecosistemas, UNAM
Antigua Carretera a Pátzcuaro No. 8701 Col. Ex-Hacienda de San José de la Huerta C.P. 58190 Morelia, Michoacán
ekdelval@cieco.unam.mx, ekdelval@gmail.com

Other authors / Otros autores:
Lucero Sevillano & Ian Mac Greggor

Resumen
Los efectos negativas de tamarisco sobre la biodiversidad han sido bien estudiados en los USA. Aunque la planta ha estado establecida en el Norte de México desde principios de los 1900’s, pocos estudios han documentado qué está sucediendo en los ecosistemas locales tras una invasión de Tamarisco. Los regímenes de los ríos a nivel regional han sido completamente modificados y hay pocas zonas prístinas en la región. Llevamos a cabo unos muestras de aves e insectos en el Parque nacional Ajos Bavispe en Sonora, para investigar si la biodiversidad local puede permanecer en áreas invadidas por el tamarisco. La fauna entomológica es muy escasa en áreas invadidas, sólo algunas especies de Coccinelidae, Apidoidea y Lepidoptera están presentes. Los valores de riqueza de aves no mostraron diferencias significativas entre hábitats invadidos y no invadidos (8.4 ± 1.4 and 8.4 ± 1.6 especies computadas, p<0.05), ni la abundancia total (16 ± 3.3 and 17.3 ± 3.0 individuos, p<0.05). Sin embargo la agrupación multivariada de Bray-Curtis, reveló que las comunidades de aves estudiadas eran altamente diferentes a pesar de su cercanía, con un promedio de similitud bajo (~33% de similitud). Encontramos un alto número de especies anidando en sitios no invadidos (6 especies incluyendo colibríes, Verdín, mosquero cardenalito y gorrión mexicano), mientras que en los sitios muy invadidos había nidos de cinco especies identificadas; la prueba de Fisher reveló una diferencia significativa en el número de nidos que se encontraron y que se podían distinguir entre ellos (p= 0.004). Aparentemente el Tamarisco también está teniendo un efecto negativo en la biodiversidad de So-
nora a pesar de que nuestro estudio se llevó a cabo en una región con bajo impacto humano. Sugerimos que deben de implementarse esfuerzos para controlar esta especie en México.

**Abstract**

Tamarisk negative effects on biodiversity have been well studied in the USA. Even though the plant is well established in northern Mexico since early 1900’s, few studies have documented what is happening in local ecosystems after Tamarisk invasion. Regional river regimes have been completely modified and seldom pristine areas are found in the region. We conducted bird and insect surveys at the Ajos Bavispe National Park in Sonora, to investigate if local biodiversity can persist in Tamarisk invaded areas. Insect fauna is very scarce in Tamarisk invaded areas, only few species of Coccinellidae, Apidoidea and Lepidoptera are present. Bird species richness values did not show significant differences among invaded and non-invaded habitats (8.4 ± 1.4 and 8.4 ± 1.6 computed species, p<0.05), nor total abundance (16 ± 3.3 and 17.3 ± 3.0 individuals, p<0.05). Similarly, relative abundances did not differ significantly among the studied conditions (individuals / point count: \( H_{123} = 5.7, p=0.12 \)). However the Bray-Curtis multivariate cluster analysis revealed that the studied bird communities were highly different regardless of their closeness, with low average similarity among them (~33% similarity). We found a higher number of species nesting in non-invaded sites (6 species, including hummingbirds, Verdin, Vermilion Flycatcher, House Finch), while severely invaded sites had nests of five identified species; the Fisher’s exact test revealed significant differences in the number of nests found for the nest that could be differentiated from each other (p = 0.004). Apparently Tamarisk is also having negative effects upon biodiversity in Sonora despite that our research was conducted in a region with low human impact. We suggest that control efforts for this species should be put in place in Mexico.

**IMPPLAN’s Role in Invasive Plant Research and Management**

*El papel de IMPLAN en la investigación y manejo de plantas invasoras*

**Jennifer Thorvaldson**

*Regional Economist / Economista Regional*

*MIG, Inc.*

502 2nd St., Suite 301 Hudson, WI 54016 USA

jenny@implan.com

Other authors / Otros autores:

Gregory Alward

IMPLAN

**Resumen**

Los ecosistemas proveen una variedad de bienes y servicios a la humanidad, a cada uno de los cuales se podría, en teoría, asignársese un valor. Se han llevado a cabo numerosos estudios para medir el valor de los efectos detrimenales de las especies invasoras en los ecosistemas naturales. Cada vez se utilizan más los estudios económicos para justificar las medidas en contra de las especies invasoras.

Debido a las relaciones económicas entre industrias e instituciones, un impacto en uno de los sectores o componentes de la economía puede tener efectos sustanciales en empleos, ingresos y gastos de otros sectores. Al describir los flujos de dinero entre industrias e instituciones, los modelos multiplicativos de Matrices de Contabilidad Social (MCS) pueden extender el análisis para incluir los impactos indirectos e inducidos que reverberan en toda la economía a raíz del impacto inicial. Aunque los modelos multiplicativos de MCS no pueden modelar directamente los impactos ambientales, si estos pueden traducirse en cambios de producción, gastos o empleos, el modelo puede utilizarse para evaluar los efectos indirectos e inducidos que se originaron de esos impactos iniciales.

**IMPLAN (IMpact Analysis for PLANning)** se desarrolló como un método rentable para construir modelos regionales de MCS. El sistema IMPLAN fue diseñado para llenar tres funciones: 1) recuperación de información, 2) reducción de datos y modelos de desarro-
Abstract
Ecosystems provide humans with a variety of goods and services, each of which can theoretically be assigned a value. Numerous studies have been carried out to measure the value of the detrimental effects invasive species have on natural ecosystems. Economic studies are increasingly being used to justify measures against invasive species.

Due to economic linkages between industries and institutions, an impact in one sector or component of the economy can have substantial effects on employment, incomes, and expenditures in other sectors. By describing the flows of money between industries and institutions, Social Accounting Matrix (SAM) multiplier models can extend an analysis to include the indirect and induced economic impacts that ripple throughout the economy as a result of an initial impact. While SAM multiplier models cannot directly model environmental impacts, if the environmental impacts can be translated into a change in production, expenditures, or employment, the SAM multiplier model can then be used to assess the indirect and induced effects stemming from those initial impacts.

IMpact Analysis for PLANning (IMPLAN) was developed as a cost-effective means to construct regional SAM models. The IMPLAN system was designed to serve three functions: 1) data retrieval, 2) data reduction and model development, and 3) impact analysis. With the recent development of its trade flow model, IMPLAN also provides the capability to conduct multi-regional I-O analysis, which gives the user the ability to see the indirect and induced effects occurring in regions other than the directly-affected region. IMPLAN is used by a wide variety of public agencies and private firms, and has been used in a number of invasive species analyses. This presentation will describe IMPLAN’s impact calculation process and how IMPLAN can be used to augment analyses of the impacts of invasive species.

Presentation Summary

Introduction
Ecosystems provide humans with a variety of goods and services, each of which can theoretically be assigned a value. Direct goods and services might include water resources, timber resources, or other consumptive uses. Indirect services might include purification of water supplies, or pollination, or other natural processes that enhance nature’s provision of social welfare (Kaiser, 2006). Use values (such as those stemming from food production or recreational activities) can be measured more easily, while non-use values (such as existence and bequest values) are much harder to quantify.

Economics can be helpful in the management of invasive species by providing the following:
1. *Ex ante* selection and prioritization of preventative and control measures
2. *Ex post* evaluation of program efficiency
3. Economic impact analysis of:
   a. Damage due to invasion
   b. Prevention, management, or eradication activities

Numerous studies have been carried out that measure the value of the detrimental effects invasive species have on natural ecosystems. Economic studies are increasingly being used to justify measures against invasive species. However, a broad body of knowledge about the social and economic consequences of invasive species is missing (Cusack et al., 2009). Economic analyses are hindered by a lack of uniformity in methodologies used, uncertainty as to what constitutes an adverse ecological impact, and difficulties in predicting the nature and magnitude of impacts (Cusack et al., 2009). Devising a standard methodology as to which impacts to include in the assessment and which measurement tools and methods to employ would greatly improve the usefulness and comparability of such studies. This paper discusses multiplier models – and IMPLAN in particular – in the context of evaluating the economic impacts of invasive species.

Input-Output Models
Due to economic linkages between industries and in-
stitions, an impact in one sector or component of the economy can have substantial effects on employment, incomes, and expenditures in other sectors. By describing commodity flows from producers to intermediate and final consumers, input-output (I-O) models can extend an analysis to include the indirect effects that ripple throughout the economy as a result of the initial impact. The initial change in production or expenditure represents the direct effect. The indirect effects stem from input purchases and are calculated by tracing backward along the supply chain.

Suppose the direct effect is an increase in final demand for a particular sector of the economy. To meet the new demand, the directly-affected sector must purchase more inputs — these input purchases represent the first round of indirect effects. In the second round of indirect effects, those supplier industries purchase more of their own inputs to meet the new demand for their output. Each subsequent round of indirect effects is smaller than the last due to the leakage of money in the form of profits, taxes, savings, and imports, and they continue until they eventually diminish to nothing. Collectively, these rounds constitute the local supply chain of the directly-affected sector.

The calculation process can be described as follows. If the economy is divided into N sectors and we define the following:

\[ X_i = \text{the total output of sector } i \]
\[ X_{ij} = \text{inter-industry sales by sector } i \text{ to sector } j \]
\[ Y_i = \text{final demand for sector } i\text{'s product} \]

Then:
\[ X_i = X_{i1} + X_{i2} + \cdots + X_{in} + Y_i \]

The output sold to other industries depends on those industries' output levels and their technical coefficients:

\[ X_i = a_{i1} X_1 + a_{i2} X_2 + \cdots + a_{in} X_n + Y_i \]

Summing over all industries:
\[ X = AX + Y \]

Finally, combining terms and rearranging:
\[ X = (I - A)^{-1} Y \]

In economic impact analysis, this equation is typically written as follows:
\[ \Delta X = (I - A)^{-1} \Delta Y \]

This equation describes the output required by all sectors in the regional economy to meet a given change in final demand. The term \((I - A)^{-1}\) is known as the Leontief inverse and is also commonly referred to as the multiplier matrix. Multipliers describe these rounds by quantifying the total effect (direct, indirect, and induced) relative to the direct impact. A sector's multiplier is an indicator of its inter-connectedness to the local economy, and depends on a number of things, including how much of the sector's inputs are purchased from within the study area, how many of its employees live in the study area, and how much it spends on intermediate inputs vs. labor income vs. taxes and profits. Multipliers vary not only across sectors but also across regions.

The I-O system focuses on inter-industry activities. Social Accounting Matrices (SAMS) extend the I-O framework to include industry-institution and inter-institution activities. By endogenizing households, SAM multipliers include the effects of household spending of labor income. These expenditures drive the induced effects. The first round of induced effects occurs when employees of the directly-affected sector spend their wages on goods and services from local businesses. When workers at these businesses spend their income, additional rounds of induced effects are generated. These rounds of induced effects continue until all of the money is leaked to savings, taxes, and imports.

The IMPLAN Data and Software System

Creating regional SAM models requires a tremendous amount of data. The costs of surveying industries within each region to derive a list of commodity purchases (production functions) are prohibitive. IMPLAN was developed as a cost-effective means to construct regional SAM models. The IMPLAN accounts closely follow the accounting conventions used in the Bureau of Economic Analysis’ “Input-Output Study of the U.S. Economy” (1980) and the rectangular format recommended by the United Nations. The IMPLAN system was designed to serve three functions: 1) data retrieval, 2) data reduction and model development, and 3) impact analysis.

With IMPLAN, the user can build a model of any U.S. 5-digit zip-code area, county, or state, or any combination of zip-codes, counties, and states, including the

---

8 In IMPLAN, institutions include households, administrative government, capital, inventory, and imports.
U.S. as a whole. With the recent development of its trade flow model, IMPLAN also provides the capability to conduct multi-regional I-O analysis, giving the user the ability to see the indirect and induced effects occurring in regions other than the directly-affected region. IMPLAN datasets have 440 industries and commodities, and nine household income categories. Multipliers can be calculated for Employment, Output, and each component of Value-Added. The tax effects associated with each impact are also estimated. The software allows the user to incorporate user-supplied data at each stage of the model-building process. The IMPLAN system is used by a wide variety of public agencies and private firms, and has been used in a number of invasive species analyses.

Converting Physical Damages into Economic Costs

SAM multiplier models cannot directly model environmental impacts; however, if the environmental impacts can be translated into a change in production, expenditures, or employment, a SAM multiplier model can then be used to assess the indirect and induced effects stemming from these initial impacts. For example, the value of a health impacts can be estimated using changes in healthcare costs. Hedonics can be used to estimate the value of aesthetic changes. And the value of lost time can be estimated using some proportion of the average wage rate of those affected. Each of the various direct economic impacts—those accruing to livestock grazing, tourism, and human health, for instance—can be modeled separately to gain additional insight into the nature of secondary impacts associated with each of these facets of direct impact.

Rich et al. (2005) list five types of economic models used in conjunction with epidemiological modeling: 1) benefit-cost analysis, 2) linear programming, 3) input-output analysis, 4) partial equilibrium analysis, and 5) computable general equilibrium. SAMS such as IMPLAN’s can be used as a data source to inform analyses that use any one of these economic models. For example, they can provide useful contextual information about an economy’s structure to benefit-cost and LP-based studies. In addition to its role in providing the multipliers for economic impact analysis, IMPLAN’s SAM is a database capable of providing necessary data for use in a wide variety of other economic models—for example, it provides the majority of the structural equations for an environmental CGE.

Pendell et al. (2007) used a partial equilibrium analysis to estimate the value of the direct impacts to animal production and meatpacking of three Foot and Mouth Disease (FMD) outbreak scenarios. Estimates associated with grain farming and truck transportation were estimated based on familiarity with the region and the overall value of production in the livestock and meatpacking sectors. These direct effects were then incorporated into IMPLAN to estimate the regional economic impact.

Hirsch and Leitch (1996) estimated the economic impact of knapweed based on procedures developed for leafy spurge (Leitch et al., 1994). Basically, direct economic impacts of knapweed on livestock grazing, wildlife-associated recreation, and soil and water conservation were estimated from biophysical relationships identified by Wallace (1991). These direct impacts were then applied to an input-output model to estimate secondary economic effects of knapweed on wildlands (Figure 10).
Determining Net Economic Impacts

The impact of an invasive species will depend on the frame of reference of the analysis. For instance, if the federal government were to entirely fund a local eradication program, then the program may not impose any costs on the local community and therefore will be a net benefit. However, from a national perspective, the net benefits clearly depend on the relative magnitude of the costs and benefits. Table 10, adapted from Whitten and Bennett (undated), lists some potential value stemming from wetlands in New South Wales, Australia, separated into those values that are purely private and those that are both private and public.

Table 10. Some Potential Values Drawn from Wetlands

<table>
<thead>
<tr>
<th>Benefits</th>
<th>Pure Private Values</th>
<th>Private and Social Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grazing production</td>
<td></td>
<td>Flora and fauna values</td>
</tr>
<tr>
<td>Firewood and timber production</td>
<td></td>
<td>Ecosystem values</td>
</tr>
<tr>
<td>Water supply</td>
<td></td>
<td>Beautify the farm and regional landscape</td>
</tr>
<tr>
<td>Drainage storage/basin</td>
<td></td>
<td>Attract birds that help reduce pests</td>
</tr>
<tr>
<td>Tourism</td>
<td></td>
<td>Existence values</td>
</tr>
</tbody>
</table>
Some invasive species may confer both costs and benefits even to the same group of individuals. Ideally, all costs and benefits should be included in the analysis to provide a more complete picture of the situation.

Some control and/or eradication costs may simply be a change in the type of spending rather than a change in the actual amount spent. For example, suppose the federal government does not increase spending to fund the eradication program, but rather diverts funds from some other existing program. Then from a national perspective, the true net impact will depend on the benefits gained from the eradication program relative to the program from which the funding was diverted. In these cases, the true impact depends on whether/how the money would have been spent otherwise and who pays for the activity and who benefits from the activity relative to the previous expenditure pattern. Again, it is up to the analyst to make these determinations and divulge them in any reports.

### Table 11. Potential Direct Value Changes and Estimation Techniques for Impacts on Wetlands

<table>
<thead>
<tr>
<th>Net Cost or Benefit</th>
<th>Type of Value</th>
<th>Estimation Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduced grazing production</td>
<td>Monetary</td>
<td>Production loss valued at historical prices</td>
</tr>
<tr>
<td>Reduced timber harvests</td>
<td>Monetary</td>
<td>Production loss valued at historical prices</td>
</tr>
<tr>
<td>Reduced crop irrigation / cost of water acquisition</td>
<td>Monetary</td>
<td>Current water prices assumed to equal the capitalized benefits of future water usage and hence the cost of lost producer surpluses</td>
</tr>
<tr>
<td>Changed wetland management</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
SAM multiplier models assume fixed prices, such that any changes in demand are assumed to lead to changes in physical output rather than prices. Related to this is the assumption of no supply constraints. By ignoring supply constraints, SAM multiplier models may overstate impacts (Breisinger et al., 2010).

SAM multiplier models are based on fixed production technology and prices (for the given model year), and no economies of scale – in other words, the proportion of inputs used in an industry’s production process is the same regardless of the level of production. In Implan, production technology is based on national average production functions, with gross absorption coefficients adjusted according to regional value added to output ratios and net absorption coefficients adjusted according to regional import rates.

**Note:** some private values may accrue to public sector organizations such as the returns from timber harvesting in publicly-owned wetlands.

<table>
<thead>
<tr>
<th>Net Cost or Benefit</th>
<th>Type of Value</th>
<th>Estimation Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rehabilitation (earthworks and re-vegetation)</td>
<td>Monetary</td>
<td>Benefit transfer from similar actions in other regions</td>
</tr>
<tr>
<td>Ongoing management</td>
<td>Monetary</td>
<td>Costs of existing programs and projects in the region</td>
</tr>
<tr>
<td>Fencing for stock control</td>
<td>Monetary</td>
<td>Costs of existing programs and projects in the region</td>
</tr>
<tr>
<td>Alternative stock water source</td>
<td>Monetary</td>
<td>Benefit transfer from Forest Creek proposal</td>
</tr>
<tr>
<td>Alternative irrigation buffer storage</td>
<td>Monetary</td>
<td>Expert estimate of costs</td>
</tr>
<tr>
<td>Tourism and recreation</td>
<td>Monetary and Non-Monetary</td>
<td>Benefit transfer from King River, a similar riverine and wetland environment</td>
</tr>
<tr>
<td>Healthy wetlands (biodiversity, existence, scenic amenity, etc.)</td>
<td>Non-Monetary</td>
<td>Choice modeling survey of local residents</td>
</tr>
</tbody>
</table>

Implan cannot provide any insight into the value of non-market goods such as ecosystem services, scenic views, existence values, and option values. Non-market valuation techniques can be used to determine the value that individuals gain from a non-market good, which is the price a consumer is willing to pay for the good net of the cost to society of providing it, aggregated across consumers of the good. Direct non-market valuation techniques include the Contingent Valuation Method (CVM) and Conjoint Analysis. These related methodologies survey individuals to ask them directly their values for non-market goods. Indirect non-market valuation techniques tie a market good to a non-market good and “portion out” the value of the market good to its composite characteristics, including the non-market good (Kaiser, 2006).
Additional Considerations

Because invasive species will continue to propagate if not entirely eradicated, the problem has a temporal component. Essentially, one must consider in each time period whether the benefit of removing a marginal unit of the invasive species is greater than the cost of doing so, while at the same time considering the present value of all future costs and benefits of that action (Kaiser, 2006).

Conclusions

Economic analyses can be helpful in the management of invasive species by assisting in the selection and prioritization of preventative and control measures, as well as post-implementation evaluation of such measures. Numerous studies have been carried out that measure the value of the detrimental effects invasive species have on natural ecosystems – many of which have used I-O analysis in general and several of which have used IMPLAN in particular. This paper has described multiplier models – and IMPLAN in particular – and how they can be used to augment analyses of the impacts of invasive species.

References


Resumen
Se monitorearon los márgenes de Río Grande desde Ojinaga al pueblo de Benito Juárez (122 km) y los márgenes del río Conchos corriente arriba desde su confluencia con el Río Grande (220 Km) hasta la Presa Luis L. Leon (El Granero), para observar la distribución del escarabajo y su efecto en el Tamarisco. Determinamos el grado de herbivoría en base a una tasa de cinco categorías, de acuerdo al grado de defoliación causado por la presencia del escarabajo al momento del monitoreo. Se encontraron daños evidentes causados por heladas (-14°C) para el mes de febrero de 2011 en Tamarix aphylla. Detectamos la presencia del escarabajo desde el pueblo de Benito Juárez en el APFF de Cañón de Santa Elena y los márgenes del Río Conchos hasta el pueblo de Herrera (Falomir). En general el grado de herbivoría en Tamarisco es alto (60-79% de defoliación) a excelente (80-100%). Los individuos de Tamarisco que se encontraron lejos del río no tenían presencia de escarabajos o esta era mínima con restos de escarabajos o larvas secas. Hasta ahora no se ha detectado daños a la flora nativa por el escarabajo, a pesar de su abundancia en varias áreas, en los casos se le observó alimentándose de Tamarisco. El control biológico con el escarabajo ha tenido un impacto social muy grande en las comunidades rurales de los márgenes del Río Grande y Conchos. Recomendamos una campaña de difusión sobre el escarabajo y sus efectos, específicamente en el Athel (Tamarix aphylla) para mantener a la población informada y que a su vez pueda reportar daños (si los hay) a la flora nativa. Recomendamos el diseño de estaciones de monitoreo permanentes en puntos estratégicos a lo largo de los Ríos Grande y Conchos, que recaben datos continuamente sobre el comportamiento alimenticio del escarabajo (Diorhabda spp). Se requiere desarrollar un programa de control para la recuperación de los árboles de Tamarix aphylla (Sabinos) dañados por el escarabajo. En Agosto de 2011 se organizó un taller con autoridades, productores y miembros de las comunidades para reportar sobre las acciones de control y de mitigación para cumplir con las demandas sociales.

Abstract
We monitored margins of the Rio Grande from Ojinaga to the town of Benito Juarez (122 km) and margins of the Conchos River from its confluence with the Rio Grande upstream (200 km) to the Presa Luis L. Leon (El Granero), to observe the distribution of the beetle and the effect it has on Tamarix. We determined the degree of herbivory on base at a rate of five categories according to the degree of defoliation due to the presence of the beetle at the time of monitoring. Obvious damage was found on the effects of frost (-14°C) for the month of February 2011 on Tamarix aphylla. It detects the presence of the beetle to the town of Benito Juarez in the Santa Elena Canyon APFF and the margins of the Conchos River to the town of Herrera (Falomir). In general the degree of herbivory on base at a rate of five categories according to the degree of defoliation due to the presence of the beetle at the time of monitoring. Obvious damage was found on the effects of frost (-14°C) for the month of February 2011 on Tamarix aphylla. It detects the presence of the beetle to the town of Benito Juarez in the Santa Elena Canyon APFF and the margins of the Conchos River to the town of Herrera (Falomir). In general the degree of herbivory on Tamarix tested is high (60-79% of defoliation) to Excellent (80 - 100% defoliation). Tamarix individuals that were located away from the river, had no pres-
ence of beetles, or this was minimal and in some cases only remnants of it, dumb or larvae dry. So far there has been no damage by the beetle native flora, despite the abundance that occurs in some areas, in all cases was spotted feeding on species of Tamarix. Biological control by the beetle has had a major social impact on those living in rural communities on the margins of the Rio Grande and Conchos. We recommend a diffusion campaign on the beetle and the effects it causes especially in the athel (Tamarix aphylla) to inform the population and thus has knowledge and can (if any) reporting beetle damage on native flora. We recommend the design of permanent monitoring stations at strategic locations along the Rio Grande and Conchos, which continuously provide data on the feeding behavior of the beetle (Diorhabda spp.). It requires the development of a control program for the recovery of Tamarix aphylla trees (Sabine) affected by the beetle. Also in August 2011 a workshop was organized with autoridades, producers and local people to report on biological control and the actions undertaken to meet the social demand.

**Presentation Summary**

**Success of defoliation and advance in Mexican territory of the Biological control (Diorhabda spp.) on Salt cedar (Tamarix spp.)**

**Introduction**

Different species of saltcedar, Tamarix spp. (T. ramosissima, Tamarix aphylla, T. parviflora, T. chinensis, T. gallica), were introduced as ornamental plants for erosion control in the USA approximately 200 years ago, using specimens from Eurasia and the North of Africa (Lum, 2003). However, due to its intrinsic characteristics it displaced native species such as Alamo (Populus spp.) and willow (Salix spp.), and became an invasive species of arid and semiarid areas of the west of the USA and the north of Mexico (Dudley y Kazmer, 2005; Shafroth et al., 2005; Wood, 2005).

Given this problem, in the year 2001, a group of researchers from the USDA introduced the beetle Diorhabda spp., natural defoliator of saltcedar (D. carinulata, D. carinata, D. elongata, D. e. deserticola y D. sublineata; De Loach et al., 2009) in Nevada, Utah, Colorado and Wyoming as biological control to diminish the expansion and population of this invasive plant with great success, therefore in 2006 the group of researchers began a campaign to free D. elongata in Texas and in 2008, in spite of the opinions of the Mexican environmental sector, the beetle was released in the margins of the Rio Grande, or Rio Bravo in Mexico, however the release of D. elongata was not successful due to the environmental conditions that prevail in the south of Texas, so in 2009 D. sublineata, from Tunez, was used given that it is well adapted to more extreme heat and drought conditions (Tracy & Robbins, 2009) in 2010 the presence of the beetle was detected in Mexico with unprecedented success (CONANP, 2010; PROFAUNA, 2011). The beetle was released at 15 locations along the Rio Grande (seven for D. sublineata y ocho para D. elongata).

The adult insect deposits agglutinated masses of eggs that stick to the terminal branches, these eggs hatch after five days resulting in small larvae of only a few millimeters that feed of Tamarix leaves. Three stages are observed in the development of the larvae, in the first one the larva reaches a size of 2mm, in the second 4mm and in the third 9mm. In the first two the larvae feed of the youngest leaves of the Tamarix, the third stage is the most aggressive because if the foliage diminishes, the larvae start eating the trunk and new growths of the year. All this occurs during five days after which it falls to the ground and forms a pupa with the organic matter from the soil and silk secretions produced by the larva. A week later adult beetles emerge from the pupae. Two or more generations are produced each year. When the winter arrives, the adults live under the leaves found at the foot of the Tamarix.

Previous to the release of the beetle a series of tests were carried out in the lab and in controlled environments in the field to determine its specificity as well as its efficiency in the control of salt cedar (Dudley y Kazmer, 2005), tests that have confirmed that the species that are phylogenetically related to saltcedar could be potentially affected by the beetle (Balcuintas, 2000). Among the flora species that could potentially be affected are Myricaria sp., Frankenia salina, F. jamesii, F. plamari y F. johnstonii as well as other Tamarix species (T. aphylla y T. parviflora) that are also introduced but not as problematic. In the case of Frankenia y Myricaria, researchers found that although the beetles can feed on them, they always prefer Tamarix and their development is low when they can only eat Frankenia in addition to the fact that they never lay eggs on this.
species (De Loach et al., 2003; De Loach et al., 2009), among the species of Mexican flora that could be in danger due to the introduction of the beetle are F. johnstonii and F. margaritae, which are considered by NOM-059-SEMARNAT-2010 as endangered and threatened species respectively (Alanis et al., 2004; Soltis et al., 2006; Stevens, 2008).

The specificity tests with T. aphylla were different, D. sublineata develops well when it eats this species and is capable of defoliating this species even though it prefers T. ramosissima (Lindsey and DeLoach, 2006), situation that was not seen in Mexico since the beetle ate both species in equal proportions (PROFAUNA, 2011). Tamarix aphylla is socially relevant for Mexico because it is a widely used species in the region of the Chihuahua desert mostly for shade and as a windbreaker.

The death of Tamarix due to the beetle does not occur in one single defoliation event, it regrows after several weeks and therefore the repeated defoliations are the ones that lead to the death of a Tamarix forest which takes several years (DeLoach y Carruthers, 2004), due to the severe decrease of the non-stuctural carbohydrate reserves in the crown of each tree (Hudgens et al., 2007), through years of exposure to the predator. The biological control of Tamarix due to the Diorhabda spp. beetle will not eradicate the species, but has the potential to decrease populations 75-85% after both (beetle and Tamarix) reach a balance in the lower levels (Tracy y DeLoach, 1999).

Given the complexity of interactions in the natural environment and the response capacity of the introduced beetle, as well as the concern of the local population and Mexican authorities about the possibility of the beetle affecting other native Chihuahua desert species it is necessary to carry out monitoring on their advance and behavior and evaluate the risk of impact on non-target species and their possible propagation in the north border of Mexico.

**Background**

Along the Río Bravo starting from the state of New Mexico, USA and later on in the border between Mexico and Texas, the species known as saltcedar (Tamarix ramosissima) and its different varieties T. chinensis, T. gallica; and salt cedar (Tamarix aphylla), are found along the margins of the river displacing native species of the genus Fraxinus, Populus, Salix, Sapindus, Bacharis and several herbaceous and grass species. Recognizing the negative impacts of Tamarix on these environments and their biodiversity several strategies have been adopted for their control and eradication, among these options are mechanical, chemical and biological control methods and their possible combinations (CONANP, 2010).

Starting on the year 2000, several organizations from the USA have been developing strategies for its control through the use of biological agents, indicating that this is a relatively cheap and easy to implement option against these invasive species, therefore these results have been presented in several academic forums based on the introduction of a species of the Diorhabda beetle which in its native regions of Asia and West Europe is a natural control agent.

The genus Diorhabda contains several species of insects that are defoliators of the genus Tamarix, therefore several tests have been carried out to adapt them to the environments of the north, central and south United States. The proposal of the USDA (US Department of Agriculture of the United States), is to carry out adaptation tests in different environments and climates of the USA and the release of the beetle.

In the year 2006 they started a series of informative meetings between USDA, IBWC (Internacional Boundary Water Comisión) and organizations such as the Río Grande Institute, WWF, National Park Service, and International Boundary and Water Commission (CILA in spanish), SEMARNAT, CONABIO, INE and CONANP among other meetings in which they made known the advances in the research on the beetle and its possible release.

Throughout the different meetings, the Mexican organizations were against the release of the beetles mostly for three reasons: 1) the project lacked a contingency program that ensured that the liberated species would not affect other native plants, 2) lack of a monitoring program in Mexico that allowed for early detection to any modification of the habits of the insect and 3) lack of a social program that informed and communicated to the general public and farmers on the introduction of the species.

Currently there are photographic records showing that the individuals that were released intentionally by the
USA have crossed the border and are moving along the Bravo and Conchos Rivers feeding of the species *Tamarix ramosissima* effectively. However there is discontent among society since they argue that they were not informed about the project, they are unaware of the collateral impacts that this could have on regional economy and ecology and mostly that this species is affecting *Tamarix aphylla* (locally known as wind-breaker or sabino) which is a species of arboreal habits used as shade in the desert communities. The Mexican government implemented in 2009 the monitoring project for salt cedar as a consequence of the series of events that originated from the release of the beetle.

**Methodology**

In order to observe the distribution and the advance of the beetle in the margins of the Bravo River, perpendicular transects were established at the beetle release sites with a length of 200m and segmented in sampling sites every 20m and secondary transects at a distance of 1000m on each side of the main transect with a length of 100m (Figure 11).

For the Conchos River several sites were arbitrarily selected where the impact of the beetle was observed on *Tamarix*, specifically in urban areas and isolated individuals.

For the monitoring of the impact of the beetle on non-target species the technique of the nearest neighbor was used, this is based on quadrants around each sampling site. The *Tamarix* individual that has been consumed by the beetle is located, later on three individuals of native species in three vegetative strata type are identified, one arboreal species, one herbaceous species and one grass species, in order to determine if they have been consumed by the insect and estimate the damage (Figure 12).

The degree of herbivory and death of *Tamarix* due to the biological control was determined based on an index of five categories according to the degree of defoliation observed at the time of the monitoring (Table 12). The degree of defoliation is a visual interpretation of the absence of foliage due to consumption by the beetle. To obtain such information 41 monitoring sites were established, distributed as follow: 16 in the municipality of Manuel Benavides, 14 in the municipality of Manuel Ojinaga, 7 in the municipality of Coyame del Sotol, 3 in the municipality of Aldama and 1 in the municipality of Julimes, this last one has the greatest advance reported in 2011.
The following follows belong to the monitoring carried out by the CONANP and the non-government organization Protección de la Fauna Mexicana, A.C. (PROFAUNA) in 2011 within the Flora and Fauna Protection Area Cañón de Santa Elena (APFFCSE) and in the margins of the Bravo and Conchos rivers. Both studies were coordinated and financed by the National Institute of Ecology (INE).

About the affluent of the Bravo River, monitoring began in the month of April in front of the release site known as Alamito Creek and finished in December in the site known as La Bolsita in the El Mulato ejido, municipality of Ojinaga, Chih., while the monitoring on the Conchos River began in June and finished in November. Approximately 500km were covered (Figure 13).

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>% DEFOLIATION</th>
<th>DEGREE OF HERBIVORY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>80 – 100</td>
<td>Excellent</td>
</tr>
<tr>
<td>2</td>
<td>60 – 79</td>
<td>Good</td>
</tr>
<tr>
<td>3</td>
<td>40 – 59</td>
<td>Regular</td>
</tr>
<tr>
<td>4</td>
<td>20 – 39</td>
<td>Poor</td>
</tr>
<tr>
<td>5</td>
<td>0 - 19</td>
<td>Very Poor</td>
</tr>
</tbody>
</table>

Table 12. Index of categories of the degree of herbivory and percent defoliation caused by Diorhabda spp.
Results

Figure 3 shows the sites where the beetle has been detected, on the Río Bravo from Ojinaga to the town of Benito Juárez within the Flora and Fauna Protection Area Cañón de Santa Elena covering and approximate length of 122 km. Additionally, on the Conchos River from the confluence with the Bravo River to the town of Maclovio Herrera (Falomir) downstream from the Luis E. León dam (El Granero) and near the town of Julimes covering approximately 200 km.

In general, the degree of herbivory on the saltcedars assessed went from high to excelent (60-100% of defoliation) (Table 13), finding the beetle mostly in sites where the distribution of Tamarix is continuous, while in isolated organisms the presence of the beetle is minimal and in some cases only moult remains or dry pupa were observed. In addition in the coloured points shown in Figure 3 it is possible to observe that the degree of herbivory in the surroundings of Ojina-ga is excellent; in Manuel Benavides all the categories are shown, in Coyame it ranges from bad to regular, in Aldama from regular to excellent and the only registry in Julimes has a category of 3.
Table 13. Location of monitoring sites in the Bravo and Conchos rivers, Chihuahua and the degree of registered herbivory.

<table>
<thead>
<tr>
<th>SITE</th>
<th>LATITUDE (N)</th>
<th>LONGITUDE (W)</th>
<th>DEGREE OF HERBIVORY</th>
<th>MUNICIPALITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>103.52417</td>
<td>29.11694</td>
<td>Category 1 Excellent</td>
<td>Manuel Benavides</td>
</tr>
<tr>
<td>2</td>
<td>103.61076</td>
<td>29.16445</td>
<td>Category 5 Very poor</td>
<td>Manuel Benavides</td>
</tr>
<tr>
<td>3</td>
<td>103.61080</td>
<td>29.16442</td>
<td>Category 3 Regular</td>
<td>Manuel Benavides</td>
</tr>
<tr>
<td>4</td>
<td>103.60883</td>
<td>29.16440</td>
<td>Category 2 Good</td>
<td>Manuel Benavides</td>
</tr>
<tr>
<td>5</td>
<td>103.60875</td>
<td>29.16440</td>
<td>Category 5 Very poor</td>
<td>Manuel Benavides</td>
</tr>
<tr>
<td>6</td>
<td>103.60979</td>
<td>29.16350</td>
<td>Category 3 Regular</td>
<td>Manuel Benavides</td>
</tr>
<tr>
<td>7</td>
<td>103.60893</td>
<td>29.16259</td>
<td>Category 5 Very poor</td>
<td>Manuel Benavides</td>
</tr>
<tr>
<td>8</td>
<td>103.60877</td>
<td>29.16259</td>
<td>Category 2 Good</td>
<td>Manuel Benavides</td>
</tr>
<tr>
<td>9</td>
<td>103.71921</td>
<td>29.18111</td>
<td>Category 5 Very poor</td>
<td>Manuel Benavides</td>
</tr>
<tr>
<td>10</td>
<td>103.77985</td>
<td>29.05308</td>
<td>Category 5 Very poor</td>
<td>Manuel Benavides</td>
</tr>
<tr>
<td>11</td>
<td>103.76228</td>
<td>29.01361</td>
<td>Category 5 Very poor</td>
<td>Manuel Benavides</td>
</tr>
<tr>
<td>12</td>
<td>103.78306</td>
<td>29.22222</td>
<td>Category 1 Excellent</td>
<td>Manuel Benavides</td>
</tr>
<tr>
<td>13</td>
<td>103.77900</td>
<td>29.25340</td>
<td>Category 3 Regular</td>
<td>Manuel Benavides</td>
</tr>
<tr>
<td>14</td>
<td>103.78389</td>
<td>29.25750</td>
<td>Category 1 Excellent</td>
<td>Manuel Benavides</td>
</tr>
<tr>
<td>15</td>
<td>103.78391</td>
<td>29.26509</td>
<td>Category 4 Poor</td>
<td>Manuel Benavides</td>
</tr>
<tr>
<td>16</td>
<td>103.83667</td>
<td>29.27222</td>
<td>Category 1 Excellent</td>
<td>Manuel Benavides</td>
</tr>
<tr>
<td>17</td>
<td>104.12389</td>
<td>29.37000</td>
<td>Category 1 Excellent</td>
<td>Ojinaga</td>
</tr>
<tr>
<td>18</td>
<td>104.14583</td>
<td>29.37333</td>
<td>Category 1 Excellent</td>
<td>Ojinaga</td>
</tr>
<tr>
<td>19</td>
<td>104.16833</td>
<td>29.39500</td>
<td>Category 1 Excellent</td>
<td>Ojinaga</td>
</tr>
<tr>
<td>20</td>
<td>104.19056</td>
<td>29.40361</td>
<td>Category 1 Excellent</td>
<td>Ojinaga</td>
</tr>
<tr>
<td>21</td>
<td>104.22083</td>
<td>29.47861</td>
<td>Category 1 Excellent</td>
<td>Ojinaga</td>
</tr>
<tr>
<td>22</td>
<td>104.22167</td>
<td>29.47861</td>
<td>Category 1 Excellent</td>
<td>Ojinaga</td>
</tr>
<tr>
<td>23</td>
<td>104.32472</td>
<td>29.51222</td>
<td>Category 1 Excellent</td>
<td>Ojinaga</td>
</tr>
<tr>
<td>24</td>
<td>104.41959</td>
<td>29.49962</td>
<td>Category 1 Excellent</td>
<td>Ojinaga</td>
</tr>
<tr>
<td>25</td>
<td>104.41639</td>
<td>29.56444</td>
<td>Category 1 Excellent</td>
<td>Ojinaga</td>
</tr>
<tr>
<td>26</td>
<td>104.64777</td>
<td>29.56809</td>
<td>Category 1 Excellent</td>
<td>Ojinaga</td>
</tr>
<tr>
<td>27</td>
<td>104.67472</td>
<td>29.52778</td>
<td>Category 1 Excellent</td>
<td>Ojinaga</td>
</tr>
<tr>
<td>28</td>
<td>104.74111</td>
<td>29.50500</td>
<td>Category 1 Excellent</td>
<td>Ojinaga</td>
</tr>
<tr>
<td>29</td>
<td>104.76457</td>
<td>29.50633</td>
<td>Category 1 Excellent</td>
<td>Ojinaga</td>
</tr>
<tr>
<td>30</td>
<td>104.86398</td>
<td>29.55500</td>
<td>Category 1 Excellent</td>
<td>Coyame del Sotol</td>
</tr>
<tr>
<td>31</td>
<td>104.88034</td>
<td>29.44327</td>
<td>Category 1 Excellent</td>
<td>Coyame del Sotol</td>
</tr>
<tr>
<td>32</td>
<td>104.87626</td>
<td>29.43874</td>
<td>Category 1 Excellent</td>
<td>Coyame del Sotol</td>
</tr>
<tr>
<td>33</td>
<td>105.08897</td>
<td>29.45634</td>
<td>Category 1 Excellent</td>
<td>Coyame del Sotol</td>
</tr>
<tr>
<td>34</td>
<td>104.92354</td>
<td>29.33084</td>
<td>Category 3 Regular</td>
<td>Coyame del Sotol</td>
</tr>
<tr>
<td>35</td>
<td>104.95580</td>
<td>29.32758</td>
<td>Category 5 Very poor</td>
<td>Coyame del Sotol</td>
</tr>
<tr>
<td>36</td>
<td>104.98528</td>
<td>29.30723</td>
<td>Category 3 Regular</td>
<td>Coyame del Sotol</td>
</tr>
<tr>
<td>37</td>
<td>105.11305</td>
<td>29.10210</td>
<td>Category 1 Excellent</td>
<td>Aldama</td>
</tr>
</tbody>
</table>
In the following series of graphs and photographs it is possible to see the degree in the relationship/apparent death according to the field records. It can be observed that the relationship keeps certain proportion, however the real death rate in saltcedar occurs only in the terminal branches and it is total when the plant finished its reserves, normally after three years with two defoliations per year (DeLoach et al., 2009).

<table>
<thead>
<tr>
<th>SITE</th>
<th>LATITUDE (N)</th>
<th>LONGITUDE (W)</th>
<th>DEGREE OF HERBIVORY</th>
<th>MUNICIPALITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>38</td>
<td>105.14380</td>
<td>29.06657</td>
<td>Category 1 Excellent</td>
<td>Aldama</td>
</tr>
<tr>
<td>39</td>
<td>104.98751</td>
<td>28.99052</td>
<td>Category 3 Regular</td>
<td>Aldama</td>
</tr>
<tr>
<td>40</td>
<td>105.43830</td>
<td>28.41773</td>
<td>Category 3 Regular</td>
<td>Julimes</td>
</tr>
</tbody>
</table>

**Category 1 Excellent.-** Percent of defoliation from 80 to 100% with an apparent death of 40 to 90%. The individuals in this category have a deteriorated physical aspect; the branches have no foliage or have a few grey colored clusters although they maintain a green color on the inside. The average diameter of the individuals found in this category was of 8.12 cm of basal diameter.

**Category 2 Good.-** Percent of defoliation of 60 to 79% and an apparent death of 40%. The aspect of the individuals is greenish gray with little foliage on the branches and presence of sap on the inside. Average basal diameter of the trees was of 8.25 cm.

**Category 3 Regular.-** The defoliation/apparent death relationship was one of the lowest in this category, since death sometimes barely reaches 10% and a greater presence of young foliage or foliage in recovery and a lower appearance of deterioration. Individuals maintained an average diameter of 8.95 cm.
Category 4 Poor.- With a defoliation of 20 to 39% a low relationship was observed between the defoliated Tamarix and those apparently dead. The individuals in this category have a grey to green coloration with a dense biomass with little space between the branches. The average basal diameter of analyzed Tamarix was of 8.08cm.

Category 5 Very poor.- No differences are perceived among the defoliated organisms and those that are apparently dead. Individuals with turgent and dense foliage with little evidence of defoliation and a basal average diameter of 5.25cm.

The sampling system of the nearest neighbor that was used to detect possible impacts on the native flora of the Chihuahua desert allowed to obtain evidence of the consumption habits of the beetle indicating that in spite of the abundance with which the beetle is found in some sites no damage to native flora was observed, among these species are Bacharis salicifolia, Echinocloa crusgali, Nicotiana glauca, Prosopis sp., Celtis pallida and Parkinsonia aculeata.

Conclusions
The release of the salt cedar beetle in the south of Texas in 2009 was carried out under the normal conditions of the area (warm summers and benign winters with minimal temperatures of minus 6 to minus 8 °C). The insect, adapted during laboratory tests, had great reproductive and expansive success and in the first year invaded almost 200km of river and marginal areas (Ejido Benito Juárez, Manuel Benavides, Maclovio Herrera, Coyame del Sotol), with a social impact in Mexico (Municipalities of Ojinaga and Coyame del Sotol) due to the intensive defoliation on the target species (salt cedar) as well as on Tamarix aphylla, ornamental tree and used for shade in the urban areas and which wasn’t included in the species for control, at least not in this magnitude. However in February 2011 the region recorded its lowest temperatures in the last 50 years reaching minus 18°C. This event altered the components of the biological control project and of the monitoring itself with T. aphylla one of the most affected species, most of its arboreal mass died and only the basal portion remained and had the capacity to regrow.

Regarding the saltcedar, target species of the biological control, it is a plant that loses its foliage during the winter and regrows during the spring. The low temperatures were recorded when it was starting a new cycle so that its aerial mass died. The other component affected by the cold temperatures is the beetle, its populations diminished and recovered in the late summer, this is reflected in the slow advance of 2011; local observers indicate that there were few insects in comparison with the dense populations of the summer of 2010.

The lack of knowledge about biological control and the way it acts led the common citizen to prune their trees (T. aphylla) to prevent them from dying (apparent death) because of the defoliation caused by the
beetle, even though more than one defoliation event is needed for the tree to die. This indicates the need to establish a communication and information program on biological control and its environmental impact.

The speed at which the insect moves in mexican territory has been higher than expected and with no discrimination of tamarisk species, therefore the consumption of *T. ramosissima* and *T. aphylla* is in equal proportion, at least in the projects reported here, no preference has been found by the beetle for a certain size of target organisms, therefore it is recommended to establish permanent monitoring stations in strategic sites along the Bravo and Conchos rivers that provide continuous data on the feeding behavior of the beetle (*Diorhabda spp*).

The presence of the beetle on *Tamarix* individuals away from the river was detected either in moultting remains or as dry larvae or not detected at all, this can be interpreted as the need of the presence of a humid environment (river) for the success in the movement of the biological control and well as a density dependent population of the insect, since isolated individuals or small groups die when they are separated from an established population. This means that biological control is only successful in large populations which suggests that the beetle will move in large groups through the Conchos River consuming *Tamarix ramosissima* until reaching *T. aphylla* populations in the Meoqui-Delicias-Saucillo-Camargo agricultural corridor, which will have an important social repercussion because of the use given to *T. aphylla* as a wind-breaker in agricultural areas, in the same was that it was observed in the towns near the Bravo River and the lower part of the Conchos, where the tree is the only shade available in an extremely sunny region, in addition it is a source of income from the production of honey from its flower by some local families. These social impacts must be attended to and compensated by those that were technically, intellectually and diplomatically responsible and who released the beetle as a biological control for salt cedar without taking all of the above into consideration, the economic impacts must also be remediated.

It is also necessary to have training and resources to implement a *T. aphylla* protection program in the future as a medium term activity, these trees are considered of social interest for the people in the region and a project to restore and replace these trees with native species that can fulfill the same environmental services provided by *T. aphylla* for the families in the area.

From the environmental point of view, biological control has been a success and up until now no damage to native flora has been observed despite the abundance with which it is found in some areas. In spite of this it is necessary to continue monitoring the advance of the beetle in Mexico to detect on time any change in its habits and have proved and field tested information to maintain all sectors of society that are concerned about biological control informed. This requires technical and financial support from the government in the USA to continue with the research.

References


**Preliminary project to modify the Official Mexican Norm NOM-043-FITO-1999. Specifications to prevent the introduction of quarantine weeds into Mexico.**

**Anteproyecto de modificación de la Norma Oficial Mexicana NOM-043-FITO-1999. Especificaciones para prevenir la introducción de malezas cuarentenarias a México**

**Gustavo Torres**

*Chief of the Rodent, Birds and Weeds Department / Jefe del Departamento de Aves, Roedores y Malezas*

Plant Health General Directorate of *senasica*, *sagarpa* / Dirección General de Sanidad Vegetal- *senasica*, *sagarpa*

Guillermo Pérez Valenzuela 127 Col. del Carmen, Coyoacán, México

jose.torres@senasica.gob.mx

**Resumen**

México publicó en el año dos mil la norma oficial mexicana NOM-043-FITO-1999 Especificaciones para prevenir la introducción de malezas cuarentenarias a México, con el objetivo de establecer las especificaciones para prevenir la introducción y el eventual establecimiento y dispersión de especies de malezas de importancia cuarentenaria. Considerando que se han detectado más especies de malezas en productos de importación, se ha realizado análisis de riesgo y con fundamento en la Ley de Metrología y Normalización y la Ley Federal de Sanidad Vegetal, se propone modificar esta norma. El anteproyecto de modificación propone declarar las especies cuarentenarias, eliminar las especificaciones de toma y envío de muestras y los procedimientos de guarda custodia y responsabilidad ya que estos se incluyen en los requisitos fitosanitarios para importar los productos.

**Abstract**

México published the Official Mexican Norm NOM-043-FITO-1999 Specifications to prevent the introduction of quarantine weeds into Mexico in the year 2000, with the aim of establishing the guidelines to prevent the introduction and possible establishment and spread of quarantine weeds. Considering that we have detected more weeds in import goods, we have developed the corresponding risk analysis and, based on the Laws of Metrology and Standardization and Federal Law f Plant Health, we are currently in the process of modifying the NOM. The new version es-
establishes the list of quarantine weeds, eliminates the
guidelines for sampling, shipping and safekeeping
and responsibilities, as these are established in the dif-
ferent import sheets.

Presentation summary
The international trade of agricultural products car-
ries a risk of pest introduction for a country. In the
case of weeds, these can be dispersed from one coun-
try to another through seeds, for example, when these
pollute grain harvests or mix with seeds for planting.
For these reason, countries generally have a regula-
tory framework to prevent the introduction of pests
to their territories. However, few countries have spe-
cific regulations to prevent the introduction of weeds.

In Mexico, the Federal Law of Plant Health in its ar-
ticle 7 fraction xviii, enables the Secretariat of Ag-
culture, Livestock, Rural Development, Fisheries
and Food (sagarpa) to prevent the introduction into
the country of pests that affect plants, their products
or subproducts and agents that cause phytosanitary
problems. According to article 19 of the same law,
this will be carried out through phytosanitary mea-
asures established in official mexican norms, agree-
ments, decrees, guidelines and other legal disposi-
tions applicable to plant health. With this legal base
and given the previously mentioned reasons, in the
year 2000 Mexico published official mexican norm
NOM-043-FITO-1999: Specifications to prevent the
introduction of quarentenary weeds to Mexico,
whose objective was to establish the specifications to
prevent the introduction and the eventual establish-
ment and dispersal of weed species of quarentenary
importance.

The same laws also allow sagarpa to propose the
modification or cancellation of official norms in mat-
ters of plant health, when the assumptions that reg-
ulate or justify these have been scientifically proved
to change. In the case of this norm there are vari-
tions that justify its modification. In the first place
species of weeds not included in the norm have been
detected in import products such as fresh fruit and
canary seed. There are also reports of the presence in
the country of exotic species that should be regulated
to prevent their dispersal. The procedures included in
this norm such as sampling, use of approved labs and
chain of custody are included in the phytosanitary re-
quirements to import seeds.

Taking all of the above into consideration, a pre-
project to modify the norm was prepared, the main
change being proposed is to eliminate the procedures
and phytosanitary measures when a weed is detected.
These measures will be established in the legal disposi-
tions applicable to the merchandise where the weed
is detected. Additional species of weeds are also in-
cluded. Any person interested can comment on the
project to modify this norm.
roduction of quarentenary weeds into Mexico was published.

That in the analysis of samples of grains and seeds and other products weeds of quarentenary importance have been found as well as other contaminant species not included in such norm.

That given the above it is necessary to modify the norm, thus issuing the

PROJECT FOR THE MODIFICATION OF OFFICIAL MEXICAN NORM NOM-043-FITO-1999, THROUGH WHICH THE QUARENTENARY WEEDS FOR MEXICO ARE SPECIFIED.

Index
1. Objective and field of application
2. References
3. Definitions
4. Specifications
5. Observance to the Norm
6. Sanctions
7. Bibliography
8. Agreement with international norms
9. Transitory dispositions

1. Objective and field of application
This Mexican Official Norm establishes the listing of quarentenary important weeds for Mexico.

This listing is applicable to:

a) Plants, their products and subproducts, transports used for their international mobilization, materials and equipment susceptible of transporting or carrying quarentenary weeds.

2. References
For the correct application of this Norm it is necessary to consult the following official Mexican Norms:

NOM-006-FITO-1995. Establishes the minimum requirements applicable to general situations for the import of plants, their products and subproducts when they are not established in a specific official norm.

As well as others that the Secretariat generates to regulate vegetables, their products, and subproducts susceptible to carrying weeds.

3. Definitions
For the effects of this Norm the following terms are considered as:

3.1. Weed: Plant species or part of the plant that affect the interests of man in a specific time and place.

3.2. Weeds of quarentenary importance: Weed not present in Mexico or in a localized area and officially regulated.

3.3. Plant product: Organs or useful parts of vegetables that due to their nature, their production, transformation, commercialization or mobilization can be a danger for the propagation of pests.


3.5. Plant subproduct: Derived from a plant product whose production or transformation process does not ensure its phytosanitary quality free of pests.

3.6. Taxa: A taxonomic group in any rank.

3.7. Plants: Individuals belonging to the Plant kingdom, taking into consideration agricultural species, their products or subproducts, that maintain their original qualities and have not suffered any transformation.

4. Specifications
4.1. The following are quarentenary weeds for Mexico:

<table>
<thead>
<tr>
<th>Scientific name</th>
<th>Family</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abutilon theophrasti Medik.</td>
<td>Malvaceae</td>
</tr>
<tr>
<td>Acanthospermum australe (Loefl.) Kuntze</td>
<td>Asteraceae</td>
</tr>
<tr>
<td>Acanthospermum hispidum DC.</td>
<td>Asteraceae</td>
</tr>
<tr>
<td>Scientific name</td>
<td>Family</td>
</tr>
<tr>
<td>--------------------------------------</td>
<td>--------------------</td>
</tr>
<tr>
<td>Acroptilon repens (L.) DC</td>
<td>Asteraceae</td>
</tr>
<tr>
<td>Aegilops cylindrica Host.</td>
<td>Poaceae</td>
</tr>
<tr>
<td>Agrostemma githago L.</td>
<td>Caryophyllaceae</td>
</tr>
<tr>
<td>Aira elegantissima Schur</td>
<td>Poaceae</td>
</tr>
<tr>
<td>Alopecurus myosuroides Huds.</td>
<td>Poaceae</td>
</tr>
<tr>
<td>Anthoxanthum aristatum Boiss.</td>
<td>Poaceae</td>
</tr>
<tr>
<td>Anthoxanthum odoratum L.</td>
<td>Poaceae</td>
</tr>
<tr>
<td>Apera spica-venti (L.) Beauv.</td>
<td>Poaceae</td>
</tr>
<tr>
<td>Asclepias syriaca L.</td>
<td>Asclepiadaceae</td>
</tr>
<tr>
<td>Calystegia sepium (L.) R. Br.</td>
<td>Convolvulaceae</td>
</tr>
<tr>
<td>Carthamus lanatus L.</td>
<td>Asteraceae</td>
</tr>
<tr>
<td>Carthamus oxyacantha M. Bieb.</td>
<td>Asteraceae</td>
</tr>
<tr>
<td>Chrysopogon aciculatus (Retz.) Trin.</td>
<td>Poaceae</td>
</tr>
<tr>
<td>Commelina benghalensis L.</td>
<td>Commelinaceae</td>
</tr>
<tr>
<td>Conringia orientalis (L.) Dumort.</td>
<td>Brassicaceae</td>
</tr>
<tr>
<td>Crepis capillaris (L.) Wallr.</td>
<td>Asteraceae</td>
</tr>
<tr>
<td>Crupina vulgaris Cass.</td>
<td>Asteraceae</td>
</tr>
<tr>
<td>Cuscuta L.</td>
<td>Cuscutaceae</td>
</tr>
<tr>
<td>Digitaria abyssinica (Hochst. ex A. Rich.) Stapf.</td>
<td>Poaceae</td>
</tr>
<tr>
<td>Digitaria velutina (Forssk.) Beauv.</td>
<td>Poaceae</td>
</tr>
<tr>
<td>Echium vulgare L.</td>
<td>Boraginaceae</td>
</tr>
<tr>
<td>Emex australis Steinh.</td>
<td>Polygonaceae</td>
</tr>
<tr>
<td>Emex spinosa (L.) Campd.</td>
<td>Polygonaceae</td>
</tr>
<tr>
<td>Epilobium (excepto especies presentes en México)</td>
<td>Onagraceae</td>
</tr>
<tr>
<td>Euphorbia esula L.</td>
<td>Euphorbiaceae</td>
</tr>
<tr>
<td>Euphorbia helioscopia L.</td>
<td>Euphorbiaceae</td>
</tr>
<tr>
<td>Fumaria officinalis L.</td>
<td>Papaveraceae</td>
</tr>
<tr>
<td>Galega officinalis L.</td>
<td>Fabaceae</td>
</tr>
<tr>
<td>Galeopsis tetrahit L.</td>
<td>Lamiaceae</td>
</tr>
<tr>
<td>Galium spurium L.</td>
<td>Rubiaceae</td>
</tr>
<tr>
<td>Gastrolobium grandiflorum F. Muell.</td>
<td>Fabaceae</td>
</tr>
<tr>
<td>Heliotropium europaeum L.</td>
<td>Boraginaceae</td>
</tr>
<tr>
<td>Heracleum mantegazzianum Somm. &amp; Lev.</td>
<td>Apiaceae</td>
</tr>
<tr>
<td>Holcus mollis L.</td>
<td>Poaceae</td>
</tr>
<tr>
<td>Hypochaeris glabra L.</td>
<td>Asteraceae</td>
</tr>
<tr>
<td>Hypochaeris radicata L.</td>
<td>Asteraceae</td>
</tr>
<tr>
<td>Imperata cylindrica (L.) Beauv.</td>
<td>Poaceae</td>
</tr>
<tr>
<td>Ischaemum rugosum Salisb.</td>
<td>Poaceae</td>
</tr>
<tr>
<td>Coronopus didymus (L.) Smith</td>
<td>Brassicaceae</td>
</tr>
<tr>
<td>Leptochloa chinensis (L.) Nees</td>
<td>Poaceae</td>
</tr>
<tr>
<td>Linaria vulgaris Mill.</td>
<td>Scrophulariaceae</td>
</tr>
<tr>
<td>Lithospermum arvense L.</td>
<td>Boraginaceae</td>
</tr>
<tr>
<td>Scientific name</td>
<td>Family</td>
</tr>
<tr>
<td>----------------------------------------</td>
<td>-----------------------</td>
</tr>
<tr>
<td><em>Lycium ferocissimum</em> Miers</td>
<td>Solanaceae</td>
</tr>
<tr>
<td><em>Tripleurospermum maritimum</em> (L.) W.D.J. Koch</td>
<td>Asteraceae</td>
</tr>
<tr>
<td><em>Melaleuca quinquenervia</em> (Cav.) Blake.</td>
<td>Myrtaceae</td>
</tr>
<tr>
<td><em>Melastoma malabathricum</em> L.</td>
<td>Melastomataceae</td>
</tr>
<tr>
<td><em>Mikania cordata</em> (Burm. f.) B. L. Rob.</td>
<td>Asteraceae</td>
</tr>
<tr>
<td><em>Monochoria vaginalis</em> (Burm. f.) C. Presl ex Kunth</td>
<td>Pontederiaceae</td>
</tr>
<tr>
<td><em>Nassella trichotoma</em> (Nees) Hack.</td>
<td>Poaceae</td>
</tr>
<tr>
<td><em>Neslia paniculata</em> (L.) Desv.</td>
<td>Brassicaceae</td>
</tr>
<tr>
<td><em>Orobanche</em> L.</td>
<td>Orobanchaceae</td>
</tr>
<tr>
<td><em>Oryza longistaminata</em> Chev. &amp; Roer.</td>
<td>Poaceae</td>
</tr>
<tr>
<td><em>Oryza punctata</em> Kotschy ex Steud.</td>
<td>Poaceae</td>
</tr>
<tr>
<td><em>Oryza rufipogon</em> Griff.</td>
<td>Poaceae</td>
</tr>
<tr>
<td><em>Oxalis articulata</em> Savigny</td>
<td>Oxalidaceae</td>
</tr>
<tr>
<td><em>Oxalis perdicaria</em> (Molina) Bertero</td>
<td>Oxalidaceae</td>
</tr>
<tr>
<td><em>Paspalum orbiculare</em> G.Forst.</td>
<td>Poaceae</td>
</tr>
<tr>
<td><em>Pennisetum macrourum</em> Trin.</td>
<td>Poaceae</td>
</tr>
<tr>
<td><em>Pennisetum pedicellatum</em> Trin.</td>
<td>Poaceae</td>
</tr>
<tr>
<td><em>Pennisetum polystachion</em> (L.) Schult.</td>
<td>Poaceae</td>
</tr>
<tr>
<td><em>Polygonum convolvulus</em> L.</td>
<td>Polygonaceae</td>
</tr>
<tr>
<td><em>Ranunculus repens</em> L.</td>
<td>Ranunculaceae</td>
</tr>
<tr>
<td><em>Richardia brasiliensis</em> Gomes</td>
<td>Rubiaceae</td>
</tr>
<tr>
<td><em>Rottboellia cochinensis</em> (Lour.) W. D. Clayton.</td>
<td>Poaceae</td>
</tr>
<tr>
<td><em>Rubus fruticosus</em> L.</td>
<td>Rosaceae</td>
</tr>
<tr>
<td><em>Rubus moluccanus</em> L.</td>
<td>Rosaceae</td>
</tr>
<tr>
<td><em>Saccharum spontaneum</em> L.</td>
<td>Poaceae</td>
</tr>
<tr>
<td><em>Salsola vermiculata</em> L.</td>
<td>Chenopodiaceae</td>
</tr>
<tr>
<td><em>Senecio inaequidens</em> DC.</td>
<td>Asteraceae</td>
</tr>
<tr>
<td><em>Setaria pallide-fusca</em> (Schum.) Stapf &amp; C. E. Hubb.</td>
<td>Poaceae</td>
</tr>
<tr>
<td><em>Silene noctiflora</em> L.</td>
<td>Caryophyllaceae</td>
</tr>
<tr>
<td><em>Silybum marianum</em> (L.) Gaertn.</td>
<td>Asteraceae</td>
</tr>
<tr>
<td><em>Solanum carolinense</em> L.</td>
<td>Solanaceae</td>
</tr>
<tr>
<td><em>Solanum ptycanthum</em> Dunal</td>
<td>Solanaceae</td>
</tr>
<tr>
<td><em>Solanum viarum</em> Dunal</td>
<td>Solanaceae</td>
</tr>
<tr>
<td><em>Striga</em> Lour.</td>
<td>Scrophulariaceae</td>
</tr>
<tr>
<td><em>Themeda quadrivalvis</em> (L.) O. Ktze.</td>
<td>Poaceae</td>
</tr>
<tr>
<td><em>Thlaspi arvense</em> L.</td>
<td>Brassicaceae</td>
</tr>
<tr>
<td><em>Tripleurospermum inodorum</em> (L.)Sch.Bip.</td>
<td>Poaceae</td>
</tr>
<tr>
<td><em>Ulex europaeus</em> L.</td>
<td>Fabaceae</td>
</tr>
<tr>
<td><em>Urochloa panicoides</em> P. Beauv.</td>
<td>Poaceae</td>
</tr>
<tr>
<td><em>Vaccaria hispanica</em> (Mill.) Rauschert</td>
<td>Caryophyllaceae</td>
</tr>
<tr>
<td><em>Veronica arvensis</em> L.</td>
<td>Scrophulariaceae</td>
</tr>
</tbody>
</table>
4.2. The secretariat will determine the risk mitigation measures for any plants, their products and subproducts, the transport used for their international mobilization, materials and equipment where quarentenary weeds are detected.

4.3. Any taxa not considered under 4.1 of this norm will be subject to a risk analysis or evaluation. In case it is determined that a weed is of quarentenary importance the corresponding phytosanitary measures will be established in the applicable legal instruments.

5. Norm observancy
The Secretariat through the official personnel in charge of the phytosanitary inspection in ports, airports and frontiers as well as the state delegations, will ensure the compliance with this ordinance.

6. Sanctions
The non compliance of dispositions contained in the current Norm will be punished according to the established in the Federal Law of Plant Health and in the Federal Law on Metrology and Normalization.

7. References


USDA, ARS, National Genetic Resources Program. Germplasm Resources Information Network - (GRIN) [Base de Datos en Linea]. National Germplasm Resources Laboratory, Beltsville, Maryland. url: http://www.ars-grin.gov/cgi-bin/npgs/html/genform.pl (25 May 2010).
8. Agreement with international norms
This norm has no agreement with international norms up to the moment of its elaboration.

9. Transitory dispositions
The current Mexican Official Norm will become effective the next day of its publication in the Official Diary of the Federation.

Weeds Found in Transgenic Cotton (Gossypium hirsutum)
Agrosystems in La Laguna, Durango
Malezas presentes en agroecosistemas de algodón (Gossypium hirsutum)
transgénico en La Laguna, Durango

Cándido Márquez Hernández
Researcher / Investigador
Superior School of Biology, University of Juárez of the State of Durango / Escuela Superior de Biología, Universidad Juárez del Estado de Durango
Av. Universidad s/n Fracc. Filadelfia C.P. 35070 Gómez Palacio, Dgo. México
canoh2@yahoo.com.mx

Other authors / Otros autores:

Resumen
Los organismos genéticamente modificados aumentan y siguen generado controversia medio-ambiental; el algodón, familia Malvacea, transgénico no es la excepción. Las malezas son un problema en el algodón, son combatidas mediante azadón, herbicidas y el algodón transgénico, que contiene el gen que codifica para resistencia al herbicida glifosato: no obstante, la resistencia genética del algodón transgénico puede originar polinización cruzada con otras malváceas y/o plantas arvenses en general; por lo anterior es importante determinar las plantas arvenses presentes en el algodón transgénico con resistencia a herbicida. El presente estudio se llevó a cabo el municipio de Gómez palacio Durango, en el Ejido La Esmeralda. Se colectaron todas las plantas encontradas en un predio de dos hectáreas así como diez metros a la redonda de la parcela, durante todo el ciclo de cultivo en 2011. Las colectas fueron mensuales; los ejemplares se colocaron en prensa botánica; posteriormente se trasladaron al Laboratorio de Biología Agrícola de la ESB-ÚJED para su identificación mediante guías de campo y/o las claves especializadas. Se determinaron 67 especies diferentes, de las cuales 42 están identificadas y 25 ejemplares están en proceso de identificación. Están representadas 14 familias botánicas: Poaceae, Asteraceae, Amaranthaceae, Chenopodiaceae, Euphorbiaceae, Brassicaceae, Malvaceae, Compositae, Solanaceae, Asclepiadaceae, Fabaceae, Convolvulaceae, Nyctaginaceae y Zygophyllaceae. Las malváceas presentes fueron cinco: Malvastrum coromandelianum, Anoda cristata, Sida hederacea y Sphaeralcea angustifolia; dichas especies pudieran ser más susceptibles a una posible polinización cruzada con el algodón transgénico resistente a herbicida o bien, cualquiera de las otras 62 especies restantes, lo que pudiera originar perdida de la biodiversidad

Abstract
Genetically Modified Organisms (gmos) are increasing and they keep generating environmental controversies; transgenic cotton (Malvaceae) is no exception. Weeds are a problem in cotton crops, and they are treated with hoes, herbicides and the use of transgenic cotton, which contains the gene that codifies for resistance to the herbicide glyphosate. However genetir resistance of transgenic cotton can cause cross pollination with other Malvacea or agricultural weeds. It is thus very important to determine the agricultural weeds growing
with herbicide resistant cotton. The current study was undertaken in the Gómez Palacio County, in Durango in the common land known as Ejido la Esperalda. We undertook monthly visits to collect all the plants within the 2 Ha plot including a surrounding buffer zone of 10 mt, during the full 2011 crop cycle. All the plants were pressed and taken to the Laboratorio de Biología Agrícola de la ESB-UD for their correct identification using field guides and dichotomic codes. We found 67 different species, of which 42 are already identified and 25 are currently being processed. The results show representatives of 14 botanic families Poaceae, Asteraceae, Amaranthaceae, Chenopodiaceae, Euphorbiaceae, Brassicaceae, Malvaceae, Compositae, Solanaceae, Asclepiadaceae, Fabaceae, Convolvulaceae, Nyctaginaceae and Zygophyllaceae. We found five representatives of the Malvaceae family: Malvastrum coromandelianu, Anoda cristata, Sida hederacea and Sphaeralcea angustifolia; said species could be more susceptible to a possible cross pollination with herbicide resistant transgenic cotton or, any of the other 62 species, which could cause a loss of biodiversity.
A Guide to the Identification and Control of Exotic Invasive Species in Hardwood Forests
Una guía para la identificación y control de especies exóticas invasoras en bosques

Lisa Derickx
Invasive Species Liaison Officer / Oficial de Enlace de Especies Invasoras
Invasive Species Research Institute
226 Albert St. W Sault Ste Marie, ON P6A 1B6, Canada
lisa.derickx@algomau.ca

Other authors / Otros autores:
Pedro M. Antunes
Invasive Species Research Institute & Department of Biology

Resumen
Las especies invasoras terrestres son cada vez más frecuentes en bosques de madera dura, representando una amenaza potencial para un componente significativo de la economía. Las especies invasoras pueden reducir el valor de la madera y la calidad y cantidad de otros productos derivados del bosque. Considerando el número creciente de especies exóticas invasoras estableciéndose en bosques de madera dura, hay una necesidad clara de lineamientos para su manejo, enfocados en aquellas especies que tienen el potencial más grande para de perjudicar zonas arboladas de madera dura. Actualmente, no existe ninguna panorámica que incluya las especies de plantas invasoras prioritarias presentes en bosques de madera dura en Ontario. Aquí mostramos una guía completa que pretende ser el recurso base para la identificación rápida y el manejo de especies invasoras priorizadas en Ontario, Canadá. Las especies de plantas terrestres invasoras fueron identificadas como prioridades para el manejo, basado en los riesgos económicos, ambientales y sociales que presentan con relación a los bosques de madera dura. La guía incluye instrumentos de identificación en forma de materiales visuales, llaves dicotómicas fáciles de seguir y descripciones escritas. Esta guía describe la biología, mecanismos de éxito, impactos ecológicos y vías de introducción para cada especie. Las estrategias esenciales para el manejo incluyen la prevención, la detección temprana y las opciones de control. Las invasiones biológicas son dinámicas y cada caso es único. Sin embargo, cada dueño o responsable de un terreno boscoso tiene la capacidad de tomar medidas sin importar su nivel de experiencia o recursos disponibles. Nuestra guía está diseñada para ayudar a dueños y administradores de terrenos boscosos a tomar decisiones sobre cómo manejar especies invasoras. Aunque la guía se concentra en el manejo en Ontario, puede ser usada como una plantilla para otras organizaciones a través de Norteamérica.

Abstract
Terrestrial invasive species are increasingly prevalent in hardwood forests, posing a potential threat to a significant component of the economy. Invasive species may result in reductions to timber value and the quality and quantity of other forest-derived products. Considering the increasing number of exotic invasive species establishing in hardwood forests, there is a clear need for management guidelines that focus on those species that have the largest potential to be detrimental to hardwood stands. Currently, no overview exists that encompasses the priority invasive plant species present in Ontario hardwood stands. Here we showcase a comprehensive guidebook that aims to be the go-to resource for fast identification and management of priority invasive species in Ontario, Canada. Terrestrial invasive plant species were identified as priorities for management based on the economic, environmental and social risks they pose in relation to hardwood forests. The guide includes identification tools in the form of visual aids, easy to follow dichotomous keys and written descriptions. It describes the biology, success mechanisms, ecological impacts and pathways of introduction for each species. Essential strategies for management include prevention, early
detection and control options. Biological invasions are dynamic and each case is unique. However, every woodlot owner or manager has the ability to take action regardless of their level of experience or available resources. Our guide is meant to help woodlot owners and managers make decisions on how to deal with invasive species. Although the guide is focused on management in Ontario, it can be used as a template for other organizations across North America.

Presentation summary

Introduction

Invasive species are increasingly prevalent in Ontario’s hardwood forests, including the boreal forest, a vast terrestrial biome covering much of northern Ontario (Sanderson et al., 2012). Forestry represents an important part of Ontario’s economy, at an estimated $14 billion in 2008 (MNDM, 2011). Economically, Ontario’s hardwood forests provide high value non-timber products, areas for recreation and sustain a resource-based tourism industry (Daily et al., 1997). Invasive species represent potential direct and indirect threats to timber value and the quality and quantity of other forest-derived products such as maple syrup (Mohammed, 1999). They can alter forest integrity through rapid population expansion. In turn, this may affect soil nutrient dynamics and affect biodiversity by causing shifts in species abundances, which in some cases can lead to local extinctions (Wyckoff & Webb, 1996). Exotic plant invasions can alter soil physiochemical properties and affect nutrient cycling (Mack et al., 2000), while exotic insects and pathogens can severely damage and cause large-scale mortality of indigenous trees and shrubs (Allen & Humble, 2002).

The majority of exotic plants were introduced to North America intentionally for agriculture and horticultural purposes and were thus prized for their fast-growing, sun-loving habits. Since forest understories are generally subject to low light levels, they tend to be inhospitable to many of these introduced horticultural varieties. However, some shade-tolerant species have been introduced and, not surprisingly, many of these exotic species are indeed spreading in forest environments (Martin et al., 2008).

In general, invasive forest plants have relatively long lag-times (i.e. the time it takes before a species grows exponentially and becomes invasive in the new introduced environment), which may give a false sense of security when assessing the risk of invasive forest species (Crooks, 2005). Indeed, many invasive plants are still available for sale in garden centers across Ontario. Only recently has evidence arisen concerning the detrimental effects of invasive vines such as periwinkle (Vinca minor; Darcy & Burkart, 2002) and English ivy (Hedera helix; Dlugosch, 2005). Other species, such as common barberry (Berberis vulgaris), have been banned for sale due to reported detrimental effects to agriculture. Yet its close relative, Japanese barberry (B. thunbergii), is still sold and used as a common garden plant (CFIA, 2008). Research on the ecological effects of exotic invasive plants, as well as preventative measures, need to be considered to minimize negative effects to hardwood forests in Ontario.

Considering the increasing number of invasive species establishing in Ontario’s forests, there is a clear need for management guidelines that focus on those species that have the largest potential to be detrimental to hardwood stands. There is also a requirement to engage the public in environmental protection by providing information that is science based, yet easy-to-follow. This guide focuses on invasive plants, insects and pathogens that exhibit ecological, economic and social impacts that are detrimental to Ontario’s hardwood forests. Management practices including early detection techniques and prevention strategies are included.

Methods

The guide encompasses 14 invasive plants (Table 15) and 11 invasive insects and pathogens (Table 16), and describes the risks associated with invasive species in hardwood forests. It introduces managers to the basic principles associated with different management strategies and outlines various methods of invasive species control. Species were selected based on the following risk categories:

- Economic risks:
  - Species that can directly affect commercial hardwoods by significantly reducing growth, causing widespread mortality and/or suppressing hardwood regeneration;
  - Species that can alter the quality of timber or the quantity of maple syrup produced;
  - Species whose environmental effects can result in the reduction of property value;
- Species that can incur losses resulting from movement restrictions related to timber products.

- Environmental risks:
  - Species that cause the loss of biodiversity;
  - Species that reduce ecosystem goods and services;
  - Species that can harm a species at risk.

- Social Impacts:
  - Species that can interfere with traditional lifestyles;
  - Species that can reduce aesthetic values of a hardwood stand;
  - Species that affect the recreational enjoyment of a woodlot;
  - Species that are prejudicial to human health.

Table 15. Invasive plants considered a priority for management in hardwood forests.

<table>
<thead>
<tr>
<th>Species</th>
<th>Common Name</th>
<th>Priority Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acer platanoides</td>
<td>Norway maple</td>
<td>High</td>
</tr>
<tr>
<td>Ailanthus altissima</td>
<td>Tree-of-heaven</td>
<td>High</td>
</tr>
<tr>
<td>Alliaria petiolata</td>
<td>Garlic mustard</td>
<td>High</td>
</tr>
<tr>
<td>Berberis thunbergii</td>
<td>Japanese barberry</td>
<td>High</td>
</tr>
<tr>
<td>Berberis vulgaris</td>
<td>Common barberry</td>
<td>High</td>
</tr>
<tr>
<td>Fallopia japonica</td>
<td>Japanese knotweed</td>
<td>High</td>
</tr>
<tr>
<td>Hedera helix</td>
<td>English ivy</td>
<td>High</td>
</tr>
<tr>
<td>Impatiens glandulifera</td>
<td>Himalayan balsam</td>
<td>High</td>
</tr>
<tr>
<td>Rhamnus cathartica</td>
<td>Common buckthorn</td>
<td>High</td>
</tr>
<tr>
<td>Vinca minor</td>
<td>Periwinkle</td>
<td>High</td>
</tr>
<tr>
<td>Vincetoxicum nigurum &amp; V. rossicum</td>
<td>Dog-strangling vine</td>
<td>High</td>
</tr>
<tr>
<td>Aegopodium podagraria</td>
<td>Goutweed</td>
<td>Moderate</td>
</tr>
<tr>
<td>Celastrus orbiculatus</td>
<td>Oriental bittersweet</td>
<td>Moderate</td>
</tr>
<tr>
<td>Lonicera spp.</td>
<td>Exotic bush honeysuckle</td>
<td>Moderate</td>
</tr>
<tr>
<td>Pueraria montana var. lobata</td>
<td>Kudzu</td>
<td>Moderate</td>
</tr>
</tbody>
</table>

Table 16. Invasive insects and pathogens considered a priority for management in hardwood forests.

<table>
<thead>
<tr>
<th>Species</th>
<th>Common Name</th>
<th>Priority Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agrilus planipennis</td>
<td>Emerald ash borer</td>
<td>High</td>
</tr>
<tr>
<td>Anoplophora glabripennis</td>
<td>Asian long-horned beetle</td>
<td>High</td>
</tr>
<tr>
<td>Cryphonectria parasitica</td>
<td>Chestnut blight</td>
<td>High</td>
</tr>
<tr>
<td>Cryptococcus fagisuga &amp; Neoneectria spp.</td>
<td>Beech bark disease</td>
<td>High</td>
</tr>
<tr>
<td>Lymantria dispar</td>
<td>Gypsy moth</td>
<td>High</td>
</tr>
<tr>
<td>Ophiognomonia clavignenti-juglandacearum</td>
<td>Butternut canker</td>
<td>High</td>
</tr>
<tr>
<td>Ophiostoma spp.</td>
<td>Dutch elm disease</td>
<td>High</td>
</tr>
<tr>
<td>Scolytus multistriatus</td>
<td>European elm bark beetle</td>
<td>High</td>
</tr>
<tr>
<td>Scolytus schevyrewi</td>
<td>Banded elm bark beetle</td>
<td>High</td>
</tr>
<tr>
<td>Discula destructiva</td>
<td>Dogwood anthracnose</td>
<td>Moderate</td>
</tr>
<tr>
<td>Geosmithia morbida</td>
<td>Thousand cankers disease</td>
<td>Moderate</td>
</tr>
<tr>
<td>Taeniothrips inconsequens</td>
<td>Pear thrips</td>
<td>Moderate</td>
</tr>
</tbody>
</table>
Invasive Species Accounts

Detailed accounts of each species considered a high priority for management are included in the guide. Biological characteristics, reasons for success, possible ecological impacts, and management information in the form of identification tools, prevention strategies, early detection techniques and control options are outlined in each account. Biological information such as taxonomic hierarchy, origin and distribution, habitat, type of reproduction, and life-cycle are included as they provide important clues for management. Success mechanisms are traits likely to play a role in enabling species to be invasive. Understanding these traits can help managers with the decision making process while selecting appropriate invasive species control strategies.

Species invasions can negatively affect the environment, economy and society. This is the basis for why they need to be managed for possible eradication or control. Potential negative effects caused by invasive species are included in the guide as a way of highlighting the importance of actively monitoring and managing new or existing invasions.

Effective management involves planning a strategy and having the ability to provide a certain level of commitment, effort and financial resources (Holcombe & Stohlgren, 2009). Prevention is the most efficient and effective approach to manage invasive species. There are several things a manager can do to prevent the introduction of invasive species into the hardwood stand. Prevention strategies specific to each individual species are provided. This will help managers create a prevention plan can go a long way to reducing the risk of invasions and the amount of time, effort and cost needed for invasive species management (Clark, 2003).

Although a prevention plan is considered an effective management approach, these are not always foolproof and it is best to have a backup plan in place (Clout & Williams, 2009). Early detection is the identification of newly established invasive species at the initial stage of invasion. Invasive species may be eradicated and are clearly easier to control in these early stages. The larger a population is the greater the amount of labour and money required for its management (O’Neil et al., 2007). As such, management actions should occur promptly after detection to save money and minimize damage to the hardwood stand. It is thus important for managers to identify new invasions quickly and accurately. Tools in the form of visual aids, written descriptions and dichotomous keys are included to help managers distinguish invasive exotics from similar native species. Early detection techniques unique to each species are provided.

Monitoring is the key to early detection. Once an invasive species is detected, implementing actions to immediately address the problem is highly recommended. Having a plan that outlines the management options for priority species will allow for quick and efficient control of new invasions (Grice, 2009). As such, recommendations for integrated control of large invasions are provided with the option of using chemical or nonchemical control methods. Management tables outline various methods of control for small invasions and satellite populations, as well as larger invasions including those intermingled with desirable vegetation. Depending on the extent of the invasion, an integrated approach may be needed. Forest managers and woodlot owners should choose methods that are well aligned with their objectives and goals for the present and future use of the hardwood stand.

Conclusions

Through the production of the guidebook it became obvious that species invasions are dynamic and each case of local invasion is unique. Management recommendations in this guide may not be the most appropriate for everyone. Forest managers and woodlot owners should gauge their level of experience, commitment and finances when considering control options. It is also important to understand that these recommendations and management strategies may change as on-going research provides new insights into invasive species control. We recommend that anyone with an interest in forests should try to keep abreast of the status of priority species and of current management practices.
References


The Emergence of Parthenium (Parthenium hysterophorous) as a Trans-border Invasive Weed in the Caribbean

El surgimiento de Parthenium (Parthenium hysterophorous) como una maleza invasora transfronteriza en el Caribe

Puran Bridgemohan
Weed Scientist / Científico en malezas
Biosciences, Agriculture and Food Technology, Waterloo Research Campus, University of Trinidad and Tobago
Bungalow 26 Waterloo States Carapichaima 121 Trinidad and Tobago
puran.bridgemohan@utt.edu.tt

Resumen
La escoba amarga o Parthenium [Parthenium hysterophorous L. (f)] se considera una maleza nociva transfronteriza en el Caribe ya que es ecológicamente competitiva e invasora. Se llevó a cabo una revisión y evaluación de la maleza usando el método de Índice [IVI] de Valor de Importancia y el Protocolo de Evaluación de Especies Invasoras para determinar su impacto a la cosecha de verduras durante las temporadas secas y húmedas en Trinidad y Tobago. La maleza ha demostrado resistencia en contra de herbicidas de bipyridylium, y es difícil de manejar por métodos mecánicos, culturales y biológicos. Esto ha reducido el 100% de la producción de tomate (Lycopersicon esculentum Mill.) cv. Calypso y afectado entre el 75% y 100% la calidad de la cosecha en coliflor (Brassica oleracea var. botrytis L.) debido a su capacidad competidiva y efecto alelopático. La maleza demostró tener un Impacto Ecológico alto (46), y una Distribución y Abundancia actual significativa (20). La Tendencia en Distribución y Abundancia (12) y Dificultad de Manejo (8), confirman los atributos de persistencia de la maleza. La maleza sirve como ‘sitio de descanso conveniente’ para el insecto adulto Plutella xylostella (L) [Lepidoptera: Yponomenitidae] que ataca cruciferous crops. White top weed is not restricted by boundaries and is a weed of severe agroonomic and bio-diversity significance throughout the Caribbean territories.

Abstract
White top or Parthenium [Parthenium hysterophorous L. (f)] is considered a trans-border, noxious weed in the Caribbean as it exhibits wide ecological amplitudes that is competitive and invasive. A weed survey and assessment was conducted using the Importance Value Index [IVI] method and the Invasive Species Assessment Protocol to determine its impact on vegetable crop during the wet and dry seasons in Trinidad and Tobago. The weed has displayed resistance to bipyridylium herbicides, and is difficult to manage by mechanical, cultural and biological methods. It has reduced yields of tomato (Lycopersicon esculentum Mill.) cv. Calypso by 100%, and crop quality in cauliflower (Brassica oleracea var. botrytis L.) by 75% to 100% due to its competitive ability and allelopathic effect. The weed exhibited a high Ecological Impact (46), and had a significant Current Distribution and Abundance (20). The Trend in Distribution and Abundance (12) and Management Difficulty (8), confirmed the weed’s persistence attributes. The weed serves as a suitable ‘resting site’ for the adult insect pest Plutella xylostella (L)[ Lepidoptera: Yponomenitidae] which attacks cruciferous crops. White top weed is not restricted by boundaries and is a weed of severe agroonomic and bio-diversity significance throughout the Caribbean territories.

Presentation summary

Introduction
Invasive weed species have a major impact on the Caribbean agricultural environment, threatening biodiversity and reducing overall species abundance and diversity. Weeds reduce crop yield and quality, and increase environmental degradation through destruction of native plant and animal habitat. Additionally, in the Caribbean Islands chain there are no boundaries with respect to invasiveness as weeds have been reported to harbour insects and diseases of crops, create unsafe conditions, reduce property values and the aesthetics of an enjoyable landscape and many can poison humans, livestock and wildlife ((Bridgemohan and Brathwaite, 1987, 1989).

White top or Parthenium (Parthenium hysterophorous L. (f) #PTNNY) has emerged as a significant noxious weed throughout the Caribbean (Hammerton, 1980). The plant exhibits wide ecological amplitude, and in-
vades and competes with all types of crops, especially vegetables, with substantial losses in yield (Gupta and Sharma, 1977). The plant displays characteristics of profuse seedling ability, photo-thermal insensitivity, non-dormancy, high growth rate, and low photosynthetic rate (Bridgemohan and Brathwaite, 1987; Kholi, 1992; Tamado, 2001).

Braithwaite (1978) noted the frequent presence of the weed in that major vegetable growing areas of Trinidad, and reported that it was effectively controlled by dinitroanilines, e.g., butralin [4-(1,1-Dimethylethyl)-2,6-dinitro-benzenamine] in eggplant (Solanum melongena L.), and by the amide herbicide, diphenamid [N, N-Dimethyl-2,2-diphenylacetamide] in cabbage (Brassica oleracea var. capitata L.).

Parthenium is difficult to control physically as the plant has the ability to survive carbohydrate depletion approach to control and shown resistance to bipyridylum herbicides (Brathwaite, 1978; Hammerton, 1980; Bridgemohan, 1987). The weed was identified in Trinidad early as 1956. However, it was not of any significance until the 1960’s when the use of paraquat [1,1’-dimethyl-4,4’-bipyridylum] and diquat [6,7-dihydrodipyrido (1,2-a:2,1-c) pyrazinedium] became widespread.

The weed competitive ability and economic significance with respect to management has been reviewed. However, the relative invasive characteristics has not been objectively determined or quantified. The Australian Weed Risk Assessment (wra) system has been used to evaluate the potential invasiveness of species (Pheloung et al., 1999). The system is a plant assessment method developed for screening of new species and the identification of species already in cultivation that may become invasive. It is essential to reduce the ecological and economic consequences of invasive weeds introductions and the potential invasiveness of weed species not yet introduced (Gordon and Gantz, 2008).

The Invasive Species Assessment Protocol is another tool for assessing, categorizing, and listing non-native invasive vascular plants according to their impact on native species and natural biodiversity or ecological region. This protocol was designed to make the process of assessing and listing invasive plants objective and systematic, and to incorporate scientific documentation of the information used to determine each species’ rank. (Morse et al., 2004)

The objective of this study is determine the potential invasiveness, the relative importance value index and the characteristics that make Parthenium hysterophorus a trans-border invasive weed in the Caribbean.

**Materials and Methods:**

Three weed assessment protocols were used in this study to evaluate non-native plants on their impact on bio-diversity over two seasons [wet and dry] during the period 2010 and 2011 in several of the major vegetable growing and non-farm areas in Trinidad and Tobago. The methods were:

1. Importance Value Index (ivi)
2. Australian Weed Risk Assessment (wra)
3. An invasive species assessment protocol (NatureServe)

The weed survey was conducted in the major vegetable production areas of the wet and dry seasons, and the weed number, height, physiological stage of growth, and basal area were recorded. The data were summarized using seven quantitative measures as previously used and described by Tiwari and Bisen (1981), and Thomas (1985), and modified by Bridgemohan (2012). Visual estimated (ve), Abundance (ap), Density (dp), Percentage frequency (fp), Relative dominance (rdi), Relative density (rdp), and Relative frequency (rfp) were determined, These were used to compute the Importance Value Index (ivi).

\[ \text{ivi} = \text{rdi} + \text{rdp} + \text{rfp} \]

The Australian Weed Risk Assessment (wra) system (Pheloung et al., 1999) was selected to perform the test for invasiveness. The wra uses an additive approach for each of the 49 questions with set scores. This survey instrument covered distribution, and agro-climatic conditions, invasive characteristic, and morphological and physiological traits of the species. All forty-nine questions are required for completion of the wra on any species or taxon. If the summed scores are >6, the taxon is predicted to become invasive and should be rejected for import/production; if the sum is <1, the taxon is not predicted to become invasive and should be accepted; scores of 1 to 6 indicate that further evaluation is necessary before a prediction is possible.
The NatureServe’s protocol is used to assess species (or infraspecific taxa, as appropriate) individually for a specified “region of interest” and to assign each species an Invasive Species Impact Rank (I-Rank) of High, Medium, Low, or Insignificant to categorize its negative impact on natural biodiversity within that region (Moores, 2004). The protocol includes 20 questions, each with four scaled responses (A-D, plus U = unknown). The 20 questions are grouped into four sections: Ecological Impact, Current Distribution and Abundance, Trend in Distribution and Abundance, and Management Difficulty. Each species is assessed by considering these questions, with the answers used to calculate a subrank for each of the four sections. An overall I-Rank is then calculated from the subranks.

**Results and discussion**

Irrespective of the visual estimate (ve) of parthenium infestations, the frequency (fp) in both seasons was greater than 50% (Table 17). There was no variation in the mean Importance Value Index (ivi) for parthenium for the wet (491) and dry (438) seasons. Also, variations between seasons were minimal under similar levels of weed management for cabbage (360), cauliflower (215), and spinach (365.6).

There was no significant difference between visual estimates (ve) for Parthenium in the wet and dry seasons for the major vegetable growing areas of Trinidad (Table 18). Visual estimates in the range of 25 to 60% can be considered as moderate infestations (Phillipson, 1974). There were no changes in abundance (ap) between seasons. Cyperus rotundus (L.) #CYP, “the world’s worst weed” (Holm et al., 1977), is a serious weed in vegetable crops in India with an abundance of 2.7 to 9.6 (Tiwari and Bisen, 1981). The Ap for Parthenium fell outside (15) range in the wet seasons. Wet season density [Dp] (5.77) was lower than dry season (15.04). The Dp for Parthenium emphasizes and predominate of this weed in both seasons.

Frequency (fp) was over 65% in both seasons. Thomas (1985) indicated that weeds occurring in the frequency levels 60 to 100 are serious weeds that require some level of control. The 1vi indicated that there were no shifts in Parthenium population between seasons in vegetable growing area of Trinidad (Table 19). These finding indicate that Parthenium is a serious problem in all the major vegetable growing areas in Trinidad, where the 1vi is even greater for the dry season.

All farmers found that the presence of the weed within or around the field can result in a reduction of the marketable yield of cabbage and cauliflower. The Authors observed a 75 to 100% damage to marketable curds of cauliflower caused by the larvae of Plutella xylostella (L.) (Lepidoptera: yponomentidae). Apparently, the adult pest found Parthenium to be a suitable “resting site” (Mona Jones, Pers. Comm., 2012).

The reduction in crop yield and quality is probably due to the competitive ability and allelopathic potential of Parthenium. Rajendra and Rama Das (1981) noted that although the weed was a C3 plant, a low carbon dioxide compensation concentration and photo respiratory rate were observed. This was attributed to the activity of PRP carboxylase. The authors described the weed as having a luxurious growth and high survival potential. Sukhada and Jayachandra (1984) reported that Parthenium produced allelopathic compounds that influenced pollen germination and tube growth in solanaceous and bean crops where yield reductions between 27 to 73% were observed.

The invasiveness of parthenium as determined by the Nature Serve Assessment Protocol is presented in Tables 19 and 20. The results indicate that the ecological impact was significant and high (98) as was the current distribution and abundance (26). Similarly, the trend in distribution and abundance (53) and management difficulty (40) were high and on the extreme end. When all the sub-ranks were tabulated, the overall invasive Rank (I. Rank) was 100 (Table 20). This demonstrated that parthenium has emerged over the last 60 years as a significant noxious weed, with the highest potential to continue to be a trans-border weed in the Caribbean.

The wra test to determine invasiveness revealed that the scores were 17, and since it is >6, the weed is predicted to become a significant invasive weed both in the farm and non-farm areas (Tables 21 and 22). The weed biology has demonstrated the weed resilience, its adaptability to varying soil conditions, and tolerance to manual and chemical control.

This study using the three known and accepted tests has demonstrated that parthenium has not only emerged as a problematic and noxious weed in Trinidad, and also present in the Caribbean Islands, but if unchecked has the propensity to explode as a major
trans-border invasive weed in the Caribbean. This will further be exasperated as trade between the is-

lands in root crops and fruits continue without proper border inspection and surveillance.

References
Adams, C.D. (1972). Flowering plants of Jamaica. The University of the West Indies, Mona, Jamaica 151pp
Bridgemoha, P. 2012. Manual of invasive alien weeds spp. In Trinindad and Tobago, The University of Trinidad and Tobago, in press
Salisbury S. Oil-yielding tree gains attention in Florida, <http://www.palmbeachpost.com/travel/content/business/epaper/2008/04/21/m1bz_jatropha_0421.html?cxntlid¼inform_artr>; 2008 [accessed 06.08.09].
### Table 17. Incidence of *P. hysterophorous* in the major vegetable crops during the wet and dry seasons

<table>
<thead>
<tr>
<th>Crop</th>
<th>VE</th>
<th>Fp</th>
<th>IVI</th>
</tr>
</thead>
<tbody>
<tr>
<td>squash</td>
<td>90</td>
<td>100</td>
<td>674.9</td>
</tr>
<tr>
<td>tomatoes</td>
<td>75</td>
<td>100</td>
<td>836.4</td>
</tr>
<tr>
<td>cabbage</td>
<td>10</td>
<td>50</td>
<td>360.0</td>
</tr>
<tr>
<td>spinach</td>
<td>25</td>
<td>100</td>
<td>365.6</td>
</tr>
<tr>
<td>Bodie beans</td>
<td>10</td>
<td>100</td>
<td>207.8</td>
</tr>
<tr>
<td>cauliflower</td>
<td>10</td>
<td>50</td>
<td>215.8</td>
</tr>
<tr>
<td>Mean</td>
<td>36</td>
<td>83</td>
<td>443.4</td>
</tr>
<tr>
<td>SE</td>
<td>2.45</td>
<td>2.07</td>
<td>6.5</td>
</tr>
</tbody>
</table>

### Table 18. Incidence of *P. hysterophorous* for the major vegetable growing areas in Trinidad and Tobago

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Wet (Oct – Jan)</th>
<th>Dry (Feb – Apr)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SE</td>
</tr>
<tr>
<td>Visual Estimates (VE)</td>
<td>43.87</td>
<td>1.78</td>
</tr>
<tr>
<td>Abundance (Ap)</td>
<td>7.46</td>
<td>1.11</td>
</tr>
<tr>
<td>Density (Dp)</td>
<td>5.6</td>
<td>0.66</td>
</tr>
<tr>
<td>Frequency (Fp)</td>
<td>65.32</td>
<td>14.96</td>
</tr>
<tr>
<td>Relative Dominance (RD)</td>
<td>53.02</td>
<td>9.04</td>
</tr>
<tr>
<td>Relative Density (RDp)</td>
<td>412.0</td>
<td>37.46</td>
</tr>
<tr>
<td>Relative Frequency (RFp)</td>
<td>58.43</td>
<td>5.9</td>
</tr>
<tr>
<td>Importance Value Index (IVI)</td>
<td>491.19</td>
<td>37.92</td>
</tr>
</tbody>
</table>

### Table 19. The invasiveness of *Parthenium* as determined by the Nature Serve Assessment Protocol

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Invasive, , morphological and physiological traits</th>
<th>Points</th>
<th>Scoring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ecological Impact</td>
<td>Impact on Ecosystem Processes and System-Wide Parameters</td>
<td>32</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Impact on Ecological Community Structure</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Impact on Ecological Community Composition</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Impact on Individual Native Plant or Animal Species</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Conservation Significance of the Communities and Native Species</td>
<td>24</td>
<td></td>
</tr>
</tbody>
</table>
### Table 20. Summary of the invasiveness of Parthenium as determined by the Nature Serve Assessment Protocol

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Invasive, morphological and physiological traits</th>
<th>Points</th>
<th>Scoring</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Current Distribution and Abundance</strong></td>
<td>Current Range Size in Region</td>
<td>10</td>
<td>26 High</td>
</tr>
<tr>
<td></td>
<td>Proportion of Current Range Where Species Is Impacting Biodiversity</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Proportion of Region’s Biogeographic Units Invaded</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Diversity of Habitats or Ecological Systems Invaded in Region</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td><strong>Trend in Distribution and Abundance</strong></td>
<td>Current Trend in Total Range Within Region</td>
<td>9</td>
<td>53 High</td>
</tr>
<tr>
<td></td>
<td>Proportion of Potential Range Currently Occupied</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Long-Distance Dispersal Potential Within Region</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Local Range Expansion or Change in Abundance</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Inherent Ability to Native Species Habitats</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Similar Habitats Invaded Elsewhere</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reproductive Characteristics</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td><strong>Management Difficulty</strong></td>
<td>General Management Difficulty</td>
<td>18</td>
<td>40 High</td>
</tr>
<tr>
<td></td>
<td>Minimum Time Commitment</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Impacts of Management on Native Species</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Accessibility of Invaded Areas</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section</th>
<th>Subrank Values</th>
<th>Points</th>
<th>I-Rank Intervals</th>
<th>I-Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ecological Impact</td>
<td>50 33 17 0</td>
<td>50</td>
<td>76 – 100 High</td>
<td></td>
</tr>
<tr>
<td>Current Distribution and Abundance</td>
<td>25 17 8 0</td>
<td>25</td>
<td>51 – 75 Medium</td>
<td>100 High</td>
</tr>
<tr>
<td>Trend in Distribution and Abundance</td>
<td>15 10 5 0</td>
<td>15</td>
<td>26 – 50 Low</td>
<td></td>
</tr>
<tr>
<td>Management Difficult</td>
<td>10 7 3 0</td>
<td>10</td>
<td>0 – 25 NS</td>
<td></td>
</tr>
</tbody>
</table>
## Table 21. Summary of the invasiveness of Parthenium as determined by Australian Weed Risk Assessment (WRA)

<table>
<thead>
<tr>
<th>Section</th>
<th>Biological traits</th>
<th>Invasive characteristic</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biogeographical Characteristics</td>
<td>Domestication Cultivation</td>
<td>Highly domesticated</td>
<td>-3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>naturalized</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>weedy races</td>
<td>-1</td>
</tr>
<tr>
<td></td>
<td>Climate &amp; Distribution</td>
<td>Suited to Trinidad and Tobago climates</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Quality of climate match data</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Environmentally versatile</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Native or naturalized [ extended dry periods]</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>History of repeated introductions outside its natural range</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Weed Elsewhere</td>
<td>Naturalized beyond native range</td>
<td>-2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Garden/amenity/disturbance weed</td>
<td>-2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weed of agriculture/horticulture/forestry</td>
<td>-2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Environmental weed</td>
<td>-2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Congeneric weed</td>
<td>0</td>
</tr>
<tr>
<td>Biology and Ecological</td>
<td>Undesirable Traits</td>
<td>Spines, thorns or burrs</td>
<td>0</td>
</tr>
<tr>
<td>Characteristics</td>
<td></td>
<td>Allelopathic</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Parasitic</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unpalatable to grazing animals</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Toxic to animals</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Host for pests and pathogens</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>allergies or toxic to humans</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>fire hazard in natural ecosystems</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>shade tolerant plant at some stage of its life cycle</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Grows on infertile soils</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Climbing or smothering growth habit</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dense thickets</td>
<td>1</td>
</tr>
<tr>
<td>Plant type and Reproduction</td>
<td>Aquatic</td>
<td>Evidence of s reproductive failure in native habitat</td>
<td>0</td>
</tr>
<tr>
<td>Characteristics</td>
<td>Grass</td>
<td>Produces viable seed</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Nitrogen fixing woody plant</td>
<td>Hybridizes naturally</td>
<td>-1</td>
</tr>
<tr>
<td></td>
<td>Geophyte</td>
<td>Self-fertilization</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Requires specialist pollinators</td>
<td>-1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Vegetative propagation</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Minimum generative time (years)</td>
<td>1</td>
</tr>
<tr>
<td>Reproduction</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dispersal</td>
<td>Unintentionally</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Intentionally by people</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Produce contaminant</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Wind</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Buoyant</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bird</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other animals (externally)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other animals (internally)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Persistence Attributes</td>
<td>Prolific seed production</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Persistent propagule bank is formed (&gt; 1 yr)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Controlled by herbicides</td>
<td></td>
<td>-1</td>
</tr>
<tr>
<td></td>
<td>Tolerates or benefits from mutilation, cultivation or fire</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Effective natural enemies present in Trinidad and Tobago</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Conservation Implications of *Lantana camara*: Research in Progress
Implicaciones de *Lantana camara* en la conservación: Investigación en progreso

Christie Sampson
Graduate Student / Estudiante de posgrado
Biological Sciences Department, Clemson University / Departamento de Ciencias Biológicas, Universidad Clemson
24 Dove Circle Clemson, SC 29631 USA
sampso2@clemson.edu

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Biological Traits</th>
<th>Final Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biogeographical characteristics</td>
<td>Domestication/ Cultivation</td>
<td>-3</td>
</tr>
<tr>
<td></td>
<td>Climate &amp; Distribution</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Weed elsewhere</td>
<td>-8</td>
</tr>
<tr>
<td>Undesirable traits</td>
<td>Undesirable traits</td>
<td>8</td>
</tr>
<tr>
<td>Plant type and Reproduction characteristics</td>
<td>Plant type</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Reproduction</td>
<td>1</td>
</tr>
<tr>
<td>Propagation and spread</td>
<td>Dispersal mechanisms</td>
<td>8</td>
</tr>
<tr>
<td>Persistency and invasiveness</td>
<td>Persistence attributes</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>18</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Outcome</strong></td>
<td><strong>REJECT</strong></td>
</tr>
</tbody>
</table>

Table 22. Summary of the invasiveness of *Parthenium* as determined by Australian Weed Risk Assessment (WRA)

Resumen
*Lantana camara*, una especie nativa de América Central y América del Sur, ha cruzado fronteras innumerables y ha invadido regiones tropicales y subtropicales a través del globo. En colaboración con el Instituto Smithsonian y el Centro de Conservación e Investigación, estoy evaluando como esta planta invasora afecta objetivos de conservación en dos hábitats críticos de la fauna silvestre en Sri Lanka. Mi proyecto se concentra en los impactos ambientales e impactos a la biodiversidad a la vegetación sobre todo con relación a la presencia de fuego en la Reserva Forestal Hurulu y el Parque Nacional Udawalwe. Usando SIG, y a través de verificación en campo en parcelas permanentes de vegetación, superviso la dispersión y la regeneración post-fuego de *L. camara* en cuatro tipos de cobertura de terreno: prado, de transición, matorral, y bosque. Los resultados de este estudio serán usados para hacer recomendaciones de manejo de hábitat al Departamento de la Fauna y Departamento Forestal de Sri Lanka.

Abstract
*Lantana camara*, a native of Central and South America, has crossed countless borders and invaded tropical and sub-tropical regions across the globe. Working with the Smithsonian Institution and the Centre for Conservation and Research, I am assessing how this invasive plant is affecting conservation objectives in two critical wildlife habitats in Sri Lanka. My project focuses on the environmental and biodiversity impacts on vegetation especially in relation to the presence of fire in Hurulu Forest Reserve and Udawalwe National Park. Using GIS and on the ground sampling of permanent vegetation plots, I am monitoring the spread and post-fire regeneration of *L. camara* in four landcover types: grassland, transitional, scrub, and forest. Results of this study will be used to make habitat management recommendations to the Sri Lankan Department of Wildlife and Sri Lankan Forest Department.
Conserving habitats invaded by *Lantana camara*:
Research in progress  
C. Sampson

**Biological Sciences Department, Clemson University, South Carolina, USA**

---

**Presentation summary**

**Figure 14.** Poster: Conserving habitats invaded by *Lantana camara*

---

**Project Overview**

The leading threats to the survival of wild Asian elephants are habitat loss and human elephant conflict (HEC) (Sukumar 1989, 2001; Fernando et al. 2005; Fernando & Semprebro 2012). Sri Lanka has one of the largest wild elephant populations in Asia and due to high human population, it also has one of the highest levels of HEC in Asia. As habitat fragmentation continues, elephant populations will decline and be pushed into the existing protected areas.

I am conducting some of the first basic and applied research on the management of the most critical and limiting elephant habitat, grasslands, in Sri Lanka. My project examines the importance of fires in:

1. Reducing or facilitating the distribution of exotic species, primarily *Lantana camara*.
2. Maintaining open grasslands.
3. Maintaining higher elephant densities in recently burnt areas over other habitats.

---

**Study Site**

Sri Lanka has over 8,500 km<sup>2</sup> of protected areas, 13% of its land surface. I am conducting research in

- **Huwila Reserves**, 25,000 ha
- **Udawalawe National Park**, 30,000 ha

---

**Figure 2.** Sri Lanka

---

**Lantana camara**

- Native to Central and South America
- Aggressive invasive weed in over 60 countries
- Forms dense monocultures
- Can severely impact the fire regime of an invaded ecosystem by increasing fire frequency and severity
- Displays many fire survival characteristics which allow for quick regeneration post-fire
- The foliage can be toxic to herbivores

---

**Research focus areas invaded by Lantana camara**

- Assess elephant and cattle use of invaded areas.
- Determine changes to composition and structure of the vegetation.
- Determine changes to fire regime.
- Assess vegetation regeneration after fire.

---

**Methods: Vegetation Plots**

Over the summer of 2011, a total of 15 plots occurred; two in UNP and thirteen in HRP. Within these two parks we have conducted 22 one-kilometer elephant and cattle dung transect surveys across four different habitat types: grassland; transitional, scrub, and forest. I have established 168 permanent 20m x 20m vegetation plots, which involve collecting data from 40 point intersect locations across 5 height strata and recording all shrubs and trees within a 10m by 10m subplot. These plots will give a detailed analysis of the composition and structure of the vegetation within the habitat types. All shrubs, trees and common grasses are identified to species. Other grasses are assigned to categories: medium grasses which are not favored by the elephants and short grasses which are consumed by the elephants.

---

**Methods: Dung Transsects**

Elephant and cattle/buffalo abundance is determined using an indirect survey method. A single observer, maintaining a randomly chosen cardinal direction within a habitat type (grassland, transitional, scrub, or forest) identifies all visible dung along a 1 km transect. The distance from the transect line to the center of the dung is recorded and the results are analyzed using Distance (Thomas et al. 2010).

---

**Conclusions**

Based on preliminary results, I have determined that the maintenance of grassland habitats is critical to support elephant populations in the few remaining habitat islands. However, without regular fires, natural succession may convert these areas into scrub and forest lands which contain fewer resources for elephant populations. And the presence of *L. camara* in these sensitive environments may make the use of fire as a tool for habitat management ineffective if its spread is enhanced by fire. I believe that this research is key in determining whether fire should be used in active management to improve elephant habitat.

---

**Major Outputs**

- Increased knowledge and capacity for elephant habitat management in Sri Lanka
- Increased knowledge and capacity to manage *L. camara*
- Establishment of permanent vegetation plots
- Habitat management recommendations
- Critical baseline data on elephant populations
- Capacity building

---

Acknowledgments: Thanks to Clemson University, The Smithsonian Institution, the Center for Conservation and Research, and the USFWS and Wildlife Asia Elephant Conservation Fund for their support of this project. Special thanks to my field guide, Nirosh Gunawardena, for his help. Funding from USFWS, World Wildlife Fund-Sri Lanka, and the US Agency for International Development.

---

**Figure 3.** Elephant and cattle/buffalo abundance in the four habitat types.
Weeds as a Disturbance Indicator in the Temperate Forest of the Magdalena River Basin
Las malezas como un indicador de perturbación en el bosque templado de la cuenca del Río Magdalena

Yuriana Martínez-Orea
Laboratory technician / Técnico de Laboratorio
Faculty of Sciences, UNAM / Facultad de Ciencias, Universidad Nacional Autónoma de México
Av. Universidad 3000, Ciudad Universitaria, Coyoacán, 04510 Ciudad de México, Distrito Federal
yurimar29@yahoo.com.mx

Other authors / Otros autores:
Silvia Castillo-Argüero, Ileana Gabriela Reyes-Ronquillo & Gabriela Santibáñez-Andrade
Universidad Nacional Autónoma de México

Resumen
La Cuenca del Río Magdalena es una de las áreas boscosas que aún permanecen en la Ciudad de México, posee una alta heterogeneidad biótica y abiótica. Esta zona está constantemente expuesta a disturbios de distinto origen, lo que ha traído como consecuencia una pérdida de su riqueza, así como la incorporación de malezas. Este trabajo tiene el objetivo de conocer el componente de malezas así como su presencia en procesos de la regeneración natural como son la lluvia y el banco de semillas. Con este fin se ha generado una base de datos florísticos y estructurales con atributos biológicos (origen, distribución biogeográfica, síndrome de dispersión entre otros). Los resultados muestran la presencia de 135 especies de malezas de 38 familias, lo que corresponde a un 26 % de la flora vascular reportada para esta zona (520 especies). 18 % de estas especies están presentes en la lluvia y 15 % en el banco de semillas. Las familias mejor representadas fueron la Asteraceae (30 especies) y la Brassicaceae (9 especies), Un 23 % son especies introducidas y 76 % nativas. Las hierbas representaron la forma de crecimiento dominante. Por su distribución destacan las especies cosmopolitas (19 %). La dispersión de la mayoría de las especies es favorecida por el viento. Acaena elongata y Alchemilla procumbens, malezas nativas, presentaron los valores de importancia y frecuencia más elevados. También se observaron diferencias en la presencia de estas especies en cada tipo de vegetación de este bosque. A partir de lo anterior se puede concluir que esta zona presenta un estado de conservación relativamente bueno, sin embargo se requieren hacer estudios puntuales de las especies encontradas dado que ya están incorporadas en la dinámica de la comunidad. Asimismo, se requieren estudiar las condiciones que favorecen su presencia.

Abstract
The Rio Magdalena basin is one of the wooded areas that still remain in Mexico City, it possesses a high biotic and abiotic heterogeneity. This area is constantly exposed to different kinds of disturbances, which has resulted in a loss of its richness, as well as in the introduction of weeds. This work aims to explore the weed component in general as well as the presence of weeds in natural regeneration processes such as rain and seed banks. To this end a database has been set up containing floristic and structural data with biological attributes (origin, biogeographic distribution, dispersion syndrome etc.). The results show the presence of 135 weeds species of 38 families, which correspond to 26 % of the vascular flora reported for this area (520 species), 18 % of these species are found in the rain and 15 % in the seed banks. The better represented families were the Asteraceae (30 species) and the Brassicaceae (9 species), 23 % are introduced species and 76 % natives. Grasses represented the dominant form of growth. For its distribution they stand out the cosmopolitan species (19 %). The dispersion of most of the species is favored by wind. Acaena elongata and Alchemilla procumbens, native weeds, presented the highest values regarding importance and frequency. Also differences were observed in the presence of these species in every type of vegetation of this forest. From these results it is possible to conclude that this area presents a relatively good conservation state, nevertheless it is needed to do punctual studies of the opposing species since they are already incorporated in the dynamics of the community. Also, it is needed to study the conditions that favor its presence.
Presentation summary

Introduction

Weeds are species that can successfully colonize a wide variety of habitats. Attributes such as high reproductive and survival rates make them highly competitive. They can be native or introduced. When introduced (or non indigenous) weed species replace native species they are denominated “invasive species” (McKinney and Lockwood, 1999). Non indigenous or introduced weeds are more aggressive because they possess high phenotypic plasticity and due to the absence of their natural competitors and predators in the site they have colonized (Agrawal, 2001).

Abundance, density and extension of the colonized area by an introduced species are important factors for determining whether it is becoming invasive especially if the colonized area is a natural place (Pimentel et al., 2000). Together with these parameters, we should take into account that some invasive species are successional and they have the ability to form a persistent seed bank therefore the presence of these species in seed banks could be a criterion to distinguish invasive from non invasive species (Van Clef and Stiles, 2001).

Invasion by a non indigenous weed species comprises various stages. After the entrance of a potential invader to a site (occasionally aided by a human transport vector), this species will pass through ecological filters such as propagule pressure, competition and other community interactions. When propagules survive its transport and more propagules are released after the establishment of individuals, the species is considered to be in an introduction and establishment phase. Phases of invasion should be studied in order to describe the invasiveness potential of a certain species. The entrance of an invasive species to a site can continue with different scenarios: a species can be localized and be numerically rare, be broadly distributed but rare, localized but dominant or broadly distributed and dominant (Collauti and MacIsaac, 2004).

It is important to quantify the abundance of native weed and introduced species in extant vegetation and in natural regeneration processes such as seed rain and seed bank to make projections on how anthropogenic activities might be favoring these species spread and dominance and to localize what stage of invasion they are in a certain time.

The aim of this work is to asses the component of the weed species (introduced and native) in the extant vegetation as well as in natural regeneration processes such as seed rain and seed bank in the MRB. We estimated “propagule pressure” in terms of the presence and abundance of weed and introduced species in the seed rain and we assessed their presence in propagules sources as the seed bank.

Study site

Magdalena river basin (MRB) is one of the remaining natural areas in Mexico city (Figure 15). With 3000 hectares, it is characterized by a temperate forest where three vegetation types are distributed along an altitudinal gradient from 2 700 to 3 850 m asl: Quercus rugosa, Abies religiosa and Pinus hartwegii forests. It is highly heterogeneous in space and it shows two contrasting seasons: dry season: from November to April and the rainy one: May to October. Close to 553 vascular plant species conform this forest plant richness. Important economic services are provided by this area to one of the biggest cities of the world such as aquifer filtration. It is under constant anthropogenic pressure due its closeness to the city, activities such as agriculture, deforestation and cattle rising are diminishing its area as well as its biodiversity (Ávila-Akerberg, 2004).
Method

We determined landscape units by photo-interpretation and geographic information systems (SIG) according to plant cover, slope and aspect in each vegetation type. In each unit we established five 25 x 25 m plots where cover and height of herbaceous, shrub and tree species were recorded. Relative Importance Values of the weed species were calculated. In two permanent plots for each each vegetation type seed rain was assessed by setting 30 seed traps (50 cm diameter), the deposited material was collected every two months for one year, and determined to species level. A data base was build with the abundance of each weed species found in the seed rain and dispersal syndrome according to van der Pijil (1982) was recorded. Seed bank assessment consisted in the sampling of 30 soil samples in each vegetation type. Soil sampling was carried out twice: once at the end of the rainy season (October), and in the dry season (March). Soil was collected in the first 10 cm in the soil profile and deposited in germination trays 15X15 cm, 5 cm deep. Seedling emergence was recorded during 9 months for each sampling. Emerged seedlings were transplanted to make determination possible. Number of weed species seedlings was recorded.

In order to know the origin of the weed species found in the extant vegetation, seed rain and seed bank we consulted: http://www.conabio.gob.mx/malezasdemexico/2inicio/home-malezas-mexico.htm. Geographical distribution of the weed species found was searched in http://www.tropicos.org/. We also followed Rzedowski and Rzedowski (2005).

Results and discussion

We found 135 species of weeds in the extant vegetation. According to their life cycles 52 correspond to annual species and 83 to perennial ones. Weed species with the highest relative importance values were Acaena elongata, Alchemilla procumbens, Salvia mexicana, Stellaria cuspidata, Iresine diffusa and Sigesbeckia jorullensis (Figure 16). It is important to notice that A. elongata, A. procumbens and S. mexi-
cana were found widely distributed in the three vegetation types in the MRB.

*Hedera helix* was found in the extant vegetation of the *Q. rugosa* forest only. It should be monitored to predict changes from localized status to possible future stages with an increase in its dominance and spread to the other vegetation types at higher altitudes forests of this area, since it is an introduced species. We think it escaped to the natural areas from the nearby urban town and irregular settlements because it is commonly used as ornamental species in houses and walls.

Most of the weed species (native and introduced) found in the extant vegetation are herbs. Shrubs and trees include less species (Table 23). Asteraceae, Caryophyllaceae, Lamiaceae, Onagraceae, Rosaceae and Geraniaceae were the most important families according to the number of weed species.

According to their origins some have been introduced from Europe and North Africa (*H. helix*), others from Europe and Asia (*Taraxacum officinale, Euphorbia peplus*), others from Europe and the Mediterranean (*Sonchus oleraceus*). Species as *Sambucus nigra* is known as a circumpolar species, found in all northern hemisphere, it is probable that most of the populations are native, but it is also possible that some might be introduced (Heike Vibrans, pers. com.)

According to their distribution ranges most of the weeds in the extant vegetation have a cosmopolitan distribution (53%), 31% have a distribution in tropical portions of Africa, Asia and Oceania as well, and 16% are distributed in tropical areas of America.
Most of weed species (native and introduced) in the seed rain were characterized to present a “pap-pus” (Sonchus oleraceus, Taraxacum officinale) and/or wings (Bouvardia ternifolia) appendages for wind dispersal. Those species with very small diaspores (< 3 mm) were also classified into this category (anemochory) of dispersal syndrome (Urtica chamaedryoides, Cyperus hermafroditus). Other important proportion was characterized by species with fleshy diaspores, as fruits which are ingested and dispersed by birds and small mammals (Phytolacca icosandra). Ectozoochorous dispersed species such as Acaena elongata and Siggensbeckia jorullensis comprised a 5 % of the species in the seed rain (Figure 17), these species’ diaspores have thick spiny appendages (A. elongata) and sticky resinous substances (S. jorullensis), this is why they are dispersed by birds and/or mammals feathers/hair. Balochory dispersal syndrome was represented by the fewest number of species (Geranium seemannii, Erodium cicutarium).

**Table 23.** Number of species of weeds in different categories: life form, growth form, life cycle and origin in the seed bank, in the seed rain and in extant vegetation in the temperate forests of MRB, Mexico City.

<table>
<thead>
<tr>
<th>Types of species</th>
<th>Seed bank</th>
<th>Seed rain</th>
<th>Extant vegetation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Native</td>
<td>10</td>
<td>27</td>
<td>104</td>
</tr>
<tr>
<td>Introduced</td>
<td>4</td>
<td>10</td>
<td>31</td>
</tr>
<tr>
<td>Annual</td>
<td>2</td>
<td>6</td>
<td>52</td>
</tr>
<tr>
<td>Perennial</td>
<td>12</td>
<td>31</td>
<td>83</td>
</tr>
<tr>
<td>Shrubs</td>
<td>2</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>Herbs</td>
<td>12</td>
<td>31</td>
<td>124</td>
</tr>
<tr>
<td>Trees</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Therophytes</td>
<td>2</td>
<td>6</td>
<td>52</td>
</tr>
<tr>
<td>Hemicriptophytes</td>
<td>3</td>
<td>8</td>
<td>43</td>
</tr>
<tr>
<td>Phanerophytes</td>
<td>3</td>
<td>10</td>
<td>31</td>
</tr>
<tr>
<td>Criptophytes</td>
<td>6</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>Chamaephytes</td>
<td>0</td>
<td>6</td>
<td>11</td>
</tr>
</tbody>
</table>

Figure 17. Dispersal syndromes of weed species in the seed rain.

Most abundant introduced species in the seed rain were: Taraxacum officinale, Poa annua, Erodium cicutarium, Urtica urens, Euphorbia peplus, Sambucus nigra, Sonchus oleraceus, Poa pratensis, Cyperus esculentus, Cyperus hermafroditus, Oxalis corniculata.

S. nigra was exclusive to the A. religiosa forest seed rain, while others as T. officinale, E. cicutarium and S. oleraceus were widely distributed in the seed rain of the three vegetation types in the MRB.
Introduced species in the seed bank were: *Taraxacum officinale*, *Erodium cicutarium*, *Sonchus oleraceus*, *Cyperus esculentus*. It is important to mention that all of them were present in the three vegetation types.

*Hedera helix*, which was found in the extant vegetation of the *Q. rugosa* forest, was not found in the regeneration entities under study.

The presence of some of the introduced species in regeneration strategies and in the extant vegetation allows us to place them in different stages of invasion, this with the aim of identifying them as possible threats to natural vegetation of this site and to consider them in management programs, especially if anthropogenic disturbances (and the modifications in the habitat caused by these) are allowing them to spread their populations.

For example, *H. helix* as found in only one vegetation type, it is a localized and dominant introduced weed species. No propagule pressure was identified for this species because we didn’t find it in the seed rain nor in the seed bank. Nevertheless broader sampling (in area and time) of seed rain and seed bank of weed native and especially introduced species are included in a future and continuous monitoring program for this area.

Species as *S. nigra* and *T. officinale*, *E. cicutarium*, *S. oleraceus*, *C. esculentus* found in seed rain and seed bank of the three vegetation types have been therefore identified as fulfilling the propagule pressure requirement for invasion process. Further monitoring includes a study of these species spread and dominance. When we find them as dominant and widely spread in the extant vegetation and abundant or at least present in seed rain and/or seed bank will give us hints of whether these species have survived propagule pressure filters, transport vectors of these propagules, local dispersal filters, physicochemical requirements and community interactions (according to Collauti and MacIsaac, 2004).

In search of community dynamics of weed and introduced species and to determine the fluxes of these species between the extant vegetation and the regeneration sources, we also calculated the species similarity and the proportions of species represented in the studied regeneration entities. We found that 21% of the species in the extant vegetation are native weeds, while 3% are introduced ones. In the seed bank 32% are native weeds and the percentage of introduced species was 10%. Seed rain contained 23% of native species and 8% of introduced species. The highest similarity value was observed between the seed rain and the extant vegetation (60%) while only 20% of the species was shared between the extant vegetation and the seed bank (Figure 18).

![Figure 18. Percentages of species in extant vegetation, seed rain and seed bank.](image-url)
The proportion of native weeds in the extant vegetation that was present in the seed bank was 10%, while 25% of the native weeds in the extant vegetation were present in the seed rain. 15% of the weed species in the seed rain are present in the seed bank. The proportions of introduced weeds behaved in the following way: 25% of these species present in the extant vegetation were present also in the seed rain and 15% of them were present in the seed bank.

*Phytolacca icosandra, Acaena elongata, Sambucus nigra* and *Oxalis corniculata* were the most abundant weed species in seed rain and seed bank, this means that they are included in regeneration entities and monitoring of their abundances should be carried out in order to predict which modifications in the habitat favor their spread.

In this sense the elaboration of field guides with the picture of the species and specific information is a tool for their recognition and future inclusion in management and eradication plans, especially when it comes to introduced species recognition. The aim of this project is to generate this type of information and make it available to people in the community for future management programs. A field guide with native and introduced weeds plant and diaspore pictures, information of their presence in different vegetation types and in regeneration entities (seed rain and seed bank) is being elaborated (Figure 19).

---

**Figure 19.** Common weeds in the Magdalena river Basin temperate forest, Mexico City
As the MRB temperate forests are affected by irregular urban settlements in its lower parts, a reduction of its area and habitat modification are being observed (Ávila-Akerberg, 2004). This area corresponds to the Quercus rugosa forest, where native weeds have extended their distribution (A. elongata, A. procumbens, S. mexicana). In higher parts, where Abies religiosa and Pinus hartwegii forests are established, disturbances such as cattle rising and deforestation for agriculture seem to have favored the spread of A. elongata, this species' achene is easily spread by cattle and its distribution especially in the A. religiosa forest has been expanded. Some authors consider it as a disturbance indicator species (García-Romero, 2002). This could also be the case of Sigesbeckia jorullensis.

Species such as Sonchus oleraceus, Taraxacum officinale, Gnaphalium americanum, Cyperus hermaphroditus and C. esculentus distribution could be increased since their dispersal occurs by wind as we mentioned, but their presence in the seed bank could also be an indicator of disturbance. It is known that some weed and introduced species have the as a strategy the storage of their seeds in permanent seed banks (Van Clef and Stiles, 2001).

As the establishment of new populations of many plant species strongly depends on disturbance (Harper, 1977), the impact of cattle, deforestation and agriculture in this area could result in an increased susceptibility to invasion as it has occurred in many communities (Elton, 1958). Therefore our results of the presence of introduced and native weeds in the seed rain and seed bank and their dominance in the extant vegetation can already be applied in forest management programs for this area.

References


The Plants of Canada Database
La base de datos de plantas de Canadá

Karen Castro
Plant Health Risk Assessor- Botany / Asesor de Sanidad Vegetal- Botánico
Canadian Food Inspection Agency
1400 Merivale Road, Ottawa, Ontario K1A 0Y9, Canada
karen.castro@inspection.gc.ca; ken.allison@inspection.gc.ca

Other authors / Otros autores:
Claire Wilson, Ken Allison, Kevin Lawrence, Susan J. Meades & Dan McKenney

Resumen
La Agencia de Evaluación de Riesgos de Biotecnología y Planta de la Agencia de Inspección de Comida canadiense y el servicio forestal canadiense de Recursos naturales Canadá han liberado recientemente unas nuevas bases de datos de Plantas de Canadá. El objetivo de la base de datos era compilar una base de datos actualizada, exacta, disponible para buscar la flora vascular completa de Canadá. Anteriormente esta información sólo estaba disponible buscando en varias fuentes dispersas. La base de datos incluye la información básica para cada especie, incluso nombres comunes y científicos, origen, distribución y estado de conservación. También incluye una sección de legislación de plagas, identificando especies que son reguladas como malezas o plantas invasoras en Canadá, federalmente o provincialmente. En el futuro, puede ser ampliado para incluir más grupos taxonómicos (p.ej bryofitas), campos adicionales (p.ej hábitat, importancia económica), fotos y otra información relevante. La base de datos de las Plantas de de Canadá fue desarrollada de acuerdo a la Estrategia de Especies exóticas Invasoras para Canadá. Fue publicada en línea en septiembre de 2011. Por favor visite el sitio web en: www.plantsofcanada.info.gc.ca o www.plantesducanada.info.gc.ca.

Abstract
The Canadian Food Inspection Agency’s Plant and Biotechnology Risk Assessment Unit and the Canadian Forest Service of Natural Resources Canada have recently released a new Plants of Canada database. The objective of the database was to compile an up-to-date, accurate, searchable database of the complete vascular flora of Canada. This information was previously only available by searching a number of disparate sources. The database includes basic information for each species, including scientific and common names, nativity, distribution and conservation status. It also includes a section on pest legislation, identifying species that are regulated as weeds or invasive plants in Canada, either federally or provincially. In the future, it may be expanded to include more taxonomic groups (e.g. bryophytes), additional fields (e.g. habitat, economic importance), photos and other relevant information. The Plants of Canada database was developed under An Invasive Alien Species Strategy for Canada. It was publicly released online in September 2011. Please visit the website at: www.plantsofcanada.info.gc.ca or www.plantesducanada.info.gc.ca.

Presentation summary

Background
The Plants of Canada database is an up-to-date source of information about the vascular plants that grow naturally (i.e., outside of cultivation) in Canada. It provides quick and easy access to basic information about identity, distribution, conservation status and pest legislation, for both native and introduced species in the Canadian flora.

The Plants of Canada database was developed by the Canadian Food Inspection Agency (CFIA), in partnership with the Canadian Forest Service of Natural Resources Canada (NRCan/CFS), as a joint initiative under An Invasive Species Strategy for Canada. Data were provided by Environment Canada, coordinator of Canada’s Wild Species Program (www.wildspecies.ca), and compiled in collaboration with NatureServe Canada. The database is hosted and maintained by CFIA and NRCan/CFS.

Database Content and Sources
The Plants of Canada database includes all vascular plants in the Canadian flora. Individual species can be searched from the home page, by scientific or com-
mon name (Figure 20). Information for each species is presented in a “Species Profile” page, which includes the following six components:

1. Species profile: Scientific and common names, synonymy, family, and growth habit are provided for each species. Classification and nomenclature are based on *Flora of North America* (www.fna.org) and Kartesz (1999), and are regularly updated using other up-to-date sources and accepted research (e.g., Brouillet et al., 2010+; IPNI, 2008+; Missouri Botanical Garden, 2012; USDA, ARS, no date).

2. Distribution: Presence/absence by province, native status by province, and native range by continent are based on *Flora of North America* plus field data reported from provincial and territorial Conservation Data Centres (http://www.natureserve-canada.ca/).

3. General Status: General status ranks are assigned to each species both nationally and provincially by Canada’s Wild Species Program (www.wildspecies.ca) (Table 24). Ranks are determined by a working group of provincial, territorial and federal government representatives, coordinated by Environment Canada. The ranks indicate conservation status and allow species at risk to be prioritized for protection.

4. Pest status: The pest status section is under development. When complete, it will indicate if a species is described as a weed or invasive plant in a predetermined set of Canadian references.

5. Pest legislation: This section indicates whether or not a species is regulated as a weed or invasive plant at the federal or provincial level in Canada.

6. Links: This section provides a link to Canada’s *Plant Hardiness Site* of the Canadian Forest Service (www.planthardiness.gc.ca), and additional links may be added in the future. Examples of some of the information available at Canada’s *Plant Hardiness Site* include synonymy, plant descriptions, maps, bioclimatic profiles and climate change models (see also McKenney et al., 2007). The website also provides the opportunity for users to input data on their observations.

**Future Directions**

The *Plants of Canada* database is still under development. To date, the database should include all species present in the Canadian flora, but not all data fields are complete. Additional fields that may be added in future include new species, habitat, economic importance, photographs, list functions, etc. Questions, comments and suggestions on the website are welcome.

Please send feedback to: glfcweb@nrcan.gc.ca

**References**


Table 24. General Status categories used in Canada Wild Species program *(Source: cescc 2011)*

<table>
<thead>
<tr>
<th>Rank</th>
<th>General Status</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.2</td>
<td>Extinct</td>
<td>Species that are extirpated worldwide (i.e., they no longer exist anywhere).</td>
</tr>
<tr>
<td>0.1</td>
<td>Extirpated</td>
<td>Species that are no longer present in a given geographic area, but occur in other areas.</td>
</tr>
<tr>
<td>1</td>
<td>At Risk</td>
<td>Species for which a formal, detailed risk assessment (COSEWIC1 status assessment or provincial or territorial equivalent) has been completed and that have been determined to be at risk of extirpation or extinction (i.e. Endangered or Threatened). A COSEWIC designation of Endangered or Threatened automatically results in a Canada General Status Rank (Canada rank) of At Risk. Where a provincial or territorial formal risk assessment finds a species to be Endangered or Threatened in that particular region, then, under the general status program, the species automatically receives a provincial or territorial general status rank of At Risk.</td>
</tr>
<tr>
<td>2</td>
<td>May Be At Risk</td>
<td>Species that may be at risk of extirpation or extinction and are therefore candidates for a detailed risk assessment by COSEWIC, or provincial or territorial equivalents.</td>
</tr>
<tr>
<td>3</td>
<td>Sensitive</td>
<td>Species that are not believed to be at risk of immediate extirpation or extinction but may require special attention or protection to prevent them from becoming at risk.</td>
</tr>
<tr>
<td>4</td>
<td>Secure</td>
<td>Species that are not believed to belong in the categories Extinct, Extirpated, At Risk, May Be At Risk, Sensitive, Accidental or Exotic. This category includes some species that show a trend of decline in numbers in Canada but remain relatively widespread or abundant.</td>
</tr>
<tr>
<td>5</td>
<td>Undetermined</td>
<td>Species for which insufficient data, information, or knowledge is available with which to reliably evaluate their general status.</td>
</tr>
<tr>
<td>6</td>
<td>Not Assessed</td>
<td>Species that are known or believed to be present regularly in the geographic area in Canada to which the rank applies, but have not yet been assessed by the general status program.</td>
</tr>
<tr>
<td>7</td>
<td>Exotic</td>
<td>Species that have been moved beyond their natural range as a result of human activity. In this report, Exotic species have been purposefully excluded from all other categories.</td>
</tr>
<tr>
<td>8</td>
<td>Accidental</td>
<td>Species occurring infrequently and unpredictably, outside their usual range.</td>
</tr>
</tbody>
</table>
Plants of Canada Database

The Plants of Canada Database is an up-to-date source of information about the vascular plants that grow naturally (i.e., outside of cultivation) in Canada. It includes basic information about identity, distribution, habitat, biology and other plant characteristics, for both native and introduced species in the Canadian flora.

The Plants of Canada Database was developed by the Canadian Food Inspection Agency, in partnership with the Canadian Forest Service, as a joint initiative under An Invasive Species Strategy for Canada. Data were provided by Environment Canada’s General Status Program and NatureServe Canada.

The Plants of Canada Database is still under development. This is a test site. To date, the database should include all species present in the Canadian flora, but not all data fields are complete. Information on sub-specific taxa, and sections on economic importance and legislation have not yet been added. Questions, concerns, comments and suggestions are welcome.

To provide feedback, please email: gilfcweb@nrcan.gc.ca

Figure 20. Plants of Canada database homepage
Control of invasive Australian Pine (Casuarina equisetifolia) in the Fauna and Flora Protection Area of Nichupté

Control de la especie invasora (Casuarina equisetifolia) Pino australiano en el APFF Manglares de Nichupté.

Natalia Blancas
National Commission of Natural Protected Areas, Nichupté Mangroves Flora and Fauna Protection Area / Comisión Nacional de Áreas Naturales Protegidas, APFF Manglares de Nichupté
Municipio Benito Juárez, Quintana Roo
natgallangos@gmail.com

Resumen
La Casuarina equisetifolia, especie exótica originaria de Oceanía y Sureste de Asia es una de las peores plagas en los humedales, debido a su alta tasa de reproducción y crecimiento. Compete por espacio desplazando paulatinamente a especies nativas, como mangles y vegetación de duna costera; con ello cancela beneficios de refugio alimentación y microambiente que la vegetación nativa aporta a la fauna local.

En el APF Manglares de Nichupté se observaron individuos de C. equisetifolia, volviéndose una especie perjudicial que afecta principalmente a comunidades de manglar ubicadas en el sitio: Rhizophora mangle, Laguncularia racemosa, Avicennia germinans y Conocarpus erectus.

Por tal motivo se realizó una jornada de eliminación manual de casuarina en el polígono 4 del APFFMN, para controlar la población de la especie invasora, eliminando 1,636 ejemplares de casuarina mayores a 99 cm de diámetro, 140 individuos menores a 99 cm de diámetro. Se erradico un área de 4.94 Ha, equivaliendo al 67.30% del área total invadida en el polígono 4. En algunas zonas erradicadas de casuarina se reforestaron 1,500 plántulas de Conocarpus erectus abarcando una superficie de 2.37 Ha.

Abstract
Casuarina equisetifolia, is an exotic species from Oceania and Southeast Asia and one of the worst pests in the wetlands, due to its high reproduction and growth rate. The plant competes for space gradually displacing native species, like mangroves and vegetation of coastal dunes taking away benefits such as feeding refuge and micro-habitats that the native vegetation provides for the local fauna.

In the National Protected Area Mangroves of Nichupté specimens of C. equisetifolia were observed, turning into a noxious species that affects principally swamp communities located in the area consisting of: Rhizophora mangle, Laguncularia racemosa, Avicennia germinans and Conocarpus erectus.

Therefore, a one day eradication was organized in the 4 polygons of the APFFMN during which Casuarina was manually pulled out in order to control the population of the invading species. A total of 1,636 specimens of Casuarina bigger than 99 cm in diameter and 140 specimen less than 99 cm in diameter were removed. An area of 4.94 ha was cleared of Casuarina equivalent to 67.30% of the entire area invaded in the polygon 4. In some parts of the area, encompassing a surface of 2.37 ha, where the Casuarina eradication took place, reforestation efforts with 1,500 Conocarpus erectus seedlings was undertaken.
Are the Hotspots of the Floristic Richness of Mexico Also the Hotspots for the Synanthropic Richness?
¿Los “hot-spots” de riqueza florística en México también son “hot-spots” de riqueza sinantrópica?

José Luis Villaseñor
Researcher / Investigador
Botany Department, Institute of Biology, UNAM / Departamento de Botánica, Instituto de Biología, UNAM
Apartado Postal 70-233, 04510 México, D. F.
vrios@ibiologia.unam.mx

Resumen
Por su gran riqueza florística, México es considerado un país megadiverso; hasta la fecha en su territorio se ha documentado la presencia de 22,896 especies nativas, con una tasa promedio anual de incorporación de 90 especies y una riqueza estimada en alrededor de 29,000 especies. Igualmente, México es un país con una gran riqueza de especies sinantrópicas; se tiene documentada la existencia de 2,543 especies nativas (sin contar 661 especies exóticas más) asociadas a los ambientes transformados o afectados por las actividades humanas, lo que representa 11% de la riqueza florística nacional.

Pocos intentos se han hecho por evaluar los patrones de distribución geográfica de la riqueza florística de México, la mayoría de ellos realizados utilizando divisiones políticas. En este trabajo se propone presentar un análisis de la distribución de la riqueza a escala más fina, utilizando una división del país en cuadrados de 1° en latitud y longitud. Sobre esta retícula se incorporará la información recopilada hasta la fecha sobre la distribución de las especies, tanto creciendo en ambientes no perturbados como perturbados. El objetivo es identificar qué partes de México destacan por su importante riqueza de especies y evaluar si tales sitios son igualmente importantes por su contribución a la riqueza total y a la riqueza de especies sinantrópicas.

Utilizando un mapa de México que identifica los sitios registrados por INEGI (Serie III) como remanentes con vegetación no alterada y aquellos sitios con vegetación transformada por las actividades humanas, se identificarán los hot-spots ubicados en sitios con menor o mayor influencia antropocéntrica. Con este ejercicio se intentará dar respuesta a la pregunta de si regiones con mayor extensión de vegetación natural perdida contienen mayor número de especies sinantrópicas.

Abstract
Because of its floristic richness Mexico is considered a megadiverse country; until now 22,896 native species have been documented with an average annual incorporation of 90 species and an estimated richness of approximately 29,000 species. In addition, Mexico is a country with great richness in synanthropic species; 2,543 native species have documented (not taking into account the additional 661 exotic species) associated to transformed environments or those affected by human activities, which represent 11% of the national floristic richness.

Few attempts have been carried out to evaluate the geographical distribution patterns of the floristic richness of Mexico, most of them have been carried out using political divisions. The intent of this research is to present an analysis of the distribution of the richness to a finer scale, using a country division in squares of 1° in latitude and longitude. The species distribution information compiled up to date will be incorporated onto this grid, both on undisturbed as well as on disturbed environments. The objective is
to identify which parts of Mexico stand out in richness of species and to evaluate if those sites are equally important for their contribution to total richness and synanthropic species richness.

Using a map of Mexico that identifies the sites registered by INEGI (Series III) as remainders with undisturbed vegetation and sites with vegetation that has been transformed by human activities the hot spots located in areas with less or more anthropocentric influence will be identified. With this exercise we will attempt to answer the question of whether regions with greater extension of lost natural vegetation contain a greater number of synanthropic species.

Presentation summary

Introduction
Floristically speaking Mexico is a megadiverse country, the inventory of its flora, while still incomplete records over 23,000 native species, this number places it as the fourth or fifth country in the world with the greatest number of species (Villaseñor, 2003). Of this number, approximately 2,523 species have been documented as species associated to environments affected or modified by human activities (synanthropic species, most commonly known as weeds). Many synanthropic species are unwanted as they can transmit or act as vectors for diseases, compete with agricultural activities and pollute or decrease the attraction of areas of particular interest.

The synanthropic flora of a place can be formed by both native and introduced plants. On occasions an important component of the synanthropic flora of a region are invasive species, for example in Mexico, in addition to the number of native synanthropic species (2,523) there are approximately 683 exotic species (meaning, they are not native from Mexico and have been introduced either accidentally or on purpose) that have been identified as introduced and associated to the synanthropic native flora. Table 25 shows data about the floristic richness documented in Mexico, for native and exotic species.

The first integral work about weeds in Mexico was published almost fifteen years ago (Villaseñor & Espinosa, 1998), and complemented more recently with an update of introduced (exotic) species in the national flora (Villaseñor & Espinosa-García, 2004; Espinosa-García et al., 2009). However, taking as reference the published data in these reports, the information that is currently available (Villaseñor, unpublished data) indicates that the number of known native weeds has increased over 28% and the number of exotic weeds has increased over 9%.

Table 25. Richness of native non synanthropic (native and exotic) species in Mexico

<table>
<thead>
<tr>
<th></th>
<th>Non native weeds</th>
<th>Native weeds</th>
<th>Exotic weeds</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Families</td>
<td>279</td>
<td>144</td>
<td>95</td>
<td>298</td>
</tr>
<tr>
<td>Genus</td>
<td>2,681</td>
<td>850</td>
<td>403</td>
<td>3,182</td>
</tr>
<tr>
<td>Species</td>
<td>20,686</td>
<td>2,523</td>
<td>683</td>
<td>24,019</td>
</tr>
</tbody>
</table>

Villaseñor and Espinosa (1998) record, in addition to the general count, the distribution of each species for the 32 states of Mexico. Espinosa-García et al. (2004) discuss the distribution patterns of native and exotic weeds using states as operative geographic units. Apparently these reports are the only references up to date that document or discuss the geographic distribution of synanthropic species at a national level. Figure 21 shows the known distribution of the flora of Mexico at a state level; the three main components are shown: the proportion of native non weed species, native weeds and introduced weeds.

As suggested by evidence, there appears to be good knowledge at the state level of the synanthropic flora of Mexico and of the patterns of its geographical distribution. However, the scale of this work is too thick and not homogeneous, so in the last years we have concentrated in enriching the floristic information using a finer and more homogeneous scale. In this report we present...
some advances, the main objective is to evaluate whether sites of high native species concentration (hot spots) are also sites of high concentration of synanthropic species, for both native and exotic species. The hypothesis is to answer whether the non synanthropic richness hot spots contain a low number of synanthropic species since these are favored by the disturbance caused to the original plant communities, where it is more common to observe non synanthropic species. In order to carry out this analysis Mexico was divided in 253 squares of 1° latitude and 1° longitude using the meridian parallels that cross national territory (Figure 22).

Figure 21. Number of vascular plant species in Mexico registered per state and separated by their proportion of natives not registered as weeds, natives registered as weeds and exotic weeds.
The known information about the geographic distribution of the species allowed the analysis of each one of the squares of the species that intercepted their territory. Through the use of the geographic information system ArcGIS 10 (ESRI, 2010), the richness known per square was evaluated to determine which of them contained the greatest richness species (hot spots) for native and exotic species. GIS was also used in the generation of a potential richness model through the known richness interpolation using the Kriging interpolation method.

**Synanthropic richness patterns**

Figure 23 shows the potential richness of synanthropic species in Mexico, obtained through the interpolation of the richness known per square (Figure 22). The regions with lower species richness probably represent zones with an important bias in the intensity of information collection and capture; most likely, future works will show that the distribution of species richness is more homogeneous especially in regions of the north of the country and the Yucatan Peninsula where very low richness values are observed.

*Figure 22. Mexico divided in squares of 1° x 1° of latitude and longitude. The floristic information for native species not registered as weeds, for native weeds and for exotic weeds was registered for each square.*
The comparative analysis of the richness distribution of native non weed species with the synanthropic species reveals that there is an important significant correlation in the values of richness. Figure 24 shows the dispersion of contrasting values between non synanthropic and synanthropic richness. The correlation suggests that sites with high non synanthropic species diversity also contain important numbers of synanthropic species, both native and exotic. This becomes equally evident when evaluating the diversity hotspots. Table 26 shows the richness values of the 20 squares that registered the highest richness values for non-weedy native species and for native and exotic weeds. Most of the squares that register high floristic richness values, also contain important numbers of synanthropic species, native or exotic. For example, square 228, located in the north portion of the state of Oaxaca, occupies the first place in the total number of species that have been recorded in its territory, it also holds the sixth place in the number of native synanthropic species and the 12th among the 20 squares with greatest exotic weed richness. Only six squares (121, 149, 189, 190, 191 y 194) located among the 20 with greatest richness of synanthropic species are not among the total richness hot spots. Also, a similar number of squares (2, 110, 120, 191, 192 y 194) are among the 20 with the greatest number of exotic species but do not represent native floristic richness hot spots (Table 26).
In brackets is the place they occupy because of the number of registered species. The percentage of transformed territory refers to the surface without apparent natural vegetation according to the potential INEGI vegetation map Series III (INEGI, 2005).

Table 26. The 20 squares with the greatest richness of species (hot spots) in Mexico.

<table>
<thead>
<tr>
<th>Grid</th>
<th>Total especies</th>
<th>Native weeds</th>
<th>Introduced weeds</th>
<th>% of Transformed Territory</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>1361</td>
<td>248</td>
<td>(3) 163</td>
<td>20.1</td>
</tr>
<tr>
<td>72</td>
<td>(15) 2536</td>
<td>(12) 867</td>
<td>(7) 138</td>
<td>40.3</td>
</tr>
<tr>
<td>110</td>
<td>1564</td>
<td>463</td>
<td>(14) 117</td>
<td>15.4</td>
</tr>
<tr>
<td>120</td>
<td>1669</td>
<td>664</td>
<td>(16) 116</td>
<td>66.0</td>
</tr>
<tr>
<td>121</td>
<td>1799</td>
<td>(17) 757</td>
<td>67</td>
<td>9.7</td>
</tr>
<tr>
<td>149</td>
<td>2078</td>
<td>(14) 802</td>
<td>67</td>
<td>22.3</td>
</tr>
<tr>
<td>163</td>
<td>(10) 2785</td>
<td>(8) 899</td>
<td>(9) 124</td>
<td>23.8</td>
</tr>
<tr>
<td>173</td>
<td>(17) 2507</td>
<td>(5) 958</td>
<td>(19) 100</td>
<td>56.9</td>
</tr>
<tr>
<td>177</td>
<td>(12) 2738</td>
<td>(4) 990</td>
<td>(5) 148</td>
<td>55.4</td>
</tr>
<tr>
<td>178</td>
<td>(11) 2767</td>
<td>(9) 882</td>
<td>(17) 102</td>
<td>54.4</td>
</tr>
<tr>
<td>188</td>
<td>(3) 3482</td>
<td>(3) 1018</td>
<td>97</td>
<td>32.7</td>
</tr>
<tr>
<td>189</td>
<td>2157</td>
<td>(19) 747</td>
<td>67</td>
<td>40.1</td>
</tr>
<tr>
<td>190</td>
<td>2098</td>
<td>(15) 794</td>
<td>63</td>
<td>48.1</td>
</tr>
<tr>
<td>191</td>
<td>2207</td>
<td>(11) 870</td>
<td>(6) 140</td>
<td>48.3</td>
</tr>
<tr>
<td>192</td>
<td>1997</td>
<td>717</td>
<td>(20) 98</td>
<td>43.0</td>
</tr>
<tr>
<td>193</td>
<td>(8) 2940</td>
<td>(2) 1032</td>
<td>(1) 251</td>
<td>73.8</td>
</tr>
<tr>
<td>194</td>
<td>1856</td>
<td>(18) 749</td>
<td>(10) 119</td>
<td>76.0</td>
</tr>
<tr>
<td>195</td>
<td>(19) 2416</td>
<td>697</td>
<td>(8) 135</td>
<td>64.9</td>
</tr>
<tr>
<td>196</td>
<td>(4) 3230</td>
<td>(7) 933</td>
<td>(4) 161</td>
<td>82.5</td>
</tr>
<tr>
<td>209</td>
<td>(6) 3089</td>
<td>(1) 1073</td>
<td>(2) 166</td>
<td>52.2</td>
</tr>
<tr>
<td>211</td>
<td>(9) 2830</td>
<td>(16) 783</td>
<td>(15) 116</td>
<td>49.8</td>
</tr>
<tr>
<td>214</td>
<td>(18) 2438</td>
<td>548</td>
<td>(18) 101</td>
<td>78.2</td>
</tr>
<tr>
<td>225</td>
<td>(7) 3005</td>
<td>(10) 879</td>
<td>69</td>
<td>25.2</td>
</tr>
</tbody>
</table>
The important correlation observed between high numbers of native species and high numbers of synanthropic species could be, as it is the opinion of some authors, the result that a high biological diversity promotes an increase in the habitat diversity and therefore of potential niches to be occupied by these species that are more prone to invasion (MacDonald et al., 1988; Usher, 1988; Timmins y Williams, 1991).

For some authors the magnitude of the disturbance to original plant communities is one of the main factors that promote the invasion of native and exotic weeds (MacDonald et al., 1988; Usher, 1988). However, the results suggest that although there is no direct relationship between the loss of primary vegetation with a notable decrease in floristic richness. Square 2 indicates, based on the potential vegetation map of INEGI Series III (INEGI, 2005), the percentage of surface per square that does not already register primary vegetation, only secondary vegetation or not apparent vegetation (roads, cities, populations, agricultural or industrial areas etc.) Some squares show a very high percentage of modification in their natural environments; for example squares 194 or 214, that register 82.5% and 78.2% of their transformed surface but are in position 4 and 18 because of their total number of plant species and with the exception of square 214 that does not stand out for its notable native weed species but is a hot spot for exotic weeds.

It is often thought that weeds are efficient colonizers capable of invading numerous sites and environments, especially those transformed by man. The fact that there are different levels of species richness in Mexico, independently of the degree of affectation by human activities (Table 26), indicates that even among weeds there are different capabilities in their life history that allow them to colonize every environment even those similar in climate or other parameters that determine the potential area where they could be found (potential niche). For example, it is documented that 386 synanthropic species (136 exotic y 250 native) can be found in one single square, while the native species most widely distributed (Setaria parviflora (Poir.) Kerguélen) has been registered in only 30 of those and the most widely distributed exotics are known from no more than 29 squares (Ricinus communis L. and Sonchus oleraceus L.). It is necessary to better document the known (and potential) distribution of the synanthropic component of the flora of Mexico to determine the degree of trust of the geographic distribution patterns shown here, and to evaluate the capability of many of them to become invasive.

In Mexico we know little of the behavior of the weeds in the environments where they are found. For example, a preliminary evaluation indicates that some species behave strictly as ruderal species, that is, they are only know associated to roads or urban areas while others are apparently only found in association with crops. The numbers obtained to this date indicate that about 461 exotic species and 384 native species have been reported in ruderal environments; on the other hand no exotic species and 676 native species are only known in association with some type of crop. It is more difficult to know how many species we could classify as environmental weeds, that is, those species that are invading natural ecosystems. The information most commonly found in Mexico is the one for weeds competing for the main crops, unfortunately ruderal or urban weeds (Vibrans, 1998) have received very little attention and environmental weeds even less. Knowing the number of synanthropic species of a place is a first step that allows for a better understanding of its geographic distribution and it makes it possible to make proposals at least in a general way,
to explain the observed patterns. In addition, its relationship with the other plant biodiversity component of the place (non synanthropic species) will allow us to know how the ecosystem is responding to weed invasions and it may be possible to establish control or monitoring measures to know the degree of disturbance that have been reached by our high floristic richness hot spots within our megadiverse country.

Acknowledgments
A deep thank you to the organizers of Weeds Across Borders 2012, specially CONABIO (Comisión Nacional para el Conocimiento y Uso de la Biodiversidad) for the financial and logistical support to participate and present these results in the meeting in Cancún, Quintana Roo. I would also like to thank Enrique Ortiz who was handled the information and carried out the GIS analysis which are presented as tables and maps in this report.

References


Do Historical Disturbance Patterns Matter for Present-day Invasion Success?
¿Son importantes los patrones históricos de perturbación para el éxito actual de las invasiones?

Heike Vibrans
Professor-Researcher / Profesora - investigadora
The Post Graduate College in Agricultural Sciences-CP / Colegio de Postgraduados en Ciencias Agrícolas
Carretera México-Texcoco km. 36.5, Montecillo, Texcoco 56230, Estado de México
heike@colpos.mx, heike_texcoco@yahoo.com.mx

Other authors / Otros autores:
José Luis Villaseñor Ríos

Resumen
Se han desarrollado numerosas hipótesis para explicar el éxito diferencial de plantas exóticas e invasoras en diferentes regiones alrededor del mundo (diversidad, presión de propágulo, liberación de enemigos, barreras bióticas vs. Físicas, etc.). Una de las diferencias más notorias es entre Estados Unidos con aproximadamente 20% de plantas exóticas en su flora y México con solamente 2.7%. Aquí exploramos la hipótesis que los patrones y tipos de disturbios históricos son una influencia en el éxito de las especies invasoras para México. Para ello usamos una base de datos curada que incorpora los inventarios florísticos más serios del país. Se comparan los datos de distribución para tres familias importantes de malezas en México: Asteraceae (que crece principalmente en zonas de cultivo y contiene pocas invasoras en México) Brassicaceae (que también crece en zonas de cultivo pero tiene muchas malezas invasoras) y Poaceae (crece principalmente en zonas de pastoreo y tiene muchas invasoras). Históricamente, México solamente tenía pastizales con disturbios naturales en el norte: la agricultura prehispánica de la región no utilizaba ganado. Exploramos la relación entre el número de estados en los que una especie ocurre para todas las especies, para todas las especies de malezas y para especies introducidas. Los datos muestran claramente que los pastos introducidos tienen un área de distribución mucho mayor, en promedio, que las crucíferas o compuestas. Sugerimos que estos pastos son exitosos porque están llenando nichos o tipos de hábitat que no existían históricamente en la región.

Abstract
Numerous hypotheses have been advanced for explaining the differential success of exotic and invasive plants in different regions around the world (diversity, propagule pressure, enemy release, biotic vs. physical barriers, etc.). One of the most notorious differences is between the United States with approximately 20% of exotic plants in its flora, and the neighboring Mexico with only 2.7 %. Here, we explore the hypothesis that the patterns and types of historical disturbance influence the success of invasive species for Mexico. For this, we use a curated database that incorporates most serious floristic inventories of the country. Distribution data for three important weed families are compared: Asteraceae (which grow mainly in croplands and contain few invasives in Mexico), Brassicaceae (which also grows mainly in croplands but has many invasive weeds) and Poaceae (which grows mainly in pastures and has many invasives). Historically, Mexico had only naturally disturbed grasslands in the north; pre-Colombian agriculture of the region did not include livestock. We explore the relationship between the number of states in which a species occurs for all species, for all weed species and for introduced species. The data clearly show that introduced grasses have a much larger distribution area, on average, than either introduced composites or crucifers. We suggest that these grasses are successful because they are filling niches or habitat types that did not exist historically in the region.
A Synopsis of the Native and Introduced Weedy Grasses of Mexico
Una sinopsis de las malezas de gramíneas nativas e introducidas de México

Jorge Gabriel Sánchez Ken
Investigador / Researcher
Institute of Biology, UNAM / Instituto de Biología, UNAM
Apartado postal 70-233, 04510, México, D.F. México.
gabriels@hotmail.co.uk, sanchezken@ibiologia.unam.mx

Resumen
Las gramíneas o familia Poaceae, ocupa el cuarto o quinto lugar en cuanto a diversidad tanto genérica como específica en las angiospermas a nivel mundial y local. En ésta gran diversidad se encuentran especies que son malezas, forrajes, ruderales, ornamentales, para control de erosión y/o mejoramiento de suelos, cultivadas, etc. De acuerdo a la definición de maleza en el amplio sentido, se desarrolló un catálogo con 421 nombres que incluyen 406 especies (40 especies con categorías infraespecíficas) en 140 géneros tanto nativos como introducidos. Las tres subfamilias más diversas son las Chloridoideae, Panicoideae y Pooideae, mientras que el resto de subfamilias tienen pocos representantes en el país. Se presentan mapas y tablas con diversidad de géneros y especies, tanto nativas como introducidas.

Abstract
Gramineae, or the Poaceae family, occupy the fourth or fifth place in terms of both generic and specific diversity in angiosperms at a global and local level. This large diversity encompasses species that are weeds, forage, ruderal, ornamental, used for erosion control and/or soil improvement, cultivated, etc. According to the definition of weeds in a wide sense, a catalogue of 421 names with 406 species was developed (40 species with infraspecific categories) in 140 genera both native and introduced. The three most diverse subfamilies are Chloridoideae, Panicoideae and Pooideae, while the rest of the subfamilies have few representatives in the country. Maps and tables with genera and species diversity are presented both for natives and introduced.

Presentation summary

Introduction
The definition of weeds presents a large spectrum from “plants that grow where they are not wanted or out of place” (Klingman, 1961; FAO, 1987) to “plants that at a given moment, in a given place and in a certain number are bothersome, damaging or unwanted in crops or any other area or activity carried out by man” (Rodriguez, 1988). Weeds can be native or non-native, invasive or non-invasive, damaging or non-damaging. This last concept is defined by a government institution for which weeds could potentially represent a public health problem in agriculture, recreation, wildlife or property (Sheley et al., 1999). A more inclusive concept of a damaging weed is the one that defines them as plants that grow out of place and are competitive, persistent and potentially damaging (James et al., 1991).

Under these definitions for weed, any species can be considered a weed and almost entire groups or families of plants could be included in this category. Using the concept that weeds are plants that grow outside their original range, a weedy grass catalogue for Mexico was created for both native and introduced species whether they are crops, noxious weeds, ornamental, foraging, ruderal, etc.

In the agricultural field weeds can be classified in different ways, but one of the simplest ones refers to whether they have a wide or a narrow leaf. The first ones encompass the dicotyledons while the second ones the monocotyledons. Within the monocotyledons is one of the most important families from the economic point of view, the Poaceae, commonly known as grasses.

Poaceae is a diverse family with approximately 700 genera and approximately 11,000 species at a worldwide level (Clayton et al., 2006), in Mexico there are 204 genera and 1,278 species (Dávila et al., 2006). Previous to the appearance of the grasses catalogue by Dávila et al. (2006), Villaseñor and Espinosa (1998) published a weed catalogue for Mexico citing 96 genera y 329 species of grass weeds. Previous to this catalogue the authors recognized 71 genera and 174 species as non-native or introduced (Villaseñor & Espinosa, 2004). In addition, Dávila et al. (2006) registered 159 spe-
cies in 81 genera as crops and/or introduced. In the Malezas de México website (http://www.conabio.gob.mx/malezasdemexico/2inicio/home-malezas-mexico.htm) CONABIO includes 134 names of species (including synonyms and invalid names) in 65 genera of grasses, each one with a fact sheet with information on the species as well as pictures.

Based upon this data, a grass species catalogue was prepared with species that have been considered noxious weeds, potential weeds, cereals, foraging, medical, ornamental, cultivated, ruderal soil improving or erosion controlling plants. Many of the names in the previous reports have changed given recent taxonomy studies, these names have been updated accordingly. The inclusion of names does not necessarily establish the status of the species since many of them grow outside their natural habitat due to natural or artificial dispersion. It is necessary to carry out an evaluation and profile of each species to determine their condition and potential as a weed. Both native and introduced species were considered.

Method
The National Herbarium of Mexico (MEXU) of the Institute of Biology was revised, verifying that there was at least one representative specimen per species. When there were no back up samples this revision was done bibliographically (see references). When there was available material in the herbarium, pictures were taken of the whole specimen with one or two close ups.

For information on species distribution, the Grass Catalogue of Mexico was consulted (Dávila et al., 2006), www.tropicos.org, Agricultural Research Service of the U.S. Department of Agriculture (www.ars.grin.gov), CONABIO (http://www.conabio.gob.mx/malezasdemexico/2inicio/home-malezas-mexico.htm), as well as specialized references on taxonomy (monographs, thesis, floras, taxonomic treatments, etc. in the bibliography). This was complemented with the material deposited in the National Herbarium of Mexico. Valid and accepted names can be verified in www.tropicos.org, where an extensive list of synonyms is also available for all grasses.

Results
Integrating all the information, plus the species mentioned as weeds in several web pages, a list of 421 names was compiled. This includes 406 species, 40 species with infraspecific categories, in 140 genera (Table 27). The status of the species was verified as either native or introduced into the country. At the genus level, 80 species were catalogued as native and the other half as introduced. At a specific level (including infraspecific categories) 250 species are listed as native and 171 as introduced. At a specific level (including infraspecific categories) 250 names are native and 171 introduced. Of these 421 names, the greatest number is shared with the United States and South America, decreasing towards Canada, South America and Europe (Table 28).

Regarding the states of Mexico, Table 29 Figure 25 shows the number of genera and species (including infraspecific categories) organized according to their generic diversity. The last two columns of Table 29 show the number of species both native and introduced for each state. The number of native weeds varies from 28 to 165 while the number of introduced species is less and apparently more homogeneous among states.

According to the definition of weed, almost any plant can be considered a weed. The classification or category of the type of weed is not exclusive since there are species that can be noxious weeds in one place and foraging or cultivated in another. Based on these definitions a list is presented with the number of species (including infraspecific categories) with the types or categories of weeds found in Table 30.

The current classification of the Poacea family contains 12 subfamilies (GPWG, 2000, 2001, 2012; Peterson et al., 2010; Sánchez-Ken et al., 2007; Sánchez-Ken & Clark, 2010). In Mexico, representatives from 8 subfamilies are listed in this catalogue of weeds. Most of the species are included in the three largest subfamilies Chloridoideae, Panicoideae and Pooideae (Table 31, Figure 26) with 121, 176 and 95 species respectively. In categories that are inferior to subfamily, there are species registered in 20 tribes of which Cynodonteae (Chloridoideae), Andropogoneae and Paniceae (Panicoideae) and Poeae (Pooideae) contain 83, 52, 122 and 56 species respectively, these families contain the greatest number of weed species considered in this report (Table 32). At a generic level, the four most diverse genera are Eragrostis, Paspalum, Muhlenbergia and Bouteloua; these group 20 to 25
species (including infraspecific categories) considered weeds (Table 33).

At a state level a list of the states with the eight subfamilies that contain weeds is presented (Table 34). The states are organized according to the diversity of weeds in the Panicoide subfamily, which is the most diverse of the eight subfamilies in this catalogue. There are states in which the eight subfamilies are represented with at least one species, while there are states like Tlaxcala in which there are only four subfamilies represented.

The diversity patterns at a generic and specific level of native and introduced weeds are very similar, this can be observed in Figure 26. The greatest diversity of weeds is found in central-south Mexico in the states of Chiapas, Oaxaca, Veracruz, Jalisco, Mexico and Puebla, however it is interesting to note that the state of Chihuahua concentrates a high number of weeds at a species level. While the poorest states in terms of generic and specific diversity were Baja California Sur, Quintana Roo and Tlaxcala. Regarding the diversity patterns of native and introduced weeds, these differ among each other. The diversity patterns for introduced weeds is very similar to the species and infraspecific categories, occupying almost the same states. On the other hand, the diversity of species and infraspecific categories covers more states of the center and east of the country. These patterns of weed diversity for both native and introduced species coincide with the specific diversity pattern of the families in the different states of the republic (Dávila et al., 2006).

The three most diverse subfamilies have different diversity patterns (Figure 27). The Chloridoideae are most diverse in the driest states, while Panicoideae are most diverse in the states where there is most humidity available. Weeds in the Pooideae family have a diversity pattern that is more restricted to temperate zones of the country. Diversity patterns are merely the number of species present in each state with no type of analysis or monitoring of species of weeds. For the rest of the subfamilies the diversity is less than 7 species that may be present in every state or absent from several of them.

The development of the catalogue for native and introduced grass weeds in Mexico was mostly a herbarium and bibliographic revision. However it is necessary to carry out field studies for a constant monitoring of the mentioned species since some of the herbarium specimens are old and therefore the presence of some species could have been fortuitous. Also, it is important to note that the number of species can vary constantly, whether because the species have not become established, have been eradicated or because of new introductions. The catalogue is a starting point for the development of integral weed studies.

Finally the catalogue presents the general list of species, including the subfamily and tribe to which it belongs, its origin, if it is native or introduced its status, (ruderal, cultivated, ornamental, weed, etc.) its general distribution and its distribution per state. A photographic attachment is included for most species, showing the complete specimen, a close up of the vegetative parts and another for reproductive ones. Lists of species are then presented for the states and organized alphabetically.

**Acknowledgements**

I would like to thank Dr. H. Vibrans for the invitation to Weeds Across Borders 2012 and CONABIO for financing my participation.

**References**


Table 27. List of species including infraspecific categories for native and introduced grass weeds in Mexico.

<table>
<thead>
<tr>
<th>No.</th>
<th>Species Name</th>
<th>Authority</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Actinopus eminens (Cav.) Borkh.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Agilipes cylindrica Host.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Agropyron cristatum (L.) Gaertn.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Agrostis gigantea Roth</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Agrostis hyemalis (Walter) Britton Sterns &amp; Poggenb.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Agrostis perennans (Walter) Tuck.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Agrostis schaferi Fourn. ex Hemsl.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Aria caryophyllea L.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Alopecurus gobiculatus L.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Amelichloa clandestina (Hack.) Arriaga &amp; Borkworth</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Andropogon bicornis L.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Andropogon gyanus Kunth</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Andropogon gerardii Vitman</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Andropogon glomeratus (Walter) Britton Sterns &amp; Poggenb.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Andropogon ternarius Michx.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Andropogon virgatus Desv. ex Ham.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Andropogon virginicus L.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Anthephorhaphodita (L.) Kuntze</td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Anthoxanthum odoratum L.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Aristida adscensionis L.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>Aristida divaricata Humb. &amp; Bonpl. ex Willd.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>Aristida laxa Cav.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>Aristida purpurascens Poir.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>Aristida purpurea Nutt. var. nealleyi (Vasey) Allred</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>Aristida purpurea Nutt. var. longiseta (Steed.) Vasey</td>
<td></td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>Aristida schiedeauna Trin. &amp; Rupr.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>Aristida ternipes Cav.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>Arthrexron elatius (L.) P. Beauv. ex J. Presl &amp; C. Presl</td>
<td></td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>Arthrexron hispidus (Thunb.) Makino var. hispidus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>Arthrexron hispidus (Thunb.) Makino var. hispidus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>Arundinella deppeana Nees ex Steud.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>Arundo donax L.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>33</td>
<td>Avena barbata Pott ex Link</td>
<td></td>
<td></td>
</tr>
<tr>
<td>34</td>
<td>Avena fatua L.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>35</td>
<td>Avena sativa L.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>36</td>
<td>Avenella flexuosa (L.) Drejer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>37</td>
<td>Avenella flexuosa (L.) Drejer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>38</td>
<td>Bambusa multiplex (L.) Raeusch. Ex Schult. &amp; Schult. F.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>39</td>
<td>Bambusa tuldoides Munro</td>
<td></td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>Bambusa virgata Schrad. ex J.C. Wendl.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>41</td>
<td>Bothriochloa barbinodis (Lag.) Herter</td>
<td></td>
<td></td>
</tr>
<tr>
<td>42</td>
<td>Bothriochloa bladihi (Retz.) S.T. Blake</td>
<td></td>
<td></td>
</tr>
<tr>
<td>43</td>
<td>Bothriochloa ischaemum (L.) Keng var. songarica (Rupr. ex Fisch. &amp; Meyen) Celarier &amp; J.R. Harlan</td>
<td></td>
<td></td>
</tr>
<tr>
<td>44</td>
<td>Bothriochloa laguroides (DC.) Herter</td>
<td></td>
<td></td>
</tr>
<tr>
<td>45</td>
<td>Bothriochloa pertusa (L.) A. Camus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>46</td>
<td>Bothriochloa saccharoides (Swallen) Rydb.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>47</td>
<td>Bouteloua aristidoideas (Kunth) Griseb.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>48</td>
<td>Bouteloua barbata Lag.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>49</td>
<td>Bouteloua curtipendula (Michx.) G.S. Torr. curtipendula</td>
<td></td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>Bouteloua curtipendula (Michx.) G.S. Torr. temuis (Michx.) Gould &amp; Kapadia</td>
<td></td>
<td></td>
</tr>
<tr>
<td>51</td>
<td>Bouteloua dactyloides (Nutt.) Columbus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>52</td>
<td>Bouteloua dimorpha Columbus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>53</td>
<td>Bouteloua diversisipica Columbus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>54</td>
<td>Bouteloua eludens Griffiths</td>
<td></td>
<td></td>
</tr>
<tr>
<td>55</td>
<td>Bouteloua eriopoda (Torr.) Torr.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>56</td>
<td>Bouteloua gracilis (Kunth) Lag. ex Griffiths</td>
<td></td>
<td></td>
</tr>
<tr>
<td>57</td>
<td>Bouteloua hissuta Lag. var. glandulosa (Cerv.) Gould</td>
<td></td>
<td></td>
</tr>
<tr>
<td>58</td>
<td>Bouteloua hissuta Lag. var. hissuta</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
59. *Bouteloua media* (E. Fourn.) Gould & Kapadia
60. *Bouteloua parryi* (E. Fourn.) Griffiths
61. *Bouteloua repens* (Kunth) Scribn. & Merr.
63. *Bouteloua simplex* Lag.
64. *Bouteloua stolonifera* Scribn.
66. *Bouteloua williamsii* Swallen
67. *Brachypodium distachyon* (L.) P. Beauv.
68. *Briza minor* L.
69. *Bromus arenarius* Roth var. *diandrus*
70. *Bromus arizonicus* (Shear) Stebbins
71. *Bromus berteroanus* Colla
73. *Bromus catharticus* Vahl
74. *Bromus diandrus* Roth var. *diandrus*
75. *Bromus diandrus* Roth var. *rigidus* (Roth) F. Sales
76. *Bromus exaltatus* Bernh.
77. *Bromus hordaceus* L.
78. *Bromus japonicus* Thunb.
79. *Bromus madritensis* L.
80. *Bromus rubens* L.
81. *Bromus secalinus* L.
82. *Bromus secalinus* L.
83. *Catapodium rigidum* (L.) C.E. Hubb.
84. *Cenchrus brownii* Roem. & Schult.
85. *Cenchrus ciliaris* L.
86. *Cenchrus clandestinus* (Hochst. ex Chiov.) Morrone
87. *Cenchrus echinatus* L.
88. *Cenchrus longispinus* (Hack.) Fernald
89. *Cenchrus multiflorus* J. Presl
90. *Cenchrus myosuroides* Kunth
91. *Cenchrus orientalis* (Rich.) Morrone
92. *Cenchrus pilosus* Kunth
93. *Cenchrus polystachios* (L.) Morrone
94. *Cenchrus purpureus* (Schumach.) Morrone
95. *Cenchrus setaceus* (Forsk.) Morrone
96. *Cenchrus spinifex* Cav.
97. *Cenchrus villosus* (R.Br. ex Fresen.) Kuntze
98. *Coix lacryma-jobi* L.
99. *Cortaderia selloana* (Schult. & Schult. f.) Asch. & Graebn.
100. *Cotula pappophoroides* Kunth
102. *Crypsis vaginiflora* (Forsk.) Opiz
103. *Cymobogon citratus* (DC.) Stapf
104. *Cymobogon nardus* (L.) Rendle
106. *Cynodon nlemfuensis* Vandervyst
108. *Cynosurus echinatus* L.
110. *Chloris barbata* Sw.
111. *Chloris ciliata* Sw.
112. *Chloris gayana* Kunth
113. *Chloris radiata* (L.) Sw.
115. *Chloris submucula* Kunth
116. *Chloris virgata* Sw.
117. *Chrysopogon zizanioides* (L.) Robernty
118. *Dactylis glomerata* L.
120. *Dactyloctenium aristatum* Link
121. *Dactyloctenium geminatum* Hack.
122. *Dactyloctenium scindicum* Boiss.
123. *Danthonia spicata* (L.) P. Beauv.
124. *Dendrochlamopsis oldhamii* (Munro) Keng f.
125. *Dichanthium annulatum* (Forssk.) Stapf
127. *Digitaria abyssinica* (Hochst. ex A. Rich.) Stapf
128. *Digitaria bicornis* (Lam.) Roem. & Schult.
129. *Digitaria californica* (Benth) Henrard
130. *Digitaria ciliaris* (Retz.) Koeler
131. *Digitaria eriantha* Steud.
132. *Digitaria filiformis* (L.) Koeler
133. *Digitaria horizontalis* Willd.
134. *Digitaria insularis* (L.) Fedde
135. *Digitaria leucites* (Trin.) Henrard
136. *Digitaria milanjiana* (Rendel) Stapf
137. *Digitaria nuda* Schumach.
138. *Digitaria sanguinalis* (L.) Scop.
139. *Digitaria setigera* Roth
140. *Digitaria ternata* (A. Rich.) Stapf
141. *Digitaria velutina* (Forssk.) P. Beauv.
142. *Digitaria violascens* Link
143. *Distichlis spicata* (L.) Greene
144. *Echinocloa colonia* (L.) Link
146. *Echinocloa polystachya* (Kunth) Hitchc.
147. *Echinocloa pyramidalis* (Lam.) Hitchc. & Chase
148. *Echinocloa walteri* (Pursh) A. Heller
149. *Eleusine indica* (L.) Gaertn.
151. *Eleusine tristachya* (Lam.) Lam.
152. *Elmus trachycaulus* (Link) Gould ex Shinners
153. *Euphorbiaceae* subsp. *secundus* (Link) A. Love & D. Love
155. *Eragrostis amabilis* (L.) Wight & Arn. Ex Nees
156. *Eragrostis atrovirens* (Desf.) Trin. ex Steud.
158. Eragrostis barrelieri Daveau
159. Eragrostis ciliensis (Bellardi) Vignolo ex Janch.
160. Eragrostis ciliaris (L.) R.Br.
161. Eragrostis curvula (Schrad.) Nees
162. Eragrostis echinochoidea Stapf
163. Eragrostis elliotti S. Watson Nees
164. Eragrostis hirsuta (Michx.) Nees
165. Eragrostis intermedia Hitchc.
166. Eragrostis lehmanniana Nees
167. Eragrostis lugens (Hornem.) Link subsp. mexicana (J. Presl) S.D. Koch & Sánchez Vega
168. Eragrostis mexicana (Hornem.) Link subsp. virescens (L.) P. Beauv.
170. Eragrostis minor Host
171. Eragrostis obtusiflora (E. Fourn.) Scribn.
172. Eragrostis pectinacea (Michx.) Nees var. pectinacea (L.) P. Beauv.
173. Eragrostis pectinacea (Michx.) Nees var. miserrima (E. Fourn.) Reeder
174. Eriochloa acuminata (J. Presl) Kunth
175. Eriochloa contracta Hitchc.
176. Eriochloa nelsonii Scribn. & J.G. Sm.
177. Eriochloa punctata (L.) Desv.
178. Euchlaena condylotricha (Steud.) Stapf
179. Eustachys petraea (E. Fourn.) (Retz.) Trin.
180. Eremochloa atherioides (Munro) Hack.
181. Eriochloa acuminata (J. Presl) Kunth
182. Eriochloa pellispira (E. Fourn.) Hitchc. ex Hern.-Xol.
183. Gastridium ventricosum (Gouan) Schinz & Thell.
184. Glyceria fluitans (L.) R. Br.
185. Guadua angustifolia Kunth
187. Hainardia cylindrica (Willd.) Greuter
188. Hemarthria altissima (Poir.) Stapf & C.E. Hubb.
189. Heteropogon contortus (L.) P. Beauv. ex Roem. & Schult.
190. Heteropogon melanocarpus (Elliott) Benth.
191. Hilaria belangeri (Steud.) Nash
192. Hilaria cenchroides Kunth
193. Hilaria ciliata (Scribn.) Nash
194. Holcus lanatus L.
195. Homolepis atrens (Kunth) Chase
196. Hopia obtusa (Kunth) Zuloaga & Morrone
197. Hordeum arizonicum Covas
198. Hordeum brachyantherum Nevski Californicum
199. Hordeum jubatum L. intermedium
200. Hordeum jubatum L. jubatum
201. Hordeum marinum subsp. gussoneum (Parl.) Thell.
203. Hordeum murinum L. subsp. glaucum (Steud.) Zvelev
204. Hordeum pusillum Nutt.
205. Hordeum vulgare L.
206. Hymenachne amplexicaule (Rudge) Nees
207. Hyparrhenia bracteata (Humb. & Bonpl. ex Willd.) Stapf
208. Hyparrhenia cymbaria (L.) Stapf
209. Hyparrhenia hirta (L.) Stapf
210. Hyparrhenia rufa (Nees) Stapf
211. Hyparrhenia variabilis Stapf
212. Hyperthelia dissolutor (Steud.) W.D. Clayton
213. Ichnanthus pallens (Sw.) Munro ex Benth.
214. Imperata brasiliensis Trin.
216. Ischaemum rugosum Salisb.
217. Isophrora unisetus (J. Presl) Schltld.
218. Jarava ichu Ruiz & Pav.
219. Lagurus ovatus L.
220. Lamarkia aurea (L.) Moench
221. Lasiacis procerrima (Hack.) Hitchc.
222. Lasiacis ruscifolia (Kunth) Hitchc. var. ruscifolia
223. Leersia hexandra Sw.
224. Leersia oryzoides (L.) Sw.
225. Leptochloa aquatica Scribn. & Merr.
226. Leptochloa dubia (Kunth) Nees
227. Leptochloa fusca (L.) Kunth subsp. uninervia (J. Presl) N.W. Snow
228. Leptochloa fusca (L.) Kunth subsp. fascicularis (Lam.) N.W. Snow
229. Leptochloa panicea (Retz.) Ohwi subsp. mucronata (Michx.) Nowack
230. Leptochloa panicea (J. Presl) Hitchc. subsp. brachiata (Steud.) N.W. Snow
231. Leptochloa panicea (J. Presl) Hitchc.
232. Leptochloa scabra Nees
233. Leptochloa virgata (L.) P. Beauv.
234. Lolium multiflorum Lam.
235. Lolium perenne L.
236. Lolium temulentum L.
237. Luziola fluitans (Michx.) Nees
238. Megathyrsus maximus (Jacq.) B.K. Simon & S.W.L. Jacobs
239. Melica porteri (L.) P. Beauv. ex Roem. & Schult.
240. Miliacea triloba (L.) Stapf
241. Miliacea purpurascens (Hornem.) Stapf
242. Miliacea rubra (L.) Nees
243. Miscahloa virens (L.) Sw.
244. Muhlenbergia asperifolia (Nees & Meyer ex Trin.) Parodi
252. Muhlenbergia capillaris (Lam.) Trin.
253. Muhlenbergia cenchroides
   (Humb. & Bonpl. ex Willd.) P.M. Peterson
254. Muhlenbergia depauperata Scribn.
255. Muhlenbergia dubia E. Fourn.
256. Muhlenbergia dumosa Scribn. Ex Vasey
257. Muhlenbergia emersleyi Vasey
258. Muhlenbergia geminiflora (Kunth) P.M. Peterson
259. Muhlenbergia implicata (Kunth) Kunth
260. Muhlenbergia lindheimeri Hitchc.
261. Muhlenbergia macroura (Kunth) Hitchc.
262. Muhlenbergia micro sperma (DC.) Kunth
263. Muhlenbergia minatissima (Steud.) Swallen
264. Muhlenbergia palmeri Vasey
265. Muhlenbergia perviana (P. Beauv.) Steud.
266. Muhlenbergia phleoides (Kunth) Columbus
267. Muhlenbergia plumbea (Trin.) Hitchc.
268. Muhlenbergia pubescens (Kunth) Hitchc.
269. Muhlenbergia ramalosa (Kunth) Swallen
270. Muhlenbergia repens (J. Presl) Hitchc.
271. Muhlenbergia rigida (Kunth) Kunth
273. Muhlenbergia tenui folia (Kunth) Kunth
274. Murooa squarrosa (Nutt.) Torr.
275. Nassella mucronata (Kunth) R.W. Pohl
276. Nassella tenerissima (Trin.) Barkworth
277. Neyraudia reynaudiana (Kunth) Keng ex Hitchc.
278. Oclochloa stolonifera (Poir.) Zuloaga & Morrone
   var. majus (Trin.) Kunth
279. Oryza latifolia L.
280. Oplismenus burmannii (Retz.) P. Beauv. var. burmannii
281. Oplismenus compositus (L.) P. Beauv.
283. Oryza latifolia L.
284. Oryza rufipogon Griff.
285. Oryza sativa L.
286. Panicum antidotale Retz.
287. Panicum capillare L.
288. Panicum coloratum L.
289. Panicum decolorans Kunth
290. Panicum dichotomiflorum Michx.
291. Panicum hallii Vasey
292. Panicum hirticaule J. Presl var. hirticaule
293. Panicum lepidulum Hitchc. & Chase
294. Panicum pilosum Sw.
295. Panicum repens L.
296. Panicum trichoides Sw.
297. Panicum virgatum L.
298. Parapholis incurva (L.) C.E. Hubb.
299. Paspalidium geminatum (Forssk.) Stapf
300. Paspalum botterii (E. Fourn.) Chase
301. Paspalum candidum (Humb. & Bonpl.) Kunth
302. Paspalum conjugatum P.J. Bergius
303. Paspalum convexum Humb. & Bonpl.
304. Paspalum denticulatum Trin.
305. Paspalum dilatatum Poir.
306. Paspalum distichum L.
307. Paspalum fasciculatum Willd. ex Flüggé
308. Paspalum boldtianum Flüggé
309. Paspalum notatum Flüggé
310. Paspalum paniculatum L.
311. Paspalum picatum L. E. Fourn.
312. Paspalum prostratum Scribn. & Merr.
313. Paspalum pubiflorum Rupr. ex E. Fourn.
314. Paspalum scrobiculatum L.
315. Paspalum setaceum Michx. var. setaceum
316. Paspalum squamulatum E. Fourn.
317. Paspalum tenellum Willd.
318. Paspalum trinatum Chase
319. Paspalum urvillei Steud.
320. Paspalum vaginatum Sw.
321. Paspalum virgatum L.
322. Paspalum virletii E. Fourn.
323. Phalaris angusta Nees ex Trin.
324. Phalaris aquatica L.
325. Phalaris arundinacea L.
326. Phalaris brachystachys Link
327. Phalaris canariensis L.
328. Phalaris minor Retz.
329. Phalaris paradoxa L.
330. Phleum alpinum L.
331. Phleum pratense L.
332. Phragmites australis (Cav.) Trin. ex Steud.
333. Phyllostachys aurea Carrière ex Rivière & C. Revière
334. Piptochaetium angustifolium (Hitch.) Valencia & Costas
335. Pleuraphis mutica (Buckl.) Benth.
336. Poa annua L.
337. Poa compressa L.
338. Poa pratensis L.
339. Poa scabrella Hook. f.
340. Polypogon elongatus Kunth
341. Polypogon interruptus Kunth
342. Polypogon maritimus Willd.
343. Polypogon monspeliensis (L.) Desf.
344. Polypogon viridis (Gouan) Breistr.
345. Pseudechinolaena polystachya (Kunth) Stapf
346. Pseudosasa japonica (Siebold & Zucc. Ex Steud.)
   Makino ex Nakai
347. Rostraria cristata (L.) Tzvelev
348. Rottboellia cochinchinensis (Lour.) Clayton
<table>
<thead>
<tr>
<th>Page</th>
<th>Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>349</td>
<td>Saccharum officinarum L.</td>
</tr>
<tr>
<td>350</td>
<td>Saccharum villosum (Hack.) Renvoize</td>
</tr>
<tr>
<td>351</td>
<td>Scleropogon brevifolius Phil.</td>
</tr>
<tr>
<td>352</td>
<td>Schedonorus arundinaceus (Schreb.) Dumort.</td>
</tr>
<tr>
<td>353</td>
<td>Schismus arabicus Nees</td>
</tr>
<tr>
<td>354</td>
<td>Schismus barbatus (L.) Thell.</td>
</tr>
<tr>
<td>355</td>
<td>Schizachyrium brevifolium (Sw.) Nees</td>
</tr>
<tr>
<td>356</td>
<td>Schizachyrium littorale (Nash) E.P. Bicknell</td>
</tr>
<tr>
<td>357</td>
<td>Schizachyrium scoparium (Michx.) Nash</td>
</tr>
<tr>
<td>358</td>
<td>Secale cereale L.</td>
</tr>
<tr>
<td>359</td>
<td>Setaria adhaerens (Forssk.) Chiov.</td>
</tr>
<tr>
<td>360</td>
<td>Setaria grisebachii E. Fourn.</td>
</tr>
<tr>
<td>361</td>
<td>Setaria palmifolia (J. König) Stapf</td>
</tr>
<tr>
<td>362</td>
<td>Setaria pumila (Poir.) Roem. &amp; Schult.</td>
</tr>
<tr>
<td>363</td>
<td>Setaria setosa (Sw.) P. Beauv.</td>
</tr>
<tr>
<td>364</td>
<td>Setaria sphacelata (Schumach.) Stapf &amp; C.E. Hubb. ex M.B. Moss</td>
</tr>
<tr>
<td>365</td>
<td>Setaria verticillata (L.) P. Beauv.</td>
</tr>
<tr>
<td>366</td>
<td>Setaria verticilliformis Dumort.</td>
</tr>
<tr>
<td>367</td>
<td>Setaria viridis (L.) P. Beauv.</td>
</tr>
<tr>
<td>368</td>
<td>Sphenocephalus obtusatus (Michx.) Scribn.</td>
</tr>
<tr>
<td>369</td>
<td>Sorghastrum incompletum (J. Presl) Nash</td>
</tr>
<tr>
<td>370</td>
<td>Sorghastrum nutans (L.) Nash</td>
</tr>
<tr>
<td>371</td>
<td>Sorghum bicolor (L.) Moench subsp. bicolor</td>
</tr>
<tr>
<td>372</td>
<td>Sorghum halepense (L.) Pers.</td>
</tr>
<tr>
<td>373</td>
<td>Spartina patens (Aiton) Muhl.</td>
</tr>
<tr>
<td>374</td>
<td>Sphenopholis obtusata (Michx.) Scribn.</td>
</tr>
<tr>
<td>375</td>
<td>Sorobolus cryptandrus (Torr.) A. Gray</td>
</tr>
<tr>
<td>376</td>
<td>Sorobolus indicus (L.) R. Br.</td>
</tr>
<tr>
<td>377</td>
<td>Sorobolus jacobenontii Kunth</td>
</tr>
<tr>
<td>378</td>
<td>Sorobolus junceus (P. Beauv.) Kunth</td>
</tr>
<tr>
<td>379</td>
<td>Sorobolus pyramidatus (Lam.) Hitchc.</td>
</tr>
<tr>
<td>380</td>
<td>Sorobolus virginicus (L.) Kunth</td>
</tr>
<tr>
<td>381</td>
<td>Steinchenia laxum (Swc) Zuloaga</td>
</tr>
<tr>
<td>382</td>
<td>Stenotaphrum secundatum (Walter) Kuntze</td>
</tr>
<tr>
<td>383</td>
<td>Thinopyrum intermedium (Host) Barkworth &amp; D.R. Dewey</td>
</tr>
<tr>
<td>384</td>
<td>Tragus berteronianus Schult.</td>
</tr>
<tr>
<td>385</td>
<td>Trichoneura elegans Swallen</td>
</tr>
<tr>
<td>386</td>
<td>Tridens flavus (L.) Hitchc.</td>
</tr>
<tr>
<td>387</td>
<td>Triniochloa microstachya (Scribn.) Hitchc.</td>
</tr>
<tr>
<td>388</td>
<td>Tripsacum dactyloides (L.)</td>
</tr>
<tr>
<td>389</td>
<td>Tripsacum laxum Nash</td>
</tr>
<tr>
<td>390</td>
<td>Triticum aestivum L.</td>
</tr>
<tr>
<td>391</td>
<td>Uniola paniculata L.</td>
</tr>
<tr>
<td>392</td>
<td>Urochloa adspersa (Trin.) R.D. Webster</td>
</tr>
<tr>
<td>393</td>
<td>Urochloa arrecta (Hack. ex T. Durand &amp; Schinz) Morrone &amp; Zuloaga</td>
</tr>
<tr>
<td>394</td>
<td>Urochloa brizantha (Hochst. Ex A. Rich.) R.D. Webster</td>
</tr>
<tr>
<td>395</td>
<td>Urochloa distachya (L.) T.Q. Nguyen</td>
</tr>
<tr>
<td>396</td>
<td>Urochloa fusca (Sw.) B.F. Hansen &amp; Wunderlin</td>
</tr>
<tr>
<td>397</td>
<td>Urochloa humicola (Rendle) Morrone &amp; Zuloaga</td>
</tr>
<tr>
<td>398</td>
<td>Urochloa mutica (Forssk.) T.Q. Nguyen</td>
</tr>
<tr>
<td>399</td>
<td>Urochloa panicoides P. Beauv.</td>
</tr>
<tr>
<td>400</td>
<td>Urochloa plantaginea (Link) R.D. Webster</td>
</tr>
<tr>
<td>401</td>
<td>Urochloa platyphilla (Munro ex C. Wright) R.D. Webster</td>
</tr>
<tr>
<td>402</td>
<td>Urochloa reptsans (L.) Stapf</td>
</tr>
<tr>
<td>403</td>
<td>Urochloa ruzizensis (R. Germ. &amp; Evrard) Crins</td>
</tr>
<tr>
<td>404</td>
<td>Urochloa texana (Buckl.) S.F. Blake</td>
</tr>
<tr>
<td>405</td>
<td>Vulpa bromoides (L.) S.F. Gray</td>
</tr>
<tr>
<td>406</td>
<td>Vulpa microstachys (Nutt.)</td>
</tr>
<tr>
<td>407</td>
<td>Vulpa myuros (L.) C.C. Gmelin var. myuros</td>
</tr>
<tr>
<td>408</td>
<td>Vulpa myuros (L.) C.C. Gmelin var. hirsuta Hack.</td>
</tr>
<tr>
<td>409</td>
<td>Vulpa octoflora (Walter) Rydb. var. octoflora</td>
</tr>
<tr>
<td>410</td>
<td>Vulpa octoflora (Walter) Rydb. var. hirtella (Piper) Henrard</td>
</tr>
<tr>
<td>411</td>
<td>Zea diploperennis Itlis Doebley &amp; Guzmán</td>
</tr>
<tr>
<td>412</td>
<td>Zea mays L. subsp. mexicana</td>
</tr>
<tr>
<td>413</td>
<td>Zea mays L. subsp. mays</td>
</tr>
<tr>
<td>414</td>
<td>Zea mays L. subsp. parviglumis</td>
</tr>
<tr>
<td>415</td>
<td>Zizaniopsis miliacea (Michx.) Döll &amp; Asch.</td>
</tr>
<tr>
<td>416</td>
<td>Zoysia matrella (L.) Merr.</td>
</tr>
<tr>
<td>417</td>
<td>Zuloagaea bulbosa (Kunth) Bess</td>
</tr>
</tbody>
</table>
Table 28. Diversity of species including infraspecific categories by regions as well as the number of native and introduced species.

<table>
<thead>
<tr>
<th>Region</th>
<th>Species</th>
<th>Native</th>
<th>Introduced</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canada</td>
<td>82</td>
<td>35</td>
<td>47</td>
</tr>
<tr>
<td>United States</td>
<td>334</td>
<td>185</td>
<td>149</td>
</tr>
<tr>
<td>México</td>
<td>421</td>
<td>250</td>
<td>171</td>
</tr>
<tr>
<td>Central America</td>
<td>262</td>
<td>154</td>
<td>108</td>
</tr>
<tr>
<td>South America</td>
<td>292</td>
<td>152</td>
<td>140</td>
</tr>
<tr>
<td>Caribbean</td>
<td>187</td>
<td>98</td>
<td>89</td>
</tr>
<tr>
<td>Europe</td>
<td>198</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 29. Diversity of genera per state ordered from the richest to the least diverse, as well as the number of native and introduced genera.

<table>
<thead>
<tr>
<th>State</th>
<th>Genera</th>
<th>Species</th>
<th>Native</th>
<th>Introduced</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ver.</td>
<td>90</td>
<td>219</td>
<td>148</td>
<td>71</td>
</tr>
<tr>
<td>Chis.</td>
<td>90</td>
<td>232</td>
<td>152</td>
<td>80</td>
</tr>
<tr>
<td>Oax.</td>
<td>88</td>
<td>237</td>
<td>165</td>
<td>72</td>
</tr>
<tr>
<td>Méx.</td>
<td>84</td>
<td>213</td>
<td>147</td>
<td>66</td>
</tr>
<tr>
<td>Pue.</td>
<td>82</td>
<td>218</td>
<td>157</td>
<td>61</td>
</tr>
<tr>
<td>Jal.</td>
<td>80</td>
<td>232</td>
<td>162</td>
<td>70</td>
</tr>
<tr>
<td>Mich.</td>
<td>78</td>
<td>214</td>
<td>149</td>
<td>65</td>
</tr>
<tr>
<td>N.L.</td>
<td>71</td>
<td>150</td>
<td>106</td>
<td>44</td>
</tr>
<tr>
<td>Coah.</td>
<td>70</td>
<td>164</td>
<td>116</td>
<td>48</td>
</tr>
<tr>
<td>Tamps.</td>
<td>68</td>
<td>169</td>
<td>126</td>
<td>43</td>
</tr>
<tr>
<td>Mor.</td>
<td>67</td>
<td>153</td>
<td>110</td>
<td>43</td>
</tr>
<tr>
<td>Chih.</td>
<td>65</td>
<td>180</td>
<td>128</td>
<td>52</td>
</tr>
<tr>
<td>S.L.P.</td>
<td>65</td>
<td>167</td>
<td>127</td>
<td>40</td>
</tr>
<tr>
<td>D.F.</td>
<td>64</td>
<td>144</td>
<td>102</td>
<td>42</td>
</tr>
<tr>
<td>Gto.</td>
<td>63</td>
<td>158</td>
<td>120</td>
<td>38</td>
</tr>
<tr>
<td>Nay.</td>
<td>59</td>
<td>146</td>
<td>107</td>
<td>39</td>
</tr>
<tr>
<td>Dgo.</td>
<td>57</td>
<td>140</td>
<td>110</td>
<td>30</td>
</tr>
<tr>
<td>Son.</td>
<td>56</td>
<td>150</td>
<td>108</td>
<td>42</td>
</tr>
<tr>
<td>Yuc.</td>
<td>55</td>
<td>107</td>
<td>55</td>
<td>42</td>
</tr>
<tr>
<td>Hgo.</td>
<td>54</td>
<td>135</td>
<td>103</td>
<td>32</td>
</tr>
</tbody>
</table>
Table 30. Number of species and infraspecific categories classified according to the type or category of weed both native and introduced.

<table>
<thead>
<tr>
<th>Type of Weed</th>
<th>Native</th>
<th>Introduced</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Noxious weed</td>
<td>13</td>
<td>35</td>
<td>48</td>
</tr>
<tr>
<td>Potential weed</td>
<td>36</td>
<td>41</td>
<td>77</td>
</tr>
<tr>
<td>Forage</td>
<td>46</td>
<td>51</td>
<td>77</td>
</tr>
<tr>
<td>Ruderal</td>
<td>225</td>
<td>57</td>
<td>312</td>
</tr>
<tr>
<td>Erosion control, soil improvement</td>
<td>32</td>
<td>35</td>
<td>67</td>
</tr>
<tr>
<td>Ornamental</td>
<td>30</td>
<td>33</td>
<td>63</td>
</tr>
<tr>
<td>Cultivated</td>
<td>29</td>
<td>106</td>
<td>135</td>
</tr>
<tr>
<td>Parasite host</td>
<td>-</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Medicinal</td>
<td>-</td>
<td>5</td>
<td>5</td>
</tr>
</tbody>
</table>

Table 31. Number of taxa including infraspecific categories per subfamily

<table>
<thead>
<tr>
<th>Subfamily</th>
<th>Species/infrasp. cat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aristidoideae</td>
<td>8</td>
</tr>
<tr>
<td>Arundinoideae</td>
<td>2</td>
</tr>
<tr>
<td>Bambusoideae</td>
<td>7</td>
</tr>
<tr>
<td>Chloridoideae</td>
<td>121</td>
</tr>
<tr>
<td>Danthioidae</td>
<td>4</td>
</tr>
<tr>
<td>Ehrhartioide</td>
<td>8</td>
</tr>
<tr>
<td>Panicoideae</td>
<td>176</td>
</tr>
<tr>
<td>Poioideae</td>
<td>95</td>
</tr>
<tr>
<td>TOTAL</td>
<td>421</td>
</tr>
</tbody>
</table>
### Table 32. Number of taxa including infraspecific categories(*) per tribe.

<table>
<thead>
<tr>
<th>Subfamily</th>
<th>Tribe</th>
<th>Species/infrasp. cat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aristidoideae</td>
<td>Aristideae*</td>
<td>8</td>
</tr>
<tr>
<td>Arundinoideae</td>
<td>Arundineae</td>
<td>2</td>
</tr>
<tr>
<td>Bambusoideae</td>
<td>Bambuseae</td>
<td>7</td>
</tr>
<tr>
<td>Bambusoideae</td>
<td>Olyreae</td>
<td>1</td>
</tr>
<tr>
<td>Chloridoideae</td>
<td>Cynodonteae*</td>
<td>83</td>
</tr>
<tr>
<td>Chloridoideae</td>
<td>Eragrostideae*</td>
<td>29</td>
</tr>
<tr>
<td>Chloridoideae</td>
<td>Triraphideae</td>
<td>1</td>
</tr>
<tr>
<td>Chloridoideae</td>
<td>Zoysieae</td>
<td>8</td>
</tr>
<tr>
<td>Danthonioideae</td>
<td>Danthonieae</td>
<td>4</td>
</tr>
<tr>
<td>Ehrhartoideae</td>
<td>Oryzeae</td>
<td>7</td>
</tr>
<tr>
<td>Panicoidae</td>
<td>Andropogoneae*</td>
<td>52</td>
</tr>
<tr>
<td>Panicoidae</td>
<td>Arundinelleae</td>
<td>1</td>
</tr>
<tr>
<td>Panicoidae</td>
<td>Gynerieae</td>
<td>1</td>
</tr>
<tr>
<td>Panicoidae</td>
<td>Paniceae*</td>
<td>122</td>
</tr>
<tr>
<td>Pooideae</td>
<td>Brachypodieae</td>
<td>1</td>
</tr>
<tr>
<td>Pooideae</td>
<td>Bromeeae*</td>
<td>14</td>
</tr>
<tr>
<td>Pooideae</td>
<td>Meliceae</td>
<td>3</td>
</tr>
<tr>
<td>Pooideae</td>
<td>Poeae*</td>
<td>56</td>
</tr>
<tr>
<td>Pooideae</td>
<td>Stipeae</td>
<td>6</td>
</tr>
<tr>
<td>Pooideae</td>
<td>Triticeae*</td>
<td>15</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td>421</td>
</tr>
</tbody>
</table>

### Table 33. Most diverse genera with infraspecific categories (*).

<table>
<thead>
<tr>
<th>Genera</th>
<th>Especie/infrasp.cat.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eragrostis*</td>
<td>25</td>
</tr>
<tr>
<td>Paspalum*</td>
<td>23</td>
</tr>
<tr>
<td>Muhlenbergia</td>
<td>23</td>
</tr>
<tr>
<td>Bouteloua*</td>
<td>20</td>
</tr>
<tr>
<td>Digitaria</td>
<td>16</td>
</tr>
<tr>
<td>Cenchrus</td>
<td>14</td>
</tr>
<tr>
<td>Bromus*</td>
<td>14</td>
</tr>
<tr>
<td>Urochloa</td>
<td>13</td>
</tr>
<tr>
<td>Panicum*</td>
<td>12</td>
</tr>
<tr>
<td>Setaria</td>
<td>10</td>
</tr>
</tbody>
</table>
Table 34. Diversity of species, including infraspecific categories per subfamily and per state (ARIS=Aristidoideae, ARUN=Arundinoideae, BAM=Bambusoideae, CHLO=Chloridoideae, DAN=Danthonioideae, EHR=Ehrhartoideae, PAN=Panicoideae, POO=Pooideae).

<table>
<thead>
<tr>
<th>State</th>
<th>ARIS</th>
<th>ARUN</th>
<th>BAM</th>
<th>CHLO</th>
<th>DAN</th>
<th>EHR</th>
<th>PAN</th>
<th>POO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chis.</td>
<td>4</td>
<td>2</td>
<td>5</td>
<td>65</td>
<td>1</td>
<td>4</td>
<td>118</td>
<td>31</td>
</tr>
<tr>
<td>Oax.</td>
<td>5</td>
<td>2</td>
<td>1</td>
<td>79</td>
<td>0</td>
<td>3</td>
<td>116</td>
<td>29</td>
</tr>
<tr>
<td>Jal.</td>
<td>5</td>
<td>2</td>
<td>1</td>
<td>75</td>
<td>1</td>
<td>5</td>
<td>116</td>
<td>23</td>
</tr>
<tr>
<td>Ver.</td>
<td>5</td>
<td>2</td>
<td>3</td>
<td>58</td>
<td>1</td>
<td>4</td>
<td>114</td>
<td>30</td>
</tr>
<tr>
<td>Mich.</td>
<td>5</td>
<td>2</td>
<td>1</td>
<td>61</td>
<td>1</td>
<td>2</td>
<td>110</td>
<td>30</td>
</tr>
<tr>
<td>Pue.</td>
<td>6</td>
<td>2</td>
<td>2</td>
<td>65</td>
<td>2</td>
<td>2</td>
<td>100</td>
<td>36</td>
</tr>
<tr>
<td>Mex.</td>
<td>5</td>
<td>2</td>
<td>1</td>
<td>67</td>
<td>1</td>
<td>3</td>
<td>89</td>
<td>43</td>
</tr>
<tr>
<td>Gro.</td>
<td>4</td>
<td>0</td>
<td>1</td>
<td>47</td>
<td>0</td>
<td>2</td>
<td>84</td>
<td>6</td>
</tr>
<tr>
<td>Nay.</td>
<td>5</td>
<td>2</td>
<td>0</td>
<td>47</td>
<td>0</td>
<td>4</td>
<td>82</td>
<td>4</td>
</tr>
<tr>
<td>Tamps.</td>
<td>6</td>
<td>2</td>
<td>1</td>
<td>62</td>
<td>1</td>
<td>2</td>
<td>79</td>
<td>14</td>
</tr>
<tr>
<td>Mor.</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td>46</td>
<td>1</td>
<td>2</td>
<td>76</td>
<td>19</td>
</tr>
<tr>
<td>Tab.</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>33</td>
<td>0</td>
<td>3</td>
<td>73</td>
<td>2</td>
</tr>
<tr>
<td>Col.</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>28</td>
<td>0</td>
<td>2</td>
<td>70</td>
<td>3</td>
</tr>
<tr>
<td>S.L.P.</td>
<td>6</td>
<td>0</td>
<td>1</td>
<td>67</td>
<td>0</td>
<td>2</td>
<td>69</td>
<td>20</td>
</tr>
<tr>
<td>Yuc.</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>31</td>
<td>0</td>
<td>1</td>
<td>68</td>
<td>1</td>
</tr>
<tr>
<td>Qro.</td>
<td>4</td>
<td>1</td>
<td>0</td>
<td>49</td>
<td>1</td>
<td>0</td>
<td>67</td>
<td>17</td>
</tr>
<tr>
<td>Camp.</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>29</td>
<td>0</td>
<td>3</td>
<td>67</td>
<td>2</td>
</tr>
<tr>
<td>Gto.</td>
<td>6</td>
<td>2</td>
<td>0</td>
<td>60</td>
<td>1</td>
<td>2</td>
<td>66</td>
<td>19</td>
</tr>
<tr>
<td>Coah.</td>
<td>6</td>
<td>2</td>
<td>0</td>
<td>61</td>
<td>2</td>
<td>1</td>
<td>64</td>
<td>26</td>
</tr>
<tr>
<td>Son.</td>
<td>7</td>
<td>2</td>
<td>0</td>
<td>61</td>
<td>3</td>
<td>0</td>
<td>62</td>
<td>13</td>
</tr>
<tr>
<td>Sin.</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>37</td>
<td>0</td>
<td>2</td>
<td>62</td>
<td>4</td>
</tr>
<tr>
<td>N.L.</td>
<td>6</td>
<td>2</td>
<td>0</td>
<td>51</td>
<td>1</td>
<td>1</td>
<td>61</td>
<td>26</td>
</tr>
<tr>
<td>Q.R.</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>27</td>
<td>0</td>
<td>1</td>
<td>57</td>
<td>1</td>
</tr>
<tr>
<td>Chih.</td>
<td>7</td>
<td>2</td>
<td>0</td>
<td>76</td>
<td>3</td>
<td>0</td>
<td>56</td>
<td>34</td>
</tr>
<tr>
<td>Dgo.</td>
<td>6</td>
<td>1</td>
<td>0</td>
<td>53</td>
<td>1</td>
<td>1</td>
<td>56</td>
<td>20</td>
</tr>
<tr>
<td>Hgo.</td>
<td>5</td>
<td>2</td>
<td>0</td>
<td>49</td>
<td>1</td>
<td>0</td>
<td>50</td>
<td>25</td>
</tr>
<tr>
<td>D.F.</td>
<td>5</td>
<td>1</td>
<td>2</td>
<td>54</td>
<td>1</td>
<td>1</td>
<td>47</td>
<td>31</td>
</tr>
<tr>
<td>Ags.</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>45</td>
<td>0</td>
<td>1</td>
<td>47</td>
<td>18</td>
</tr>
<tr>
<td>Zac.</td>
<td>5</td>
<td>1</td>
<td>0</td>
<td>52</td>
<td>0</td>
<td>0</td>
<td>44</td>
<td>14</td>
</tr>
<tr>
<td>B.C.</td>
<td>6</td>
<td>1</td>
<td>0</td>
<td>35</td>
<td>3</td>
<td>0</td>
<td>33</td>
<td>39</td>
</tr>
<tr>
<td>B.C.S.</td>
<td>4</td>
<td>1</td>
<td>0</td>
<td>42</td>
<td>1</td>
<td>0</td>
<td>26</td>
<td>7</td>
</tr>
<tr>
<td>Tlax.</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>33</td>
<td>0</td>
<td>0</td>
<td>10</td>
<td>12</td>
</tr>
</tbody>
</table>
Figure 25. Diversity maps for grass weeds at a generic and specific level (including infraspecific categories).
Figure 26. Maps of species diversity including native and introduced infraspecific categories.
Figure 27. Diversity maps of the three most diverse subfamilies.
Condition of Invasive Weeds in Zacatecas
Condición de las Malezas Invasoras en Zacatecas

E. David Enríquez Enríquez
Professor-Researcher / Profesor – investigador
Autonomous University of Zacatecas, Academic Unit of Agronomy / Universidad Autónoma de Zacatecas, Unidad Académica de Agronomía
Cerezos 102 Col. Arboledas Guadalupe, Zacatecas 98608 Mexico
Adagon_9@yahoo.com.mx, davidenen@yahoo.com.mx

Other authors / Otros autores:
Miguel Adame González, J. Jesús Sigala Rodríguez & María del Refugio Vacío de la Torre

Resumen
Presentamos un panorama de la distribución y la invasividad potencial de especies exóticas en el territorio del estado de Zacatecas, utilizando los estudios florísticos de regiones del estado y los datos de la colección botánica del Herbario de la Universidad Autónoma de Zacatecas. El estado se ubica en la porción centro-norte de la República Mexicana, entre los 21º04' y 25º09' N y los 100º40' y 104º19' O. El clima predominante en el territorio es seco; en las regiones altas de las sierras es templado y en pequeñas regiones del sur de la entidad es cálido. Se distinguen seis diferentes tipos de vegetación: selva baja caducifolia, bosque de pino-encino, bosque de pino, matorral crasicaule, matorral desértico micrófilo y pastizal. De la revisión de literatura se registró para el Estado una lista de 107 especies de plantas invasoras. En los sitios analizados se encontró en el Cerro la Cantarilla (Municipio de Moyahua) un 9.3% de las especies, en el cerro Las Ventanas (Juchipila) un 4.6%, en la Presa San Pedro (Cuauhtémoc) un 9.3%, en el Parque Natural Sierra de Órganos (Sombrerete), y 42.9% en el área agrícola del municipio de Zacatecas. Los ecosistemas que se encuentran en estos sitios son: selva baja caducifolia en los dos primeros sitios; matorral crasicaule, matorral desértico micrófilo y bosque de encino en el tercero y bosque de pino-encino y pastizal en el último. En la mayoría de los sitios se observa un porcentaje muy bajo de especies presentes y la abundancia es escasa. Sólo en el área agrícola del municipio de Zacatecas se puede apreciar un porcentaje alto de especies invasivas con poblaciones abundantes. De una encuesta realizada a los pobladores de la región se encontró que Brassica rapa, Malva parviflora, Chenopodium album y Taraxacum officinale tienen alta importancia económica.

Abstract
We present a panorama of the distribution and potential invasiveness of exotic species in the state of Zacatecas, using floristic studies of the regions of the state and data from the botanic collection of the Herbarium of the Autonomous University of Zacatecas. The state is located in a central – northern portion of the country between the los 21°04’ y 25°09’ N y los 100°40’ y 104°19’ W. The predominant climate in the territory is dry, in the high regions it is temperate and in small southern regions it is warm. Six types of vegetation can be distinguished: tropical perennial forest, pine-oak forest, pine forest, shrubland and grassland. The number of invasive species reported in literature for the state is 107. In the analyzed sites the distribution was: 9.3% of species in Cerro la Cantarilla (Moyahua municipality) 9.3% of species in cerro Las Ventanas (Juchipila), 4.6%, en la San Pedro Dam (Cuauhtémoc), 2.8% in the Natural Park Sierra de Órganos (Sombrerete), and 42.9% in the agricultural area of the municipality of Zacatecas. The ecosystems found in these sites are tropical perennial forests in the first two sites; shrubland and oak forest in the third and, pine-oak -pine forest and grassland in the last one. Most of these sites have a low percentage of species present and the abundance is low. Only in the agricultural area of the municipality of Zacatecas is it easy to see a high percentage of invasive species with abundant populations. Of a poll carried out on the inhabitants of the region it was found that Brassica rapa, Malva parviflora, Chenopodium album y Taraxacum officinale have a high economic importance.

Presentation summary
Zacatecas is located in the north-central portion of Mexico, between 21°04’ and 25°09’ north and 100°40’ and 104°19’ west. It has a surface of 74,668 km², which comprises 3.7% of the total surface of the country (INEGI, 1981). In the state's territory the physiographic provinces of the Sierra Madre Occidental, Sierra Madre
Oriental, Altiplanicie and Eje Neovolcánico converge. The Sierra Madre Occidental province includes the southeast portion of the state and covers 39% of the total surface. Physiographically, the province consists of a series of sierras and volcanic plateaus very near to each other that form valleys and deep canyons, oriented northeast to southeast. All these provinces are formed of extrusive igneous rock accompanied by small regions of continental sedimentary rock that rest discordingly over the igneous. 16% of the area of the state of Zacatecas corresponds to the Sierra Madre Oriental, forming its northeastern portion. This province is made up mainly of marine sedimentary rocks (Ferrusquia-Villafranca, 1998). The Plateau occupies 44% of the state’s total surface and makes up a large portion of central Zacatecas. It is characterized by its extensive valleys interrupted by scattered sierras. The valleys are located between 2,000 and 2,200 m.a.s.l and the sierras reach up to 2,980m. The transverse volcanic belt province is represented in the state by a very small region which makes up just 0.84% of its surface. It includes part of the southern region of the state where municipalities like Nochistlán share their borders with Jalisco and Aguascalientes states.

The climates occur as follows: 69% of the state has a dry and semi dry climate, 17% is sub humid temperate towards the west, 6 % is very dry and occurs in the north and northeast region. The remaining 4% is a warm sub humid climate found to the south and southeast, near the border with Jalisco (INEGI, 1981).

Six vegetation types are distinguishable: temperate deciduous forest, oak forest, pine- oak forest, crasicaule shrubland, microphilic desert shrubland and grassland (Challenger y Soberón, 2008). The temperate deciduous forest is located in the valleys and gorges in the southeastern region corresponding to the Sierra Madre Occidental, at altitudes from 1000 to 1400 asl; the oak and pine oak forests are found in the sierras in mainly temperate regions; the matorral desértico crasicaule is located mainly on the plateau; the microphilic desert shrubland is located mainly to the northeast part of the state, covering part of the plateau and the Sierra Madre Oriental. The grassland is concentrated on a belt between the plateau and the Eastern slopes of Sierra Madre Occidental. 107 invasive plant species have been reported for Zacatecas (UNIBIO, 2012; Villaseñor y Espinosa-García, 2004) (see Table 35: Appendix).

**Cerro La Cantarilla, Moyahua Municipality**

Cerro La Cantarilla is found in the region known as “Cañón de Juchipila”, in the southeastern part of the state of Zacatecas. It is located 205 km to the south of the city of Zacatecas on the Méx. 54 road on the Moyahua-Ixtlahuacán del Río segment and is 8.5 km to the south of the exit from Moyahua. This cerro is located in 21°12’ north and 103°10’ west. It climbs from 1145 asl to a maximum altitude 1300 asl.

The use of this cerro is mainly cattle and sheep grazing. There is also temporary agricultural exploitation and small scale wood extraction.

The vegetation that occupies the larger part of this area is tropical deciduous forest (53%); induced grassland (23.3%), and the rest corresponds to areas reserved for agriculture. Some of the species that can be found in the tropical deciduous forest are in the following genera: Bursera, Ceiba, Guazuma, Lysiloma, Acacia, Caliandra, Coursetia, Croton, Dalembertia, Lippia, Sida, Gaudichaudia and Opuntia. In the grassland there is also Aristida ternipes, Chloris virgata, Digitaria ciliaris, Carminatia tenuiflora, Opismenus burmanni and Paspalum arsenei. The induced grassland is composed mostly of Pennisetum ciliare and is mainly established on the south facing slope and in a small portion of the flat surface of the cerro.

At this site 14 invasive plant species have been reported, representing 13.8% of the state total (see Appendix).

**Cerro Las Ventanas, Juchipila municipality**

Cerro Las Ventanas is located 5 km southwest of the town of Juchipila and 1km west of the community El Remolino; the area it encompasses is in the following coordinates: 21° 21’ 35”- 21° 21’ 55” latitude and 103° 07’ 46”-103° 08’ 46” longitude (Figure 1); it has an area of 453.2 hectares and its elevation above sea level fluctuates from 1280 to 1400 m. Cerro las Ventanas is delimited in the west by sierra de Morones, with its highest elevation at 2 280 m a.s.l; in the east by sierra Nochistlán; in the western margin the Juchipila river runs bordering cerro las Ventanas to the south (CETENAL, 1974a).

The vegetation that covers most of cerro Las Ventanas is tropical deciduous forest (CETENAL, 1974b). Among the arboreal species in this vegetation type are: Ceiba...
acuminata, Bursera fagaroides, Bursera penicillata, Bursera palmeri, Bursera schlechtendalii, Ipomoea in-trapilosa, among others; in the shrub stratum we have Buddleja sessiliflora, Tournefortia densiflora, Mimosa monancistra, Zapoteca formosa, Agonandra racemosa y en el estrato herbáceo Anoda crenatiflora, Cuphea lanceolata, Salvia tilijfolia, Melilotus indicus, Mille-ricia quinqueflora, Eragrostis tephrosanthes, Polypogon monspeliensis and Erodium cicutarium (Prieto, 2009).

In this site we can find 14 invasive plant species, representing 13.8% from the state’s total. The main economic activity in cerro las Ventanas is cattle herding but it possess potential as a touristic center due to the archaeological vestiges that can be found in the area (see Apendix).

Natural Park Sierra de Órganos, Sombrerete municipality

The study area, inside of which is the National Park Sierra de Órganos, covers an area of 792.6 ha and is ubicated in the western portion of Zacatecas state in the municipality of Sombrerete, 20 km to the North-east of the town with the same name. It belongs to the Sierra de Santa Lucía, part of the Sierra Madre Occidental in the limits of the Mexican Plateau with the following coordinates marking its borders in the following coordinates 23°44’58’’ y 23°48’29’’ latitude and 103°45’51’’ y 103°49’36’’ longitude.

Using photointerpretation, botanic collections and quantitative samplings, the vegetation types are recog- nized, defined by physonomy and dominant species: oak forest, pine-oak forest, microphyl desertic shrubland and grassland. With the last one of those, being the most affected. It is a community dominated by herbaceous plants with some compositae and Grami- nae as the most dominant. It is composed mainly of Heterosperma pinnatum, Pectis prostrata, Bouteloua gracilis, Euphorbia hirta, Melampodium sericeum, Eragrostis intermedia, Cursea diversifolia, Schkuhria pinnata, Microchloa kunthii, Dichondra argentea, Aristida adscensionis and Erodium cicutarium (Enríquez et al., 2003).

In this site, we can find 17 invasive plant species, representing the 15.8% from the state totals. This site is a natural protected area, considered as a Natural Park destined to the conservaction (see Table 35: Appendix).

San Pedro dam, municipality of Cuauhtémoc

The San Pedro dam is located in the municipality of Cuauhtémoc, in the latitude 102°23’ 30’” and longi- tude 22°27’ at 2130 m asl. It is 3.5 km west of the town of Cuauhtémoc and northeast of the Sierra Fría.

Using photointerpretation, botanic collections and quantitative samplings, the vegetation types are rec- ognized, defined by physonomy and dominant species: oak forest, spiny shrubland, grassland and aquatic vegetation.

The communities with a larger number of invasive species are:

Grassland: This type of vegetation can be found above soils in flat and open area with rolling hills. Is a community dominated by herbaceous plants where Bouteolua chondrosioides dominates forming a dense, short and uniform cover on large surfaces. Other species are present with lower abundances: Oxalis lunulata, Sanvitalia procumbens, Mecardonia procum- bens, Gomphrena serrata, Sanvitalia procumbens, Lobelia fenestralis and Evolvulus alsinoides. The upper vegetation stratus consists of Juniperus erythrocarpa, Yucca decipiens, Opuntia streptacantha, O. leucotricha, O. joconostle and O. robusta.

Aquatic vegetation: It can be found along San Pedro river and other confluen streams. In the arboreal stra- tatum there is Salix bonplandiana and S. nigra. Other species that are present are: Lemna gibba (floating), Hydrocotyle ranunculoides and H. verticillata (rooted with floating leaves), Eleocharis spp., Mimulus glab- ratus and Ranunculus petiolaris (rooted emergent). Among the subaquatic plants that grow in the mar- gins of the water body we have Cyperus niger, Polygo- num hydropiperoides, Rumex pulcher, R. crispus, Roripa nasturtium-aquaticum, Soliva anthemifolia and Sisyrinchium convolutum.

There are 21 species of invasive plants in this locality, representing the 19.6% from the total in the state. The ecosystem with the largest number of invasive species is the aquatic one, represented by the dam itself (see Appendix).

Agricultural region of the municipality of Zacatecas

The municipality of Zacatecas is located between 22°38’ and 22°50’ of latitude and the meridians
102°32’ y 102°50’ or the 0.59% from the total Zacatecas state area. The vegetation of the area is diagnosed as crasicaule shrubland with species as *Opuntia streptacantha*, *Opuntia leucotricha*, *Opuntia rastrera*, *Opuntia imbricata*, *Prosopis laevigata* and *Acacia schaffneri*. There are also elements that are typical of grasslands, like *Bouteloua gracilis*, *Bouteloua curtipendula* and *Dalea bicolor*.

In this study the economic importance of the weed plants in the agricultural región of the municipality of Zacatecas was evaluated obtaining the value of use. To that end the region was explored and the weeds that were found were collected. 302 species were identified. Interviews were also carried on with the local habitants of the region to know the ways they were using the species. From the interviews, 40 species of weeds were selected based the frequency of use. The analysis of the results points to some invasive species like *Brassica rapa*, *Malva parviflora*, *Chenopodium abum* and *Taraxacum officinale* with high economic importance. This study is the first work that sheds light on the use of the weed in the state. In the municipality of Zacatecas, the plants that are used as food for domestic animals are the ones with higher use value and are importants because complement the food for the cattle. Most of the weeds mentioned in the surveys have a medicinal use.

There are 46 invasive plant species in this locality, which makes the 42.9% of the state total (see Table 35: Appendix).

**Herbarium of the Universidad Autónoma de Zacatecas**

The herbarium of the Universidad Autónoma de Zacatecas is located in the Unidad Académica de Agronomía on km 15.5 of the Zacatecas-Guadalajara road. It houses a collection of 18,000 specimens and represents around 2,600 of the vascular plants that grow in the state of Zacatecas. According to the records found in the Herbarium, the most collected species are *Sonchus oleraceus* in 26 municipalities, of a total of 58 into which the state is divided; *Eruca sativa* in 20; *Taraxacum officinale*, *Salsola tragus* and *Nicotiana glauca* in 16; *Reseda luteola*, *Pennisetum ciliare* and *Cynodon dactylon* in 15, and *Malva parviflora* in 14.

In this study are included 87 invasive alien plant species that represent 81.3% of all those reported for the state.

**References**


Table 35. Annex
Invasive plant species reported for the state of Zacatecas, their presence in the flora of some localities are represented in the Herbarium of the Autonomous University of Zacatecas.

<table>
<thead>
<tr>
<th>Species</th>
<th>Agricultural región of the municipality of Zacatecas</th>
<th>UAZ Herbarium</th>
<th>Cerro Las Ventanas</th>
<th>Presa San Pedro</th>
<th>Parque Natural Sierra de Órganos</th>
<th>Cerro La Cantarilla</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agrostis hyemalis</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Ambrosia artemisiifolia</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Anagallis arvensis</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Arundo donax</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Asphodelus fistulosus</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Atriplex canescens</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Atriplex semibaccata</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Avena fatua</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Avena sativa</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Brassica geniculata</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Brassica nigra</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Brassica rapa</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Bromus catharticus</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Cannabis sativa</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Capsella bursa-pastoris</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Casuarina equisetifolia</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Chenopodium album</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Chloris gayana</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Chloris virgata</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Convolvulus arvensis</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Conyza bonariensis</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Cynodon dactylon</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Cyperus esculentus</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Cyperus rotundus</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Dactyloctenium aegyptium</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Digitaria ciliaris</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Digitaria sanguinalis</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Digitaria setigera</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Digitaria ternata</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Eichhormia crassipes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Echinochloa colona</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Echinochloa crus-galli</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Eleusine indica</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Eleusine multiflora</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Eragrostis ciliarisens</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Species</td>
<td>Agricultural región of the municipality of Zacatecas</td>
<td>UAZ Herbarium</td>
<td>Cerro Las Ventanas</td>
<td>Presa San Pedro</td>
<td>Parque Natural Sierra de Órganos</td>
<td>Cerro La Cantarilla</td>
</tr>
<tr>
<td>--------------------------</td>
<td>------------------------------------------------------</td>
<td>---------------</td>
<td>-------------------</td>
<td>----------------</td>
<td>----------------------------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>Eragrostis curvula</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eragrostis lehmanniana</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eragrostis superba</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Erodium cicutarium</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eruca sativa</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eucalyptus globulus</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Festuca arundinacea</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Festuca rubra</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ficus carica</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hackelochloa granularis</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Hordeum jubatum</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hordeum vulgare</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kochia scoparia</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lactuca serriola</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leonotis nepetifolia</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lepidium virginicum</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Lolium multiflorum</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lolium perenne</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Malva parviflora</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Marrubium vulgare</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medicago lupulina</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medicago polymorpha</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medicago sativa</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Melia azederach</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Melilotus albus</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Melilotus indicus</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Nerium oleander</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nicandra physalodes</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Nicotiana glauca</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Nicotiana tabacum</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Panicum antidotale</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pennisetum ciliare</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Pennisetum clandestinum</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pennisetum villosum</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Penstemon campanulatus</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phalaris canariensis</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phalaris paradoxa</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pistia stratiotes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plantago lanceolata</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Species</td>
<td>Agricultural región of the municipality of Zacatecas</td>
<td>UAZ Herbarium</td>
<td>Cerro Las Ventanas</td>
<td>Presa San Pedro</td>
<td>Parque Natural Sierra de Órganos</td>
<td>Cerro La Cantarilla</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>------------------------------------------------------</td>
<td>---------------</td>
<td>--------------------</td>
<td>-----------------</td>
<td>----------------------------------</td>
<td>---------------------</td>
</tr>
<tr>
<td><em>Plantago major</em></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td><em>Plantago ovata</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Poa annua</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td><em>Polygonum argyrocoleon</em></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Polygonum aviculare</em></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td><em>Polygonum convolulus</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Polygonum hydropiperoides</em></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Poa annua</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Polygonum monspelliensis</em></td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Portulaca oleracea</em></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td><em>Potamogeton crispus</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Rapistrum rugosum</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Reseda luteola</em></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td><em>Rhnchelytrum repens</em></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td><em>Ricinus communis</em></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td><em>Rorippa nasturtium-aquaticum</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td><em>Rumex acetosella</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td><em>Rumex crispus</em></td>
<td></td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td><em>Ruta chalepensis</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Salvia tragus</em></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td><em>Schinus molle</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td><em>Setaria adhaerens</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td><em>Sisymbrium irio</em></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Sonchus oleraceus</em></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td><em>Sorghum bicolor</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td><em>Sorghum halepense</em></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td><em>Taraxacum officinale</em></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td><em>Tragus berteronianus</em></td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Tribulus terrestris</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Tropaeolum majus</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td><em>Urochloa panicoides</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Vulpia myuros</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td><em>Xanthium strumarium</em></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>
Mexican Aquatic Weeds: Distribution and Importance
Malezas acuáticas mexicanas, distribución e importancia

Jaime Raúl Bonilla-Barbosa
Researcher / Investigador
Hydrobotany Laboratory, Department of Plant Biology / Laboratorio de Hidrobotánica, Departamento de Biología Vegetal
Center for Biological Research of the Autonomous University of Morelos State (cib-uaem) / Centro de Investigaciones Biológicas, UAEM
Av. Universidad 1001, Col. Chamilpa. 62209 Cuernavaca, Morelos, México
bonilla@uaem.mx

Resumen
México es un país con gran variedad de ecosistemas acuáticos que han permitido el desarrollo de especies de plantas tanto nativas como introducidas. Estas últimas, son la mayor amenaza para la diversidad biológica en estos ambientes ya que su introducción (intencional, accidental o natural) se manifiesta con un comportamiento invasivo o malezoide causándoles graves daños. De las aproximadamente 730 especies de plantas vasculares y vertebrados invasores registrados en México, actualmente existen 42 especies de plantas acuáticas consideradas “malezas” que están afectando los ecosistemas en todo el territorio nacional, tal es el caso de las hidrófitas enraizadas sumergidas como Egeria densa y Stuckenia pectinata, hidrófitas enraizadas emergentes como Typha domingensis o T. latifolia, o las hidrófitas libremente flotadoras como Eichhornia crassipes, Pistia stratiotes o Salvinia molesta, entre otras. Su alta tasa reproductiva y adaptativa, así como la gran concentración de nutrientes en los cuerpos de agua provenientes de la actividad agrícola, urbana e industrial, y la ausencia de enemigos naturales que puedan ejercen un control han tenido como consecuencia un crecimiento explosivo de estas plantas, las que llegan a cubrir por completo numerosos cuerpos de agua del país (lagos, presas, bordos, ríos, manantiales, etc.). Los impactos ambientales que ocasionan incluyen cambios en la estructura y composición de las comunidades acuáticas y del ecosistema, su funcionamiento, así como el desplazamiento, disminución y extinción de especies nativas. El crecimiento desmedido de estas especies conlleva impactos económicos negativos (gasto invertido en su control o erradicación) y en otros casos positivos (uso de especies con diversos fines, artesanal, forrajero, alimentario, medicinal, restauración ambiental, entre otros). La presente contribución muestra el estado actual de las malezas acuáticas presentes en México incidiendo en los puntos antes indicados, señalando las necesidades de estrategias de investigación y de vinculación que puedan ser apropiadas en los ámbitos regional y nacional.

Abstract
México is a country with a great variety of aquatic ecosystems that have allowed the development of native and introduced plant species. These last are the greatest threats for biological diversity in these environments given that their introduction (intentional, accidental or natural) is manifested as invasive or weedy behavior causing damages. Of the approximately 730 species of vascular plants and invasive vertebrates registered in Mexico, there are currently 42 aquatic plant species considered “weeds” that are affecting ecosystems in national territory, this is the case of rooted submerged hydrophytes such as Egeria densa and Stuckenia pectinata, rooted emerged hydrophytes such as Typha domingensis or T. latifolia or freely floating hydrophytes such as Eichhornia crassipes, Pistia stratiotes or Salvinia molesta, among others. Their high reproductive and adaptive rates, as well as the large concentration of nutrients in water bodies coming from agricultural, urban and industrial activities, and the absence of natural enemies have had as a consequence an explosive growth of these plants, which can completely cover numerous water bodies of the country (lakes, dams, rivers, springs, etc.).

The environmental impacts caused include changes in the structure and composition of aquatic and ecosystem communities, their functions and the displacement, loss and extinction of native species. The unrestricted growth of these species has negative economic impacts (investment in control or eradication) and in other cases positive impacts (species with uses such as handicraft, forage, food, medicine, environmental restoration, among others). This presentation shows the current state of the aquatic weeds in Mexico incurring in the previously mentioned points, signaling the needs of research and collaboration strategies that can be appropriate at the regional and national level.
**Presentation summary**

**Introduction**

Biological invasions are the second most important factor in the eradication or extinction of native species, many of these become weeds that cause important economic losses due to their negative effects on the services that humans obtain from the terrestrial or aquatic ecosystems that become infested and they are one of the most serious threats for biodiversity (Vitousek *et al.*, 1996; Lonsdale, 1999).

The term aquatic weed has been defined in several ways, it usually applies to the group of plants that constitute a “problem” in the use of water bodies or when the populations of theses plants exceed 35% of the surface of the water body. A weed is also considered to be any type of vegetation that because of its accelerated growth and reproduction can cause important ecological unbalances in the ecosystem (Pieterse, 1990; Acosta y Agüedo, 2006).

Several of the species of weeds are considered as the most destructive invasive species both economically and biologically (Holm *et al.*, 1977). Even though many aquatic plants do not cause any harm upon introduction to aquatic ecosystems, with time they adapt and in absence of natural enemies they quickly multiply in the new media and spread invading other natural ecosystems (Williamson, 1996).

During the last four decades, freshwater in Mexico have been affected due to the introduction of aquatic hydrophytes since upon naturalization and lack of natural enemies, reproduce and displace native aquatic flora (Champion, 2004). The introduction of invasive aquatic species has been identified as one of the main environmental risks facing species, aquatic habitats and biodiversity in general (Hopkins, 2001). The growth of aquatic species and among many of them the exotic ones, has been associated with the extinction of 54% of the cases of native aquatic fauna worldwide (Harrison y Stiassny, 1999), of the 70% of fish in Northamerica (Lassuy, 2002) and 60% of Mexican fish (Contreras, 1999).

In general, the studies on weeds in Mexico are still poor, most are of agricultural nature, related to the control and management of many introduced species that are considered pests, and in a lower number biological and ecological where they mostly deal with floristic aspects and other that provide information about the percentage of plants with weedy growth. In addition, the studies that are related to the distribution of introduced exotic weeds and their implications in Mexico are also few and it is unknown how many exotic species are established in Mexico and where they are distributed (Espinosa y Sarukhán, 1997; Villaseñor y Espinosa, 1998).

The little knowledge of aquatic weeds in Mexico and the need to manage them or forbid their expansion in the country makes it necessary to carry out an inventory of both native and exotic species distribution for species that are already in the country. Therefore the current contribution is focused on inventory, distribution and importance of this group of plants both native and exotic as part of the aquatic flora in the country.

**Aquatic weed diversity in Mexico**

Mexico has approximately 25,000 species of plants, 2.5% of them are aquatic. Of these aquatic weeds have an important role in the flora with 29 families, 42 genera, 59 species, 2 subspecies and one variety both in ferns and similar plants and aquatic angiosperms (monocots and dicots) (Table 36).

It is important to mention that in Mexico there are at least 800 invasive exotic species of which 665 are plants (March y Martínez, 2007), so that the majority of aquatic plants that behave as weeds are not native to our country, such is the case of the water hyacinth (*Eichhornia crassipes*), giant salvinia (*Salvinia molesta*), Hydrilla (*Hydrilla verticilata*), among other species introduced to Mexico. Other important species that can be mentioned for our country as weeds are *Pistia stratiotes*, *Typha domingensis*, *Ludwigia peploides*, *Stuckenia pectinata*, *Najas guadalupensis*, *Egeria densa*, *Schoenoplectus californicus* and *Nymphaea ampla*, among others.
Table 36. Families, genera and species of aquatic weeds present in Mexico with common names in Spanish.

<table>
<thead>
<tr>
<th>Family/Species</th>
<th>Common Name</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FERNS AND RELATED PLANTS</strong></td>
<td></td>
</tr>
<tr>
<td>Equisetaceae Rich.</td>
<td></td>
</tr>
<tr>
<td><em>Equisetum hyemale</em>  L. subsp. <em>affine</em> (Engelm.) Calder et Roy L. Taylor</td>
<td>“carrillo”, “cañuela”, “cola de caballo”</td>
</tr>
<tr>
<td>Salvinia Rchb.</td>
<td></td>
</tr>
<tr>
<td><em>Azolla filiculoides</em> Lam.</td>
<td>“helechito de agua”</td>
</tr>
<tr>
<td><em>Salvinia minima</em> Baker</td>
<td>“oreja de ratón”</td>
</tr>
<tr>
<td><em>Salvinia molesta</em> Mitchell</td>
<td>“helecho de agua”, “oreja de ratón”, “salvinia”</td>
</tr>
<tr>
<td><strong>ANGIOSPERMS: MONOCOTS</strong></td>
<td></td>
</tr>
<tr>
<td>Araceae Juss.</td>
<td></td>
</tr>
<tr>
<td><em>Pistia stratiotes</em> L.</td>
<td>“helecho flotador gigante”, “lechuga de agua”, “lechuguilla acuática”, “lechuguilla de agua”, “repollo de agua”</td>
</tr>
<tr>
<td>Cyperaceae Juss.</td>
<td></td>
</tr>
<tr>
<td><em>Cyperus articulatus</em> L.</td>
<td>“chintul grande”, “chintule”, “junco”, “tule”, “tule redondo”</td>
</tr>
<tr>
<td><em>Cyperus papyrus</em> L.</td>
<td>“papiro”</td>
</tr>
<tr>
<td><em>Eleocharis elegans</em> (Kunth) Roem. &amp; Schult.</td>
<td>Desconocido</td>
</tr>
<tr>
<td><em>Schoenoplectus americanus</em> (Pers.) Volkart ex Schinz &amp; Keller</td>
<td>“tule ancho”</td>
</tr>
<tr>
<td><em>Schoenoplectus californicus</em> (C. A. Mey.) Sojak</td>
<td>“tule ancho”, “tule bofo”</td>
</tr>
<tr>
<td>Hydrocharitaceae Juss.</td>
<td></td>
</tr>
<tr>
<td><em>Egeria densa</em> Planch.</td>
<td>“elodea”</td>
</tr>
<tr>
<td><em>Hydrilla verticillata</em> (L. f.) Royle</td>
<td>“hydrila”, “tomillo de agua”</td>
</tr>
<tr>
<td>Lemnaceae A. Gray</td>
<td></td>
</tr>
<tr>
<td><em>Lemma aquinocitialis</em> Welw.</td>
<td>“lenteja de agua”, “lentejita de agua”</td>
</tr>
<tr>
<td><em>Lemma gibba</em> L.</td>
<td>“chichicastle”, “lenteja de agua”</td>
</tr>
<tr>
<td><em>Lemma obscura</em> (Austin) Daubs</td>
<td>“lenteja de agua”</td>
</tr>
<tr>
<td><em>Wolffia brasiliensis</em> Wedd.</td>
<td>“lentejita de agua”</td>
</tr>
<tr>
<td>Marantaceae Petersen</td>
<td></td>
</tr>
<tr>
<td><em>Thalia geniculata</em> L.</td>
<td>“chantó”, “hoja de campo”, “hoja de lengua”, “hoja de queso”, “platanillo”, “papai”, “popai”, “quentó”</td>
</tr>
<tr>
<td>Najadaceae Juss.</td>
<td></td>
</tr>
<tr>
<td><em>Najas guadalupensis</em> (Spreng.) Magnus var. <em>guadalupensis</em></td>
<td>“bosque de agua”</td>
</tr>
<tr>
<td><em>Najas marina</em> L.</td>
<td>“sierrilla”</td>
</tr>
<tr>
<td>Poaceae Barnhart</td>
<td></td>
</tr>
<tr>
<td><em>Arundo donax</em> L.</td>
<td>“caña gigante”, “carrillo”, “carrizo del agua”, “carrizo gigante”</td>
</tr>
<tr>
<td><em>Glyceria fluviatilis</em> (L.) R. Br.</td>
<td>Desconocido</td>
</tr>
<tr>
<td><em>Hymenachne amplexicaulis</em> (Rudge) Nees</td>
<td>“tuetillo”</td>
</tr>
<tr>
<td>Family/Species</td>
<td>Common Name</td>
</tr>
<tr>
<td>----------------</td>
<td>-------------</td>
</tr>
<tr>
<td><em>Phragmites australis</em> (Cav.) Trin. ex Steud.</td>
<td>“carrizo común”</td>
</tr>
</tbody>
</table>

**Pontederiaceae** Kunth

*Eichhornia azurea* (Sw.) Kunth

“camalote”, “cola de pato”, “cucharilla de pato”, “pico de pato”

*Eichhornia crassipes* (C. Mart.) Solms.


*Heteranthera limosa* (Sw.) Willd.

“cucharilla”

**Potamogetonaceae** Dumort.

*Potamogeton crispus* L.

“sierrita”

*Stuckenia pectinata* (L.) Börner

“achorícillo cambrai”, “apatle”, “bosque de agua”, “cola de caballo”, “grama”, “grazna”, “lama corriente”, “zacatillo acuático”

**Ruppiaceae** Hutch.

*Ruppia maritima* L.

“cintita”

**Typhaceae** Juss.

*Typha domingensis* Pers.


*Typha latifolia* L.

“chuspata”, “espadaña”, “junco”, “masa de agua”, “plumilla”, “tule”, “tule ancho”

**ANGIOSPERMS: DICOTS**

**Acanthaceae** Juss.

*Hygrophila polysperma* (Roxb.) T. Anderson

Desconocido

**Amaranthaceae** Juss.

*Alternanthera philoxeroides* (Mart.) Griseb.

“maleza caimán”

**Apiaceae** Lindl.

*Berula erecta* (Huds.) Coville

“berro”, “choruri”, “palmita de agua” “queza-pijchi”

**Brassicaceae** Burnett

*Rorippa nasturtium-aquaticum* (L.) Hayek

“berro”, “berro de agua”, “cresón”

**Ceratophyllaceae** A. Gray

*Ceratophyllum demersum* L.

“cola de mapache”, “cola de zorra”, “mienrama de agua”

**Haloragaceae** R. Br.

*Myriophyllum aquaticum* (Vell.) Verdc.

“cola de zorra acuática”, “mil hojas acuática”, “praderita de agua”

**Lentibulariaceae** Rich.

*Utricularia gibba* L.

“utricularia”

**Lythraceae** J. St. Hil.

*Lythrum salicaria* L.

“salicaria purpúra”

**Menyanthaceae** Dumort.

*Nymphoides fallax* Ornduff

“lirio”

*Nymphoides indica* (L.) Kuntze

“camalotillo”, “estrella de agua”
<table>
<thead>
<tr>
<th>Family/Species</th>
<th>Common Name</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mimosaceae</strong></td>
<td></td>
</tr>
<tr>
<td><em>Mimosa pigra</em> L.</td>
<td>“zarza”</td>
</tr>
<tr>
<td><em>Neptunia natans</em> (L. f.) Druce</td>
<td>“mimosa”, “sensitiva”</td>
</tr>
<tr>
<td><em>Neptunia pubescens</em> Benth.</td>
<td>“mimosa”, “sensitiva”</td>
</tr>
<tr>
<td><em>Sesbania herbacea</em> (P. Mill.) McVaugh</td>
<td>Desconocido</td>
</tr>
<tr>
<td><strong>Nymphaeaceae</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Onagraceae</strong></td>
<td></td>
</tr>
<tr>
<td><em>Ludwigia peploides</em> (Kunth) P. H. Raven subsp. <em>peploides</em></td>
<td>“verdolaga de agua”</td>
</tr>
<tr>
<td><strong>Polygonaceae</strong></td>
<td></td>
</tr>
<tr>
<td><em>Polygonum acuminatum</em> Kunth</td>
<td>“chilillo”</td>
</tr>
<tr>
<td><em>Polygonum amphibium</em> L.</td>
<td>“chilillo ancho”</td>
</tr>
<tr>
<td><em>Polygonum hydropiperoides</em> Michx.</td>
<td>“chilillo”</td>
</tr>
<tr>
<td><em>Polygonum lapathifolium</em> L.</td>
<td>“ananash”, “chilillo”</td>
</tr>
<tr>
<td><em>Polygonum punctatum</em> Elliot</td>
<td>“ananash”, “chilillo”, “chilillo de perro”, “matapulga”</td>
</tr>
<tr>
<td><em>Rumex conglomeratus</em> Murr.</td>
<td>“lengua de vaca”</td>
</tr>
<tr>
<td><strong>Scrophulariaceae</strong></td>
<td></td>
</tr>
<tr>
<td><em>Limosella aquatica</em> L.</td>
<td>Desconocido</td>
</tr>
<tr>
<td><strong>Solanaceae</strong></td>
<td></td>
</tr>
<tr>
<td><em>Datura ceratocaula</em> Ort.</td>
<td>“toloache”, “toloache de agua”, “tornaloca”</td>
</tr>
<tr>
<td><strong>Sphenocleaceae</strong></td>
<td></td>
</tr>
<tr>
<td><em>Sphenoclea zeylanica</em> Gaertn.</td>
<td>“chile camarón”</td>
</tr>
</tbody>
</table>

203
**Classification of aquatic weeds in Mexico**

Based on the life form classification of vascular aquatic plants proposed by Lot et al. (1999), Bonilla-Barbosa et al. (2000), Bonilla-Barbosa (2004, 2007) and which is currently the most accepted and used in Mexico, aquatic weeds are classified in this contribution in six categories divided among two large groups: 1) those that are rooted to the substrate and 2) those that are not rooted to the substrate.

**GROUP 1. Rooted to the Substrate**

**Emergent Rooted Weeds:** these plants are rooted to the substrate with their stems and part of their vegetative structures submerged, while part of the leaves and reproductive organs are above the surface of the water. Some representatives of this group are: Alhagi nodosa, Arundo donax, Mimosa pigra, Phragmites australis, Schoenoplectus americanus, S. californicus, Thalia geniculata, Typha domingensis y T. latifolia, among others.

**Submerged rooted weeds:** these plants are rooted to the substrate with all their vegetative structures under the water level, while in some species the reproductive organs can be submerged, while in others they are above the surface of the water. This group is characterized by species such as Egeria densa, Hydrilla verticillata, Hygrophila polysperma, Myriophyllum aquaticum, Najas guadalupensis var. guadalupensis, Najas marina, Potamogeton crispus, Rippia maritima and Stuckenia pectinata.

**Rooted weeds with floating leaves:** these plants are rooted to the substrate and so are their stems, pecioles and peduncules, while their leaves float on the water surface and their reproductive structures are above the water, although the fruit matures at the bottom of the water body. Characterized by species such as Nymphaea ampla, N. mexicana, N. pulchella, Nymphoides fallax and N. indica.

**Rooted weeds of prostrated stem:** these plants are rooted in the substrate while their stems float above the surface of the water and their vegetative structures (pecioles and leaves) and the reproductive structures (flowers and fruits) develop above the stem. It is characterized by species such as Ludwigia peploides subsp. peploides, Neptunia natans and N. pubescens.

**GROUP 2. Not Rooted to the Substrate**

**Free floating Weeds:** these plants are characterized because their roots are only submerged under the water surface while the rest of the vegetative and reproductive organs remain floating above the water level. Some of the species in this group are Azolla filiculoides, Eichhornia azurea, E. crassipes, Lemna aequinoctialis, L. gibba, L. obscura, Pistia stratiotes, Salvinia minima, S. molesta and Wolffia brasiliensis.

**Free submerged Weeds:** these plants are characterized because they don't have a radical system and all its vegetative structures are either submerged or under the water level, while their reproductive organs are above it. Some species characteristic of this group are Ceratophyllum demersum and Utricularia gibba.

**Distribution**

Aquatic plants can be dispersed around the world through different routes (Figuerola and Green, 2002) and with varying frequency, in the case of aquatic weeds many has contributed to their dispersal (Dutartre y Capdevielle, 1982), in such a way that several hydrophytes used for decoration in aquaria and botanic gardens have been distributed in regions far from their place of origin (Champion, 2004; Rixon et al., 2005), and have become an issue of biosafety.

Among the studies related to weeds in Mexico there are a few that stand out such as the Weed handbook of the Valley of Mexico (Espinosa and Sarukhán, 1997) and the Catalogue of weeds of Mexico (Villaseñor y Espinosa, 1998), that give an idea of the percentage of plants that have been introduced into the country. The studies related to the distribution of introduced exotic weeds and their implications in Mexico are few (Rzedowski and Rzedowski, 1990), and it is not certain how many have established themselves in Mexico. The following lines show the general distribution of each weed species in the country based upon a literature review (McVaugh, 1987; Novelo and Martínez, 1989; Palacios-Rios, 1992; McVaugh, 1993; Novelo and Lot, 1994; Bonilla-Barbosa and Novelo, 1995; Diego-Pérez, 1997; Espinosa and Sarukhán, 1997; Novelo and Ramos, 1998, Villarreal, 1998; Villaseñor and Espinosa, 1998; Bonilla-Barbosa, 2000; Espejo and López-Ferrari, 2000; Arrivillaga, 2002; Arreguin-Sánchez et al., 2004; Martínez, 2005; Novelo, 2005; Zamudio, 2005; Grether, 2007; Castillejos and Solano, 2008; Mora et al., 2008; Steinmann, 2008; Bonilla-Barbosa and Santamaría, 2010; Pérez-Calix, 2011; Bonilla-Barbosa and Santamaría, 2012) and mostly...
with botanical specimens deposited in herbaria both national and international.

Most aquatic plants that behave as weeds are not native to the countries where they cause problems, therefore the species of aquatic weeds of wide distribution in Mexico that stand out are *Arundo donax*, *Equisetum hyemale* subsp. *affine*, *Cyperus articulatus*, *Eichhornia crassipes*, *Heteranthera limosa*, *Lemma gibba*, *Ludwigia peploides* subsp. *peploides*, *Najas guadalupensis* var. *guadalupensis*, *Phragmites australis*, *Polygonum hydropiperoides*, *P. punctatum*, *Rorippa nasturtium-aquaticum*, *Ruppia maritima*, *Typha domingensis*, *T. latifolia* and *Utricularia gibba* that covers bodies of water such as dams, lakes, canals, creeks and lagoons.

It is important to mention that there are aquatic weed species that do not have a wide territorial distribution but do infest large geographic areas in several aquatic ecosystems, among them *Azolla filiculoides*, *Berula erecta*, *Ceratophyllum demersum*, *Cyperus papyrus*, *Datura ceratocaula*, *Egeria densa*, *Hydrilla verticillata*, *Hymenachne amplexicaulis*, *Lemma aquinotialis*, *Limosella aquatica*, *Mimosa pigra*, *Najas marina*, *Neptunia pubescens*, *Nymphoides fallax*, *N. indica*, *Pistia stratiotes*, *Polygonum amphibium*, *P. lapathifolium*, *Rumex conglomeratus*, *Salvinia minima*, *S. molesta*, *Schoenoplectus californicus*, *Sesbania herba-cea*, *Stuckenia pectinata* and *Thalia geniculata*.

Finally, there are species that are more local and that completely infest several bodies of water, but with a more restricted distribution area, among these are *Alternanthera philoxeroides*, *Eleocharis elegans*, *Glycera fluitans*, *Hygrophila polysperma*, *Lemma obscura*, *Lythrum salicaria*, *Myriophyllum aquaticum*, *Neptunia natans*, *Nymphaea mexicana*, *Polygonum acuminatum*, *Potamogeton crispus*, *Schoenoplectus americanus*, *Sphenoclea zeylanica* and *Wolffia brasiliensis*.

In general, it has been estimated that in Mexico the surface infested by aquatic weeds in fresh water bodies is of 114,862 ha, which represents 9.2% of the flooded surface of the country, however there are 1’124,138 ha of fresh water bodies remaining that could be subject to the establishment of macrophytes if they are not properly attended to (Gómez, 1997).

**Introduction Pathways**
The introduction of plants to places far from their place of origin has been a common practice in the history of humanity. In general, colonizing movements of commercial practices have carried with them the movement of useful plants for humans. In addition to being useful plants, many species have moved inadvertently as contaminants or stowaways in different products (Mack, 1991).

Invasive aquatic species can be introduced into a new region through natural and artificial routes (Ashton y Mitchell, 1989).

Of the natural routes, species such as *Arundo donax*, *Pistia stratiotes* are quickly expanding their distribution in the wetlands of the country (March y Martínez, 2007), through sexual and vegetative reproduction. This giant reed is dispersed in clones and very rapidly displaces native vegetation growing faster than the native species (Dudley, 2000), and using three times more water per biomass unit than the native vegetation (Bell, 1997; Dudley, 2000).

Of the species that are dispersed by artificial routes the following stand out: *Egeria densa*, *Eichhornia crassipes*, *Hydrilla verticillata*, *Hygrophila polysperma* and *Salvinia molesta*, which have been introduced into Mexico by the ornate trade commerce for aquariums or they have been accompanying flora for fish, also exotic, that have been imported into the country; intentional release of organisms or propagules, although currently in our country these species are also spreading naturally (Novelo y Martínez, 1989; Villaseñor y Espinosa, 1998; Mora et al., 2008).

**Importance**
Aquatic plants that are considered weeds have been moved from one geographic place to a new one, for different purposes. In many cases they have escaped or they have been moved which has allowed them to find favourable conditions for their better development and infestation. Because some species of aquatic weeds have ecological, economic and social importance (Palacios-Ríos, 1992; Bonilla-Barbosa y Novelo, 1995; Adame-Castillo et al., 1996; Novelo y Ramos, 1998; Novelo y Bonilla-Barbosa, 1999; Mora et al., 2008; Quiroz-Flores et al., 2008), they have been introduced or translocated to several aquatic ecosystems.

**Ecological:** The role played by aquatic plants in natural ecosystems is very important since they fulfill cer-
tain functions, however with the evolutionary history of the infested ecosystem this role could be lost. Rooted aquatic weeds have been introduced to aquatic ecosystems for the purpose of environmental restoration because they are involved in the capture, stabilization and formation of sediments. This is the case of the species that hold sediment or clean water such as *Arundo donax*, *Eichhornia crassipes*, *Phragmites australis*, *Typha domingensis* and *T. latifolia*, which has allowed for their infestation and greater distribution. They also serve the purpose of being nesting grounds for birds such as *Agelaius phoeniceus* (Linnaeus) which nests in the leaves of *T. latifolia*.

**Economic:** The increase of the commercial exchange has allowed for the dispersion of exotic species and, in certain cases, their development as invasive species (Dukes and Mooney, 1999; Kowarik, 2001).

Among the economic problems, we can identify the loss of water through evapotranspiration, water quality, loss of hydroelectrical energy production, flood control, navigation, recreation, aquaculture, fisheries, sedimentation and canal obstruction (Gopal, 1987; TWCA, 2010).

Many species of aquatic weeds that affect some areas of the country carry benefits in other, for this reason instead of eradicating them they are cultivated and used to obtain economic gain and have been used for different purposes.

**Ornamental:** As part of the aquarium trade or in aquatic gardens, aquatic weeds have played an important role since they produce oxygen, provide an adequate habitat for fish and remove toxic substances from the water.

There are many aquatic weeds used for ornamental purpose and aquariums, including temperate and tropical climate species, their propagation is generally vegetative. Some of the most important ornamental species are: *Alternanthera philoxeroides*, *Ceratophyllum demersum*, *Egeria densa*, *Hydriella verticillata*, *Hygrophila polysperma*, *Lemma aequinoctialis*, *Lemma gibba*, *L. obscura*, *Lythrum salicaria*, *Myriophyllum aquaticum*, *Najas guadalupensis* var. *guadalupensis*, *Potamogeton crispus*, *Ruppia maritima*, *Salvinia molesta*, *Sphenoclea zeylanica*, *Stuckenia pectinata*, *Utricularia gibba* and *Wolffia brasiliensis*.

Among the species of plants that are most frequently used in aquatic gardens are the emergent weeds such as *Cyperus papyrus*, *Equisetum hyemale* subsp. *affine*, *Heteranthera limosa*, *Schoenoplectus californicus*, *Sphenoclea zeylanica*, *Thalia geniculata*, *Typha domingensis* y *T. latifolia*; de las malezas sumergidas destacan *Egeria densa*, *Hydriella verticillata*, *Myriophyllum aquaticum*, *Najas guadalupensis* var. *guadalupensis*, *N. marina*, *Potamogeton crispus*, *Ruppia maritima* y *Stuckenia pectinata*; de las malezas de hojas flotantes están *Nymphaea ampla*, *N. mexicana*, *N. pulchella*, *Nymphoides fallax* and *N. indica*; rooted weeds of prostrated stems used are *Ludwigia peploides* subsp. *peploides*, *Neptunia natans* and *N. pulchella*; freely floating weeds *Eichhornia azurea*, *E. crassipes*, *Pistia stratiotes*, *Salvinia minima* and *S. molesta*; and finally freely submerged weeds such as *Ceratophyllum demersum* and *Utricularia gibba*.

Ornamental aquatic weeds used for floral arrangement, carry with them in addition to aesthetic value, considerable social standing for anyone who possesses them. Of these weeds only some parts of the plant are used, whether it is the flower, the stems or the inflorescence. Within this group of plants are *Equisetum hyemale* subsp. *affine*, *Nymphaea pulchella*, *Typha domingensis* and *T. latifolia*, which are sold in well established businesses or municipal markets. Some are used in their natural state or in others like Typha species the inflorescence is colored to obtain the right tone for the floral arrangement.

**Green fertilizer:** Regarding their importance as Green fertilizers, aquatic weeds such as *Eichhornia crassipes* are an important component as substrate for tomato seedlings. This species is also used in the chinampas in Xochimilco, Mexico City while in other states of the country other hydrophites are very important for this purpose, some examples are *Azolla filiculoides*, *Eichhornia crassipes* y *Sesbania herbacea*.

**Construction:** The leaves of *Typha domingensis*, are used for roofs of huts or for tying posts together. In addition they are also used to make seats for chairs, mats, fans and hampers. The inflorescence of this species mixed with mud is used to make kitchen utensils such as the “tlecuil” or “pretil” and “comales” or hotplates.

**Handicrafts:** The sale of handicrafts made from ornamental aquatic weeds is a source of income especially
in the state of Michoacán. Among the plants used are *Eichhornia crassipes*, *Typha domingensis* and *T. latifolia*, which are sold in well established businesses or in municipal markets in various states of the country.

**Social Health:** Aquatic weeds are part of the aquatic ethnobotany, there are species such as *Equisetum hyemale* which is used as diuretic and against diabetes. *Berula erecta* and *Rorippa nasturtium-aquaticum*, are used in the state of Morelos against goiter and *Datura ceratocaula* known as aquatic toloache is used to alleviate pains and as a muscle relaxer and against asma.

**Food:** *Berula erecta* and *Rorippa nasturtium-aquaticum*, or watercress are used for food, all its vegetative organs are used and have high nutritional value. Their foliage is an acceptable ingredient for salads. Other species used in food preparation, although note aten are *Thalia geniculata*, whose leaf is used to wrap tomales, meat, fish and cheese instead of banana leaves which are more commonly used. *Phragmites australis*’ leaves are used to wrap piloncillo candies.

**Religious:** The flowers of *Nymphaea ampla*, *N. mexicana* and *N. pulchella* are used as a symbol of purity in some religious ceremonies, they are also used for good luck in shops and for protection against envies and “bad times”. The leaves of *Typha domingensis* is used to make “patches” or “huertos” during Holy week.

**Final Considerations**

Aquatic weeds have the capacity, not only of moving across a large number of routes, but also of establishing, prospering and dominating new aquatic ecosystems. They are currently the second threat to species, after loss of habitat.

Invasive aquatic plants are currently one of the main concerns for conservation at the international level so that useful initiatives that contribute to improve management practices and decrease the number of biological invasions by aquatic weeds must be carried out throughout the country and the world.

Exotic invasive species are the second cause of biodiversity worldwide, after habitat destruction (Simberloff, 2000; Krasny, 2003), the introduction of non native species to Mexico is due to human activities both intentional and accidental. Luckily in Mexico there are relatively few invasive species that cause problems in Mexico in comparison with most regions (although there is a possibility that the number of problematic species increases).

Within the list of 100 most invasive species published from a selection of the Global Invasive Species Database, are *Eichhornia crassipes*, *Salvinia molesta* and *Typha domingensis*. This is according to the criteria of impact on biological diversity and/or human activities (Lowe et al., 2004).

There is a need to carry out more studies related to the damage caused by aquatic weed species all over the country, these are dispersal mechanisms in different aquatic ecosystems; this document covers only some aquatic plant species.

**References**


Resumen
La subespecie introducida del carrizo común (*Phragmites australis ssp. australis*; Poaceae) es una de las plantas más invasoras en el noreste de Norteamérica. Utiliza tanto propagación vegetativa como reproducción sexual para dispersarse, pero la contribución relativa de estas dos estrategias para establecer poblaciones nuevas se desconoce. Para evaluar esta contribución se realizaron dos estudios complementarios con poblaciones de carrizo común localizadas a lo largo de zanjas de drenaje, el principal hábitat de la especie en Quebec (Canadá). Se tomaron muestras de hojas y se utilizaron marcadores nucleares de microsatélite para estimar la diversidad genética entre y dentro de las poblaciones. También se hicieron observaciones de campo para detectar brotes emergiendo de semillas o rizomas en zanjas de drenaje recientemente excavados. Entre cien poblaciones se encontró una alta diversidad genética, mientras que dentro de las poblaciones se encontró una baja diversidad. Se detectaron aproximadamente 4000 brotes de carrizo común, la mayoría (95%) emergiendo de semillas en una distancia de 6km de zanjas de drenaje. La mayoría de los brotes no sobrevivieron su primer invierno, pero los sobrevivientes iniciaron la propagación vegetativa durante la primavera siguiente. Estos datos sugieren que las semillas son los tipos principales de diáspora responsables del surgimiento de poblaciones nuevas; la propagación vegetativa se utiliza para expansión clonal. Estos resultados tienen implicaciones importantes para el manejo de esta planta invasora. Prevenir la formación de camas adecuadas de germinación (suelos descubiertos) es probablemente la estrategia más eficaz para controlar la dispersión de la planta.

Abstract
The introduced subspecies of the common reed (*Phragmites australis ssp. australis*; Poaceae) is one of the most invasive plants in northeastern North America. It uses both vegetative propagation and sexual reproduction for spreading, but the relative contribution of these two strategies for establishing new populations is unknown. To evaluate this contribution, two complementary studies were conducted with common reed populations located along road drain-
age ditches, the main habitat of the species in Québec (Canada). Leaf samples and nuclear microsatellite markers were used to estimate genetic diversity between and within populations. Field observations for detecting shoots emerging from seeds or rhizomes in freshly dug drainage ditches were also used for evaluation. A high genetic diversity was discovered between a hundred populations, whereas a low diversity was found within populations. Over a distance of 6 km of drainage ditches, about 4000 common reed shoots, mostly (95%) emerging from seeds, were detected. Most shoots did not survive their first winter, but the surviving ones initiated vegetative propagation the following spring. These data strongly suggest that seeds are the main diaspore types responsible for the emergence of new populations; vegetative propagation is then used for clonal expansion. These results have important implications for the management of this invasive species. Preventing the formation of suitable germination beds (bare soils) is probably the most effective strategy for controlling the spread of the plant.

Ecophysiological Traits of Invasive Plants: Are There Similarities Across Photosynthetic Pathways?

Rasgos ecofisiológicos de plantas invasoras: ¿existen similitudes a través de rutas fotosintéticas?

Erick de la Barrera Montpellier
Researcher / Investigador
Ecosystems Research Center, UNAM / Centro de Investigaciones en Ecosistemas, UNAM
Circuito Jacarandas 5778 Morelia 58194 México
delabarrera@unam.mx, erick@cieco.unam.mx

Resumen
La ecología fisiológica de plantas ha desarrollado herramientas metodológicas y conceptuales que pueden ser útiles para estudiar y controlar la dispersión de especies invasoras. En esta plática se revisarán dos marcos de trabajo filosóficos que pueden ser útiles para considerar especies nativas. El primero, el concepto de nicho ecológico justifica un acercamiento de ecología ambiental en un contexto ecológico. Segundo, el concepto controvertido de “fisiología de la conservación” será presentado justificando la necesidad de una investigación meticulosa y cuidadosa sobre los rasgos ecofisiológicos de especies individuales en lugar de para grupos de especies, llevando así a decisiones de manejo muy sólidas. Después discutirá las particularidades ecofisiológicas de una especie representativa de cada metabolismo fotosintético (C3, C4, CAM) que se han vuelto invasoras problema fuera de su área de origen, en particular Prosopis juliflora (un árbol C3), Cenchurs ciliariis (syn. Pennisetum ciliare, nombre común zacate buffel; un pasto C4s), y Opuntia spp. (una suculenta CAM).

Abstract
Plant physiological ecology has developed methodological and conceptual toolkits that can be useful for studying and controlling the spread of invasive species. In this talk I will first review two philosophical frameworks that can be useful for considering invasive species. The first one, the ecological niche concept, justifies an environmental physiology approach in an ecological context. Second, the controversial concept of “conservation physiology” will be presented that makes the case for a thorough and careful investigation of ecophysiological traits for individual species, rather than for groups of species, leading to very solid management decisions. Then I will discuss the ecophysiological particularities of a representative species of each photosynthetic metabolism (C3, C4, CAM) that have become problematic invasives outside their area of origin, namely, Prosopis juliflora (a C3 tree), Cenchurs ciliariis (syn. Pennisetum ciliare, common name buffel grass; a C4 grass), and Opuntia spp. (a CAM succulent). Finally, a discussion will consider whether general ecophysiological patterns can be drawn to help identify the potential for invasion by a particular species, for controlling the spread of existing exotic plants or for establishing public policies regarding invasive species.
Resumen
Las dinámicas de población de especies conforman un número de herramientas que tienen el potencial para generar información relevante y cuantitativa sobre especies invasoras y su manejo. Sin embargo, pocos estudios han usado este acercamiento principalmente porque el tiempo que se necesita para reunir suficiente información y requiere mucho esfuerzo. Los pocos estudios realizados hasta la fecha que muestran que las tasas de incremento de población son altas, indican un crecimiento anual de 47%. La importancia de tasas vitales varía entre especies e historias de vida y entre especies y longevity lo que lleva a controles que pueden ser específicos para la especie. El uso de elasticidades puede proporcionar los medios para identificar los procesos demográficos que pueden impactar significativamente en las tasas de crecimiento de la población. Usamos Kalanchoe delagoensis como modelo para ejemplificar el uso de modelos demográficos para especies invasoras. K. delagoensis es una especie de Madagascar que se conoce como invasora en muchos países. Estudiamos las dinámicas de población en dos poblaciones en México (Cadereyta, Querétaro y Tula, Tamaulipas) a lo largo de un año. Encontramos que su tasa de población intrínseca era superior a la unidad ($\lambda = 1.91$ and 1.09). Los análisis de elasticidad identificaron la transición de plántula a juvenil como importante así como la sobrevivencia de las plántulas. Las simulaciones mostraron que modificar estos dos componentes controlaría significativamente las poblaciones de K. delagoensis. Las simulaciones que redujeron la sobrevivencia y fecundidad no resultaron en una reducción significativa en $\lambda$. Los estudios demográficos fueron útiles porque proporcionaron un estimado cuantitativo de las tasas de crecimiento que pueden ser: 1) acopladas a predicciones espaciales (tasas de colonización y expansión), 2) usadas para identificar los objetivos clave para controlar ya sea como procesos demográficos o como etapas individuales en el ciclo de vida 3) una herramienta de monitoreo, 4) como componentes para evaluar invasividad potencial y 5) como medios para explorar la evolución y ecología de invasiones de plantas.

Abstract
Population dynamics species comprise a number of tools that have the potential to give relevant and quantitative information on invasive species and their management. However, few studies have used this approach mainly because of the time needed to gather sufficient information and is labor intensive. Of the few studies to date that show that rates of population increase are rather high with a mean growth of 47% per annum. The importance of vital rates differs between species and life histories also differ between species and life span which leads to controls that may be species specific. The use of elasticities however can provide the means to identify the demographic processes that can significantly impact population growth rates. We used Kalanchoe delagoensis a model to exemplify the use of demographic models for invasive species. K. delagoensis is a species from Madagascar commonly known as an invasive in many countries. We studied the population dynamics in two populations in México (Cadereyta Queretaro and Tula Tamaulipas) over one year. We found that intrinsic population growth rates were above unity ($\lambda = 1.91$ and 1.09). Elasticity analysis identified the plantlet to juvenile transition to be important as well as the survival of plantlets. Simulations showed that modifying these two components would significantly control the populations of K. delagoensis. Simulations that reduced survival and fecundity did not give a significant reduction in $\lambda$. Demographic
Invasion Plant Spread Rate Estimation as a Risk Assessment Criterion for Naturalized Species
Estimación de la tasa de dispersión de plantas invasoras como criterio para el análisis de riesgo de especies naturalizadas

Francisco Espinosa García
Researcher / Investigador
CIECO, UNAM
Antigua Carr. a Pátzcuaro #8701 Morelia, Mich 58190 México
espinosa@oikos.unam.mx

Resumen
Las especies de plantas adventicias en México no han sido evaluadas para priorizar la su manejo en todo el territorio nacional. Hasta ahora ha habido un trabajo de evaluación de especies adventicias en zonas naturales protegidas, y un intento para todo el territorio nacional; ambos basados en la opinión de expertos especializados en florística. Estos trabajos aún no son suficientes. La evaluación de especies adventicias dependiente de expertos a escala nacional requiere de recursos económicos y organizativos considerables. Además, en la evaluación se debe compensar el número desigual (y a veces insuficiente) de expertos por regiones y considerar que la pericia de la mayoría de expertos reside mucho más en plantas autóctonas que en alóctonas. Proponemos un modelo bifásico de asignación de la prioridad de manejo para las especies adventicias con menor dependencia de expertos. Primero hay una evaluación preliminar, basada en criterios derivados de especímenes de herbario e información bibliográfica, para asignar prioridad de atención. Después, se realiza un análisis de riesgo formal (con modelación de distribución potencial) a las especies de prioridad alta para seleccionar a las que requieren de manejo inmediato. La fase preliminar requiere de criterios asociados al potencial invasivo de las especies adventicias. En este trabajo desarrollamos el criterio de tasa de diseminación de las especies de acuerdo a su tiempo de residencia para más de 330 especies de malezas adventicias registradas en más de 7700 localidades en México. El modelo de regresión es una curva potencial (r = 0.61, R² = 0.374) en el que el tiempo de residencia explica cerca del 40% de la variación en las localidades ocupadas. El coeficiente de regresión de este modelo es similar o mayor que el obtenido para otras partes del mundo. Usamos la desviación de los residuales de los límites de confianza de la curva del modelo para calificar la tasa de diseminación de cada especie. Ejemplificamos el uso de este criterio en un análisis de prioridad de atención para 42 taxa de leguminosas adventicias incorporando criterios basados en el comportamiento de las especies en el extranjero y la presencia en México de los parientes congenericos nativos y no nativos.

Abstract
The adventive species in Mexico have not been completely evaluated to prioritize their management throughout the country. Currently, there has been an adventitious species assessment for protected natural areas, and an attempt for the whole country, both based on the opinion of experts on floristics. These works are not yet sufficient. The evaluation of adventitious species dependent on national experts requires considerable financial and organizational resources. Furthermore, the evaluation must compensate the uneven (and sometimes insufficient) number of experts by region and consider that expertise for most botanists is higher for native plants than for non-native ones. We propose a two-step model to allocate management priority for adventitious species with less reliance on experts. First a preliminary assessment is performed to assign priority of attention based on criteria derived from herbarium specimens and bibliographic information. The second step is a formal Risk Analysis performed with the high-priority spe-
cies identified in the first step (with potential distribution modeling) to identify those requiring immediate management. The model’s first phase requires criteria associated with the adventitious species invasiveness. In this paper we develop the spread rate criterion for adventive species using the residence time and occupied localities for more than 330 species of adventive weeds recorded in over 7700 locations in Mexico. The regression model adjusts a potential curve (r = 0.61, R² = 0.374) where residence time explains about 40% of the variation in occupied localities. The regression coefficient of this model is similar or greater than those obtained for other parts of the world. We use the residuals deviation from the curve’s confidence limits to grade the spread rate of each species. We exemplify the use of this approach with a priority attention analysis for 42 taxa of adventitious legumes incorporating criteria based on the adventive species behavior abroad and on the presence of congeneric native and non-native species in Mexico.

Ecological and Anthropic Criterions for Mapping Invasive Plant Susceptibility in Mexico
Criterios ecológicos y antrópicos para mapear la susceptibilidad de plantas invasoras en México

Ek Del Val
Researcher / Investigadora
Ecosystems Research Center, UNAM / Centro de Investigaciones en Ecosistemas, UNAM
Antigua Carretera a Pátzcuaro No. 8701 Col. Ex-Hacienda de San José de la Huerta C.P. 58190 Morelia, Michoacán
ekdelval@cieco.unam.mx, ekdelval@gmail.com

Other authors / Otros autores:

Resumen
El mapeo de los servicios ecosistémicos se ha enfocado en proporcionar datos espacialmente explícitos para conservar áreas críticas para provisión de servicios, pero se ha enfocado menos en perjuicios ecosistémicos identificando áreas para acción crítica contra pérdida adicional de servicios. Las invasiones biológicas son perjuicios importantes dado que directa o indirectamente afectan el bienestar humano y son una causa importante de pérdida de biodiversidad alrededor del mundo e interfieren con la provisión de muchos servicios ecosistémicos. Proponemos un modelo para México para detectar áreas a una escala regional en donde la probabilidad de invasión de plantas es mayor y puede causar y/o agravar efectos negativos sobre los ecosistemas. Nuestro modelo de probabilidad de invasión considera cuatro variables principales: disponibilidad de propágulo, tipo de vegetación, disturbios antrópicos y riqueza de especies de plantas nativas. Se produjeron cinco mapas, dividiendo el país en una cuadrícula de 0.5 x 0.5°, uno para cada variable y otro construido con nuestro modelo de invasividad. Validamos nuestro modelo con los datos de campo a nivel de estado para plantas exóticas por estado y obtuvimos una correlación significativa entre nuestro índice de invasividad y la densidad de especie exóticas. Las áreas con mayor susceptibilidad a invasión están cerca a grandes establecimientos humanos y a áreas de agricultura intensiva. Los corredores de invasividad muy alta y las islas se detectaron en nuestros mapas al igual que áreas de muy alta invasividad en regiones de alta diversidad como Chiapas y la frontera de Tamaulipas-Veracruz en donde recomendamos que se preste atención. Nuestro modelo aunque simple, proporciona una herramienta útil para el diseño de políticas para detectar áreas dentro de una región específica o país en donde las invasiones bióticas puedan tener un gran efecto. Localizar dichas áreas es importante para maximizar los recursos monetarios y humanos y para minimizar efectos dañinos de este perjuicio ecosistémico.

Abstract
Mapping ecosystem services has focused on providing spatially explicit data for action to conserve areas critical for service provision, but less so on ecosystem dis-services by identifying areas for critical action against further service loss. Biological invasions are important dis-services given that they directly or indirectly affect human well-being, as they are an important cause of biodiversity loss worldwide and interfere with the provision of many ecosystem services.
We propose a model for Mexico to detect areas at a regional scale where the probability of plant invasion is higher and can cause and/or aggravate negative effects upon ecosystems. Our model of probability of invasion considers four main variables: propagule availability, vegetation type, anthropic disturbance and native plant species richness. We produced five maps, by dividing the country into a 0.5 x 0.5° grid, one for each variable and another constructed with our model of invasibility. We validated our model with State level field data on exotic plants per State and obtained a significant correlation between our invasibility index and density of exotic species. Areas with greater susceptibility to invasion are closer to large human settlements and to areas of intensive agriculture. Very high invasibility corridors and islands were detected in our maps as well very high invasibility areas in high diversity regions such as Chiapas and Tamaulipas-Veracruz border where we suggest attention should be focused. Our model although simple, provides a useful tool for policy design to detect areas within a specific region or country where biotic invasions are likely to have a large effect. Localizing these areas is important in order to maximize monetary and human resources and to minimize damaging effects of this ecosystem dis-service.
Session 10

Management and Control
Manejo y Control
Moderator: Nelroy Jackson, Monsanto (retired) and former ISAC Vice Chair

Actions of the National Commission for Natural Protected Areas (CONANP) on Invasive Alien Species: Weeds in Natural Protected Areas
Acciones de la CONANP en materia de especies exóticas invasoras: Malezas en las Áreas Naturales Protegidas

Margarita García Martínez
Subdirector of Invasive Species / Subdirectora de Especies Invasoras
CONANP
mgmartinez@conanp.gob.mx, invasoras@conanp.gob.mx

Other authors / Otros autores:
Oscar Manuel Ramírez Flores
CONANP

Resumen
México cuenta con una extraordinaria diversidad vegetal; se encuentra entre los 17 países considerados megadiversos (Mittermeier et al., 1997), ocupando el cuarto lugar con la mayor diversidad biológica del mundo, además 40 % de las plantas son especies endémicas y cuenta prácticamente con todos los tipos de vegetación conocidos en el planeta (Valverde et al., 2005). Sin embargo, la introducción de especies exóticas invasoras (EEI) ha sido reconocida como una de las más graves amenazas al bienestar ecológico, social y económico a nivel mundial. En las Áreas Naturales Protegidas (ANP), la introducción de EEI, incluida la vegetación exótica invasora, ha causado severos daños a los ecosistemas terrestres y acuáticos, provocando la pérdida y alteración de los ecosistemas, la destrucción y la fragmentación de hábitats, desplazamiento de especies nativas de flora y fauna, pérdida de biodiversidad y la alteración directa o indirecta de los servicios ecosistémicos. Consciente de la problemática que estas especies representan en las ANP, la Comisión Nacional de Áreas Naturales Protegidas (CONANP), ha dado pasos importantes al implementar programas y proyectos de acuerdo a prioridades establecidas, mismos que se realizaron en estrecha colaboración con personal de las ANP, otras dependencias gubernamentales, la academia y representantes de la sociedad civil. Lo anterior como resultado de un Diagnóstico de EEI en el que se registraron al menos 491 especies de plantas exóticas e invasoras en las ANP. Entre los programas más exitosos se encuentra la “Campaña para el control de pino salado (Tamarix aphylla) en I. Cerralvo del PN Archipiélago de Espíritu Santo; el Diagnóstico de especies de vegetación exótica y eliminación de especies invasoras en R.B Mapimi: cedro salado (T. ramosissima), cadillo (Xanthium strumarium L.) y rodadora Salsola tragus y el Programa de Control de Carrizo gigante (Arundo donax) en el APFF Cuatrociénegas, entre otros.

Abstract
Mexico has an extraordinary plant diversity; it is among the 17 countries considered megadiverse (Mittermeier et al., 1997), occupying the fourth place with the greatest biological diversity in the world, in addition, 40% of plants are endemic species and it has practically all types of vegetation known in the planet (Valverde et al., 2005). However, the introduction of exotic invasive species (EIS) has been recognized as one of the greatest threats to ecological, social and economic wellbeing at a global scale. In the Natural Protected Areas (NPA), the introduction of EIS, including invasive exotic vegetation has caused severe damages to terrestrial and aquatic ecosystems, causing the loss and alteration of ecosystems, destruction and fragmentation of habitats, displacement of native flora and fauna species and direct or indirect alteration of eco-
system services. Conscious of the problem that these species represent for NPA, the National Commission of Natural Protected Areas (CONANP), has taken important steps in implementing programs and projects according to established priorities, these were prepared in close collaboration with personnel of the NPA and other government agencies, academia and representatives of civil society. All this has been carried out as a result of a diagnosis of EIS in which at least 491 species of exotic and invasive plants in NPA. Among the most successful programs are the “Campaign for control of saltcedar (Tamarix aphylla) in Cerralvo island of the National Park Archipiélago de Espíritu Santo: the diagnosis of species of exotic vegetation and elimination of invasive species in the Biosphere Reserve of Mapimi, saltcedar (T. ramosissima), Common cocklebur (Xanthium strumarium L), tumbleweed (Salsola tragus) and the Program for the Control of giant reed (Arundo donax) in the Flora and Fauna Protection Area of Cuatrociénegas, among others.

Approaches to the Planning and Implementation of Large Scale Invasive Alien Plant Control Programs in Southern Africa
Propuestas para la Planeación e Implementación de Programas de Control de Plantas Invasoras a Gran Escala en el Sur de África

Andrew E. M. Brown
Biodiversity Management Consultant / Consultor Manejo de Biodiversidad
18989 NE Marine Dr. #75 Portland, OR 97230 USA
aembrown@iafrica.com

Resumen
Sudáfrica tiene una larga historia de llevar a cabo programas de manejo de plantas exóticas en el país, actualmente gasta más de $100,000 USD al año. Estos esfuerzos se han enfocado principalmente en las plantas leñosas invasoras que desplazan a la biodiversidad nativa que es extraordinariamente rica, disminuyen el flujo de agua, incrementan el riesgo de incendios y aceleran la erosión, entro otros impactos. Aun cuando se ha logrado progreso considerable en reducir la densidad de plantas exóticas en algunas áreas también ha habido una considerable ineficiencia en la manera en la que estas operaciones de manejo se han realizado. Frecuentemente ha sido difícil contestar las preguntas más importantes: ¿Estamos ganando la bata- lla o perdiendo terreno? ¿La asignación de recursos es suficiente para atender la escala del problema? ¿La priorización espacial de las operaciones de limpieza resulta en la minimización óptima de los impactos de las plantas exóticas invasoras a largo plazo?

Este trabajo delinea algunas de las experiencias gana- das y las lecciones aprendidas en llevar a cabo programa- mas de control de especies exóticas invasoras a gran escala en Sudáfrica, incluyendo el mapeo y priorización de áreas, la planeación de operaciones de control, las especies atendidas y los métodos utilizados, fondos, temas sociales, cómo las operaciones de limpieza se organizan y se manejan y cómo se han desarrollado los sistemas de manejo.

Se han utilizado varios enfoques para el mapeo y cuantificación del problema de plantas invasoras exó- ticas a escalas nacionales, regionales y de proyecto individual, cada uno involucra diferentes costos y ben- eficios en cuanto a la escala, costo, eficacia, calidad y utilidad y la manera en la que los mapas han sido utilizados en la planeación estratégica, priorización y costeo de los programas de control de especies exóticas invasoras. Algunos de los enfoques incluyen la cuantificación de estándares y normas de producción, muestreo de la actividad de limpieza y la mejora de la supervisión de equipos de limpieza en el campo.

Abstract
South Africa has a long history of undertaking large scale invasive alien plant management programs in the country, currently spending over US$100,000 a year. These efforts have focused mainly on the invasive woody plants that displace the country’s extraordinarily rich native biodiversity, decrease water flow, increase fire risk, and accelerate erosion amongst other impacts. While considerable progress has been made
reducing alien plant density in some areas, there has also been considerable inefficiency in the way these management operations have been carried out. It has frequently been difficult to answer the most important questions. Are we winning the battle or losing ground? Is the allocation of resources sufficient to address the scale of the problem? Is the spatial prioritization of clearing operations resulting in the best long term minimization of invasive alien plant impacts?

This paper outlines some of the experience gained and lessons learnt in undertaking large scale invasive alien plant control programs in South Africa, including the mapping and prioritization of areas, planning control operations, the species targeted and methods used, funding, social issues, how clearing operations are organized and managed, and the management systems developed.

Various approaches to the mapping and quantification of the invasive alien plant problem at a national, regional and individual project or watershed scale have been undertaken, each involving different trade-offs in scale, cost, accuracy, quality and usefulness, and how these maps have been used in the strategic planning, prioritization and costing of invasive alien control programs. Some of the approaches to improve the efficiency and cost effectiveness of clearing operations include, the quantification of production norms and standards, activity sampling of clearing, and improving the supervision of clearing teams in the field.

Managing Invasive Weed Species Using Integrated Vegetation Management Principles
Manejo de malezas invasoras usando los principios de manejo de vegetación integrada

Richard Lee
Integrated Pest Management Specialist / Especialista de Manejo Integral de Plagas
USDI-Bureau of Land Management / USDI-Oficina de Administración de Tierras
Denver Federal Center, Building #50 PO Box 25047 Denver, CO 80225 USA
richard_lee@blm.gov

Resumen
Los impactos asociados con la introducción y dispersión de especies invasoras de malezas incluyen desplazamiento físico, reducción en la biodiversidad, alteración del hábitat ecológico, expresión de los aspectos tóxicos de especies selectas y otros impactos directos e indirectos. El manejo de dichas especies también involucra aplicaciones directas e indirectas. Las aplicaciones directas incluyen el uso de varias opciones de manejo disponibles: mecánicas, biológicas y químicas. Las indirectas incluyen pero no están limitadas a actividades preventivas como legislación para controlar malezas nocivas, limpieza de equipo cuando se mueve a un nuevo lugar incluyendo lugares transfronterizos, manejo/manipulación del sitio y reducción del potencial para la introducción. El manejo exitoso requiere conocimiento de las especies invasoras a tratar, del sitio y de las consideraciones económicas cuando se desarrolla el plan de manejo. Solamente con la integración de todos estos puntos se podrá tratar el tema de las especies de malezas invasoras.

Abstract
The impacts associated with the introduction and spread of invasive weed species include physical displacement, reduction in the bio-diversity, alteration of the ecological habitat, expression of the toxic aspects of selected species, and other direct and indirect impacts. The management of such species will also involve direct and indirect inputs. Direct inputs include the utilization of the various management options available; mechanical, biological, physical, and chemical. Indirect inputs include, but are not limited to, preventive activities, such as noxious weed laws, equipment cleaning when moving from one location to another, include across national boundaries, site management/manipulation, and reducing the potential for introduction. Successful management requires an understanding of the targeted invasive weed species, impacted site, and economic considerations when developing the management plan. Only through the integration of all of these points can invasive weed species be addressed.
Problems and Management of Invasive Aquatic Weeds in Mexico
Problemas y manejo de Malezas Acuáticas Exóticas Invasoras en México

Maricela Martínez Jiménez
Researcher / Investigadora
Mexican Institute of Water Technology / Instituto Mexicano de Tecnología del Agua
Paseo Cuaunháhuac 8532 Progreso, Jiutepec, Morelos. México.
mmartine@tlaloc.imta.mx

Resumen
En México, se han identificado al menos, ochocientas especies exóticas invasoras de las cuales 665 son plantas, (imta, 2008). En lo concerniente a plantas acuáticas que se han comportado como malezas, los altos costos tanto económicos como ecológicos que ha conllevado su control (debido al intensivo uso de herbicidas), hacen indispensable implementar métodos de manejo ambientalmente sostenibles y sustentables.

La mayoría de las plantas acuáticas, que se comportan como malezas, no son originarias de los países donde causan problemas. Tal es el caso del lirio acuático (Eichhornia crassipes), oreja de ratón (Salvinia spp.), Tule (Typha spp.) o Hydrilla verticillata entre otras especies introducidas a México. En México, se ha estimado que la superficie infestada por las malezas acuáticas es de 62,000 ha, lo que representa el 24% de la superficie inundada (Gutiérrez et al., 1994). En este grupo de sistemas acuáticos, se incluyen los lagos y presas con mayor actividad económica y social del país, siendo el lirio acuático la principal maleza afectando el 64% de la superficie infestada, le sigue la cola de caballo (Potamogeton sp.) con un 30%, el tule (Typha spp.) y la Hydrilla (Hydrilla verticillata) con un 4%, la lechuga de agua (Pistia stratiotes) y el chicchicaztle (Lemna sp.) con un 2% (Gutiérrez et al., 1994). Recientemente, varias especies de Salvinia han afectado diversos cuerpos de agua del país.

A pesar de que existen reportes de la introducción de estas plantas desde hace más de 100 años ninguna acción de control había sido realizada en México. En 1993 se crea el Programa de Control de Malezas (PROCMA) cuya responsabilidad de ejecución y diseño de estrategias de control estuvo a cargo del Instituto Mexicano de Tecnología del Agua (Gutiérrez et al., 1994). El PROCMA se desarrolló en 13 cuerpos de agua del país, donde se implementaron tecnologías de cobertura amplia tales como el control mecánico por trituración y el control químico (Gutiérrez et al., 1994). Para las acciones de mantenimiento los métodos de control biológico han demostrado que el uso combinado de insectos y patógenos específicos de la maleza ayudan a mantener una baja infestación (Ci-lliers, 1991; Martínez 2003, 2005, 2007). La inclusión de esta biotecnología desarrollada por el IMTA, como parte clave de un programa de control integral de malezas, es una opción viable que permitirá la disminución en el uso de control químico y mecánico y como consecuencia una reducción en los costos de mantenimiento de los cuerpos de agua.

Abstract
In Mexico at least 800 exotic invasive species have been identified, of these 655 are plants (IMTA, 2008). Regarding aquatic plants that have behaved as weeds, the high costs both economic and ecological stemmed from their control make it necessary to implement sustainable management methods.

Most of the aquatic plants that behave as weeds are not native from the countries where they cause problems. Such is the case of Eichhornia crassipes, Salvinia spp., Typha spp. or Hydrilla verticillata among other introduced species. In Mexico it is estimated that the surface infested by aquatic weeds is of 62,000 ha, 24% of the flooded surface (Gutiérrez et al., 1994). This group includes lakes and dams with greatest social and economic activity in the country. Water hyacinth is the main weed affecting 64% of the infested surface followed by Potamogeton sp. with 30%, Typha spp. and Hydrilla verticillata with 4%, Pistia stratiotes and (Lemna sp.) with 2% (Gutiérrez et al., 1994). Recently various species of Salvinia have affected the country’s water bodies.

Although there are reports of the introduction of these plants since over 100 years ago, no control actions had been carried out in Mexico. In 1993 the Weed Control Program (PROCMA) was created, the Mexican Institute of Water Technology was in charge of the execution and design of control strategies. The PROCMA was carried out in 13 water bodies in the country where tecnolo-
gies such as mechanical and chemical control were used (Gutiérrez et al., 1994). Biological control actions were used for maintenance with a combined use of insects and pathogens specific to the weed (Cilliers, 1991; Martínez 2003, 2005, 2007). The use of this biotechnology developed by IMTA as part of a key program of integrated weed management is a viable option that will allow for the decrease in the use of chemical and mechanical control and as consequence a reduction in the cost of maintenance of water bodies.

**Presentation Summary**

At least eight hundred exotic invasive species have been identified in Mexico, out of these 665 are plants (IMTA, 2008). In the case of aquatic plants that behave as weeds, the high economic and ecological costs associated to their control (due to the intensive use or herbicides) make it essential to implement management methods that are environmentally sustainable. In general most of the aquatic plants that behave as weeds are not native to the countries where they are considered a problem. Such is the case of water hyacinth (Eichhormia crassipes), salvinia spp., Typha spp. or Hydrilla verticillata among other species introduced to Mexico. The high reproductive and adaptive rates of these species, the high nutrient concentration in the water bodies originating from agricultural, urban and industrial activities and the absence of natural enemies, have resulted in an explosive growth of these plants covering completely the countries' water bodies.

It is estimated that in Mexico the surface infested by aquatic weeds is of 62,000 ha, which represents 24% of the flooded surface (Gutiérrez et al., 1994). This group of aquatic systems includes the lakes and dams of greatest social and economic activity in the country. Water hyacinth is the main weed and affects 64% of the infested surface, followed by pondweed (Potamogeton sp.) with 30%, Cattail (Typha sp.) and Hydrilla (Hydrilla verticillata) with 4%, water lettuce (Pistia stratiotes) and duckweed (Lemma sp.) with 2% (Gutiérrez et al., 1994). Recently, several species of Salvinia have affected different water bodies of the country. In the DR014 Mexicali Valley in Baja California, a severe infestation of Salvinia molesta is affecting the entire irrigation district. In Tabasco, the Illusiones Lagoon and the Tabasco Lagoon have been completely infested by S. molesta, S. mínima y S. auriculata (Martínez, 2006).

In Tabasco, the Laguna de las Illusiones and the Laguna Tabasco, have been completely infested by *S. molesta*, *S. mínima* and *S. auriculata* (Martínez, 2006).

The proliferation of aquatic plants causes economic, ecological and health problems. Among the economic problems caused are loss of water due to evapotranspiration, premature sediment accumulation in water bodies, limitation of fishing and recreational activities and obstruction of waterways and hydroelectric plants (Gopal, 1987). Ecological problems include the accumulation of large amounts of aquatic weeds resulting in the stagnation of water, decreased dissolved oxygen concentration and death of aquatic species (Barrett, 1989). Among the health problems caused, aquatic weeds are a habitat for the development of organisms that are vectors for serious diseases such as yellow fever, philarasis, helmintiasis and encephalitis, (Hernández y Pérez, 1995).

In spite of reports on the introduction of these plants since over 100 years ago (as is the case of the water hyacinth) no control actions had been taken in Mexico. Given the problems caused by aquatic plants in almost all water bodies of the country (64% of the flooded surface is covered by aquatic weeds), in 1993 the Weed Control Program was created (Programa de Control de Malezas - PROCMA), its responsibility to execute and design control strategies was in charge of the Mexican Institute of Water Technology (Instituto Mexicano de Tecnología del Agua – IMTA) (Gutiérrez et al., 1994). The three main aspects of the program are:

1. Lower the infestation of weeds to manageable levels and establish a maintenance program
2. Integral management for weeds
3. Integral management for wastewater

According to the PROCMA, the control of aquatic weeds involved long term strategies geared to controlling the causes. These strategies involved nutrient control (phosphorous and nitrogen) in waterways in the country (control of point, non-point and diffuse discharges). Short term strategies were also applied, in these cases the efforts were geared towards the effects; the procedures carried out decreased the amount of plants at a greater speed than that of its natural reproduction.

The PROCMA was carried out in 13 water bodies of the country, where wide coverage technologies such
as mechanical control by crushing and chemical con-
control were implemented (Gutiérrez et al., 1994). Once
the weed cover was diminished, it was necessary to
establish maintenance actions which are essential to
maintain the water free of weeds. Biological control
methods have demonstrated that the combined use
of weed specific insects and pathogens help maintain
low infestations as long as these are applied as part
of an integral weed control program (Cilliers, 1991;

Since 1994 the IMTA has researched several organisms
that can offer weed control without negative effects on
the environment. Currently the IMTA has a production
unit of weed biological control agents. For the use of
these organisms it was necessary to demonstrate that
they only feed and carry out their biological cycle on
the plant to be controlled. For these purpose, scientific
tests were carried out as established by the protocols
of the North American Plant Protection Organization
(NAPPO), which is the international authority that
regulates the use of biological control agents. With
these tests, the IMTA implemented a quality control
procedure for the colonies that were produced, this
control was based on a sanitary evaluation to detect
possible entomopathogens and a reproductive aptitude
exam. The procedures are based on validated standard
methodologies and protocols according to the system
of Quality Control (AC/CC) of the IMTA according to
the requirements established in Norma Mexicana NMX-
EC-025-1MNC-2000 to ensure that the insects that are
produced are healthy and apt for reproduction.

Given the high reproductive and adaptive rate of these
weeds, the large nutrient concentration in water bod-
ies originating from agricultural, urban and industrial
activity and the absence of natural enemies that can
exert control, a single biocontrol agent is not enough
to stop the growth and reproduction of the plant, the
use of several biotic stress agents is necessary. The use
of microbial agents is a synergic component of the
effect caused by insects. In this regard the IMTA has
researched pathogens that can significantly lower the
growth of the plant. These pathogens were previously
evaluated according to their efficacy and specificity
(Martínez y Charudattan, 1998; Martínez y Gutiérrez
2001) and they have the patent for microorganisms
from ATTC, which is the world authority for the patent
of microorganisms. Currently IMTA has a microherbi-
cide patent from the Mexican Institute of Industrial
Protection (I.M.P.I).

In summary, the addition of this biotechnology devel-
oped by the IMTA as a key part of an integral program
of weed control, is a viable option that will allow in
the following years, for lower chemical and mechani-
cal control and as a consequence a reduction in the
maintenance costs of the water bodies.

References
IMTA-The Nature Conservancy-CONABIO-
AridAmérica-GECL. (2008). Especies invasoras de alto
impacto a la biodiversidad, Prioridades en México.
Ignacio J. March Mifsut y Maricela Martínez Jiménez
(Editores). 74p

Cilliers, C. J. (1991). Biological control of waterhyacinth,
Eichhornia crassipes (Pontederiaceae) in South Africa.
Agriculture, Ecosystems and Environment, 37: 207-217.

Elsevier Science Publishers, B. V. Amsterdam, The
Netherlands. 471 p.

Gutiérrez, L. E., C. F. Arreguín, D. R. Huerto y F. P.
Saldána. (1994). Control de Malezas Acuáticas en

del mosquito: un debate sobre mosquitos. Avance
y Perspectiva. Órgano de difusión del Centro de
Investigación y de Estudios Avanzados del IPN., 14:
5-15.
**Understanding resistance to glyphosate inheritance in Amaranthus palmeri: recent advances and remaining conundrums**

Entendiendo la herencia de resistencia al glifosato en Amaranthus palmeri: avances recientes e interrogantes pendientes

**Daniela Ribeiro**

PhD Student / Estudiante de Doctorado  
Mississippi State Univ., Starkville, MS; USDA/ARS, Oxford, MS; USDA/ARS, Stoneville, MS; Mississippi State, MS 39762  
dnr34@pss.msstate.edu

Other authors / Otros autores:  
Z. Pan, F. E. Dayan, S. O. Duke  
USDA/ARS, Oxford, MS;  
V. K. Nandula  
USDA/ARS, Stoneville, MS;  
D. R. Shaw, B. S. Baldwin  
Mississippi State Univ., Starkville, MS;

**Resumen**

El Glifosato se considera por muchos como el herbicida más importante jamás desarrollado. Las aplicaciones repetidas de glifosato causan presión genética selectiva hacia la evolución de malezas resistentes. Poblaciones de Amaranthus palmeri resistentes al glifosato fueron identificadas en Mississippi. La herencia de la resistencia al glifosato se examinó cruzando ascendentes maternos R con ascendentes paternos (r/s) susceptibles (s) y cruzando el progenitor materno S con progenitores paternos r (s/r) para generar F1. Los individuos de las poblaciones de F1 se sometieron a dosis de glifosato resultando en un rango de fenotipos de R a S. El nivel de resistencia estaba influenciado fuertemente por la dirección de la cruzada. Esto nos llevó a tres hipótesis: 1. Efecto maternal del rasgo r, 2) reproducción facultativa apomática y 3) diferencias en tasas de transmisión entre gametos machos y hembras. La comparación de la sintasa proteína madura 5-Enolpyruvylshikimate-3-fosfato (EPSPS) de r1, r2 y s no identificó un sitio de mutación que tuviera resistencia en las poblaciones R. La actividad de EPSPS fue más baja en las plantas s y s/r que en las plantas r y r/s en ausencia de glifosato todas fueron igualmente inhibidas por la presencia del glifosato. El involucra-
miento de apomixis en la herencia de la resistencia al glifosato fue estudiada y en todos los casos se produjeron semillas con una excepción. La cantidad de semillas varió entre 1 y 1,000 con algunos individuos produciendo hasta 6,000. Estos resultados sugieren que A. palmeri puede producir semillas mediante apomixis facilitativa y sexualmente, la apomixis facilitativa garantizaría el rasgo de resistencia al glifosato en poblaciones r.

Abstract
Glyphosate is considered by many as the most important herbicide ever developed. Repeated glyphosate applications causes selective genetic pressure toward evolution of resistant weeds. Glyphosate-resistant (r) Palmer amaranth populations (r1 and r2) were identified in Mississippi. The inheritance of glyphosate resistance was examined. Individuals from the F1 populations were submitted to glyphosate dose-response assays resulting in a range of phenotypes from r to s. Thus, the level of resistance was strongly influenced by the direction of the cross. This led us to three hypotheses: (1) maternal effect of the r trait, (2) facultative apomictic reproduction, and (3) differences in transmission rates between male and female gametes. Sequence comparisons of the predicted 5-Enolpyr-uvylshikimate-3-phosphate synthase (epsps) mature protein from r1, r2, and s did not identify a target site mutation known to confer resistance in r populations. epsps activity was lower in s and s/r plants than in r and r/s plants in the absence of glyphosate; all were equally inhibited by the presence of glyphosate. The apomixis involvement in glyphosate resistance inheritance was studied. In all cases seeds were produced, with the exception of one r1 plant. We found 60 to 100% (depending on the population) produced 1 to 1,000 seeds, but some individuals produced up to 6,000 seeds. These results strongly suggest that A. palmeri can produce seed both apomictically (facultative apomixis), and sexually, with apomixis the determinant of low copy number inheritance in s/r population. Moreover, facultative apomixis would guarantee the glyphosate resistant trait stability in r populations.

Presentation summary

Palmer amaranth (Amaranthus palmeri): A native of North America
There are nearly 85 species in the genus Amaranthus, part of the Amaranthaceae family, worldwide. Palmer amaranth is a dioecious plant, subgenera Acnidia, with its inflorescence being a terminal spike. Palmer amaranth was a valuable high-protein food source for many Native Civilizations. Nowadays, this specie is among the most troublesome weeds in many cropping systems in the Southern U.S., mainly due to the historic development of resistance to herbicides commonly used in row crops. Aggressive growth habit and prolific seed production allow Palmer amaranth to compete with crops for resources. Palmer amaranth reduces yield, quality, and also harvest efficiency of cultivated crops. Moreover, this specie has been shown to have allelopathic chemicals that reduce development of several crops and weeds. Likewise, this specie can be detrimental to livestock.

Nomenclature: Palmer amaranth, Amaranthus palmeri S. Wats. amapa.
Key words: Dioecious, ecology, pigweeds, herbicide resistance, Sonoran desert.

The word describing the genus Amaranthus is derived from the Greek, a, not, maraino, to wither, and anthos, a flower; which means “everlasting” or “never failing flowers” because of the dry unwithering nature of their showy bracts (Mitich, 1997; Steckel, 2007). In Europe and for ancient Americans, such species are regarded as emblems of immortality (Blatchley, 1930; Tull, 1999).

For many Native Americans, before Columbus’s arrival, the dioecious amaranths were a valuable high-protein food source (Steckel, 2007). On the other hand, for the many modern-day farmers who struggle trying to control Palmer amaranth, it has become an expensive curse (Culpepper et al., 2006).

Amaranthus species are among the most troublesome weeds in many cropping systems in the United States (Guo and Al-Khatib, 2003). Palmer amaranth is a prevalent problem in the West and Southern productions of corn (Zea mays L), cotton (Gossypium hirsutum L.), peanuts (Arachis hypogaea L.), grain sorghum [Sorghum bicolor (L.) Moench], soybeans [Glycine max (L.) Merr.], and sunflower (Helianthus annuus) (Barkley, 1986; Bridges, 1992; Holm et al., 1977; Mayo et al., 1995; Tull, 1999; Weaver and McWilliams, 1980).

Aggressive growth habit and prolific seed production allow Palmer amaranth species to compete with crops for light, water, and nutrients (Barkley, 1986; Kene-
Palmer amaranth reduces yield, quality, and also hinder mechanical harvest (Klingaman and Oliver, 1994; Rowland et al., 1999). Moreover, this specie has been shown to produce allelopathic chemicals that reduce seedling vigor of several crops and weeds (Menges, 1987, 1988).

**Status as a Federal or State Noxious Weed**


The *Amaranthus* originally inhabited mountain, desert, riverbanks, lakeshores, tidal marshes, and open beaches (King, 1966). The dioecious *Amaranthus* spp. are all native to North America, likewise Palmer amaranth that is native of the Southern Great Plains in U.S. and Mexico. On the other hand, monoecious species are endemic to every continent (Ehleringer, 1983; Steckel, 2007; swss, 2003).

The *Amaranthus* spp. have a long documented history of being fellow travelers with humans and were distributed by the Americas during the continent colonization (Mitich, 1997; Sauer, 1967). Nowadays, *A. palmeri* is distributed worldwide, being a common weed across non-wetlands areas in the southeastern U.S. (Ehleringer, 1983; Robertson, 1981; swss, 2003; USDA/NRCS, 2012).

In recent years, Palmer amaranth has become major weed to row crops in Midsouth and Southeastern states (Culpepper et al., 2006; Mayo et al., 1995). Mainly due to its historic development of resistance to herbicides with different modes of action that are commonly used in row crops (Steckel, 2007). Currently, Palmer amaranth has evolved resistance to four herbicide modes of action that once effectively controlled this weed in U.S. row crops (Heap, 2012). The first related case was resistance to dinitroaniline at South Carolina (Gossett et al., 1992), followed by acetolactate synthase (ALS) inhibitors at Kansas (Horak and Peterson, 1995; Sprague et al., 1997), photosystem II inhibitors at Texas (Heap, 1997), and 5-enolpyruvylshikimate-3-phosphate synthase (EPSPS) inhibitors at Georgia (Culpepper et al., 2006).

Moreover, as first reported by Murray in 1940 and later by others (Frasssen et al., 2001; Jeschke et al., 2003; Sauer 1950), the dioecious *Amaranthus* spp. will readily cross with one another and with monoecious *Amaranthus* spp. Furthermore, it has been found that ALS-resistant biotypes of Palmer amaranth can cross with susceptible common waterhemp (*A. tuberculatus* (syn. rudis)) and redroot pigweed (*A. retroflexus* L.) populations; producing hybrid offspring that carry the resistance (Franssen et al., 2001). These hybrids then can backcross with the susceptible populations and produce ALS-resistant offsprings (Culpepper et al., 2006; Wetzel et al., 1999). Other studies have found that ALS-resistant common waterhemp can cross with susceptible monoecious *Amaranthus* spp., resulting in ALS-resistant hybrids. These hybrids can then be a source for introducing the ALS herbicide resistance back into the susceptible monoecious *Amaranthus* spp. (Heap, 2012; Horak and Peterson, 1995; Sprague et al., 1997; Tranel et al., 2002; Trucco et al., 2005).

**Uses and Toxicity**

Approximately 60 *Amaranthus* species are native to the Americas and 25 species are native of Africa, Asia, Australia, and Europe (Sauer, 1967). The identification of species within the genus *Amaranthus* is difficult due to the great genetic and morphological diversity in this genus (Frasssen et al., 2001). Consequently, differentiation at specie level are virtually absent from historic reports, being generically denominated Amaranth.

As cultivated plants, grain *Amaranthus* are inextricably involved in the history of the weedy ones (Saunders and Becker, 1984). Aztecs in the 15th and 16th centuries grew amaranth as a major grain crop, along with maize and beans (*Phaseolus* spp.). The seeds also were ground, made into dough, and fashioned into religious idols (Sauer, 1950). Few stories concerning the food mythology and beliefs of the North American Indians of the Prairie Bioregion were recorded. The occurrence of *Amaranthus* species in the Zuni’s tribal mythology shows its importance as a food plant and indicates its long-term use. Additionally, it was used as a dye plant and ornamental by this tribe (Saunders and Becker, 1984).
Prehistoric domestication of native *Amaranthus* species took place independently in the Americas and primarily consisted of hybrid crosses between monoecious *Amaranthus* species with pale seed coats (Kindscher, 1987; Mabberly, 1997; Robertson, 1981; Sauer, 1967). The Native American tribes located in the arid western United States, along the Colorado River, used *Amaranthus* species for food; leaves were baked and eaten by the Cocopa, Mohave, and Pima, and seeds were ground into meal and used for food by the Navajo, Pima, and Yuma tribes (Moerman, 1998; Sauer, 1967; Singh, 1961).

*Amaranthus* species seed appeared in archaeological sites from diverse cultures (King, 1966). *Amaranthus* species seed from an ancient Native American campsite near Albuquerque, NM, were determined to be 6,800 years old (Apogino, 1957). These seeds are at least 2,400 years older than samples of maize found on other 4,000-year-old sites (King, 1966).

All seeds of *Amaranthus* species are quite edible when simply toasted and milled, tasting much like cereal. The tiny dark seeds, produced on slender spikes from summer to late fall, are an excellent source of protein. The seeds contain 15 grams of protein per 100 grams. Nutritional analysis showed the grain to be comparable to cereals as carbohydrate food and superior in protein and fat content. *Amaranthus* is richer in lysine and contains more fiber and calcium than true cereals. Moreover, the leaves are high in fiber, vitamins C and A, and the minerals calcium, magnesium, and iron (Gupta and Gudu, 1991; Saunders and Becker, 1984).

For thousands of years before the arrival of the Spanish, Native Americans cultivated *Amaranthus* species for the nutritious seeds (MacNeish, 1971). Hernán Cortés, recognizing the importance of Amaranth in the diet and the religion of the Aztecs, ordered the destruction of the Amaranth fields and made growing the crop a crime punishable by death. The grain quickly disappeared as a major food source, though it has remained in quiet cultivation in isolated areas of Central and South America (Saunders and Becker, 1984). In recent times Amaranth furnish nutritious greens and grain are commonly eaten by native peoples in East and South Africa, India and other parts of Asia (Harlan, 1975; Holm *et al.*, 1977; Simmonds, 1976; Struwer, 1971; Watt and Breyer-Brandwijk, 1962).

However, Palmer amaranth has toxic botanical structures (Wagstaff, 2008). Amaranth leaves contain some oxalic acid, likewise spinach, which tends to bind calcium and thus restrict its absorption by the body (Tull, 1999). Moreover, they can accumulate nitrates in their leaves under dry conditions and, when these leaves are eaten by cattle, the nitrate is converted to nitrate. High concentrations of nitrate can be poisonous and can cause livestock losses (Burrouis and Tyrl, 2001; Tull, 1999).

Furthermore, Menges (1988) reported inhibition of grain sorghum and cabbage (*Brassica oleracea var. capitata* L.) growth resulting from Palmer amaranth allelopathic properties. Incorporation of Palmer amaranth residue was also reported to decrease carrot (*Daucus carota* L. var. *sativa*) and onion (*Allium cepa* L.) growth by 49 and 68%, respectively (Menges, 1987).

References


---

**Slowing the Spread of Invasive Species through Pathway Management: The Don’t Move Firewood Campaign**

**Demorando la Dispersión de Especies Invasoras a través del Manejo de Vías de Entrada:**

**La Campaña para no Mover Leña**

**Leigh Greenwood**

*Don’t Move Firewood Campaign Manager / Coordinador de la campaña No Muevas La Leña*

*The Nature Conservancy / Conservando la naturaleza*

526 E Front St.Missoula, MT 59802 USA

lgreenwood@tnc.org

**Resumen**

La campaña de No Muevas Leña es un esfuerzo en el continente para educar al público en el tema del movimiento de plagas en bosques a través de la ruta de la leña para fogatas. No Muevas Leña es única en los enfoques tan variados que utiliza para acercarse al público, desde Facebook hasta espectaculares, tatuajes falsos y frisbees hechos a la medida. No Muevas Leña mejora constantemente y se expande a través de asociaciones en casi todos los 50 estados y Canadá. Con el lanzamiento del sitio “No Muevas La Leña” en español (nomuevalena.org) esperamos mejorar nuestra habilidad para ayudar a México en su esfuerzo para detener la dispersión de plagas que viajan en la leña. El aprendizaje sobre el porqué este manejo es efectivo aunque lento, está cambiando el comportamiento del público en toda América del Norte. La campaña está manejada por el
Abstract
The Don't Move Firewood campaign is continent wide effort to educate the public on the issue of forest pest movement via the firewood pathway. Don't Move Firewood is unique in its tremendously varied approaches to public outreach; from Facebook to billboards, fake tattoos to custom Frisbees, Don't Move Firewood is constantly improving and expanding its reach through partnerships in nearly all 50 states and Canada. With the launch of our new Spanish language site in March, No Mueva La Leña (nomuevalena.org), we hope to also improve our ability to aid Mexico's efforts to slow the spread of pests that travel in firewood. Learn more about why this pathway management approach is well regarded, cost effective, and slowly but surely changing the behavior of the public all over North America. The campaign is managed by The Nature Conservancy's Forest Health Protection Program on the behalf of the Continental Dialogue on Non-native Forest Insects and Diseases.

Casuarina in the Sian Ka’an Biosphere Reserve
La casuarina en la reserva de la biosfera Sian Ka’an

Yadira Gómez Hernández
Research and Monitoring Coordinator / Coordinador de Investigación y Monitoreo
National Commission of Natural Protected Areas (CONANP) / Comisión Nacional de Áreas Naturales Protegidas
Calle Venado # 71, 20 Piso, SM 20 MZ 18 Cancún, QR 77500 Mexico
ygomez@conanp.gob.mx

Resumen
Los primeros individuos de Casuarina fueron introducidos en pocos sitios de la Reserva en la década de los ochenta, con el propósito de utilizarlos como cortinas rompe vientos, se dispersó de manera autónoma por las Bahías de la Ascensión y del Espíritu Santo, acarreando una invasión de las zonas costeras y provocando el desplazamiento de la flora y fauna nativa, particularmente la duna costera.

La distribución lineal de Casuarina en la Reserva se debe a causa de los espacios físicos creados por los huracanes y la propia reproducción alada y vegetativa que presenta. De acuerdo con entrevistas realizadas a los primeros colonizadores de la colonia Punta Herreo, la casuarina o pino de mar, como es conocido en la zona, empezó a invadir la Bahía del Espíritu Santo después del paso del Huracán “Janet” en 1955.

La primer campaña para el control de las casuarinas fue en 1995 en sinergia con la organización Amigos de Sian Ka’an, se le dio tratamiento a 112,859 individuos. En 1997 se puso en marcha una segunda campaña y en 1999 se realizó una tercera campaña.

Durante estas tres campañas se observó que no se lograba la mortalidad de los individuos y que con el paso del tiempo las ramas que sobrevivieron al tratamiento crecieron hasta formar un organismo con la base del tronco altamente ramificada. Por tal motivo se realizaron una serie de modificaciones subsecuentes al método inicial, de tal manera que se ha estandarizado el método de control y se utiliza el herbicida Garlon-4, como mejor alternativa.

En julio de 2000 se solicitó el apoyo de los particulares para arrancar las plántulas y retoños de casuarina en sus terrenos. A partir de esta fecha, año con año se realiza una campaña de erradicación con el personal de la reserva; logrando mitigar el crecimiento en biomasa de la casuarina; sin embargo, el paso de los huracanes y tormentas tropicales por la zona han provocado que su dispersión siga en aumento, por lo que es necesario contar con una campaña de educación ambiental de mayor impacto para poder reducir de manera efectiva las casuarinas en las zonas donde se distribuye y pensar en algún método alternativo de erradicación más efectivo.

Abstract
The first individuals of Casuarina were introduced in the few sites of the Reserve in the 80s to be used as windbreakers, and the species dispersed autonomous-
ly through the Ascensión and Espíritu Santo Bays generating an invasion of the coastal zones and displacing native flora and fauna, particularly the coastal dunes. The linear distribution of Casuarina in the reserve is due to the physical spaces created by hurricanes and its winged vegetative reproduction mechanism. According to interviews with the first people in Punta Herrero, casuarina or “pine of the sea” as it is known, first invaded the Bay of Espíritu Santo after Hurricane Janet in 1955.

The first campaign for the control of casuarina was in 1995 with the organization Amigos de Sian Ka’an, 112,859 individuals were treated. In 1997 and 1999 a second and third campaign were carried out. During these campaigns it was observed that the individuals did not die and that with time, the branches that survived grew until forming an organism with a branched base. For such reason the method was modified and now the herbicide Garlon-4 is used as a better alternative.

In July 2000 the community was invited to pull plantlets in their lands, since that day an annual eradication campaign is carried out with reserve personnel mitigating the growth of casuarina. Hurricanes and tropical storms in the area have caused that the species is still being dispersed so it is necessary to have an environmental education campaign of greater impact to decrease the presence of this species in its distribution area and find more efficient eradication methods.

Control and Eradication of Giant Reed (Arundo donax) in the Cuatrociénegas Flora and Fauna Protection Area

Control y erradicación del Carrizo gigante (Arundo donax) en el Área de Protección de Flora y Fauna Cuatrociénegas

Martin Alfonso Carrillo Lomas
Operating technician / Técnico Operativo
National Commission of Natural Protected Areas (CONANP) / Comisión Nacional de Áreas Naturales Protegidas
Escobedo #200 Poniente, Zona Centro Cuatro Ciénegas, Coahuila, 27640 Mexico
martin.carrillo@conanp.gob.mx

Other authors / Otros autores:
Ivo García Gutiérrez & Juan Carlos Ibarra Flores
CONANP

Resumen
Las especies invasoras son la segunda causa de pérdida de biodiversidad a nivel mundial. Reducen la capacidad de los ecosistemas para producir servicios ambientales, afectan la salud pública y generan grandes pérdidas económicas. Este trabajo muestra un caso exitoso de control de Carrizo Gigante (Arundo donax) con la participación de pobladores locales en el humedal más importante del Desierto Chihuahuense, Cuatro Ciénegas, Coahuila, México. El Carrizo Gigante es una especie invasora que consume grandes cantidades de agua e invade humedales desplazando especies nativas. Para el control del Carrizo Gigante se implementa un método misceláneo, que consiste en la combinación de varias técnicas. Se inicia con el uso de fuego o la poda de tallos. Posteriormente de forma manual se realizan la extracción, deshidratación e incineración de rizomas. El seguimiento consiste en visitas mensuales para la extracción manual de rebrotes. Los resultados obtenidos muestran un avance en el control del 85% en poblaciones que ocupan de 20 a 2000 metros cuadrados, distribuidas en una superficie total de 2.16 has. Los resultados positivos se deben al seguimiento en el control a largo plazo, aunado al fomento de la participación social y capacitación mediante actividades de educación para la conservación. Sugerimos este método de control para superficies menores a una hectárea. Se espera erradicar las poblaciones de carrizo en los próximos 5 años.

Abstract
Invasive species are the second cause of loss of biodiversity worldwide. They lower the capacity of ecosystems to generate ecosystem services, affect public health and generate large economic losses. This work shows a successful case of control for Giant Reed (Arundo donax) with the participation of locals in the
most important wetland of the Chihuahuan Desert, Cuatro Ciénegas, Coahuila, México. Giant reed is an invasive species that uses up large amounts of water and invades wetlands displacing native species. For the control of giant reed a miscellaneous method is implemented, this consists of the combination of several techniques. This begins with the use of fire and cutting of branches. Later manually the extraction, dehydration and incineration of rhizomes is carried out. This is followed up with monthly visits for the hand extraction of regrowths. Results show an advance in the control of 85% of populations that occupy from 20 to 2000 square meters, distributed in a total surface of 2.16 has. Positive results are due to the follow up in the long term control, together with the promotion of social participation and training through education activities for conservation. We suggest this control method for surfaces less than one hectare. It is expected that reed populations will be eradicated in the next 5 years.

Presentation summary

National Commission of Protected Areas
Cuatrociénegas Flora and Fauna Protection Area
Protocol for the control and eradication of the giant reed (Arundo donax L.).
April 2012

![Figure 28. Rhizome extraction](image)

Introduction

In the arid and semiarid regions of the North of Mexico, one of the environmental problems is the lack of precipitation that feeds the most valuable watersheds of the Valley of Cuatro Ciénegas. Given the importance of the Cuatrociénegas Flora and Fauna Protection Area and the fragility of the wetlands, a study on invasive species was carried out (Valdés, 2009). The study identified 67 invasive species out of which approximately 10 are wetland species. March and Martínez (2007) identified 20 invasive species in the wetland, these include plants, fish, crustaceans, mollusks, amphibians and reptiles, therefore it is of vital importance to promote the restoration of the fragile aquatic ecosystems. The Giant Reed (Arundo donax L.) is one of 10 control priority species that is found in the protected area wetlands. Its water requirements are very high so it represents a priority for its control and eradication. In addition it is considered one of the “One Hundred of the World’s Worst Invasive Alien Species” and a priority for its eradication and control (IUCN, 2000). The giant reed propagates mostly asexually through the stem and
rhizomes, the main negative effects caused by the presence of this species in the wetlands is that it modifies the structure and composition of the species in riparian zones which, together with wetlands, are prone to reed invasions due to the transport of rhizomes or fragments of stems transported by water (Bell, 1997), this increases the possibilities of fire in such areas and decreases the diversity of native flora and fauna species (Bell, 1997).

Another one of the effects of the giant reed is that it uses large amounts of water so it is of great concern in semiarid regions (Iverson, 1993). It decreases the availability of water of neighboring plants and can affect the hydric balance of hydrographic basins, mostly in dry periods. One of the abilities of the giant reed is to regrow with more strength after a fire thus promoting its invasive potential (Bell, 1997).

As a result of the above, the Direction of the Cuatrociénegas Flora and Fauna Protection Area executes a Program for the Control and Eradication of Invasive Species that contains strategic lines to be followed in carrying out activities for its execution and communication during the period of 2011 to 2015. Some of the strategies considered for the control of the invasive species are: project communication, coordination and implementation.

**Objective**
Control and eradicate the populations of Giant Reed (*Arundo donax* L.) in the protected area.

**Materials and Methods**

**Study area description**
The Cuatrociénegas Flora and Fauna Protection Area is located in the central region of the state of Coahuila, occupying a surface of 83,347-47-00 Ha; 80 kilómetros west of Monclova; between the coordinates 26° 45’ 00” and 27° 00’ 00” North Latitude; 101° 48’ 49” y 102° 17’ 53” West longitude, (PROFAUNA, 1999).

A semiwarm climate predominates in the PA with Little rain in the Winter, varying temperatures, precipitation between 100 and 440 mm per year, most of this in the summer. Maximum temperature exceeds 30°C and minimum is under 12°C INEGI (1988).

**Wetland vegetation**
The vegetation in the wetland is comprised mostly by species such as *Phragmites australis* (Cav.) Trin. ex Steud), *Thypa domingensis* Pers., *Nymphaea ampla* Salisb. dc. and some species of the cyperae family, although in parts of the brook and intermittent flooding areas it is possible to find grasses such as saltgrass (*Distichlis spicata* L. Greene), Alkali sacaton (*Sporobolus airoides* (Torr). Torr.), Digitaria Haller and gulf cordgrass (*Spartina spartinae* (Trin.) Merr. ex Hitchc.), among others.

**Wetland fauna**
Among the aquatic species in the wetland are the Cuatro ciénegas sardine (*Cyprinella xanthicara* Minckley and Lytle), Cuatrociénegas Gambusia (*Gambusia longispinis* Minckley), mojarra de cuatrociénegas Minckley’s cichlid (*Herichthys minckleyi* Kornfeld & Taylor), Coahuilan Box Turtle (*Terrapene coahuila* Schmidt & Owens), Cuatro Ciéneas darter (*Etheostoma lugoi* Norris & Minckley), some of them endemic from the Cuatro Ciéneas valley.

The control and eradication activities began in 2006 in an infested site of approximately 300 square meters. During the following years (2007 and 2008) more sites were included, these are found in table 37 where giant reed control and eradication activities are carried out.

The method used for the control of giant reed in the protected area is miscellaneous, it combines several techniques like fire, cutting, extraction, rhizome dehydration and incineration and finally monthly visits for the extraction of regrowths.

**Materials**
- Gloves
- Safety gloves
- Rubber boots
- Rake
- Lawn sissors
- Visit registration form
- Logbook
- Pen or pencil
- Camera
- 50m measuring tape
- GPS

**Procedure**

1. **Site location:**
Inspections were carried out to detect reed populations, sometimes local inhabitants report such populations. When infested sites are detected a site visit must be programmed.
2. Measurement of the affected surface:
Once the site has been identified site visits are carried out to verify if the reed is present, if the site is infested the following information is collected:

- Decimal geographic coordinates and datum WGS84
- Photographs of the site
- Affected surface measurements
- Coverage of the giant reed in one square meter
- Flora and fauna at the site
- Characteristics of the site (wetland, flooding area, canal, pond, among others).

3. Inventory of material, human and economic resources:
After obtaining the field data, the information must be processed to determine the following points:

- **Total infested surface in square meters**

  Example: if 3 sampling points were used and the coverage data obtained was of P1 50%, P2 80%, P3 60%, the percentage used would be 63.3%. In the case of number of plants P1 100, P2 80, P3 200, we would take 126.6 plants.

- **Average plant cover and number of plants present.**
  - Based on the affected surface data in square meters, average cover and plant density. The human and financial resources required for the implementation of activities in the control of Giant Reed are estimated. It is calculated that one person covers 1m² per day.

- **Human and material resource estimate:** Based on the affected surface data in square meters, average cover and plant density. The human and financial resources required for the implementation of activities in the control of Giant Reed are estimated. It is calculated that one person covers 1m² per day.

- **Some sources of financing for the implementation of projects and invasive species control is the Temporary Employment Program (PET) and the Program for the Conservation and Sustainable Development (PROCODES) operated by APFF Cuatrociénegas.**

4. Personnel training:
When the human requirements have been estimated and there are economic resources to implement projects to control invasive species a training plan must be prepared for the participants in the project. This should contain information on the problems of Giant Reed in wetlands and the importance of preventing it’s introduction to other ecosystems as well as information on the activities to be carried out in the field. It is important to organize people in work groups with one person as a leader.

5. Control and eradication activities
The steps to be followed in the miscellaneous control are the following:

1. **Fire:**
The fire can be started with fuel (oil, gasoline and a match) to destroy the aerial part of the plant (cane and leaves). It should be mentioned that the fire does not kill the rhizome (roots) which causes the giant reed to grow again and can even expand its impact area. For this activity it is necessary to pay workers and personnel to prevent the fire from going out of control and can be mitigated thus preventing damage to surrounding flora and fauna. One of the benefits of this activity is that it also eliminates the ivy *Rhus toxicodendron* (L.) Kuntze, which is a plant that secretes a type of dust that causes itchiness. There are regulations for the use of fire in forest areas so the appropriate permits should be obtained, especially for large areas.

2. **Cutting:**
This is carried out with scissors, preferably with cutting capacity greater than 4cm. The cut must be made as superficially as possible, up to a height of 20cm and in a straight line, not diagonal. If it is done diagonally it can be a risk to workers in case they slip and fall on the cut canes and could cause serious damage or even death.

3. **Rhizome extraction:**
The rhizomes of giant reed form interlocked knots tied in all directions forming a layer of about 15cm thick. The extraction of rhizomes is carried out manually with a pick ax cutting the rhizomes in pieces to deposit them in a safe place where they can't sprout.

4. **Rhizome dehydration:**
The rhizomes, when extracted, are transported to a place where it is possible to dehydrate them. This process is carried out during 3-4 months since it is carried out in open areas in compact places to prevent their sprouting.

5. **Rhizome incineration:**
During this stage the rhizomes are eliminated through incineration which is carried out in areas free of vegetation to prevent fires and during the days with no wind. Incineration is very important since it eliminates rhizomes to prevent propagation to other places.

6. **Site monitoring:**
Once the reed has been removed from the site monthly visits should be carried out to follow up, the field information is captured in a predesigned format (Attachment 1).
**7. Extraction of sprouts:**
If there are sprouts in the sites that are controlled, these must be removed manually. The activity should be carried out during monthly visits.

**8. Site evaluation:**
The controlled sites should be evaluated at least once a year. The data to be measured is: surface with presence of reed regrowth, cover per square meter and plant density per surface unit. The data must be registered in a database per site in order to compare the success of the technique used.

**Results**
The success in the implementation of the projects is due to the annual follow-up that has been possible thanks to government funding allowing for long term planning. The following are data of the surface that has been treated per year and the advances in the control of the reed.

**Table 37.** Sites where control and eradication activities have been carried out for populations of Giant Reed in Cuatrociénegas.

<table>
<thead>
<tr>
<th>Site name</th>
<th>Approximate surface (m²)</th>
<th>Years</th>
<th>Number of regrowths/monthly average</th>
<th>Percentage of advance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Juan García Lujan</td>
<td>3,180</td>
<td>2007</td>
<td>5</td>
<td>90%</td>
</tr>
<tr>
<td>Angostura 1</td>
<td>2,603</td>
<td>2008, 2007</td>
<td>2</td>
<td>85%</td>
</tr>
<tr>
<td>Antejo</td>
<td>152</td>
<td>2008</td>
<td>50</td>
<td>70%</td>
</tr>
<tr>
<td>José Jaime Ramos Hinostroza</td>
<td>3,010</td>
<td>2008</td>
<td>2</td>
<td>95%</td>
</tr>
<tr>
<td>Rene Cantú Garza</td>
<td>96</td>
<td>2008</td>
<td>4</td>
<td>95%</td>
</tr>
<tr>
<td>Canal Tío Julio</td>
<td>681</td>
<td>2008</td>
<td>18</td>
<td>90%</td>
</tr>
<tr>
<td>La Vega</td>
<td>260</td>
<td>2008</td>
<td>2</td>
<td>98%</td>
</tr>
<tr>
<td>Angostura 2</td>
<td>1920</td>
<td>2009</td>
<td>25</td>
<td>78%</td>
</tr>
<tr>
<td>Antiguos Mineros</td>
<td>150</td>
<td>2009</td>
<td>8</td>
<td>75%</td>
</tr>
<tr>
<td>El Borbollón</td>
<td>36</td>
<td>2009</td>
<td>3</td>
<td>90%</td>
</tr>
<tr>
<td>Las Salinas</td>
<td>1,160</td>
<td>2009</td>
<td>25</td>
<td>80%</td>
</tr>
<tr>
<td>Río Mezquite</td>
<td>120</td>
<td>2009</td>
<td>15</td>
<td>95%</td>
</tr>
<tr>
<td>El Venado</td>
<td>370</td>
<td>2010</td>
<td>8</td>
<td>75%</td>
</tr>
<tr>
<td>Luis Roberto Carrillo Villegas</td>
<td>160</td>
<td>2010</td>
<td>15</td>
<td>70%</td>
</tr>
<tr>
<td>Alejandro Garza</td>
<td>4,620</td>
<td>Sin erradicar</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ejido San Juan</td>
<td>3,100</td>
<td>2011</td>
<td>20</td>
<td>85%</td>
</tr>
</tbody>
</table>

**Figure 29.** Economic resources invested per year in the control and eradication of the Giant Reed populations in the Cuatrociénegas FFFA.
Discussion

Ther mechanical, chemical and biological methods for the control and eradication of Giant Reed (*Arundo donax* L.), are the following:

The mechanical method includes the following three techniques:
1. Use of fire, burning the aerial part of the plant (stem and leaves), this does not remove the root or the rhizome.
2. Remove the aerial part of the plant by cutting the stems at a height of 4cm above ground surface.
3. Trapping or covering is another technique of the mechanical method consisting in cutting or folding the reed as close to the ground as possible and placing a black plastic during two or four months to block sunlight and remove the plants. This technique is costly because the plastic has to be a thick membrane that can withstand the sun during four months. It should be noted that once the plastic is removed, the plants are not completely eliminated.

Chemical control consists on sprinkling chemical substances (glyphospahte), these herbicides are absorbed by the foliage of the weed moving throughout the plant affecting up to the roots.

Biological control consists on the use of two insect species a wasp (*Tetramesa romana* Walker) and the Arundo Scale (*Rhizaspidiotus donacis* Leonardi), that are spread in the reed infestations to reproduce and control the weed.

The previously describe methods are not recommended, the use of fire causes the weed to return with more strength and can expand the population,
it is cheap but does not control the reed populations. The cutting technique is not effective as the plants regrow after 15 days. Trapping or covering is not recommendable since the plastic is very expensive. To use chemical control, and considering that these products are not selective for a particular species, they could cause death to other species plus there could be residual effects in water, soil and air. In the case of biological control, the use of insects is not recommended since they could proliferate and hybridize with native insects generating a larger problem.

**References**

**Table 38.** Site visits to detect giant reed regrowth.

<table>
<thead>
<tr>
<th>Name of the site</th>
<th>Approximate surface (m²)</th>
<th>Geographic coordinates</th>
<th>Previously treated site</th>
<th>Date</th>
<th>Number of regrowths</th>
<th>Inspector's name</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Team Arundo: A Partnership for Management and Control of Giant Reed (*Arundo donax*) and Restoration of Habitat in Southern California**

**Equipo Arundo: una colaboración para el manejo y control del Carrizo gigante (*Arundo donax*) y la restauración del hábitat en el Sur de California**

**Nelroy Jackson**
*Monsanto (retired) and former isac Vice Chair / Monsanto (jubilado) y antiguo presidente de isac*
1187 Stillwater Rd. Corona, CA 92882 USA
nelroy.jackson@att.net

**Resumen**

*Arundo donax* (carrizo gigante) ha infestado hasta 10,000 acres en la cuenca del río Santa Ana en tres condados del sur de California. Los problemas causados por Arundo donas incluyen el desplazamiento de plantas nativas, fuente pobre de alimento y cubierta para la vida silvestre incluyendo el Vireo de Bells (*Vireo bellii pusillus*), incrementa el riesgo de incendios, impide el control de inundaciones bloqueando canales y consume más agua que la vegetación nativa.

Nature Conservancy estaba interesado en restaurar el hábitat para el vireo de Bells. El Departamento de Silvicultura y protección de incendios de California estaba interesado en reducir el contenido de combustible y el peligro de incendios. El Distrito de Parques y Espacios Abiertos de Riverside estaba interesado en obtener tierra para el parte, contactaron personas que tuvieran información sobre *Arundo donax* incluyendo la Agencia de Manejo Ambiental de Orange County
y Monsanto (Nelroy Jackson). Se realizaron reuniones periódicas y el grupo se expandió para incluir intereses regulatorios y involucrando así a agencias regulatorias.

Se eligió el nombre Equipo Arundo para indicar que no hay una agencia como jefe, se eligió un líder y se realizaron juntas mensuales para definir temas como conflictos en metas, necesidad de permisos, métodos de control, obtención de fondos. No se hizo un Memorando de Entendimiento oficial debido a limitaciones legales y el tiempo y costo involucrados en el proceso.

Algunos de los logros del equipo han sido: tratar el área con herbicida como demostración, cambios en la legislación de "puedo evitar que hagas cualquier cosa en hábitat designado para especies T&E" a "la remoción de especies invasoras y restauración de hábitat es la mejor forma para ganar hábitat para las especies T&E". Por lo tanto incrementó la cooperación. El grupo de Ingenieros de la Armada cambió su posición de "nece-sitas mi permiso para cortar Arundo donax" a "deberá haber un programa para remover especies invasoras y emitiré un permiso regional para facilitar las cosas".

Aprendimos el lado de relaciones públicas de los proyectos – ¡los reporteros pueden ser nuestros amigos! Siempre haz lo que sabes que se puede lograr.

**Abstract**

*Arundo donax* (giant reed, giant cane, wild cane, bamboo) was estimated to infest up to 10,000 acres in the Santa Ana River Basin in 3 Southern California counties. Problems caused by *Arundo donax* include: displacement of native plants, is a poor food source and cover for wildlife, including the least Bell’s vireo, increases fire hazard and firefighting costs, impedes flood control by clogging channels, consumes more water than native vegetation

The Nature Conservancy was interested in restoring habitat for the least Bells vireo. The California Department of Forestry and Fire Protection was interested in reducing the fuel load and fire hazard. The Riverside Parks and Open Space District was interested in reclaiming parkland in the river bottom. They contacted a number of people to learn about the habits and possible control measures for *Arundo donax* including Orange County Environmental Management Agency and Monsanto Company (Nelroy Jackson). Periodic meetings were held and the group was expanded to include Regulatory interests and regulatory agencies got involved.

A name was chosen - **Team Arundo**. This is significant since no one agency or unit is 'the boss'. A leader was chosen. Monthly meetings were used to raise and define issues such as: - conflicting goals, conflicting jurisdictions, the need for permits, methods of control, raising money. A formal Memorandum of Understanding (MOU) was not written because of the legal constraints, time and cost involved in that process.

Some of the accomplishments of the team have been: small area treated with herbicide as a demonstration and pilot and then expanded. Regional General Permit - Fish & Wildlife Service – change in regulatory approach “I can prevent you from doing anything in designated T&E species habitat” to “Removal of Invasive Species and Restoration of habitat is the best way for us to acquire more habitat for T&E species”. Therefore, I will cooperate with you.

The Army Corps of Engineers moved from a regulatory position of “You need my permission to cut *Arundo donax* in the watershed” to “Thou shalt have a program to remove invasive species from my watershed, and I have issued a Regional General Permit to make regulatory life easier for you”.

We learned the Public Relations Side of projects – Reporters could be our Friends! Always “DO THE DOABLE”.
**Sian Ka’an Biosphere Reserve**
In Maya, Sian Ka’an means “Origin of the Sky”. Located on the east coast of the Yucatán peninsula in the municipalities of Felipe Carrillo Puerto, Cozumel and Solidaridad. The east limit is the Caribbean sea and it covers two large bays and the barrier reef up to a depth of 50m in the continental platform.

**Isla Contoy National Park**
Located in the state of Quintana Roo, 30 km north of Isla Mujeres, and 12.8 km from the northeast coast of the Yucatán Peninsula. Among the mexican Caribbean island system, this is the island located furthest to the north and marks the end of the reef system that borders the east coast of the Yucatán peninsula.

![Figure 31. Field trip to Sian Ka’an Biosphere Reserve](image1)
![Figure 32. Field trip to Sian Ka’an Biosphere Reserve](image2)
![Figure 33. Field trip to Isla Contoy](image3)
![Figure 34. Casuarina equisetifolia in Sian Ka’an](image4)