2001 Research Grants Program Progress Report

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Center for Invasive Plant Management
Dept. Land Resources and Environmental Sciences
Montana State University
Bozeman, Montana

Center for Invasive Plant Management
2001 Research Grants Program
Progress Report

Executive Summary

The Center for Invasive Plant Management (CIPM) was established in 2000 to promote proactive, ecologically sound management of invasive plants in western North America by sponsoring research, conducting public education, and facilitating collaboration and communication among researchers, educators, and land managers.

Invasive plant research is supported through annual grants to establish and support innovative, ecologically-based projects throughout the West. Integrated approaches to weed management are emphasized; multidisciplinary programs are encouraged. The objective of the Center's research grants program is to promote new approaches to invasive plant management, as well as to synthesize and communicate research results to improve on-the-ground land management.

Early in 2001, CIPM issued a request for proposals in its first round of research grants. Proposals were accepted in three categories: Seed Money, Applied Science, and Multidisciplinary Research Planning. Sixteen proposals from five states were received, requesting $99,605. Twelve projects in five western states were awarded a total of $70,352 in research funding. Awards ranged from $1,000 to $10,000.

The *Seed Money* grants support the collection and analysis of ecological data to better understand the prevention, introduction, spread, management, and ecology of invasive plants. The four funded projects were all very productive in spawning continuing research and in developing new research directions. The goal of the *Applied Science* grants is to apply scientific research to field-level situations. The five Applied Science projects funded in 2001 more than met these goals with immediate outcomes ranging from online distribution maps of leafy spurge and yellow starthistle, to an improved spraying regime implemented at a California state park. One *Multidisciplinary Research Planning* award was made with the aim of developing a regional consortium and a research proposal to be submitted to major funding sources. This goal was met in an unexpected way by contributing to pending national legislation to secure long-term federal funding for tamarisk control.

This report was compiled in Summer 2003 to document the 2001 research projects funded by CIPM, as well as to follow up on the "ripple effects" of the grantees' research and evaluate the success of the Center's research grants program. Information was gathered from grant proposals, final reports, and interviews with the Principal Investigators.

Results indicate a successful first-year granting program with benefits directly awarded to four universities, one tribe, and two nongovernmental organizations. Funded research resulted in a number of professional papers and presentations, practical tools for land managers, and potential national legislation. In several cases, CIPM grants leveraged additional funding for research projects and built new working relationships among project partners.

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2001 Research Grants Program Highlights

- CIPM awarded $7,953 to Dr. Jodie Holt (University of California – Riverside) to develop ecologically based, practical strategies for prevention and management of invasion by seed of artichoke thistle. This funding was the impetus for expanding the program and gaining an **additional $80,000** in funding.
- Findings from the artichoke thistle seedling phenology study have already been implemented at Crystal Cove State Park where spraying is now concentrated on seedlings rather than adult plants, **increasing the effectiveness** of the control program and saving public funds. **New working relationships** between researchers and park personnel were developed.
- Data on the distribution and relative abundance of leafy spurge and yellow starthistle were combined into single **maps** for the entire West through a $7,800 project to the Western Weed Coordinating Committee. The maps are available online, and the mapping project itself demonstrates a method for combining maps developed with a variety of software systems.
- The Rillig group at the University of Montana received $4,730 to study the effect of individual invasive plant species on the soil ecosystem. This work has resulted in an **National Science Foundation proposal** that was submitted in July 2003, pursuing the links between knapweed invasion and glomalin, a glycoprotein produced by arbuscular mycorrhizal fungi that is used as an indicator of soil aggregation.
- Drs. Holt and Rillig both commented on the value of a small grant program to their **graduate students**, boosting their self-confidence and allowing them to take the initiative in writing a grant and pursuing their own research directions.
- Issues raised at the *Strategies for Long-Term Management of Tamarisk* conference in Colorado supported by CIPM contributed to **pending national legislation** to establish a consistently funded, long-term tamarisk management program.
- An award of $8,000 to the Pacific Biodiversity Institute produced maps of the distribution of six weed species, which are now in use by the ecologist for the Okanogan and Wenatchee National Forests. The project also produced an easily learned, user-friendly **sampling protocol**, which is now in use in a related project in the Sonoran Desert.
- In funding a multiscale ecological assessment of yellow toadflax in the West Yellowstone area by Dr. Paul Alaback of the Univ. of Montana School of Forestry and his Ph.D. student Anibal Pauchard, CIPM suggested they collaborate with Bruce Maxwell of Montana State University. Dr. Pauchard has now accepted a faculty position in Chile, but he expects to continue this **collaboration** with a visit to the Maxwell lab planned for July 2004.
- A start-up grant of $4,940 to Bruce Maxwell of Montana State University to develop methods to inventory weed populations in remote areas was used to get **further funding** from the Park Service to complete the development of the inventory/survey methodology.
- Overall, CIPM-funded research resulted in at least three professional **papers** (several others pending) and numerous **presentations**.

CIPM 2001 Research Grants Program

Program Description

The mission of the Center for Invasive Plant Management is to promote ecologically sound management of invasive plants in western North America by sponsoring research, conducting public education, and facilitating regional collaboration and communication among researchers, educators, and land managers. Invasive plant research is supported through annual grants to establish and support innovative, ecologically based projects that impact the West. Integrated approaches to weed management are emphasized; multidisciplinary programs are encouraged. The objective of the Center's research grants program is to promote new approaches to invasive plant management, as well as to synthesize and communicate research results to improve on-the-ground land management.

In 2001, CIPM issued a request for proposals for its first round of research grants. Proposals were accepted in three categories: Seed Money, Applied Science, and Multidisciplinary Research Planning. Sixteen proposals from five states were received, requesting $99,605. Twelve projects in five western states were awarded a total of $70,352 in research funding. Awards ranged from $1,000 to $10,000.

The plants and their related ecosystems studied in the funded projects included spotted knapweed (3 projects), diffuse knapweed (2), and Russian knapweed; yellow toadflax (2) and Dalmatian toadflax; and leafy spurge (2), tamarisk, Himalayan blackberry, artichoke thistle, whitetop, hairy whitetop, and yellow starthistle.

This report was compiled to document the 2001 research projects funded by CIPM, as well as to follow up on the "ripple effects" of the grantees' research and evaluate the success of the Center's research grants program. Information was gathered from grant proposals, final reports, and interviews with the Principal Investigators. Each of the grant projects is described in detail within one of the three funding categories.

Online grant application forms, abstracts of funded projects, and final reports are available on the CIPM web site, www.weedcenter.org.

Seed-Money Grants

Seed-money grants are awarded to support the collection and analysis of ecological data to better understand the prevention, introduction, spread, management, and ecology of invasive plants. The results of these one-year projects are expected to provide a springboard for subsequent longer-term investigations. Seed-money grants are one-time awards to applicants from universities, government agencies, or non-profit organizations. Proposals are evaluated according to the following criteria:

- Relevance to the ecological management of invasive plants in western North America.
- Potential for collected data to be relevant to subsequent long-term programs.
- Potential for regional application of research results.

Of the nine proposals submitted, the following six were funded. Four were completed. (SM07-01 was awarded $5,000, but the award was declined when the PI accepted a position at another university; SM08-01 requested $4,723, was awarded $1,000 for travel and education, but the award was declined because of its limited indirect cost rate.)

CIPM 2001 Seed Money Grants		
No. / Title	**PI**	**Award**
SM02-01 *Linaria vulgaris* Mill. invading the West Yellowstone area: A multi-scale ecological assessment	Paul Alaback School of Forestry University of Montana, Missoula	$5,000
SM04-01 Effects of spotted knapweed and leafy spurge invasion on key soil functions	Matthias Rillig Division of Biological Sciences University of Montana, Missoula	$4,730
SM05-01 Identifying the factors that determine the invasion of a weed into native plant communities	Bruce Maxwell Dept. Land Resources & Env. Science Montana State University, Bozeman	$4,929
SM06-01 Methods to inventory weed populations in remote areas	Bruce Maxwell Dept. Land Resources & Env. Science Montana State University,	$4,940
SM07-01 (Declined) Multiscale detection of invasive plant species in riparian zones along the Grande Ronde River, Northeast Oregon	Kathleen Dwire Dept. of Forest Science Oregon State University, Corvallis	$5,000 Declined
SM08-01 (Declined) Rehabilitating medusahead-infested uplands through the use of herbicides and interspecific competition	Jess Wenick Dept. of Fish and Wildlife Burns Paiute Tribe, Burns, Oregon	$1,000 Declined

Highlights of the Seed Money Grants program are listed below:

- In funding a multiscale ecological assessment of yellow toadflax in the West Yellowstone area by Dr. Paul Alaback of the UM School of Forestry and his Ph.D. student Anibal Pauchard, CIPM suggested they collaborate with Bruce Maxwell of MSU. Dr. Pauchard has now accepted a faculty position in Chile, but he expects to continue this **collaboration**, with a visit to the Maxwell lab planned for July 2004.

- A start-up grant of $4,940 to Bruce Maxwell of MSU to develop methods to inventory weed populations in remote areas was used to get **further funding** from the Park Service to complete the development of the inventory/survey methodology.
- The Rillig group at the University of Montana received $4,730 to study the effect of individual invasive plant species on the soil ecosystem. This work has resulted in an **NSF proposal** that was submitted in July 2003 to pursue the links between knapweed invasion and glomalin, a glycoprotein produced by arbuscular mycorrhizal fungi that is used as an indicator of soil aggregation
- Drs. Holt and Rillig both commented on the value of a small grant program to their **graduate students**, boosting their self-confidence and allowing them to take the initiative in writing a grant and pursing their own research directions.
- A start-up grant of $4,940 to Bruce Maxwell of MSU to develop methods to inventory weed populations in remote areas was used to get **further funding** from the Park Service to complete the development of the inventory/survey methodology.

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SM02-01 *Linaria vulgaris* Mill. invading the West Yellowstone area: A multi-scale ecological assessment

Paul Alaback and Anibal Pauchard
School of Forestry, University of Montana - Missoula
$5,000

Proposal

We propose that a multi-scale research approach is needed to capture both patterns and potential mechanisms of the invasion process in protected areas. To illustrate the utility and viability of a multi-scale approach in invasion of protected areas, we will assess and monitor yellow toadflax (*Linaria vulgaris* Mill.) in the West Yellowstone, MT, area at multiple scales.

This proposal is part of the project "Cross-boundary plant invasions: The case of West Yellowstone Area," which has been partially funded by the Rocky Mountain Cooperative Ecosystem Unit of the National Park Service. The main objective of the overall project is to determine the interaction between disturbance and dispersion of exotic plant invasions at multiple scales in the West Yellowstone area. This proposal is aimed at determining the invasive strategy of yellow toadflax at multiple spatial scales in the study area and to characterize its potential to invade areas in relation to disturbance types and regimes, both inside Yellowstone National Park and the Gallatin National Forest.

Results

The multi-scale approach proved to be useful in understanding invasion processes at each of the three scales (landscape, population, and patch) and in evaluating the overall potential threat of the species to ecosystems of the West Yellowstone area. Long-distance dispersal and patterns of overall invasion at the landscape scale, rapid patch expansion at the stand scale, and loss of native vegetation at the patch scale indicate that yellow toadflax can strongly impact ecosystems both through its rapid expansion and its competitive ability. These results show strong potential of yellow toadflax to invade high-elevation protected areas in the Rocky Mountains. The species can follow road corridors to establish new patches in a wide range of disturbance regimes and habitats. Once established in a new environment, it continues to grow in terms of number of patches, density of patches, and regularity of patch distribution, ultimately causing the decline of native plant species.

At the landscape scale, we studied patterns of propagule flow and susceptible communities. Our results show that the species occurs over a broad range of sites, apparently coming from two historical sources. The landscape results show heavily infested areas that can act as sources of propagules for non-infested areas.

At the stand scale, we assessed clonal patch dynamics and infilling of areas already affected by the invasive plant. We found that patches tend to be aggregated in newly invaded areas and become dispersed in heavily infested areas. Radial patch growth rates are related to site characteristics. The stand scale data suggest that once a new patch is established, it grows both by clonal advance and by creating new satellite patches.

Finally, at the micro-scale of the clonal patch, we studied changes in the invader population attributes and the effects on native plant species. The clonal patch scale analysis showed that ramet densities and effects on native plants are higher in the patch centers than at the edges. Both mean ramet height and reproductive vs. vegetative ramet height ratios are higher in patch cores. *Linaria vulgaris* may displace natural vegetation by its vigor even in large and old clonal patches.

Publications

Pauchard, A., P.B. Alaback, and E. G. Edlund. Plant invasions in protected areas at multiple scales: *Linaria vulgaris* (Scrophulariaceae) in the West Yellowstone area. Submitted to Western North American Naturalist. In press. To be published in October 2003 or January 2004.

We expect to publish at least one more paper with the results of this research.

Presentations

Pauchard, A. and P. Alaback. 2001. Assessing plant invasions from the landscape to the patch scale: *Linaria vulgaris* Mill. crossing Yellowstone National Park boundary. Ecological Society of America 86th Annual Meeting. Madison, Wisconsin.

Pauchard, A., P.B. Alaback, and E. G. Edlund. 2002. Monitoring plant invasions in protected areas: Why is it important to look at multiple scales? *Linaria vulgaris* in West Yellowstone. Ecological Society of America 87th Annual Meeting. Tucson, Arizona.

Pauchard, A. and P. Alaback. 2003. Detecting plant invasions at multiple scales in natural areas: *Linaria vulgaris* in West Yellowstone. Workshop: Detecting Invasive Exotic Plants: Approaches for the Florida Landscape. Miami, Florida. February 12-14, 2003.

Long-term goal and continued progress of research

The long-term goal of the research is to evaluate the threat imposed by *L. vulgaris* to the biodiversity of harsh, high elevation areas in the Rocky Mountains and generate information that could be applied in its management; to increase the understanding the exotic plant invasion processes within protected areas; and to recognize the advantages of multiscale approaches to plant invasion assessment.

In connection with Anibal Pauchard's doctoral studies on the comparative ecology of Yellowstone National Park and Villarrica National Park in Chile, the research has been completed. However, we expect to continue working on the same topic in cooperation with Dr. Bruce Maxwell of Montana State University as soon as funding is secured.

Benefits of seed money

The seed money contributed to the progress of this research in that it enabled the researchers to collect and analyze sufficient data to achieve their research objectives, using other funding for Dr. Pauchard's salary and tuition. Furthermore, additional research will be conducted in cooperation with Dr. Maxwell. Part of the money was used to attend the Ecological Society of America meeting in Madison, Wisconsin, where Dr. Pauchard was able to establish new working

relationships. Finally, CIPM recommended this work for a Florida workshop on detection of alien species, which was highly constructive.

Further assistance in advancing this research

CIPM could further assist the progress of this research by posting research reports on the web site, as well as by alerting researchers about meetings, workshops, and funding sources related to their work topic. CIPM could search for people interested in the practical application of these findings (e.g., land owners, agencies) that may also be interested in publishing short papers for the general audience.

Finally, Dr. Pauchard looks forward to continuing to work in cooperation with Bruce Maxwell. He has accepted a faculty position in Chile, and is planning a visit to the Maxwell lab at MSU. Originally, this was planned for July 2003 to collect additional monitoring data. For lack of funding we expect that this visit could be carried out in July 2004.

Web sites

Papers related to this Yellowstone study can be found at
http://www.forestry.umt.edu/personnel/faculty/palaback/forest_ecology_lab/pauchard/publica.html

SM04-01 Effects of spotted knapweed (*Centaurea maculosa*) and leafy spurge (*Euphorbia esula*) invasion on key soil functions

Matthias C. Rillig and Emily Lutgen (M.S. student)
Division of Biological Sciences, University of Montana - Missoula
$4,730

Proposal

The goal of the proposed research was to examine the influences of individual invasive plant species on the soil ecosystem – specifically, spotted knapweed (*Centaurea maculosa*) and leafy spurge (*Euphorbia esula*). The specific objectives were to compare invaded and non-invaded areas with respect to three key soil functions: 1) soil aggregation (water-stable aggregates) as mediated by arbuscular mycorrhizal fungi and the novel protein glomalin produced by these fungi; 2) soil respiration; and 3) soil carbon storage.

Soil aggregation and soil respiration are integrative indicators of soil health and soil biota activity. Soil carbon storage is a major function of soils at the ecosystem scale. This research will test whether invasive weeds can impact the capacity of soils to store carbon, which would lead to a novel link between invasion biology and important ecosystem and soil processes, as well as a novel assessment of the economic impact of weeds. Data collected during this proposed project will form the basis of a grant to be submitted to a major federal agency. Longer-term impacts may be the elucidation of invasion mechanisms.

Results

- Soil structure can deteriorate in areas where spotted knapweed infestations are not managed, and negative effects on soil parameters are proportional to the density of spotted knapweed.
- Methods to manage spotted knapweed do not negatively affect soil structure as compared to the soil structure in knapweed-invaded areas.
- Inter-annual and seasonal variability in effects of spotted knapweed on glomalin (used as an indicator of soil aggregation) in soil exists through drought and wet years.
- No significant variations in glomalin concentrations, hyphal length, and soil aggregate size fractions were observed along a gradient of leafy spurge (dense to sparse invasion).

Publications

Lutgen, E. R, and M. C. Rillig. Influence of spotted knapweed and spotted knapweed management treatments on arbuscular mycorrhizae and soil aggregation. Submitted to Weed Science.

Lutgen, E. R., D. Muir-Clairmont, J. Graham, and M. C. Rillig. Seasonality of arbuscular mycorrhizal hyphae and glomalin in a western Montana grassland. Plant and Soil. In press.

Long-term goal and continued progress of research

The long-term goal of this research is to serve as a platform from which to examine other soil-related mechanisms and effects of knapweed and leafy spurge invasion. On the basis of this project, an invasive plant biology research program will be initiated in the Rillig laboratory,

which has so far specialized on global change effects on soil biota. In the future, interactions of global change factors on invasive weeds could be a focus of research.

Any changes detected in soils that are invaded by spotted knapweed and leafy spurge will provide insight into how these weeds alter the communities they invade, since soil has so far been treated as a "black box" in invasive plant biology. Other soil properties, such as porosity, nitrification, and decomposition, can be examined in areas where invasive weeds have become established. By examining possible changes in soil properties caused by invasive weeds, a mechanism for their invasion may be discovered, which in turn may lead to more effective ways to eradicate the invasive plant species.

Benefits of seed money

This seed money helped in the progress of the research primarily by paying the summer salary for an M.S. student, Emily Lutgen, as well as for lab supplies. This work resulted in an NSF proposal to be submitted in July 2003, investigating how invasion by knapweed changes the arbuscular mycorrhizal fungal community in ways that are conducive to further invasion. The Rillig group is interested in pursing the link between present knapweed cover and soil aggregation, and in finding out what role the arbuscular mycorrhizal fungi is playing in the reduction of glomalin in knapweed-infested areas.

Dr. Rillig commented that from his point of view the greatest benefit of this grant was that his student was able to write a grant and get it funded, giving her a great boost in self-confidence and an excellent addition to her resume, as well as providing funds for the work. Furthermore, an undergraduate student from Salish-Kootenai College, Deborah Muir-Clairmont, worked on the project during the summers, making substantial contributions that resulted in her being a co-authorship of a publication in *Plant and Soil.*

Further assistance in advancing this research

The Rillig lab is beginning to move into invasive species research and would like to become more involved with MSU researchers in their areas of interest. They would appreciate help with identifying funding sources or collaborative opportunities for grants. Although they depend on peer-reviewed journals for dissemination of results, any work they do of interest to land managers or others can readily be made available, particularly through a web site.

Web site

As results from this research are published, articles will be linked to the Rillig lab web site, http://biology.dbs.umt.edu/fungus/default.htm.

SM05-01 Identifying the factors that determine the invasion of a weed into native plant communities

Bruce Maxwell
Dept. of Land Resources and Environmental Sciences, Montana State University – Bozeman
$4,929

Proposal

The proposed research would create permanent experimental installations in the Hegben Lake area of southwestern Montana to monitor yellow toadflax (*Linaria vulgaris*) invasions. Documenting the spatial location, frequency, abundance, and fecundity of yellow toadflax in relation to the diversity, frequency and abundance, and natural disturbance of native plant species will provide preliminary data to formulate specific hypotheses for processes that determine invasion. Further proposals will be submitted to test the hypotheses developed in this research.

Results

Three existing metapopulations (patches) of yellow toadflax were mapped at two different sites. Weed and native plant frequency and abundance were measured and the identity and extent of natural disturbance in and adjacent to the invaded areas were quantified. The spatial and temporal dynamics of the invaded communities will continue to be quantified by annual measurements on the same place in a permanently established grid. After one year of observation, the patch edges were very distinct at Site 1, but not at the other site, indicating that the spread of the patches at Site1 may be restricted to vegetative reproduction, coinciding with the heavy infestation of seed-feeding weevils at this site.

Publications

To date, publications consist of presentations and abstracts.

Long-term goal and continued progress of research

The preliminary results and the established experimental installation will be used to submit a grant proposal to the National Science Foundation (NSF) Population Biology program in 2003.

Benefits of seed money

The seed money was helpful in progressing the research, spawning additional research, and making connections with other scientists. It also may help attain additional research money. In addition, this seed money resulted in models for how protocols can be developed for managers to measure invasiveness and impact of invasive species.

Further assistance in advancing this research

This research could be further assisted by help with identifying funding sources and by extending information to managers via workshops, publications, Extension, web sites, or other appropriate means.

SM06-01 Methods to inventory weed populations in remote areas

Bruce Maxwell
Dept. of Land Resources and Environmental Sciences, Montana State University – Bozeman
$4,940

Proposal

In collaboration with Yellowstone National Park personnel and using their previous data, we propose to identify, through simulation, a range of sampling techniques that may most efficiently inventory weeds away from trails and roads.

Results

We found that 2-km, continuously observed transects, perpendicular to roads, trails, or other human disturbances, extending out into the wilderness were the most effective technique for discovering isolated weed patches under a wide range of possible distribution. All the weed species declined in frequency with distance from roads and trails. Also, vegetation dominated by Idaho fescue and big sagebrush had a significantly higher frequency of weed species.

Publications

To date, publications consist of presentations and abstracts.

Long-term goal and continued progress of research

The results from this seed grant were used to obtain funding through 2003 from the National Park Service to complete the development of the inventory methodology.

Benefits of seed money

The seed money was helpful in progressing the research, spawning additional research, and gaining further funding through a three-year project from the National Park Service. This project was particularly helpful in developing connections with other scientists. In addition, this project resulted in models for how to develop protocols for managers to measure invasiveness and impact of invasive species.

Further assistance in advancing this research

This research could be further assisted by help with identifying funding sources and by extending information to managers via workshops, publications, Extension, web sites, or other appropriate means.

SM07-01 Multiscale detection of invasive plant species in riparian zones along the Grande Ronde River, Northeast Oregon

Kathleen Dwire
Dept. of Forest Science, Oregon State University, Corvallis
$5,000 awarded; grant declined

The PI moved to a new job in Laramie, Wyoming, and therefore declined the grant since she would be unable to conduct the proposed research.

SM08-01 Rehabilitating medusahead-infested uplands through the use of herbicides and interspecific competition

Jess Wenick
Burns Paiute Tribe, Dept. of Fish and Wildlife, Burns, OR
$1,000 awarded; grant declined

A grant of $1,000 was awarded for travel and education, but because the required indirect cost rate of the Paiute Tribe, the PI's employer, was 35% rather than the 10% stipulated, the grant was declined.

Multidisciplinary Research Grants

The goal of CIPM's Multidisciplinary Research Planning grants program is to develop regional research proposals that will be submitted to major funding sources. CIPM is committed to facilitating multidisciplinary, team-based research. This grant program will not fund actual research; rather it will fund travel and communications necessary to design a team approach to major research topics in the field of invasive plant management. It is expected that proposals developed by these teams will be submitted to multiple funding sources until funding is awarded.

In 2001, one multidisciplinary research planning grant was funded to coordinate a long-term program involving many partners to manage tamarisk over a large region in the West. CIPM funds were used to hold a conference to design and implement a long-term funding and management strategy for regional tamarisk control in Colorado and Utah.

CIPM 2001 Multidisciplinary Research Grants		
No. / Title	**PI**	**Award**
MR01-01 Development/Demonstration of a long-term management approach to tamarisk control	John Heideman (for Russell Walker) Mesa State College Grand Junction, CO 81506	$5,000

MR01-01 Development/demonstration of a long-term management approach to tamarisk control
John Heideman for Russell Walker, Mesa State College, Colorado
$5000
(*Information on results and current status provided by Tim Carlson, Executive Director, Tamarisk Coalition*)

Proposal
In 1999, representatives from 49 organizations (federal and state agencies, local weed control authorities, and drainage districts) formed the Western Slope Tamarisk Coalition to coordinate their expertise and efforts toward suppression of tamarisk *(Tamarix* spp.; also known as saltcedar) and restoration of native riparian habitats in western Colorado and eastern Utah. In April 200l, the Tamarisk Coalition was awarded $78,400 from the National Fish and Wildlife Foundation to conduct seven small tamarisk control projects and convene an education symposium on tamarisk control scheduled for September 26-27, 2001.

The original proposal to CIPM requested $10,000 to add a third day to the symposium to concentrate on the role of public input and participation in implementing suitable tamarisk control methods as they are identified. Recognizing the efforts of the Western Slope Tamarisk Coalition[*] to coordinate a long-term program involving many partners, CIPM awarded the coalition travel expenses for speakers to the September conference ($3,000) and proceedings

[*] Tamarisk Coalition, Tim Carlson, Executive Director. P.O. Box 1907, Grand Junction CO 81502. (970) 248-1683.

printing costs ($2,000). However, in the aftermath of September 11, many speakers were unable to travel to the symposium so the funds were re-budgeted for a later half-day conference entitled *Strategies for Long-Term Management of Tamarisk,* held on June 28, 2002.

Results

A half-day conference entitled *Strategies for Long-Term Management of Tamarisk* was held on June 28, 2002. The overall goal of the conference was to identify potential funding mechanisms for a coordinated tamarisk control effort and to identify opportunities and obstacles related to developing an overarching management structure. Critical research issues were also identified, recognizing that a political solution to a problem is only possible if the problem is serious and well-defined.

The main conclusion of the group was that they should concentrate on getting legislators to recognize that a long-term approach with continuous, reliable funding is essential to tamarisk control. They discussed the various arguments for the federal government, the states, the users, or the landowners taking overall responsibility for coordinated, long-term tamarisk control. They concluded that the obstacles to a coordinated approach are numerous, but as they deal with them, they may come up with a model that other groups dealing with other species can use.

Representatives from the office of Rep. Scott McInnis of Colorado were present at the meeting. Rep. McInnis is sponsor of HB 695, which aims to develop and fund a long-term approach to tamarisk control in the Upper Colorado watershed. Issues raised at the conference informed this bill, as well as SB 1051 introduced by Sen. Pete Domenici of New Mexico.

> **H.R.695** To authorize the Secretary of Agriculture to make a grant to support research to develop enhanced methods for the long-term control and suppression of the invasive plant species tamarisk in the Colorado River watershed in western Colorado and eastern Utah.
>
> **S.1051** A bill to direct the Secretary of the Interior to carry out a demonstration program to assess potential water savings through control of Salt Cedar and Russian Olive.

The Tamarisk Coalition is now established as a nonprofit organization, with an informational web site[*] and brochures. The Department of Interior has asked them to co-host a workshop to develop a roadmap to long-range tamarisk control in the West, to be presented at a special meeting of the Western Governors' Association in August 2003 in either Denver or Grand Junction, CO. The meeting will be by invitation only, with expected attendance by the regional heads of agencies of the U.S. Department of Interior, Department of Agriculture, Department of Defense, and Department of Energy; governors, department heads of state agencies, and state weed coordinators; tribal representatives; and environmental groups and nonprofits.

In addition, the 2003 Tamarisk Coalition Symposium is set for three days in October with an expected 300 participants. The coalition is hoping to prepare education materials (fact sheets, brochures) for distribution to land managers and the general public at the conference. They have already developed information for the Interior Department on the nonbeneficial use of water in plant communities.

[*] http://www.tamariskcoalition.org/index.html

Products
The coalition hopes to produce educational materials from their October symposium if funding and time constraints allow.

Long-term goal and continued progress of research
The long-term goal of the Tamarisk Coalition is to improve riparian health, so tamarisk control is just one aspect of that, albeit a major one. They are also interested in restoration and revegetation. Research on tamarisk invasion has shown the nonbeneficial use of water in a tamarisk community vs. a natural cottonwood-willow community differs only one foot, while in an upland community of bunchgrass, sage, and rabbitbrush the difference can be up to four feet.

As outlined in a recent newsletter available on the web site, one grant currently in the review process is the National Fish & Wildlife Foundation *Pulling Together Initiative*. The Tamarisk Coalition proposal included 12 different project sites in western Colorado and eastern Utah, as well as an educational component for the 2003 Tamarisk Symposium scheduled for October 2003.

Benefits of seed money
The issues raised by the half-day conference funded by CIPM have funneled directly into pending legislation aimed at long-term control of tamarisk. Cooperation among interested parties was reinforced by that meeting, and the Tamarisk Coalition is continuing to build a network in the West.

Further assistance in advancing this research
As a nonprofit, the Coalition is always seeking funding opportunities. They would also like their Symposium and other activities to be linked to the CIPM site.

Web sites
The Tamarisk Coalition web site, www.tamariskcoalition.org, promises to be an important source of information for all interested parties involved in tamarisk issues.

Applied Science Grants

The goal of CIPM's Applied Science grants program is to apply scientific research to field-level situations, resulting in products, knowledge, or services that directly assist land managers dealing with invasive plants problems. The following applied science projects were funded in 2001.

Applied Science Grants		
No. / Title	**PI**	**Award**
AS01-01 Restoration of native plant communities inhabited by Himalayan blackberry	Steve Radosevich Dept. of Forest Science Oregon State University, Corvallis	$8,000
AS02-01 Ecological approaches for prevention and management of artichoke thistle (*Cynara cardunculus*) invasion by seed	Jodi Holt Dept. of Botany & Plant Sciences University of California, Riverside	7,953
AS03-01 Alien plant demographics in the Chewuch watershed	Peter Morrison Pacific Biodiversity Institute Winthrop, Washington	8,000
AS04-01 Developing a regional approach to noxious weed management	Eric Lane Western Weed Coordinating Committee Lakewood, Colorado	7,800
AS05-01 Revegetation strategies to minimize weed re-colonization following herbicide application	Catherine Zabinski Dept. of Land Resources & Env. Science Montana State University, Bozeman	8,000

Some of the highlights of these applied science programs are listed below:

- CIPM awarded $7,953 for Dr. Jodie Holt to develop ecologically based, practical strategies for prevention and management of invasion by seed of artichoke thistle. This funding was the impetus for expanding the program and gaining an **additional $80,000** in funding.
- Findings from the artichoke thistle seedling phenology study have already been implemented at Crystal Cove State Park, where spraying is now concentrated on seedlings, rather than adult plants, **increasing the effectiveness** of the control program and saving public funds. **New working relationships** between researchers and park personnel were developed.
- An award of $8000 to the Pacific Biodiversity Institute produced maps of the distribution of six weed species, which are now in use by the ecologist for the Okanogan and Wenatchee National Forests. The project also produced an easily learned, user-friendly **sampling protocol** which is now in use in a further project in the Sonoran Desert.
- Data on the distribution and relative abundance of leafy spurge and yellow starthistle were combined into single **maps** for the entire West through a $7,800 project to the Western Weed Coordinating Committee. The maps are available online, and the mapping project itself demonstrates a method for combining maps developed with a variety of software systems.

AS01-01 Restoration of native plant communities inhabited by Himalayan blackberry

Steve Radosevich
Dept. of Forest Science, Oregon State University, Corvallis
$8,000

Proposal

Himalayan blackberry *(Rubus discolor)* is an invasive shrub that poses a serious threat to the integrity and conservation of riparian ecosystems throughout much of the Pacific Northwest because of its capacity for rapid growth, vegetative spread, and high quantities of seed production. Himalayan blackberry forms impenetrable thickets of arching barbed canes, which hinder movement of animals and people, displace native and other more desirable vegetation, and alter the composition, structure, and function of the communities it colonizes. The shrub is also difficult to control by hand, mechanical methods, or herbicides. It is unlikely that direct restoration of blackberry-occupied sites to more pristine conditions will result from a successful control tactic alone. A more likely scenario is that blackberry seedlings or sprouts will reinvade the site after control. It also may be that only an aggregate community with some Himalayan blackberry still present will result from any restoration scenario. We hypothesize that re-colonization by Himalayan blackberry will be faster when sites are vacant than if its recruitment sites are populated.

We propose, as a yet-unfunded part of a broader program to restore plant communities infested with exotic invasive species, to

1. Test differing management scenarios for their short- and long-term ability to capture sites and limit the recruitment potential of Himalayan blackberry
2. Compile information into a population-based model to develop biologically feasible management approaches for restoration of Himalayan blackberry infested riparian areas of the lower Willamette and Columbia River floodplains.

Experiments for the first objective have been established and are in progress. Data from these and other ongoing experiments and the literature will be used to construct the model discussed in the second objective. Information from this project will be parts of one M.S. and one Ph.D. thesis, both in progress.

Results

Results indicate that site preparation (plowing and/or raking) plus shade inhibit the spread and growth of Himalayan blackberry. Data suggest that primary stress (site disturbance) plus shade interact to reduce the rate of production of Himalayan blackberry and that such approaches should be tried on larger areas. However, the rate of revegetation on undisturbed or mowed-only plots by blackberry also indicates that repeated treatment, though perhaps less intense than the initial site preparation, may be required until planted or natural vegetation can maintain a site against the blackberry.

A Himalayan blackberry monoculture probably represents a static state of succession. Whether a static “equilibrium” truly exists in a dynamic ecosystem has been debated. However, the temporary removal of the Himalayan blackberry in this study by site preparation allowed the site

to revert to a condition that may or may not have existed prior to the invasion of blackberry. From a restoration viewpoint, the fact that the site is now in an earlier successional state suggests that it is closer to the "pre-disturbance" condition than when Himalayan blackberry was present, i.e., easier to restore to a desired condition in succession. In this study, the soil seed bank and planting native grasses following site disturbance achieved this earlier stage from which further management can be implemented.

This study demonstrated that it is possible to manipulate a large area of blackberry and by doing so, change site conditions. The plowing and raking of the soil to remove the majority of root crowns of Himalayan blackberry provided the opportunity for other vegetation to respond to the reduction of blackberry cover and disturbance. By shading Himalayan blackberry sprouts, it was found that low levels of light reduce biomass accumulation progressively as the light diminished. This fact is important for management because it indicates that Himalayan blackberry will not flourish in some habitats that are common to the Pacific Northwest, such as mid- and older Douglas fir plantations, ash swales, and oak woodlands. Taken together, the destruction of Himalayan blackberry stands and the manipulation of light or other resources by planting vegetation or stimulating the seedbank during restoration provides a direction for management of areas invaded by Himalayan blackberry.

Finally, this project revealed more than just responses of Himalayan blackberry to different control treatments. While many restoration efforts have been directed toward the response of a given species to specific control measures, it is apparent that the treatment of an individual plant species provokes a response from the entire habitat it occupies. Efforts that consider the response of the entire habitat to both invasion and manipulation will probably be more productive (restorative) than efforts that only describe target plant responses.

Publications
Submitted

AS02-01 Ecological approaches for prevention and management of artichoke thistle (*Cynara cardunculus*) invasion by seed

Jodie S. Holt
Botany and Plant Sciences Department, University of California-Riverside
$7,953

Proposal

The goal of the proposed research is to use ecological data already obtained from several years' work on artichoke thistle (*Cynara cardunculus*) to develop ecologically based, practical strategies for prevention and management of invasion by its seed. Specific objectives are to:

1. Use completed data to construct a phenological model to predict the timing of seed emergence and seedling development and validate the model over one growing season in coastal grasslands.
2. Conduct experiments on seedling mortality following burning, mulching, mechanical control, and chemical control in order to develop effective management techniques.
3. Combine ecological data from objectives 1 and 2 to initiate practical experiments to prevent and manage artichoke thistle seedlings, which will be monitored beyond the time frame of this grant program.

The proposed research will permit the investigators to develop and test ecologically based, applied prevention and management approaches for artichoke thistle and to work with land managers at Crystal Cove State Park in Laguna Beach, California, to implement them.

Results

CIPM awarded $7,953 for this research. In July 2002, a 12-month, no-cost extension of the project was approved in order to complete objectives 2 and 3. At that time, approximately half the funds had been expended to cover travel to the field site and to support Virginia White, the Ph.D. student studying seedling phenology of artichoke thistle. Permission was given to carry the remaining funds forward through June 30, 2003.

Dr. Holt commented, "We got a lot for the money." The CIPM money provided one quarter's funding for Virginia White and travel money to the field site, and it was the impetus for expanding the program and gaining additional funding. The Holt group received a parallel grant for another student to study sprouting phenology, and the CIPM funding also spurred a seed dispersal project. Virginia White is writing up her results as part of her thesis, while the student studying sprouting phenology has another season of fieldwork. The additional funding amounts to about $80,000. Enough preliminary data have been gained to submit another federal grant proposal this fall.

Publications

Journal articles will be published as the two graduate students work on their dissertations, and several abstracts and papers have already been given.

Products

In addition to the more effective management methods implemented by the managers at Crystal Cove State Park, this work will eventually produce a degree-day model so that land managers

will know when to spray for maximum effectiveness. The model will be posted under the "interactive tools and models" page (http://www.ipm.ucdavis.edu/WEATHER/ddretrieve.html) of the UC Davis IPM web site where Dr. Holt's yellow nutsedge model is already posted (http://www.ipm.ucdavis.edu/PHENOLOGY/yellownutsedge.html).

Long-term goal and continued progress of research
The long-term goal of the project is to develop and test ecologically based, applied prevention and management approaches for artichoke thistle, to work with land managers to implement them, and to develop a degree-day model of artichoke thistle control that will be posted on the IPM site for use by growers, land managers, and others. The research funded by CIPM is continuing with $80,000 of additional funding to study sprouting phenology and seed dispersion. Further funding from proposals to be submitted to federal agencies is anticipated.

Benefits of seed money
The lab first had to find a place to do the fieldwork, so since early in the project they have been building relationships with the park rangers and ecologists at Crystal Cove State Park in Laguna Beach, California. Park personnel now know all the researchers and their vehicles, take pride in being a research area, and have taken ownership of the research, protecting the plots from the spraying crews. They have become interested in understanding the basic biology of weed management and have been using information from the project to control seedlings, which perennialize right away, rather than periodically spraying the adult plants to no effect. In this way, the research has met one of its original goals which was to develop and test improved prevention and management approaches for artichoke thistle and to work with land managers to implement them.

Dr. Holt commented that a small grant program such as CIPM's gives a graduate student the chance to write a proposal, and if it is funded, take control of the project, possibly pursuing new approaches or research directions. The student experiences the challenges and rewards of research, as well as gaining experience in grant writing and project management.

She added that an applied science project such as this is harder to do than a strict research project, because it forces the researcher to focus on a useful product and on how and why the research is important and useful to managers in the field.

Further assistance in advancing this research
Since funding sources for applied weed management projects tend to be rather obscure, it would be helpful if CIPM could post a list of opportunities as they appear.

AS03-01 Alien plant demographics in the Chewuch watershed

Peter Morrison, Ecologist and Executive Director
Pacific Biodiversity Institute, Winthrop, Washington
$8,000

Proposal

The proposed project will fund the 2001 field season of the Alien Plant Demographics project, which began in the summer of 2000. This long-term project is designed to provide the scientific information necessary for effective, economical, and ecologically responsible control of invasive species in the Chewuch watershed of the Methow Valley of Washington state. Its overall goals are to develop models of population trends for six noxious weed species; determine risk factors for each species; and produce maps of their distribution. The study area is the watershed of the Chewuch River, a tributary within the Methow Valley Basin north of Winthrop, Washington. The Chewuch watershed covers about 334,000 acres.

The specific tasks to be funded by the proposed work are to:

- Conduct field sampling within the predicted range using a grid system with continuous sampling along grid lines. Sample along all road systems in the area; establish transects out from roads.
- Process and analyze field data; develop GIS data layers to refine a preliminary model.
- Refine prediction models though database analysis.
- Develop final range and population distribution maps.
- Analyze population location, density, and trends to predict population dynamics.
- Analyze the correlation between weed population dynamics and land use activities.

The species under study are:

- diffuse knapweed (*Centaurea diffusa* Lam.)
- Russian knapweed (*Acroptilton repens* (L.) DC. syn. *Centaurea repens* L.)
- spotted knapweed (*Centaurea maculosa* Lam.)
- Dalmatian toadflax (*Linaria dalmatica* ssp. *dalmatica* (L.) P. Mill.)
- whitetop (*Cardaria draba* (L.) Hand.)
- hairy whitetop *(Cardaria pubescens* (C.A. Mey.) Jarmolenko).

These species were chosen on the basis of their propensity for dominance, persistence, invasiveness, and rate of spread, as well as their abundance within the study area. Several control strategies will be assessed to model the likely distribution of weed species in five to 15 years.

Results

As of June 5, 2002, data on the distribution and abundance of weed species along about 90% of the road system within the watershed had been collected (during 2000 and 2001 field seasons) using mountain bikes, GPS receivers, and a rigorous field sampling procedure. Detailed data have been gathered at each of the 2,870 study plots established, and public agency staff and private landowners had been interviewed with regard to weed control approaches and the history of weed invasion. Preliminary analysis of data collected during the two preceding field seasons was underway.

After the 2002 season (funded by CIPM) was completed, range maps were prepared for the 3- and 10-meter road plots for the six target species. The most abundant and widely distributed species was diffuse knapweed, followed by spotted knapweed. The presence and abundance of both species is strongly correlated with proximity to roads, but the more limited distribution of spotted knapweed is probably due to its more recent introduction to the area.

The other four species were much more limited in their distribution, with the two species of *Cardaria* and *Centaurea repens* reaching their greatest abundance in areas with greater surface moisture.

Trend analysis of the two knapweed species in resampled plots showed an overall decrease in target species coverage with a major decline in diffuse knapweed cover of about 50% per year, from 4.8% coverage in 2000 to 1.2% in 2002. Spotted knapweed also decreased by about half, although it was initially present at lower coverage. The greatest decrease in diffuse knapweed occurred along a stretch of East Chewuch Road just north of Winthrop, where four species of knapweed biocontrol insects are well established. Diffuse knapweed was sampled in 2000 and 2002, so change just beginning to be seen and should be more apparent this season.

The observed decline in the relative abundance of diffuse knapweed may signal the end of 30 years of explosive growth of this species. Major factors that may be contributing to the decline of diffuse and spotted knapweed in the Chewuch watershed include revegetation efforts with roadside seeding of grasses and introduction of biological control insects, particularly the seed-head weevil (*Larinus minutus*). The effect of herbicide treatments can only be indirectly inferred, since none of the sampled roads were treated in 2000-2002. However, the abundance of two knapweed species along roads treated with glyphosate and picloram in 1999 implies that the herbicide treatments were less successful than hoped. Other factors, such as vehicle use and road maintenance are essentially unchanged on the sampled areas, and therefore should not have contributed to the observed decline. Further study on the relationship of knapweed abundance to cattle grazing is planned as part of this study.

Publications
Submitted

Products
This work has produced maps of weed distribution for field-level managers, which have been distributed to Terry Lilybridge, ecologist for the Okanogan and Wenatchee National Forests. Also, the Institute is planning to present a workshop on the effects of disturbances and roads on the spread of invasive species.

In this and previous work in the Chewuch Watershed, the Pacific Biodiversity Institute developed a protocol designed to systematically sample a representative portion of a large area. Mountain bikes are used to establish plots one-half mile apart and primarily along roadsides. GPS receivers allow a record to be kept of sample locations. This system was judged to be suitable for studying species range. Finer details of distribution patterns of individual species and relationships between different individuals are assessed by measurements taken within the pair of 3-meter-radius plots at each roadside station. This sampling protocol is now being used in a

BLM-funded project to sample invasive species in the Sonoran Desert. The protocol is easily learned and can easily be used by volunteers in community projects as well as by interns or professionals in more comprehensive projects.

Knowledge about the effectiveness of various land management strategies and continuing community cooperation and education are additional benefits of the research.

Long-term goal and continued progress of research
The long-term goal of the research is to determine the effects of disturbance types and dispersal vectors on the distribution of invasive plants; to determine their response to environmental gradients and their change in distribution over time; to demonstrate strategies based on the dynamics of an entire watershed; to develop cooperation among agencies and landowners so that weeds can be managed on the basis of their distribution rather than administrative or ownership boundaries. This research will be continued for 5 to 15 years to see how weed populations change over time and to determine how sampling can be continued over time.

Benefits of seed money
The seed money helped in completing the sampling and producing maps for use by land managers (see Results), and it was instrumental in getting a contract from BLM via The Nature Conservancy for work in the Sonoran Desert. The sampling protocol used in the CIPM-funded project is now being used in the new project to sample exotic species in the Sonoran Desert National Monument. The existing natural communities are being mapped and their ecological condition is being assessed to determine which species are impacting which communities.

Finally, the Pacific Biodiversity felt that it was able to develop new relationships with agency and university personnel during the course of the CIPM-funded project.

Further assistance in advancing this research
The Institute could use help with publications (editing, suggesting where to submit), as well as with grant writing and finding funding sources.

Web sites
http://www.pacificbio.org/contributors.htm
Will be updated summer 2003, with greater emphasis on invasive species research and education.

The Southwest Exotic Management Program is developing public database, will have data from Sonoran Desert project. http://www.usgs.nau.edu/SWEPIC/swemp/maps.html.

AS04-01 Developing a regional approach to noxious weed management

Eric Lane, Chairman
Western Weed Coordinating Committee, Lakewood, Colorado
$7,800

Proposal

The goal of the proposed project was to refine two maps developed in 2001 by western state weed coordinators that depicted the relative abundance and distribution of leafy spurge (*Euphorbia esula*) and yellow starthistle (*Centaurea solstitialis*) by county. The utility of these maps is limited by the coarseness of the acquired data. The Western Weed Coordinating Committee (WWCC) proposed to refine each map by further defining the distribution of each species, particularly in newly invaded areas where incipient infestations are isolated and distinct.

Results

WWCC developed two maps depicting the distribution and abundance of leafy spurge and yellow starthistle by surveying county weed supervisors and state weed coordinators in 15 western states. We determined the number of acres infested per quarterquad (one fourth of a USGS topographic quadrangle) for approximately 90% of the West, representing about 90% of the western counties.

Publications

These results were presented at the 2002 Western Society for Weed Science annual conference in Salt Lake City in a poster presentation and the abstract appeared in conference proceedings.

Products

The maps from the 2001 and 2002 surveys are posted at http://weedcenter.org/wwcc/docs/projects.html. The full datafile is also available and will be posted on the web for the use of researchers.

Long-term goal and continuing progress of research

WWCC met in 2002 and agreed to work to complete the map and approach 100% coverage. In addition, at the 2003 annual meeting, WWCC agreed to initiate the development of a similar map for tamarisk (*Tamarix parviflora*).

Other benefits of seed money

To develop the map products, WWCC developed a mapping protocol and demonstrated that very few resources are necessary to develop extremely useful mapping products that span an entire region. These products have been used to develop a strategic plan to stop the spread of leafy spurge and yellow starthistle and WWCC is beginning the process of refining and implementing this plan. WWCC hopes to utilize this plan to obtain new federal resources and better direct existing public and private funds to implement a coordinated, cooperative approach to managing two pervasive noxious weeds in the West.

Further assistance in advancing this research
CIPM may be helpful in providing a facilitation and coordinating role in refining and implementing the strategic plans developed in 2002. In addition, as we prepare to shop this idea to leaders of the federal government, assistance in preparing marketing materials may be helpful.

Web sites
Results from this project are already posted at the CIPM web site (http://weedcenter.org/wwcc/docs/projects.html) and we will continue to update the postings as new information becomes available.

Questions from grants panel

How will maps be developed using a variety of software system (or by hand) actually be put into a single system?

All data submitted were prepared by hand by respondents on a standard form prepared by the PI. These forms were then transcribed directly into ArcInfo or Microsoft Excel and integrated into the database. The respondents took the best available information at their disposal (usually not written down or captured on paper or electronically) and put it into the format requested.

Land managers cannot and many will not re-draw their maps by hand onto the one provided by the PI, so how will non-respondents be handled?

This project did not ask respondents to re-draw their maps. They simply took what they know and put it into the simple format we requested. I think most researchers would be pleased with a response rate of close to 90%. Non-respondents are simply badgered with repeated requests to provide the data.

What scale will be used on the finals map(s) produced by the PI? Can the map be broken down by county or watershed if a weed manager just wants a printout of his/her assigned area?

The scale is a quarterquad which is a standard unit provide by USGS. Once the dataset is posted, anyone with an ArcInfo or ArcView product should be able to select their data and reprint just their county, or perhaps a larger geographic area in which their jurisdiction resides.

Please clarify methodology and details on the final product.

We sent a map of each county to every respective county weed supervisor and state weed coordinator in the West. This map was overlaid with the quarterquad grid. Each county weed supervisor, or state weed coordinator in some cases, then entered the number of infested acres (NAWMA definition) of leafy spurge and yellow starthistle into each quarterquad. These data were collected and assembled into one ArcInfo database for projections.

It would be a great contribution to field assess (and report) what's needed as far as mapping and to identify constraints in multi-state/multi-agency mapping projects—whether or not the leafy spurge and yellow starthistle maps were completed at the end of the 18-month period.

I agree but this was not within the scope of our time and budget for the project. Our goal was to simply gather data about the species, not local weed management programs' capacity to capture such data.

AS05-01 Revegetation strategies to minimize weed re-colonization following herbicide application

Catherine Zabinski and Lew Stringer (M.S. student)
Dept. of Land Resources and Environmental Sciences, Montana State University - Bozeman
$8,000

Proposal

This research focuses on revegetation after herbicide application on spotted knapweed infested sites in northwestern Montana grasslands. The seed stored in the soil of weed-infested sites will be measured to test the hypothesis that seed bank composition and density can be a good predictor of revegetation patterns after herbicide application. Site preparation approaches will be compared to determine whether the seed bank can effectively be manipulated to further management goals. Finally, revegetation methods will be compared to test the efficacy of contrasting seeding rates, species mixes, and transplants in reducing available habitat for weed colonization. The research will be done at two sites in Glacier National Park and one site on the Blackfeet Reservation on the eastern border of the park.

Results/

There is an immediate and ongoing need in Glacier National Park (GNP), and on other public and private lands, to determine effective methods to re-establish and sustain native plant populations following control treatments of *Centaurea maculosa*. My research was developed in response to GNP concerns regarding annual herbicide treatment of *C. maculosa* invaded sites. The aim of this study was to determine whether herbicide applications, site preparation, and revegetation methods would increase the density and percent cover of native species while reducing spotted knapweed at two sites in and near Glacier National Park. A priori contrast analysis was used to determine differences in treatment effects. The results of my experiment show that spot spray herbicide application reduced *C. maculosa* cover without significantly reducing existing native forbs. However, a repeat-herbicide application increased exotic graminoid cover. Tillage reduced the density of *C. maculosa* seedlings, but resulted in an increase in *C. maculosa* percent cover and an overall decline in native forbs. Revegetation methods had limited success at increasing native species and reducing *C. maculosa*. The only effect was at Swift Current where the percent cover of native forbs was significantly higher with the planting treatment and most pronounced in plots with repeat-herbicide application. Additionally, we measured the composition and density of the seed bank in *C. maculosa* dominated sites using the seedling emergence method. *C. maculosa* density was 3,900 and 6,714 seeds / m^2 at the two sites, which was 2 and 3 times higher than the sum of all other species. Seed bank composition and density need to be considered in efforts to restore *C. maculosa* infested areas.

Publications

Thesis to be defended in October 2003. Chapter 2 will be submitted to *Restoration Ecology* for publication.

Benefits of seed money

The results of this research will directly benefit Glacier National Park managers in their efforts to control spotted knapweed.

APPENDIX

Center for Invasive Plant Management **2001 Grants Program**			
Grant number **Title**	**PI**	**Request**	**Award**
Seed Money			
SM02-01 *Linaria vulgaris* Mill. invading the West Yellowstone area: A multi-scale ecological assessment	Paul Alaback School of Forestry, University of Montana Missoula, MT 59812 palaback@forestry.umt.edu	$5,000	$5,000
SM04-01 Effects of spotted knapweed and leafy spurge invasion on key soil functions	Matthias Rillig Division of Biological Sciences, University of Montana Missoula, MT 59812 matthias@selway.umt.edu	$4,730	$4,730
SM05-01 Identifying the factors that determine the invasion of a weed into native plant communities	Bruce Maxwell Dept. of Land Resources and Environmental Science Montana State University, Bozeman, MT 59717 bmax@montana.edu	$4,929	$4,929
SM06-01 Methods to inventory weed populations in remote areas	Bruce Maxwell Dept. of Land Resources and Environmental Science Montana State University, Bozeman, MT 59717 bmax@montana.edu	$4,940	$4,940
SM07-01 (Declined) Multiscale detection of invasive plant species in riparian zones along the Grande Ronde River, Northeast Oregon	Kathleen Dwire Dept. of Forest Science, Oregon State University Corvallis, OR 97331-5752 kdwire@fs.fed.us	$5,000	$5,000 Declined

SM08-01 (Declined) Rehabilitating medusahead-infested uplands through the use of herbicides and interspecific competition	Jess Wenick Burns Paiute Tribe, Dept. of Fish and Wildlife HC 71 100 Pasigo St., Burns, OR 97720 jessw@centurytel.net	$4,723	$1,000 for travel/ education Declined
Multidisciplinary Research Planning			
MR01-01 Development/Demonstration of a long-term management approach to tamarisk control	John Heideman (for Russell Walker, Mesa State College) 1733 Crestview Dr., Grand Junction, CO 81506 heideman@gj.net	$10,000	$5,000 ($3,000 travel, $2,000 printing)
Applied Science			
AS01-01 Restoration of native plant communities inhabited by Himalayan blackberry	Steve Radosevich Dept. of Forest Science, Oregon State University Corvallis, OR 97331-5752 steve.radosevich@orst.edu	$8,000	$8,000
AS02-01 Ecological approaches for prevention and management of artichoke thistle (*Cynara cardunculus*) invasion by seed	Jodi Holt Department of Botany and Plant Sciences UC-Riverside, Riverside, CA 92521 judy.corbett@ucr.edu	$7,953	$7,953
AS03-01 Alien plant demographics in the Chewuch watershed	Peter Morrison Pacific Biodiversity Institute P.O. Box 298, Winthrop, WA 98862 peter@pacificbio.org	$8,000	8,000
AS04-01 Developing a regional approach to noxious weed management	Eric Lane Western Weed Coordinating Committee 700 Kipling St., Ste 4000 Lakewood, CO 80215-5894 eric.lane@ag.state.co.us	$7,800	$7,800
AS05-01 Revegetation strategies to minimize weed re-colonization following herbicide application	Catherine Zabinski Dept. of Land Resources & Environmental Science Montana State University, Bozeman, MT 59717 cathyz@montana.edu	$8,000	$8,000