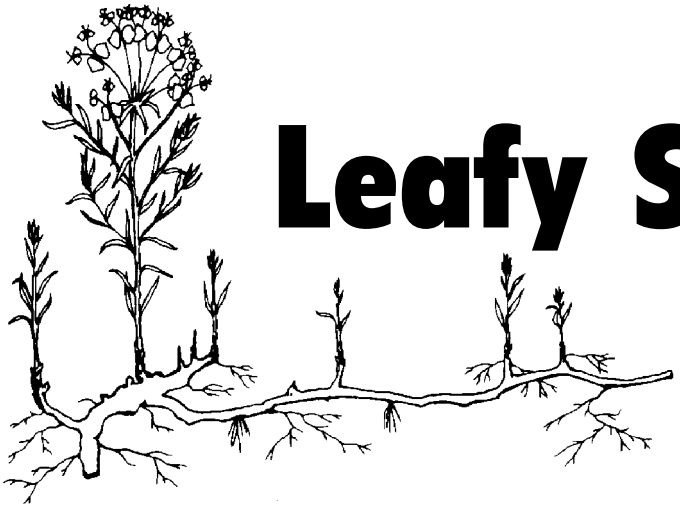

Leafy Spurge *News*

Agricultural Experiment Station
NDSU Extension Service
North Dakota State University, Fargo, ND 58105

Volume XXIV, Issue 1 May 2002

From the Editor's Desk

This is the first issue for 2002. It brings you the remaining information that was presented at Medora last summer. Once again we have the usual Leafy Spurge Honoree, a great lady from the state of Montana, Barbra Mullin, Weed Coordinator, Montana Department of Agriculture, Agricultural Sciences Division. You will find her story interesting.

In this issue you will find some items from Team Leafy Spurge as well as a list of items about leafy spurge — all freebees. What a deal! Once again I urge all of you to send me info on what your problems are with leafy spurge. I need material for future issues. That is what **Letters to the Editor** is for. So let's communicate!

If you have a change of address, please include your old zip code as our files can only be accessed by zip codes and not by names.

Claude Schmidt
Editor
(701) 293-0365, Fax (701) 231-8474
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Leafy Spurge Honoree

Barbra H. Mullin

Barbra received BS degrees in Botany and Ag Science/Plant Protection and an MS in Plant Pathology from Montana State University. She has worked for the Montana Department of Agriculture for the past 23 years, as Plant Pathologist, Botanist, Weed Specialist, and State Weed Coordinator with the Department. She is active in a number of regional and national organizations, including serving as President of the Western Society of Weed Science from 1997-98 [WSWS]. She has also served as chair of the WSWS Noxious Weed Short Course Ad Hoc Committee; project chair for WSWS Projects 5 and 7; Secretary of WSWS; Program Chair and President of WSWS; President of the Western Aquatic Plant Management Society; and Secretary-Treasurer and Executive Secretary of the Montana Weed Control Association. She has been active in development of state and federal legislation for weed management, including helping to develop and implement the Montana Noxious Weed Trust Fund grant program, and writing language for Section 2814 of the Federal Noxious Weed Act, which implements integrated weed management programs on federal lands. She served as chair for the development of the CAST Invasive Plant

Honoree continued on page 2

Honoree continued from page 1

Species issues paper. She is currently active on the Montana Weed Summit Steering Committee and was instrumental in the development of the Montana Weed Management Plan.

As Weed Coordinator for the Montana Department of Agriculture, she administers the Noxious Weed Trust Fund grants program and other weed programs in the Department. These include providing technical information on weed control methods and herbicides; coordinating the state biological weed control program; working with pesticide applicator training programs and conducting training seminars; providing technical expertise for special registrations of herbicides and fungicides for use in Montana; and coordinating the aquatic weed management program for private and commercial aquatic applicators.

She has worked closely with the development of a long term, integrated approach to leafy spurge management in Montana. She has been an active participant in the Leafy Spurge Symposium since the early 1980's. As coordinator for the Montana Noxious Weed Trust Fund grant program, she has actively supported the development of new biological control agents for leafy spurge, the redistribution effort for biological controls on leafy spurge, the use of sheep and goat grazing as a practical and economical control for leafy spurge, and educational efforts to land managers on the most effective leafy spurge management techniques. She was part of the original working group in the development an area-wide management plan for leafy spurge and has served on the TEAM Leafy Spurge Ad Hoc Committee since its inception in 1997.

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Letters To The Editor

Dear Leafy Spurge News:

Thoughts by an Old Long-time Spurge Fighter —
I wish to express my thanks and appreciation for the "Outstanding Achievement Award" presented to me at Spurgefest '99. Those of you in attendance witnessed one of the few times that I have been at a loss for words! You need to know that I did none of the actual research and development that brought us to our present status of leafy spurge control. But I did a lot of drum-beating and promotion that led to the 1979 Leafy Spurge Symposium in Bismarck, ND. After I retired from ARS in 1985, I was asked to coordinate all aspects of leafy spurge research, education and control in a multi-state area. I soon learned that facilitating was more effective and easier to do than coordinating. So I changed my title! Others did the actual productive work. All I did was to facilitate.

As facilitator, I helped to make things happen to provide support from legislators, administrators, and policy makers for advancement of the leafy spurge control and management programs. This provided the support to those doing the research, education, and applied control. All of those people are deserving of praise and thanks for their combined efforts in making leafy spurge control more effective and less costly than it was in 1979.

We have come a long way in 20 years, but don't forget to use **all the tools** in the box. The current success with biological control may cause some to depend too heavily on it. It will take biological control agents many years to catch up with all the leafy spurge we have now. So to help the "bugs" catch up, we need to continue to use herbicides, sheep or goat grazing and all the other less glamorous leafy spurge management tools to prevent further spread and infestations of clean land by this highly aggressive, persistent weed.

Some of the slogans developed through the years are still valid:

- Spraying leafy spurge is expensive, but you can't afford to ***not*** spray if you want to keep clean land, clean.
- No patch of leafy spurge is too small to spray.
- It is never too late to start a leafy spurge control program.
- It is only too late to start to control leafy spurge if you don't start now.
- Leafy spurge is here to stay — learn to manage it so you can live with it.

Russ Lorenz
Leafy Spurge Fighter – Retired
(701) 233-3421

Letters To The Editor

Dear Leafy Spurge News:

Leafy Spurge Control at Castlewood Canyon State Park

Castlewood Canyon State Park is a relatively small Colorado State Park of about 2000 acres. Castlewood is a day use park that offers 12 miles of hiking trails, over 50 picnic sites, several climbing routes and excellent wildlife viewing opportunities. The park is also a Colorado State designated Natural Area and contains the ruins of an historic dam that burst in 1933. Located just thirty minutes from the Denver Metro area, Castlewood Canyon is very popular with local hikers, climbers and weekend picnickers.

The terrain of Castlewood Canyon is extremely variable. The park encompasses the short-grass prairies of Douglas County, the coniferous forest habitat of the Black Forest region, the rocky canyon walls, the riparian areas where Cherry Creek flows through the canyon and the surrounding thick scrub oak. Castlewood's wide variety of habitats provides a home for a wide variety of plant life, including weeds.

The Governor's Executive Order on Weeds in 1999 specified that each state park should have an integrated weed plan in place by 2001. State Parks began the process of creating this plan by mapping weed patch locations using GIS. The data obtained was used to create priority species and priority patches to control as well as general suggestions on how to control and prevent weed infestations.

A little less than one acre of Leafy Spurge was mapped at Castlewood Canyon. It does not sound like a lot of spurge, but Castlewood presents some unique problems for controlling weeds. The steep areas and thick vegetation presents constant access problems. Leafy Spurge tends to grow in some of the most remote and difficult locations to reach. Herbicides must be carried in with backpack sprayers because ATV's will not fit on trails or through the thick scrub oak. Leafy Spurge also grows mostly in riparian areas or under trees. This also makes herbicide application tricky. In addition, the Leafy Spurge patches are small and spread throughout the park rather than a few large patches. Every control method is small scale and time consuming.

Castlewood Canyon's staff uses a wide variety of control methods. We do not have a certified applicator on site, so we use a contractor to apply picloram where it is possible to use it. Otherwise, the park staff uses other herbicides for hand applications. I also organize a volunteer "Weed Warrior" group that is trained on weed identification and control techniques. These volunteers mostly pull or dig weeds, but they also roam the park extensively and usually find and report several weed patches. Volunteers are also an excellent tool in getting weed information out to the public. Several species of *Aphthona* beetles have been released in the park with varying results. Small patches and different habitats make getting the right species to the right areas and maintaining them fairly difficult. Revegetation of any areas that are disturbed is also a priority. We immediately revegetate with native grasses.

The key to controlling spurge and all weeds at Castlewood Canyon State Park is to be creative and flexible. What works in other areas, does not necessarily work here because of our unique environment. General recommendations for control are often not practical for Castlewood. Careful monitoring and persistent control efforts have allowed park staff to get the upper hand on weeds in several areas and we will continue to work toward our goals of control and eradication.

Sincerely,

Julie Arington
jarington@castlewoodstatepark.org

Letters To The Editor

April 3, 2002

Dear Sir or Madam,

We're writing to inform you of several FREE informational products on leafy spurge management that are now available individually or in bulk through USDA-ARS TEAM Leafy Spurge in Sidney, Montana. TEAM Leafy Spurge, is a five-year, research and demonstration program funded by the U.S. Department of Agriculture's Agricultural Research Service and managed cooperatively with USDA's Animal and Plant Health Inspection Service. "The Ecological Area-wide Management" (TEAM) of Leafy Spurge project stresses partnerships, teamwork, and a cooperative approach to solving the leafy spurge problem. A big part of that effort is getting new research information out to those who need it.

To that end, TEAM Leafy Spurge is ready to provide you with one or a hundred of the informational products it has developed over the life of the program. The items, all free, are great for handing out at Extension Field Days, Weed Board meetings, or other gatherings, or just to have on hand for interested individuals. You may already be familiar with some of them, but did you know you could order them in bulk for your weed events?

Just give us a call, mail in the enclosed form, or send us an e-mail to order any of the following products in any amount (address information listed below):

CD-ROMs (Mac or PC)

- **Purge Spurge: Leafy Spurge Database, Version 4.0 –** This CD-ROM provides a wealth of information on different management techniques along with basic research information. It includes more than 900 articles from scientific journals, Extension publications and meeting proceedings and has handy search tools to find the information you need.
- **Biological Control of Leafy Spurge –** This multimedia CD-ROM contains resources focusing on biological control of the weed, including a narrated PowerPoint presentation for use with groups and an extensive photo section. It is the first in a series of CDs being produced by TEAM Leafy Spurge on the Integrated Pest Management of Leafy Spurge.
- **Available Soon: Multi-species Grazing and Leafy Spurge –** This is the second in the TEAM Leafy Spurge IPM series and focuses on the use of multi-species grazing to control leafy spurge. Like its predecessor, it contains a narrated PowerPoint presentation, photos for use in your own presentations, and several in-depth reports on grazing and leafy spurge. It will be available in June 2002.

Printed Manuals

- **Biological Control of Leafy Spurge –** This comprehensive, 24-page manual discusses how to use biological control as an effective management tool alone or incorporated with other tools. A popular item, more than 40,000 manuals have been distributed throughout the Western United States and the Prairie Provinces of Canada.
- **Multi-species Grazing and Leafy Spurge –** This easy-to-read, 28-page handbook describes how to use multi-species grazing to manage leafy spurge. It discusses economic considerations such as the pros and cons of buying or leasing sheep or goats, stocking rates, fencing needs and predation, as well as how to integrate grazing with other control measures.

The next offering in our manual/CD-ROM series is expected to be a very popular item, as well. Entitled Herbicide Control of Leafy Spurge, it is due to appear later this year. Watch the TEAM Leafy Spurge web site at http://www.team.ars.usda.gov to learn when it becomes available.

Again, for up-to-date information on all TEAM Leafy Spurge products be sure to check our website. You may also reach us by e-mail at teamls@sidney.ars.usda.gov; by phone at 406-433-2020 or by regular mail at USDA-ARS Northern Plains Agricultural Research Laboratory, 1500 N. Central Ave., Sidney, MT 59270. You may also contact Beth Redlin or Jill Miller at 406/433-9427; Bredlin@sidney.ars.usda.gov; Jmiller@sidney.ars.usda.gov.

For faster response, please contact us through the TEAM Leafy Spurge web site at http://www.team.ars.usda.gov or by e-mail at teamls@sidney.ars.usda.gov to place your order.

Sincerely,

Gerald L. Anderson, Project Director
Chad Prosser, Project Coordinator

TEAM Leafy Spurge
Information Resource Centers Popular

TEAM Leafy Spurge has distributed all of its 2,000 *Information Resource Center* binders to county weed supervisors and Extension agents across a seven-state region. The *Information Resource Center* is a convenient three-ring binder sporting a collection of informational and educational resources developed by TEAM Leafy Spurge on successfully managing the noxious weed using integrated pest management techniques.

"We knew we had a good product and we're happy the binders have been so well received, but, frankly, we didn't expect them to go so fast," TEAM Leafy Spurge Coordinator Chad Prosser said. He added, however, that while the binders may be gone "the bulk of the materials contained in them are still available."

The last of the *Information Resource Centers* were distributed in Washington state, where an initial request for the product led to the distribution of thirty-five more copies to all of the state's County Weed Supervisors in late March. That distribution then generated requests for even more to be delivered to partner organizations and other agencies in the state.

"That's fairly typical of the response we've had," Prosser said. "Once they see it, they generally want more."

Prosser noted that in addition to distributions to County Weed Supervisors and Extension agents in Montana, Wyoming, North and South Dakota, Nebraska and now Washington, the manuals have also gone out to Minnesota Ag Inspectors and various agencies in that state as well as to a wide variety of other federal and state agencies and organizations. They include: Bureau of Land Management; Bureau of Indian Affairs; U.S. Forest Service; National Park Service; Animal and Plant Health Inspection Service; Fish and Wildlife Service (North Dakota); Department of Transportation (North Dakota) and Parks and Recreation Department (North Dakota). The Canadian provinces of Manitoba and Saskatchewan have also requested and received several of the *Information Centers.*

Included in the binders are CD-ROMs, brochures, manuals and reports aimed at helping public and private land managers combat leafy spurge. Among the CDs are the latest update of the *Purge Spurge: Leafy Spurge Database* and the *Biological Control of Leafy Spurge: Information Resource CD,* the first in a series of TEAM Leafy Spurge CDs highlighting different IPM techniques for leafy spurge control. Also included are copies of two "how-to" manuals, the first entitled, *Biological Control of Leafy Spurge,* and the second, *Multi-species Grazing and Leafy Spurge.* The former has been extremely popular, with more than 40,000 biocontrol manuals distributed to date. Additional materials currently in development — including the next offerings on herbicides and grazing in the IPM manual and CD series — will be mailed to binder recipients as they become available.

In response to the demand, several key materials included in the *Information Center* are being reordered. The *Biological Control of Leafy Spurge* manual is now in its third printing of 20,000 copies, while the more recent *Multi-species Grazing and Leafy Spurge* manual is now in its second printing. Among the CDs being reordered are the latest update of the *Purge Spurge: Leafy Spurge Database,* version 4.0 CD and the *Biological Control of Leafy Spurge Informational Resource* CD. Five thousand copies of both CD's were initially released during Winter 2001. Included on this latest reorder of the Biological Control CD — and all subsequent CDs in the Informational Series — is an electronic copy of "Meeting the Invasive Species Challenge," the management plan drafted by the National Invasive Species Council.

Additional materials are available by contacting TEAM Leafy Spurge at 406-433-2020; by e-mail at teamls@sidney.ars.usda.gov or by writing to NPARL, 1500 North Avenue, Sidney, MT 59270. TEAM Leafy Spurge is an area-wide, IPM research and demonstration project funded by the USDA's Agricultural Research Service in cooperation with the USDA's Animal and Plant Health Inspection Service. The success of the program has earned it a one-year extension. It is headquartered at the USDA-ARS Northern Plains Agricultural Research Laboratory in Sidney, MT.

Order Form

CD ROMs (Mac and PC) — Quantity

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This CD-ROM provides a wealth of information on different management techniques along with basic research information. It includes more than 900 articles from scientific journals, Extension publications and meeting proceedings and has handy search tools to find the information you need.

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Your name _____

Company / organization _____

Mailing address _____

City, state and postal code _____

Phone number _____

E-mail address _____

Please return form to: USDA-ARS TEAM Leafy Spurge, 1500 N. Central Ave., Sidney, MT 59270
(Please include a phone number or e-mail address in case we have questions about your order.)

Web-accessible Items

The following items are available on the TEAM Leafy Spurge Internet, http://www.team.ars.usda.gov.

Agricultural Economics Reports

Copies of these reports, accessible on the TEAM Leafy Spurge web site, are also available from the Department of Agricultural Economics, North Dakota State University, P.O. Box 5636, Fargo, ND 58105-5636; (701) 231-7441; Fax (701) 231-7400; email cjensen@ndsuext.nodak.edu or alternatively on the web at http://agecon.lib.umn.edu/ndsu/html

Impediments to Controlling Leafy Spurge in the Northern Great Plains
Ag. Economics Misc. Report 185 (May 2000)
Randall S. Sell, Dean A. Bangsund, and
F. Larry Leistritz

Feasibility of a Sheep Cooperative for Grazing Leafy Spurge: Summary
Ag. Economics Report 435-S (Jan. 2000)
Randall S. Sell, Dan J. Nudell, Dean A. Bangsund, F. Larry Leistritz, and Tim Faller

Economic Analysis of Controlling Leafy Spurge with Sheep: Summary
Ag. Economics Report 431-S (Jan. 2000)
Dean A. Bangsund, Dan J. Nudell, Randall S. Sell, and F. Larry Leistritz

Perceptions of Leafy Spurge By Public Land Managers, Local Decision Makers, and Ranch Operators: Summary
Ag. Economics Report 406-S (Sept. 1998)
Randall S. Sell, Dean A. Bangsund,
F. Larry Leistritz, and Dan Nudell

Ranch Operators' Perceptions of Leafy Spurge: Summary
Ag. Economics Report 400-S (July 1998)
Randall Sell, Dean Bangsund, F. Larry Leistritz, and Dan Nudell

Predicted Future Economic Impacts of Biological Control of Leafy Spurge in the Upper Midwest
Agricultural Economics Report No. 382-S (December 1997)
Dean A. Bangsund, F. Larry Leistritz, and Jay A. Leitch

Economic Analysis of Herbicide Control of Leafy Spurge in Rangeland
Agricultural Economics Report No. 342-S (February 1996)
Dean A. Bangsund, Jay A. Leitch, and F. Larry Leistritz

Economic Effect of Leafy Spurge in the Upper Great Plains: Methods, Models, and Results
Agricultural Economics Report No. 316 (March 1994)
Jay A. Leitch, F. Larry Leistritz, and Dean A. Bangsund

The following items were published in limited quantities, however, they are available for viewing and/or printing from the TEAM web site listed (http://www.team.ars.usda.gov).

TEAM Leafy Spurge Brochures

The SPURGE Scourge
A Success Story in Progress
Biological Control and Leafy Spurge
Give Leafy Spurge Biocontrol a Chance to Work for YOU!
Integrated Pest Management (IPM) Pyramid

TEAM Leafy Spurge Posters

Biocontrol
Flea Beetle Life Cycle
Leafy Spurge Biological Control Agents
TEAM Leafy Spurge "Other TEAM Players" Map
So, does biological control for leafy spurge really work?

Web-accessible Items (cont.)

The following items are available on the TEAM Leafy Spurge Internet, http://www.team.ars.usda.gov.

TEAM Publications

Aphthona Flea Beetle Establishment Determined by Soil Composition and Root Growth Pattern. Donald A. Mundal and Robert B. Carlson, Research Specialist and Professor, Department of Entomology, North Dakota State University, Fargo, ND 58105. Leafy Spurge Symposium, Pg 9. Medora, ND. June 29, 1999.

Biological Control of Leafy Spurge: An Emerging Success Story. Anderson, G.L., E.S. Delfosse, N.R. Spencer, C.W. Prosser, and R.D. Richard. 2000. In Proceedings, X International Biological Control Symposium, Bozeman, MT, July 4-9. (Invited, Accepted 4 May 1999).

The Effect of Aphthona spp. Flea Beetle (Coleoptera: Chrysomelidae) Larval Feeding on Leafy Spurge, Euphorbia esula L., Root Systems and Stem Density in North Dakota: 1986-96. Donald A. Mundal, Denise L. Olson, and Robert B. Carlson Research Specialist, Assistant Professor, and Professor North Dakota State University, Entomology Department 202 Hultz Hall, PO Box 5346 Fargo, North Dakota 58105-5346.

Miscellaneous documents

Guidelines for Weed Management

These guidelines are for use by local landowners and land managers when developing weed management programs. They are designed to be used as a working document and can be put into a three ring binder with additional information specific to your area added to the appropriate sections.

Flea Beetle Release Form

Using this "Flea Beetle Release Site Information Form" is not a requirement for using biological control, but it is a good idea. Using the form will allow you to keep track of your sites and compare success between different sites. It will also get you thinking about the kinds of things that make a good release site. In addition, information on the form might help identify factors that are limiting your success with biocontrol.

Directions for Making the Aphthona Accelerator Bug Sorter

Sorting flea beetles allows you to remove weed seeds and other debris from your sweep net collections, but is not a requirement. The *Aphthona* Accelerator requires about an hour of time and $25 to $30 in materials to build. Another advantage is that sorted, or "clean," flea beetles can be easily counted. Sorting and counting make it easier to keep track of how many flea beetles you are releasing.

Scale Dependent Spread Predictions of Leafy Spurge Using Multi-Elevation Remote Sensing and GIS Collateral Data

Spread predictions of leafy spurge are of vital importance to both rangeland users and land management agencies. Focused and timely control efforts need to address the most pressing population expansions or new infestations. Project scale and data resolution are key decisions in developing any model or tool to predict spread. Available data, cost of new data, and method of acquisition all influence cost, tactical project scale, and reliability. The prediction problem spans the synoptic (landscape) view, to the stream drainage and minimum mapping unit view of detail for site-specific control efforts. To enhance decision support, this predictive effort will compare and contrast the costs, methods, and traits of multi-scaled data, and the resultant confidence and reliability achieved by using those data. Distance from streams serves as a major known factor in patch expansion. That factor, combined with slope, aspect, and soil type can define favorable moisture micro sites on the landscape. Spatial relationships and data dependencies between environmental variables can be evaluated by autocorrelation and other spatial statistical methods. The desired tool allows the user to utilize existing common data types to predict spread at a given resolution. Employing finer detail data allows the user to define smaller and more specific predictions; however, the costs of all aspects of the analysis increase. Land managers and owners can employ this new tool to enhance the overall framework for leafy spurge control decisions.

Karl Brown
USGS Center for Biological Informatics, Denver, CO

Ralph Root
USGS Rocky Mountain Mapping Center, Denver, CO

Ray Kokaly
USGS Spectroscopy Laboratory, Denver, CO

Gerry Anderson
USDA Agricultural Research Service, Sidney, MT

Steve Hager
National Park Service, Theodore Roosevelt National Park, Medora, ND

Bob Nowierski
Department of Entomology, Montana State University, Bozeman, MT

Ed Holroyd
USGS Spectroscopy Laboratory, Denver, CO

Detection of Leafy Spurge Infestations through Imaging Spectroscopy using the Compact Airborne Spectrographic Imager

Leafy spurge *(Euphorbia esula)* is one of the most aggressive and hard-to-control invasive plant pests in the upper Midwestern United States, from the Mississippi River to the Northern Rocky Mountains. TEAM (The Ecological Area-wide Management) Leafy Spurge (http://www.team.ars.usda.gov/), sponsored by the U.S. Department of Agriculture Agricultural Research Service, is evaluating the capabilities of numerous remote-sensing platforms for the regional mapping of leafy spurge. As part of a larger study, Compact Airborne Spectrographic Imager CASI-II data were collected over a part of the South Unit of the Theodore Roosevelt National Park and neighboring U.S. Forest Service National Grasslands; the purpose is to test the effectiveness of low-altitude hyperspectral data with approximately 5 m spatial resolution for detecting and mapping leafy spurge. Preliminary results were compared to ground surveys and previous leafy spurge maps generated through the manual interpretation of 1:24,000-scale aerial photographs. This study can help in describing future strategies for further applications of CASI in mapping leafy spurge on a region wide basis.

Ralph Root
USGS Rocky Mountain Mapping Center, Denver, CO

Ray Kokaly
USGS Spectroscopy Laboratory, Denver, CO

Karl Brown
USGS Center for Biological Informatics, Denver, CO

Gerry Anderson
USDA Agricultural Research Service, Sidney, MT

Steve Hager
National Park Service, Theodore Roosevelt National Park, Medora, ND

Evaluation of Diflufenzopyr Applied With Quinclorac and Dicamba for Leafy Spurge (*Euphorbia Esula* L.) Control

Chemical control of leafy spurge continues to be the most common and effective method used. Picloram plus 2,4-D has historically been the standard herbicide treatment for leafy spurge. Preliminary research found that diflufenzopyr applied with auxin herbicides can dramatically increase leafy spurge control compared to auxin herbicides alone. The purpose of this research is to evaluate quinclorac applied alone or with diflufenzopyr for leafy spurge control and herbage production. Quinclorac is an auxin herbicide registered in non-cropland and fallow for control of annual grass, broadleaf, and some perennial weeds including leafy spurge. Diflufenzopyr is an auxin transport inhibitor that inhibits the flow of indoleacetic acid (IAA) and other synthetic auxin-like compounds within the plant. Currently, diflufenzopyr is not available to land managers alone; however, diflufenzopyr is included in a premix with dicamba. The premix consists of a 2.5:1 ratio of dicamba plus diflufenzopyr and is registered for corn and non-cropland weed control. Quinclorac, diflufenzopyr, and dicamba plus diflufenzopyr (premix) were applied either alone or together for leafy spurge control in a series of field and greenhouse experiments. Field treatments were applied to dense stands (approximately 20 plants/m^2) of leafy spurge at two locations. Studies included an application timing experiment, which compared spring and fall applied treatments and a herbicide rate experiment that will help determine optimum treatment rates. A greenhouse experiment was established to evaluate grass injury from the various herbicide treatments on four warm-season and six cool-season perennial grass species.

Kenneth J. Deibert, Graduate Research Assistant
Rodney G. Lym, Professor

Plant Sciences Department
North Dakota State University, Fargo, ND 58105

Herbicide Evaluation for Leafy Spurge in South Dakota

Leafy spurge *(Euphorbia esula)* infests 302,000 acres in South Dakota. Ninety-two percent of the infestation is in grassland or noncrop areas. Environmental sensitivity and economic constraints are critical factors in many areas. Field studies were established in 1998 in Harding County, SD. Data provided comparative performance under more critical precipitation conditions compared to other areas of South Dakota. In the long-term study, reduced rates of picloram + 2,4-D applied in the spring, spring and fall 2,4-D ester and spring and fall imazapic + 28% N + MSO provided at least 90% stand reduction 12 months after two application sequences. Initial high rates of picloram followed by annual 2,4-D in the spring, spring 2,4-D at high rate, spring dicamba and spring fosamine provided at least 75% control for the same period. Evaluation of emerging herbicide technologies compared rates and timing of imazapic. Fall treatments of .06 and .12 lb/A provided 70% to 85% control 9 months after treatment, respectively. Spring treatments at the same rates provided 47% and 45% control 3 months after initial treatment. Integrating reduced rates of fall-applied herbicides following sheep grazing provided 75% to 90% reduction after two seasons.

The studies provided data to improve herbicide decisions in drought stress situations. The concepts integrated into the TEAM Leafy Spurge Project resulted in increased awareness of leafy spurge; provided data and first-hand observation for producers and land managers and has dramatically increased acres of leafy spurge subjected to control practices in the project and surrounding area using biological agents, new herbicide technologies and livestock grazing.

Leon J. Wrage
Extension Weed Specialist
South Dakota State University, Brookings, SD 57007
Darrell L. Deneke
Extension IPM Coordinator
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Effects of Leafy Spurge (*Euphorbia esula* L.) Control on the Western Prairie Fringed Orchid *(Platanthera praeclara* Sheviak and Bowles)

Habitat invasion by leafy spurge is a threat to the survival of the western prairie fringed orchid (WPFO). Leafy spurge is very difficult to control with methods other than herbicides, but by law, herbicides cannot be used in habitats that support the orchid. Long-term control of leafy spurge without harming the WPFO may be achieved with the use of flea beetles (*Aphthona* spp.) as biological control agents. However, establishment of the flea beetles has not yet been successful within the habitat of the WPFO. Initial research found imazapic and quinclorac provided good leafy spurge control with little or no injury to the orchid. The purpose of this research was to control leafy spurge using both herbicides and biological control agents in an area that supports the WPFO. Treatments include insects alone, insects plus herbicides, and herbicides alone. Each herbicide was applied in the fall of 2000 at two application rates to 1 m^2 containing a single orchid in the Sheyenne National Grassland. During the summers of 2001 and 2002, the effect of treatment on orchid recruitment and flower and seed production will be determined. Flea beetle populations will be estimated by determining the number of adults that emerge from soil cores and by evaluating adult population in the field. Leafy spurge control will be monitored by sampling density of leafy spurge stems, both before and after treatment. The long-term goal is to maintain leafy spurge below densities that interfere with the WPFO.

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Effects of Multi-Species Grazing and Bio-Control on Leafy Spurge Infested Rangeland Golden Valley County, North Dakota

A study to evaluate the effects of multi-species grazing and bio-control insects in the control of leafy spurge (*Euphorbia esula* L.) was established near Sentinel Butte, North Dakota in 1998. The objectives of this study were to determine if simultaneous grazing of leafy spurge-infested rangeland with cattle and sheep employing a twice-over rotational grazing treatment (TOR) in conjunction with bio-control would: 1) enhance plant species diversity and richness, and reduce leafy spurge stem density compared to season-long grazing (SL) and 2) enhance livestock efficiency and performance compared to SL. Leafy spurge stem densities were different ($P<0.05$) between the upland and lowland range sites on the TOR from 1998 to 2000. A significant ($P<0.05$) treatment effect was found when comparing stem densities between TOR and SL on both upland and lowland range sites. There was no change ($P>0.05$) in species richness or diversity in either the TOR or SL treatments from 1998 to 1999. There was no difference ($P>0.05$) in cow average daily gain (ADG) between the TOR and SL treatments; however, cow ADG was lower ($P<0.05$) in 1999 when compared with 1998 and 2000 on the TOR treatment. Calf ADG was not ($P>0.05$) different between the TOR and SL treatments for all three years of study. Calf ADG was lower ($P<0.05$) in 1998 than 2000 on the TOR. There was no ($P>0.05$) difference in ewe ADG between the TOR and SL treatments for all three years of the study. Ewe ADG was higher ($P<0.05$) on the SL and TOR treatments in 1999 compared to 1998 and 2000.

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Investigations on Potential Ways to Improve Leafy Spurge Control by Livestock

In 1998, we applied high amounts of nitrogen fertilizer to spurge-infested sites in ND, SD and WY with the hope that we could decrease the toxicity of leafy spurge and consequently improve its palatability to cattle and sheep and their control of it. Unfortunately, this did not occur. In 1999 and 2000, we compared leafy spurge ingestion by four breeds of sheep (Columbia, Polypay, Rambouilett and Suffolk) on spurge-infested pastures in western ND to see if one or more breeds are superior for spurge control. In 1999, all sheep were young ewes with no previous exposure to leafy spurge, and in 2000 these same sheep were used again on the same pastures.

In the beginning of the trial in the first summer when there was plenty of grass and spurge available, Rambouiletts ate more spurge (as a % of their diet) than did the other breeds, but by the end of the first summer's trial Polypays had the largest % of spurge in their diets. In the second year with the sheep having considerable previous experience on spurge, none of the four breeds showed a consistently greater preference for leafy spurge. Further, the small differences observed among the breeds did not indicate that significantly greater leafy spurge control could be realized by simply grazing only one of these breeds. These findings indicate that it will likely prove difficult to improve leafy spurge control with livestock unless special efforts are made to select individuals with greater tolerance for the toxins in the weed or to increase detoxification of spurge toxins in the rumen before they can elicit their aversive effects.

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Economics of Using Sheep to Control Leafy Spurge

Analysis of the economic feasibility of using a multi-species grazing program to control leafy spurge was based on adding a sheep enterprise to an existing ranch or leasing sheep during the grazing season. Several sheep enterprise budgets were developed for different flock size, performance, and financial characteristics. Fencing expenses were estimated for adding wire to an existing fence or for constructing new fence.

Treatment costs included fencing expenses and net returns from a sheep enterprise (which could be positive or negative) or expenses from leasing sheep. Returns from control included recouping lost grazing outputs (for cattle) from within the infestation and maintaining existing grazing capacity by preventing current infestations from expanding. Rangeland with 0.2 to 0.8 AUMs/acre stocking rates was evaluated.

When flock performance (e.g., lambing rate, weaning weight) was equal to that of established sheep producers (best-case scenario) over a ten-year period, treatment benefits greatly exceeded costs in all situations. When flock performance was equal to that of unassisted lambing flocks (worst-case scenario), treatment benefits generally exceeded costs only on more productive rangeland (0.7 AUMs/acre or greater). However, in most of those situations, a multi-species grazing program resulted in less economic loss than not controlling the infestation. The majority of ranchers adopting a sheep enterprise will likely be somewhere in between these two scenarios. A lease rate of $1 per head per month was economical in many of the control situations, but lease rates of $2 per head per month would not be recommended.

Probably the biggest factor influencing the economics of control was enterprise returns. Since numerous factors can affect the net returns for a sheep enterprise, a careful evaluation using site- and rancher-specific inputs would be recommended before implementing sheep grazing as a leafy spurge control method.

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Feasibility of Using a Sheep Cooperative to Control Leafy Spurge

This study examined the economic feasibility of a 5000-head, cooperatively owned sheep operation for leafy spurge control. The objectives were to determine 1) return on investment of the cooperative, 2) feasible structures for the cooperative, and 3) capital investment required by members in the cooperative. The sheep flock management alternatives considered were 1) winter lambing, 2) spring lambing, and 3) fall lambing. The fall lambing scenario was determined operationally infeasible.

Total capital investment per ewe for the winter lambing scenario was $301 versus $216 for the spring lambing scenario. The expected net income for the winter lambing scenario was negative. The minimum break-even lamb selling price and number of lambs sold per ewe for the winter lambing scenario was $84.10/cwt and 1.33, respectively. Alternatively, the spring lambing scenario net income was estimated at $124,000 annually. The minimum break-even lamb selling price and number of lambs sold per ewe for the spring lambing scenario was $59.51/cwt and 0.94, respectively. The expected annual return on investment (assuming 50% equity) for members with the spring lambing scenario, based on a 50-acre leafy spurge infestation in a 100-acre pasture with new fence, was 16 percent, based on 1 ewe with lamb per acre of leafy spurge.

A sheep cooperative would be an economically viable alternative to individual ownership of sheep by cattle producers. While these returns are not a guarantee of success, they do indicate the economic feasibility of using a sheep cooperative to control leafy spurge.

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An Ecologically Based Decision Support System for Managing Leafy Spurge *(Euphorbia esula)* Infested Rangeland

Successful leafy spurge management depends upon our understanding of plant community response to management. Our object was to use current information and field research to develop an ecology-based computer-driven predictive model designed to aid land managers in making cost-effective and sustainable leafy spurge management decisions. The model is based on a conceptual diagram of a weed population including life history stages (state variables) and the demographic processes that regulate the rates of transition between state variables over a one-year period. Intra- and inter-specific density-dependent regulation of leafy spurge, Kentucky bluegrass, and western wheatgrass, grasses that are often found growing in association with leafy spurge, are included in the model. The model predicts the number of individual spurge plants and grass biomass per unit area every year (generation) for a selected number of years. The impact of weed management was inserted as a selected level of mortality, and a selected level of fecundity reduction was included to simulate biological control. A series of input menus allow the user to describe the plant community being managed and propose management alternatives. The program then provides graphical output of predicted plant community dynamics.

Field experiments are being conducted to determine the competitive relationship between leafy spurge, Kentucky bluegrass, and western wheatgrass. Data from natural plant communities will be used to validate the model, collect starting parameter values, and assess site-to-site and year-to-year variation. Information from past research and research conducted by TEAM Leafy Spurge will be incorporated into the model.

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A Most Troublesome Weed: What Has Been Done, What Else Can We Do?

In weed science, the most troublesome weeds are generally deep-rooted, creeping, herbaceous perennials cpable of vegetative reproduction from roots or rhizomes. For many ranchers and land-managers in the Northern Great Plains, the most troublesome weed is leafy spurge. To date, management of leafy spurge has focused on preventing its spread by creating awareness and controlling infestations by applying all possible control measures. In fact, this is consistent with the goal of the TEAM Leafy Spurge program for ecologically-based integrated pest management. One component of integrated weed management is biological research to understand the fundamental cause of the problem in order to improve existing and identify new control measures. Although the payoff from fundamental research can be uncertain, and it may take 10 to 20 years to realize the benefits, it will continue to be a critical component for the effective control of leafy spurge. The primary reason that many weeds like leafy spurge are able to escape, avoid, and persist despite the application of chemical, cultural, mechanical, and biological weed control measures is they develop reproductive propagules such as buds and seeds and maintain them in various states of dormancy until growing conditions are suitable for plant growth. We are using cutting edge biotechnology like microarray analysis to reveal signals, pathways, and mechanisms regulating root bud dormancy in leafy spurge. We plan to examine gene function using viruses and to devise new ways to control leafy spurge and other perennial weeds based on virus-induced gene slicing.

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Genomic Approach to Investigate Growth and Development of Root Buds in Leafy Spurge

Leafy spurge is a deep-rooted, perennial weed that propagates vegetatively from an abundance of underground adventitious buds located on the roots and crown and is the primary characteristic leading to its invasive nature. Each of these buds has the capacity to regenerate a new plant when the aerial portion of the plant is either removed or dies. Since arrested development (dormancy) of the buds allows leafy spurge to escape most control measures, knowledge of genetic pathways that regulate bud growth and development will provide novel ways to control this and other perennial weeds. We are using a genomic approach, based on DNA microarrays, to investigate the biology of bud growth and development because this technology has the capability to simultaneously detect large differences in gene expression related to genetic pathways that govern bud growth and development. Clones identified using this method will be further characterized using a functional genomic-based approach. This method uses modified viral vectors to suppress target gene expression based on virus-induced gene silencing. Genes that are proven to have essential roles in controlling the growth and development of buds in leafy spurge will be used to develop 'bio-herbicides' as a new control measure. The details of research scheme and current progress will be discussed.

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Three-way Herbicide Mixture Increased Leafy Spurge Control

Herbicide mixtures often provide greater control of perennial weed species than the single components alone. For example, picloram plus 2,4-D provides a 20 to 30% increase in long-term leafy spurge control compared to either herbicide applied alone. Timing of herbicide application also affects herbicide efficacy on leafy spurge. For instance imazapic fall-applied provides 80 to 90% leafy spurge control 1 yr after treatment, but only 20 to 30% control when the same treatment is applied in the spring. The purpose of this research was to evaluate long-term leafy spurge control with herbicide mixtures.

The study evaluated leafy spurge control by imazapic applied in the spring (or fall) followed by picloram plus 2,4-D in the fall (or spring), picloram plus 2,4-D applied in the spring (or fall) followed by imazapic in the fall (or spring), and all three herbicides applied tank-mixed together in the spring (or fall). The three-herbicide mixture of picloram plus 2,4-D plus imazapic applied once in the spring provided the best long-term control and averaged 98% 24 MAT (months after treatment) compared to less than 60% when the herbicides were applied alone. The same three-herbicide treatment applied in the fall only averaged 15% control 24 MAT. The best split treatments were picloram plus 2,4-D applied in the spring followed by imazapic in the fall and imazapic fall-applied followed by picloram plus 2,4-D in the spring. These treatments averaged 85 and 61% control in August of 1999 and 2000, respectively. No grass injury was observed following any of the rotational treatments.

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Effects of Leafy Spurge Thinning on Establishment and Population Increase of *Aphthona* Flea Beetles

Two congeneric flea beetles, *Aphthona lacertosa* and *A. nigriscutis,* are proving to be effective biological control agents of leafy spurge *(Euphorbia esula* sensu lato). However, at the onset of this study, it was thought that the beetles were ineffective on extremely high-density infestations of leafy spurge, such as those found in riparian areas. We hypothesized that cutting of leafy spurge prior to release would increase flea beetle impacts on leafy spurge by increasing soil temperatures or reducing resistance to flea beetle attack through increased plant stress levels. A 2×2 factorial experiment (spurge cut/not cut, beetles released/not released) was conducted at each of three sites (eastern Montana, northeastern Wyoming, southeastern Wyoming) using a randomized complete block design at each site. The combined impacts of *A. lacertosa* and *A. nigriscutis* on leafy spurge were not significantly affected by cutting of leafy spurge. However, the beetles increased in numbers and had significant impacts on leafy spurge at only two of the three sites.

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What Plant Growth Regulators Affect Leafy Spurge Bud Growth?

Leafy spurge is a deep rooted perennial weed that propagates vegetatively from an abundance of underground adventitious buds located on the roots and crown. During the normal growing season, the signals derived from the shoot inhibit the growth of these underground buds — a phenomenon that scientists call correlative inhibition. Correlative inhibition is one type of dormancy found in leafy spurge buds. Several years ago, Dr. David Horvath (USDA-ARS, Fargo) discovered that there are two separate signals, one from the leaves and one from the meristems at the apex of the plant or from meristems in the axils of the leaves, that cause correlative inhibition. In addition, the leaf-derived signal requires photosynthesis. Based on his findings, I decided to examine a few plant growth regulators, mainly sugars and plant hormones, to see if they have a promotive or inhibitory effect on the growth of leafy spurge root buds.

Using a hydroponic system for plant growth, we determined that sucrose, glucose, auxin, cytokinin, and paclobutrazol (a gibberellic acid biosynthesis inhibitor) cause repression of root bud growth. In contrast, gibberellic acid promotes root bud growth; in addition, gibberellic acid and sucrose are functionally antagonistic. Our results suggest that some of these growth regulators may be involved in bud dormancy or growth. Moreover, the results provide us with some leads for further investigating bud dormancy. DNA microarrays are becoming an important tool for quickly screening the expression of hundreds to thousands of genes simultaneously; genes that might affect bud development. As DNA microarrays become available for plants like leafy spurge, we will use them to investigate how sugars and plant hormones signal buds to remain dormant or resume their growth. The Plant Science Research unit is supporting several initiatives to develop DNA microarrays for leafy spurge.

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