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# **2001 Spurgefest II Symposium Medora, North Dakota June 19, 2001**

## **Forward/Program**

In 1997 The Ecological Area-wide Management (TEAM) Leafy Spurge program became a reality. The program was funded as part of the USDA-ARS Area-wide Program and conducted cooperatively with the USDA-Animal and Plant Health Inspection Service (APHIS). The original concept of the program was to conduct demonstrations of integrated leafy spurge management strategies for state, federal and private land managers.

The TEAM Leafy Spurge (TLS) program has evolved substantially since its inception. Nineteen ninety seven saw the departure of the USDA-ARS Co-Principal Investigator, Dr. Paul Quimby Jr. and the subsequent assignment of Dr. Gerald L. Anderson as the ARS Co-Principal Investigator along with Dr. Lloyd Wendel of USDA-APHIS. The scope of the program was broadened to include research needed to complement the existing body of work, public relations and education became a major priority, and due to the abundance of biological control agents, the program distributed more than 40 million insects within the four state study region, as well as, three additional states (enough for more than 13,000 releases). TLS will distribute an additional 20 million insects within the original study area plus Iowa, Nebraska, Colorado, Idaho and two Canadian provinces if all goes as planned in 2001.

The papers presented in these proceedings represent the culmination of three to four years of research and demonstration, conducted in North Dakota, South Dakota, Wyoming and Montana. TLS will officially end 30 September 2001, however, a great deal of work remains. ARS will continue to provide administrative support for the next one to two years to ensure research and demonstration results are synthesized, published and provided to users in a usable format.

How will TLS be remembered? Hopefully we will be remembered for conducting a fair, comprehensive and coordinated approach to leafy spurge management. The intent of the program managers and the ad-hoc advisory committee continues to be heightening awareness of the problem leafy spurge poses and the various integrated pest management tools needed to effectively manage the weed. Program development was also designed to establish a new level of understanding and increase the participation of individuals in all sectors of society.

Two parting thoughts from the Principal Investigators:

1. Given the state of our agricultural economy and current funding levels, leafy spurge and other invasive weeds are not a problem we can expect landowners and land managers to deal with effectively alone. This means that we all have to be proactive in supporting local weed control efforts in the private and public sector. Simply put, invasive weeds are everybody's problem regardless of how the situation came about. We will never legislate weeds away nor will we kill a single weed by pointing fingers at those who are "the problem," but we can work together to ensure sufficient resources are available to get the job done. This extends to federal and state lands as well. Under-funded and unfunded mandates have already stretched most agencies beyond their ability to comply with existing invasive weed mandates. We encourage you to remember that federal and state lands belong to all of us and if they are not being managed properly, then it is up to us to ensure they have the resources needed to meet the obligations that have been placed on them.
2. Integrated pest management (IPM) provides the only hope for successfully controlling invasive weeds and preventing the establishment of new problem species. But, IPM is more than a set of weed management tools. True IPM includes the integration of landowners, land managers, policy makers and agency decision makers. If you are on the front lines of the weed control battle and there aren't at least ten people tripping over their feet trying to provide you with support, then something is wrong. Don't stop the fight, simply start contacting your state and federal representatives and impress upon them that your income is as important to our nation and your state as it is to you and your family.

TLS has contributed to our understanding of the weed and how to control it. However, the success achieved during the program was only possible because of the contributions of countless individuals who have been fighting invasive weeds most of their careers, and in some cases all their lives. Thank you for your efforts and thanks to all the partners that participated in the program. TLS is your program and we hope that TLS undergirded your efforts and promoted new management approaches that will be useful for years to come. The legacy of TLS is yet to be determined, but we hope it will be this – TLS made a difference – in controlling leafy spurge and in providing an effective example for future invasive weed programs.

Dr. Gerald L. Anderson  
USDA,ARS  
Sidney, MT

Dr. Lloyd Wendel  
UDSA, APHIS  
Mission, TX

## Program

Morning Session Moderator – Ernest “Del” Delfosse, acting laboratory director, USDA-ARS Northern Plains Agricultural Research Laboratory, Sidney, Montana.

- 8:00 a.m. Welcome – **Ollie Golberg**, Mayor of Medora.
- 8:05 a.m. Welcome – **Gerry Anderson**, TEAM Leafy Spurge co-principal investigator.
- 8:15 a.m. Operations Component Contributions to TEAM Leafy Spurge. **Robert D. Richard**, USDA, APHIS, PPQ Bozeman, Montana; **Chad W. Prosser**, USDA, ARS, Sidney, Montana; and **Connie O’Brien**, North Dakota State University, Belfield, North Dakota.
- 8:30 a.m. Leafy Spurge Bio-Control in the Little Missouri River Drainage. **Don Kirby**, North Dakota State University, Fargo, North Dakota.
- 8:50 a.m. Assessing Biological Control Agents for Area-Wide Control of Leafy Spurge with Foci in Montana and South Dakota. **Matthew S. Parker** and **Jack L. Butler**, Central Missouri State University, Warrensburg, Missouri.
- 9:10 a.m. TEAM Leafy Spurge Demonstration Assessment. **James S. Jacobs** and **Roger S. Sheley**, Montana State University, Bozeman, Montana.
- 9:30 a.m. Wyoming Assessment Project and Remote Sensing of Leafy Spurge. **Amy Parker Williams** and **David J. Kazmer**, University of Wyoming, Laramie, Wyoming.
- 9:50 a.m. Causes and Consequences of Female-Biased Sex Ratios in *Aphthona* Flea Beetles. **David J. Kazmer**, University of Wyoming, Laramie, Wyoming.
- 10:05 a.m. Break
- 10:20 a.m. Ecological Barriers for the Establishment and Population Increase of Flea Beetles on Leafy Spurge. **Robert Nowierski**, Montana State University, Bozeman, Montana; **David Kazmer**, University of Wyoming, Laramie, Wyoming; **David Horvath**, USDA, ARS, Fargo, North Dakota; and **Richard Hansen**, USDA, APHIS, PPQ, Montana State University, Bozeman, Montana.
- 10:40 a.m. The Utilization of *Oberea erythrocephala* as an Additional Bio-Control Agent on Leafy Spurge in the Little Missouri River Basin and in Southeast and North Central North Dakota. **Denise L. Olson** and **Donald Mundal**, North Dakota State University, Fargo, North Dakota.
- 11:00 a.m. Impact of Grasshopper Treatments on Established Populations of Biological Control Agents (*Aphthona* spp.) for Leafy Spurge. **R. Nelson Foster**, and **K. Chris Reuter**, USDA, APHIS, PPQ, Phoenix, Arizona; **Loren K. Winks** and **Terry E. Reule**, USDA, APHIS, PPQ, Bismarck, North Dakota; and **R.D. Richard**, USDA, APHIS, PPQ, Bozeman, Montana.

- 11:20 a.m. Nutritional Composition of Selected Invasive Species. **Kevin Sedivec**, North Dakota State University, Fargo, North Dakota; and **Chad Prosser**, USDA, ARS, Sidney, Montana.
- 11:40 a.m. TEAM Leafy Spurge Survey of Ranch Operators, Land Managers, and Local Decision Makers. **Nancy M. Hodur** and **Larry Leistritz**, North Dakota State University, Fargo, North Dakota.
- 12:00 p.m. Lunch
- Afternoon Session Moderator – **Gerry Anderson**, TEAM Leafy Spurge co-principal investigator.
- 1:00 P.M. Management Approach for Leafy Spurge Control. **Andrew Canham**, School and Public Lands, Pierre, South Dakota; **Dennis Mann**, Game Fish and Parks, Rapid City, South Dakota; **Jerry Moller**, Bureau of Land Management, Belle Fourche, South Dakota; and **Larry Nelson**, Redig, South Dakota.
- 1:20 p.m. Development of a GIS Database for the TEAM Leafy Spurge Project. **Steve Hager**, USDI, Medora, North Dakota.
- 1:40 p.m. Scale Dependent Spread Predictions of Leafy Spurge Using Multi-elevation Remote Sensing and GIS Collateral Data. **Karl Brown**, **Ralph Root** and **Raymond Kokaly**, USGS, Denver, Colorado; **Gerry Anderson**, USDA, Sidney, Montana; **Steve Hager**, USDI, Medora, North Dakota; **Bob Nowierski**, Montana State University, Bozeman, Montana; and **Ed Holroyd**, USGS, Denver, Colorado.
- 2:00 p.m. Detection of Leafy Spurge Infestations Through Imaging Spectroscopy Using the Compact Airborne Spectrographic Imager. **Ralph Root**, USGS Rocky Mountain Mapping Center, Denver, Colorado; **Ray Kokaly** USGS, Denver, Colorado; **Karl Brown**, USGS, Denver, Colorado; **Gerry Anderson**, USDA, Sidney, Montana; and **Steve Hager**, USDI, Medora, North Dakota.
- 2:20 p.m. Evaluation of Diflufenzopyr Applied with Quinclorac and Dicamba for Leafy Spurge Control. **Kenneth J. Deibert** and **Rodney G. Lym**, North Dakota State University, Fargo, North Dakota.
- 2:40 p.m. Herbicide Evaluation For Leafy Spurge in South Dakota. **Leon J. Wrage** and **Darrell L. Deneke**, South Dakota State University, Brookings, South Dakota.
- 3:00 p.m. Break
- 3:15 p.m. Effects of Leafy Spurge Control on the Western Prairie Fringed Orchid. **Ann M. Erickson** and **Rodney G. Lym**, North Dakota State University, Fargo, North Dakota.
- 3:35 p.m. Effects of Multi-Species Grazing and Bio-Control on Leafy Spurge Infested Rangeland in Golden Valley County, North Dakota. **Luke W. Samuel**, and **Kevin K. Sedivec**, North Dakota State University, Fargo, North Dakota; **Timothy C. Faller** and **Jack D. Dahl**, North Dakota State University, Hettinger, North Dakota.

- 3:55 p.m. Investigations on Potential Ways To Improve Leafy Spurge Control By Live-stock. **Scott L. Kronberg**, USDA, ARS, Mandan, North Dakota.
- 4:15 p.m. Economics of Using Sheep to Control Leafy Spurge. **Dean A. Bangsund**, North Dakota State University, Fargo, North Dakota; **Dan Nudell**, North Dakota State University, Hettinger, North Dakota; and **Larry Leistritz**, North Dakota State University, Fargo, North Dakota.
- 4:35 p.m. Feasibility of Using a Sheep Cooperative to Control Leafy Spurge. **Dan J. Nudell**, North Dakota State University, Hettinger, North Dakota; **Dean A. Bangsund** and **Larry Leistritz**, North Dakota State University, Fargo, North Dakota; and **Timothy Faller**, North Dakota State University, Hettinger, North Dakota.
- 4:55 p.m. An Ecologically Based Decision Support System for Managing Leafy Spurge Infested Rangeland. **Roger L. Sheley**, **Matthew J. Rinella**, and **James S. Jacobs**, Montana State University, Bozeman, Montana.
- 5:15 p.m. A Most Troublesome Weed: What Has Been Done, What Else Can We Do? **Michael E. Foley**, **James V. Anderson**, **Wun S. Chao**, and **David P. Horvath**, USDA, ARS, Fargo, North Dakota.
- 5:30 p.m. Closing comments

### **Posters:**

Genomics Approach to Investigate Growth and Development of Root Buds in Leafy Spurge. **Wun S. Chao**, **James V. Anderson**, and **David P. Horvath**, USDA, ARS, Fargo, North Dakota.

Three-Way Herbicide Mixture Increased Leafy Spurge Control. **Katheryn M. Christianson** and **Rodney G. Lym**, North Dakota State University, Fargo, North Dakota.

Effects of Leafy Spurge Thinning on Establishment and Population Increase of *Aphthona* Flea Beetles. **David J. Kazmer**, University of Wyoming, Laramie, Wyoming; **Chad Prosser** and **Gerry Anderson**, USDA, ARS, Sidney, Montana.

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## Operations component contributions to TEAM Leafy Spurge, area wide integrated management of leafy spurge (*Euphorbia esula*)

ROBERT D. RICHARD<sup>1</sup>, CHAD W. PROSSER<sup>2</sup>, and CONNIE O'BRIEN<sup>3</sup>

<sup>1</sup>Robert D. Richard, Station Director, USDA, APHIS, PPQ, Bozeman Laboratory, Bozeman, MT 59717; <sup>2</sup>Chad W. Prosser, TEAM Leafy Spurge Coordinator, USDA, ARS, Sidney, MT 59270; and <sup>3</sup>Connie O'Brien, Field Technician, North Dakota State University, Belfield, ND 58622.

### Abstract:

USDA, APHIS and USDA, ARS teamed together to organize, manage, and implement a biologically based Integrated Pest Management (IPM) project, focused along 300 miles of the Little Missouri River in Wyoming, Montana, North Dakota, and South Dakota. The Ecological Area-Wide Management of Leafy Spurge (TEAM LS) began in 1997. The goal of the project was to develop and demonstrate ecologically based IPM strategies that could be used to achieve affordable, effective, self-sustainable leafy spurge control. Successes in establishment and collection allowed for over 13,000 releases of *Aphthona* spp. throughout the Little Missouri drainage. Additionally, through TEAM Leafy Spurge Operations, insects have been provided to additional states and provinces for leafy spurge control. Within the "TEAM" Program, biological control methodologies were designed as a control foundation, to be used alone or as a base strategy, coupled with other control methods, such as multi-species grazing and herbicides. Specific contributions of Operations include development of large volume insect collection, sorting, packaging for transport, and delivery of biological control insects. More than 40 million *Aphthona* spp. insects were collected from established populations. These insects provided the basis for research and demonstration projects within the program. Operations developed and provided a standardized scalable data collection form, used by all research assessment teams within the four-state-area and provided spreadsheets of the data for their use in interpreting insect establishment and leafy spurge control. Operations supported and hosted nine tours and field demonstrations in four states, developed "Leafy Spurge Biological Control Information and Photo Resource Gallery" CD, and provided information and support for the development of a second CD, a

multimedia biological control information suite, including: Biological Control of Leafy Spurge Brochure, Power Point presentation, Biological Control Photos, and Information and Resources.

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# Leafy spurge biocontrol in the Little Missouri River drainage

DON KIRBY<sup>1</sup>

<sup>1</sup>*Don Kirby, Professor, Department of Animal and Range Sciences, North Dakota State University, Fargo, ND 58105.*

## **Abstract:**

The study began in 1997 to assess the impacts of biological control agents (*Apthona* spp.) on leafy spurge and the ecological effects of leafy spurge on mixed grass prairie. Biocontrol agents—flea beetles—were released into leafy spurge infested rangeland in 1998. In only two growing seasons, leafy spurge control has been phenomenal. Of 98 release sites, 85% have had good leafy spurge control (>400 m<sup>2</sup>), while only 5% have shown poor control (<200 m<sup>2</sup>). Leafy spurge canopy cover at release sites was reduced from 40% to less than 5%. Leafy spurge control has been similar across aspects, topographic positions, soil types and range sites. Results from a soil seedbank study indicated that over 70% of seedlings germinated from soils taken across light-to-heavy leafy spurge-infested rangeland were leafy spurge. Desirable cool- and warm-season grasses only comprised 5% of the seedlings germinated from soil cores. The dominance of leafy spurge and other “weedy” plant species in the soil seedbank of leafy spurge-infested rangeland will necessitate a long-term leafy spurge control program for these affected sites.



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## Assessing biological control agents for area-wide control of leafy spurge with foci in Montana and South Dakota

MATTHEW S. PARKER<sup>1</sup> and JACK L. BUTLER<sup>1</sup>

<sup>1</sup>Matthew S. Parker and Jack L. Butler, Department of Biology, Central Missouri State University, Warrensburg, MO 64093.

### Abstract:

The objective of this study is to document micro-scale distribution, density, dynamics and trends of leafy spurge populations in response to flea beetle control within the Montana and South Dakota study areas. Ninety-three permanently located sample sites were established during the 1998 field season within the Mill Iron (Montana) and South Fork of the Moreau River (South Dakota) study areas. The selected sites represent the wide range of topographic, soil, vegetation, and landform situations typical of the region. Approximately 6,000 beetles (3,000 *Aphthona lacertosa* and 3,000 *A. nigriscutis*) were released in June 1998 at each of the 62 permanently located release sites. Beetle abundance was estimated using insect sweeps conducted in 1999 and 2000. Foliar cover of leafy spurge was estimated in 1998, 1999, and 2000 using a digital analysis system. Species composition and foliar cover of the extant vegetation was estimated on each sample site during the 1998 and 2000 field seasons. Beetle numbers increased dramatically between 1999 and 2000, and did not appear to demonstrate any particular affinity for site differences in slope and aspect in either South Dakota or Montana. Concomitantly with the increases in insect abundance, foliar cover of leafy spurge decreased an average of 76% and 77% in South Dakota and Montana, respectively, from 1998 to 2000. The native vegetation increased in frequency and abundance in response to the decrease in leafy spurge. Grass foliar cover at the Montana site increased 42% while species richness increased 27% in the two years following flea beetle release.

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## **TEAM Leafy Spurge demonstration assessment, Medora N.D.**

JAMES S. JACOBS<sup>1</sup> and ROGER S. SHELEY<sup>2</sup>

<sup>1</sup>James S. Jacobs, Research Assistant Professor, Land, Resources and Environmental Sciences, Montana State University, Bozeman, MT, 59717. <sup>2</sup>Roger L. Sheley, Associate Professor, Land, Resources and Environmental Sciences, Montana State University, Bozeman, MT, 59717.

### **Abstract:**

TEAM Leafy Spurge demonstrations are an important link between research and managers. The Medora N.D. demonstrations included grazing treatments, biological control releases and herbicide applications. Our objective was to collect data to determine the outcome of, and evaluate the demonstration treatments. The grazing demonstration was conducted at two sites and had 4 grazing treatments consisting of cattle and sheep grazing in season long pastures or rotation grazing. *Aphthona* flea beetles were also released in the pastures.

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## Causes and consequences of female-biased sex ratios in *Aphthona* flea beetles

DAVID J. KAZMER<sup>1</sup>

<sup>1</sup> David J. Kazmer, Assistant Professor, Department of Renewable Resources, University of Wyoming, Laramie, WY 82071.

### Abstract:

All North American populations of *Aphthona nigriscutis* examined to date (N=121 populations) have strongly female-biased sex ratios (79-100% female). In contrast, North American populations of *A. lacertosa* (N=13), *A. flava* (N=3) and *A. cyparissiae* (N=1) have approximately equally sex ratios (41-62% female). Sex ratios do not vary across the approximately 3-month summer period during which adults are active in each of the four species. One possible cause of the biased sex ratios in *A. nigriscutis* is infection by *Wolbachia*, an intracellular parasitic bacterium that is known to cause female-biased sex ratios in other arthropods. Consistent with this hypothesis, *Wolbachia* has been detected by an imperfect PCR assay in most populations of *A. nigriscutis* (85%, N=68) but not in populations of *A. lacertosa* and *A. flava* (0%, N=27). *Wolbachia* infections in *A. nigriscutis* are detected in females (42% infected, N=635 ind.) but not males (0% infected, N=247). Unfortunately, antibiotic experiments that would demonstrate the causative role of *Wolbachia* have not been successfully executed at this time. One possible consequence of female-biased sex ratios is reduced population growth rate due to the rarity of males and reduced female insemination rates. We tested this hypothesis by examining female insemination rates across the period of adult activity in two high density populations of *A. nigriscutis* and one high density population of *A. lacertosa*. In both species, female insemination rates were low at the beginning of the season but rapidly increased to nearly 100%. We are currently testing this hypothesis in both high- and low-density populations to determine if density and density X sex ratio effects on female insemination rates are present.

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## Ecological barriers for the establishment and population increase of flea beetles on leafy spurge

ROBERT NOWIERSKI<sup>1</sup>, DAVID KAZMER<sup>2</sup>, DAVID HORVATH<sup>3</sup>, and RICHARD HANSEN<sup>4</sup>

<sup>1</sup>Department of Entomology, Montana State University, Bozeman, MT. **Presenter.** <sup>2</sup>Department of Renewable Resources, University of Wyoming, Laramie, WY. <sup>3</sup>USDA-ARS, Fargo, ND. <sup>4</sup>USDA-APHIS-PPQ, Montana State University, Bozeman, MT

### Abstract:

Ecological barriers were investigated that may negatively affect the establishment and population increase of the five flea beetle species released against leafy spurge. Habitat association models of the flea beetles, developed from European data, were validated with insect, plant, and soil data collected from 48 research sites in Montana, North Dakota, and Wyoming. European and U.S. habitat association models were found to be statistically similar. The genetic variability of leafy spurge is being evaluated using AFLP (Amplified Fragment Length Polymorphism) techniques. Preliminary results have shown relatively little genetic polymorphism either within or among spurge populations. The results of flea beetle sex ratio studies showed that populations of *Aphthona nigricutis* have a highly female-biased sex ratio, while those of *A. cyparissiae*, *A. flava*, and *A. lacertosa* are close to a 50:50 sex ratio. Greater than 85% of the *A. nigricutis* populations were infected with parasitic bacterium, *Wolbachia* spp., which has been shown to cause female-biased sex ratios in other insect species. None of the other *Aphthona* species sampled was found to be infected with *Wolbachia* spp. The ecological amplitude of leafy spurge is being assessed using geographic, soil, and plant community information obtained from TEAM Leafy Spurge research sites. The impact of the flea beetles on plant species richness and diversity was evaluated at four research sites in Montana and North Dakota. By reducing high cover levels of leafy spurge the beetles may increase the diversity and species richness of forbs and may contribute to a substantial increase in the cover of grasses compared to areas still dominated by spurge.

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## The utilization of *Oberea erythrocephala* as an additional bio-control agent on leafy spurge in the Little Missouri River basin, and in southeast and north central North Dakota

DENISE L. OLSON<sup>1</sup> and DONALD A. MUNDAL<sup>2</sup>

<sup>1</sup>Denise Olson, Assistant Professor, Department of Entomology, North Dakota State University, Fargo, ND 58105.

<sup>2</sup>Donald Mundal, Research Assistant, Department of Entomology, North Dakota State University, Fargo, ND 58105.

### Abstract:

Leafy spurge inhabits a wide range of different environmental habitats. Leafy spurge placement in the soil appears to limit the success of *Aphthona* spp. to only a particular range of environmental conditions. The beneficial cerambycid beetle, *Oberea erythrocephala*, has a different reproductive and feeding behavior and therefore, may be better suited for successful establishment in the environmental habitats where *Aphthona* flea beetles are less than satisfactory. The successful establishment of *Oberea* will support the efforts of managing leafy spurge with another bio-control agent. *Oberea erythrocephala* was released at four sites in the little Missouri River basin, and five sites in southeast and one site in north central North Dakota. Each site was examined for the presence of *Oberea* population development and activity (stem girdling and oviposition punctures). At all the sites (not including north central North Dakota) *Oberea* was present the following year after release. An average of 3.7 adults per sweep and 8.5 adults were collected two and three years after release in southeast North Dakota. An average of 5.7% and 4.9% of the spurge plants were damaged by *Oberea* among the release sites in the Little Missouri River basin during the initial release year and one year following release. Leafy spurge stand counts were reduced an average of 4.22 stems/m<sup>2</sup> at two of these locations and increased by 4.6 stems/m<sup>2</sup> at one location. This study indicates that *O. erythrocephala* will establish under different environmental conditions that vary in annual temperature and precipitation, soil composition, and landscape.

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## Impact of grasshopper treatments on established populations of biological control agents (*Aphthona* spp.) for leafy spurge

R. NELSON FOSTER<sup>1</sup>, K. CHRIS REUTER<sup>2</sup>, LOREN K. WINKS<sup>3</sup>, TERRY E. REULE<sup>4</sup> and R. D. RICHARD<sup>5</sup>

<sup>1</sup>R. Nelson Foster, Supervisory Entomologist, USDA-APHIS-PPQ, Phoenix Plant Protection Laboratory, Phoenix, AZ 85040. <sup>2</sup>K. Chris Reuter, Technician, USDA-APHIS-PPQ, Phoenix Plant Protection Laboratory, Phoenix, AZ 85040. <sup>3</sup>Loren K. Winks, State Plant Health Director, USDA-APHIS-PPQ, Bismarck, ND 58501. <sup>4</sup>Terry E. Reule, Technician, USDA-APHIS-PPQ, Bismarck, ND 58501. <sup>5</sup>R. D. Richard, Laboratory Director, USDA-APHIS-PPQ, Bozeman Plant Protection Laboratory, Bozeman, MT 59715.

### Abstract:

Established populations of flea beetles (*Aphthona* spp.) on leafy spurge may be in jeopardy in areas of western rangelands where damaging populations of grasshoppers require insecticide treatments. The impacts of actions to manage grasshoppers on flea beetles have not been determined and are of great concern.

Do treatments applied for controlling grasshoppers on rangeland infested with leafy spurge cause mortality to adult flea beetles? Which treatments if any, do not cause mortality? Of those that do, what is the immediate mortality level? What level of suppression on the population of biological control agents' results after one year? How long is required for the affected population to return to pretreatment population levels?

Laboratory bioassays and field evaluations were conducted to determine the impacts of grasshopper control treatments. In laboratory bioassays, diflubenzuron produced no significant mortality. Malathion spray produced moderate (25%-41%) mortality while carbaryl spray produced high (86%-96%) mortality. No differences in mortality in direct impingement studies were detected between *A. nigriscutis* and *A. lacertosa* with malathion, carbaryl or in untreated populations. However, on treated vegetation *A. nigriscutis* was observed higher on the plants and demonstrated higher mortality than *A. lacertosa*. In the season of treatment, field evaluations showed that diflubenzuron resulted in 18% and 0% mortality at 1 and 2 weeks post treatment respectively. Carbaryl bait resulted in low (17%) mortality while malathion spray resulted in moderate (21%-44%) mortality and carbaryl spray resulted in high (60%- 82%) mortality. The impacts at one year after treatment will be determined in 2001.

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## Nutritional composition of selected invasive species

KEVIN SEDIVEC<sup>1</sup> and CHAD PROSSER<sup>2</sup>

Kevin Sedivec<sup>1</sup>, extension rangeland specialist, Department of Animal and Range Sciences, North Dakota State University, Fargo, ND 58105 and Chad Prosser<sup>2</sup>, ecologist, Northern Plains Agricultural Research Laboratory, Sidney, MT 59270

### Abstract:

It has long been recognized that weed management systems on rangelands could incorporate grazing as an effective tool using an integrated pest management system. The objective of this study was to evaluate the nutritional composition of spotted knapweed (*Centaurea maculosa* Lamarck), diffuse knapweed (*Centaurea diffusa* Lamarck), leafy spurge (*Euphorbia esula* L.), and Canada thistle (*Cirsium arvense* L.) near Big Timber, MT and Bowman, ND. Samples from the aforementioned species were collected monthly during the growing season (May-October). Plant specimens were separated into rosettes, leaves, stems, and whole plant. Crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (lignin), in vitro dry matter digestibility, and minerals were analyzed on each of the plant parts. Preliminary data to date include CP and ADF from the Bowman study site. Crude protein was greater ( $P < 0.05$ ) and ADF lower ( $P < 0.05$ ) in leaf tissue than stem material for all clipping dates (22 May, 22 June, 19 July, 22-August, 10 October) for all species. Crude protein content of leafy spurge stems was 8.0, 6.1, 4.1, 3.1, and 3.2 % for the aforementioned dates while 27.0, 17.5, 20.6, 13.5, and 12.4 % for leaf tissue. The ADF content ranged from 51.7 % on 22 May to 60.6 % on 10 October for leafy spurge stems and 16.1 % on 22 May to 16.9 % on 10 October for leaves. Only leafy spurge contained a low ADF content in leaf tissue from 22 May through 10 October (16.1, 20.5, 23.5, 14.2, and 16.9 %). Nutritional quality was much higher in leaf tissue than stem tissue for all four-plant species. It appears leafy spurge provides the highest CP content and a lower ADF content during the second half of the growing than the other plant species.

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## **TEAM Leafy Spurge survey of ranch operators, land managers and local decision makers**

NANCY M. HODUR and F. LARRY LEISTRITZ<sup>1</sup>

<sup>1</sup>*Nancy M. Hodur, Research Associate, Department of Agribusiness & Applied Economics, North Dakota State University, Fargo, ND 58105. F. Larry Leistritz, Professor, Department of Agribusiness & Applied Economics, North Dakota State University, Fargo, ND 58105.*

### **Abstract:**

A 1998 survey of ranchers, local decision makers and public land managers reported on perceptions and attitudes regarding weed management in general and specifically on perceptions and weed management practices regarding leafy spurge. The survey identified and evaluated managerial, institutional and social factors that affect the rate and extent of implementation of various leafy spurge controls. Overall, respondents shared similar concerns about controlling leafy spurge and understood that leafy spurge is a long-term management problem. Results of the 1998 survey have been used by the TEAM Leafy Spurge (TLS) effort in implementing Integrated Pest Management (IPM) research and demonstration projects to address concerns and constraints to leafy spurge control identified in the survey. A second survey of the same ranchers, local decision makers and public land managers is scheduled for June 2001 to measure changes in perceptions of weed management issues as well as to identify needs for future research, demonstration and outreach efforts and compare the results to the initial survey. The survey will also include a number of questions designed to measure the producers' interaction with the TLS program and their evaluation of various TLS products and activities.



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# Management approach for leafy spurge control

ANDREW CANHAM<sup>1</sup>, DENNIS MANN<sup>2</sup>, JERRY MOLLER<sup>3</sup>, and LARRY NELSON<sup>4</sup>

<sup>1</sup>Andrew Canham, School and Public Lands, 500 East Capitol Avenue, Pierre, S.D. 57501. <sup>2</sup>Dennis Mann, Game Fish and Parks, 3305 West South Street, Rapid City, S.D. 57792. <sup>3</sup>Jerry Moller, Bureau of Land Management, 310 Roundup Street, Belle Fourche, S.D. 57717. <sup>4</sup>Larry Nelson, Box 3, Redig, S.D. 57776.

## **Abstract:**

Implementing various control methods by land managers for leafy spurge has had a wide array of success and failures. Part of the problem is not having current knowledge of field conditions and accurate history of field operations. Because of the increase in noxious weeds and vast acreages to manage, the most efficient methods available must be used to address weed problems in our day-to-day operations as well as their long range planning. Some of the most useful components of a weed management plan will identify areas of concern, the degree of infestation and a history of control methods used.

Using GIS & GPS technology, a complete geographical inventory of invasive species, land ownership, topography, and land use has been developed. By utilizing trained, experienced personnel, Trimble GPS receivers, and USGS digital quads, base accuracy of 2-3 meters was maintained for this project. This project has provided land managers and county weed districts with an example of the cost effectiveness of conducting inventory and survey of invasive species.

A database of field-collected data will enable matching of site-specific needs with predetermined methods. A coordinated effort now exists with private and governmental entities in identifying and managing invasive vegetation on the Moreau River watershed in northwestern South Dakota.

The results of this project have demonstrated the effectiveness of inventory methods and database design in creating an overall Integrated Management Plan dealing with invasive species.

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# **Development of a GIS database for the TEAM Leafy Spurge Project**

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<sup>1</sup>*Steve Hager, USDI, Theodore Roosevelt National Park, P.O. Box 7, Medora, ND 58645.*

## **Abstract:**

The value of a geographic information system (GIS) lies in its ability to link spatial data (the location of leafy spurge on the earth's surface) with descriptive data (the characteristics of the infestation, controls, history) and analyze to answer complex questions. During the past three years, Theodore Roosevelt National Park staff has developed GIS data for the TEAM Leafy Spurge (TLS) project area – a land base of 17 million acres. Project staff have acquired and processed over 1,000 individual data layers including: federal, state and county boundaries; digital elevation models (DEM); digital ortho-quarter quads (DOQQ); land use; leafy spurge biological control sites; leafy spurge infestations; public land survey; soils; streams; topographic contours; transportation and wetlands. The layers are organized into a logical structure and contain Federal Geographic Data Committee (FGDC) compliant metadata. Map products have been produced and distributed illustrating leafy spurge infestations and controls by all cooperating agencies. All processed GIS data have been distributed on CD-ROM including free GIS software for viewing data and producing maps. This project has established the GIS data foundation for technology transfer into the future. Land managers and the research community now have a valuable set of data to analyze leafy spurge and develop techniques for its long-term control.

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## **Scale dependent spread predictions of leafy spurge using multi-elevation remote sensing and GIS collateral data**

KARL BROWN<sup>1</sup>, RALPH ROOT<sup>2</sup>, RAY KOKALY<sup>3</sup>, GERRY ANDERSON<sup>4</sup>, STEVE HAGER<sup>5</sup>, BOB NOWIERSKI<sup>6</sup>, and ED HOLROYD<sup>3</sup>

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### **Abstract:**

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.

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# Detection of leafy spurge infestations through imaging spectroscopy using the compact airborne spectrographic imager

RALPH ROOT<sup>1</sup>, RAY KOKALY<sup>2</sup>, KARL BROWN<sup>3</sup>, GERRY ANDERSON<sup>4</sup>, and STEVE HAGER<sup>5</sup>

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## Abstract:

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.

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## **Evaluation of diflufenzopyr applied with quinclorac and dicamba for leafy spurge (*Euphorbia esula* L.) control**

KENNETH J. DEIBERT\* and RODNEY G. LYM<sup>1</sup>

<sup>1</sup>*Kenneth J. Deibert and Rodney G. Lym, Graduate Research Assistant and Professor, Plant Sciences Department, North Dakota State University, Fargo, ND 58105. \*Presenter.*

### **Abstract:**

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 could 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<sup>2</sup>) of leafy spurge at two locations. Studies included an application timing experiment, which compared spring and fall applied treatments and an 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.

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## Herbicide evaluation for leafy spurge in South Dakota

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### Abstract:

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 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.

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## **Effects of leafy spurge (*Euphorbia esula* L.) control on the western prairie fringed orchid (*Platanthera praeclara* Sheviak and Bowles)**

ANN M. ERICKSON\* and RODNEY G. LYM<sup>1</sup>

<sup>1</sup> Ann M. Erickson and Rodney G. Lym, Graduate Research Assistant and Professor, Department of Plant Sciences, North Dakota State University, Fargo, ND 58105. \* Presenter.

### **Abstract:**

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<sup>2</sup> 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

LUKE W. SAMUEL<sup>1</sup>, KEVIN K. SEDIVEC<sup>1</sup>, TIMOTHY C. FALLER<sup>2</sup>, and JACK D. DAHL<sup>2</sup>

<sup>1</sup>Luke W. Samuel and Kevin K. Sedivec, Graduate Research Assistant and Associate Professor, Animal and Range Sciences, North Dakota State University, Fargo, ND 58105. <sup>2</sup>Timothy C. Faller and Jack D. Dahl, Superintendent and Research Specialist, Hettinger Research Extension Center, North Dakota State University, Hettinger, ND 58639.

### Abstract:

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**

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<sup>1</sup>*Scott L. Kronberg, USDA-ARS, Northern Great Plains Research Lab, Mandan, ND 58554.*

### **Abstract:**

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, Ramboulett 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, Rambouletts 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**

DEAN A. BANGSUND, DAN J. NUDELL, and F. LARRY LEISTRITZ

*Dean A. Bangsund, Research Scientist, Department of Agribusiness and Applied Economics, North Dakota State University, Fargo, ND 58105. Dan Nudell, Research Specialist, Hettinger Research and Extension Center, North Dakota State University, Hettinger, ND 58639. F. Larry Leistritz, Professor, Department of Agribusiness and Applied Economics, North Dakota State University, Fargo, ND 58105.*

### **Abstract:**

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**

DAN J. NUDELL, DEAN A. BANGSUND, F. LARRY LEISTRITZ, and TIMOTHY FALLER<sup>1</sup>

<sup>1</sup>*Dan Nudell, Research Specialist, Hettinger Research and Extension Center, North Dakota State University, Hettinger, ND 58639. Dean A. Bangsund, Research Scientist, Department of Agribusiness and Applied Economics, North Dakota State University, Fargo, ND 58105. F. Larry Leistritz, Professor, Department of Agribusiness and Applied Economics, North Dakota State University, Fargo, ND 58105. Timothy Faller, Director, Hettinger Research and Extension Center, North Dakota State University, Hettinger, ND 58639.*

### **Abstract:**

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**

ROGER L SHELEY, MATTHEW J. RINELLA, and JAMES S. JACOBS

*Roger L. Sheley, Associate Professor, Land, Resources and Environmental Sciences, Montana State University, Bozeman, MT, 59717. Matthew J. Rinella, Graduate Research Associate, Land, Resources and Environmental Sciences, Montana State University, Bozeman, MT, 59717. James S. Jacobs, Research Assistant Professor, Land, Resources and Environmental Sciences, Montana State University, Bozeman, MT, 59717.*

### **Abstract:**

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?**

MICHAEL E. FOLEY<sup>1</sup>, JAMES V. ANDERSON<sup>1</sup>, WUN S. CHAO<sup>1</sup>, and DAVID P. HORVATH<sup>1</sup>

<sup>1</sup>*Michael Foley, Research Leader, James Anderson, Research Chemist, Wun Chao, Research Molecular Geneticist, and David Horvath, Plant Physiologist, USDA, Agricultural Research Service, Biosciences Research Laboratory, Plant Science Research, P.O. Box 5674, Fargo, ND 58105-5674.*

### **Abstract:**

In weed science, the most troublesome weeds are generally deep-rooted, creeping, herbaceous perennials capable 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 T.E.A.M. 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 silencing.

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# **Genomic approach to investigate growth and development of root buds in leafy spurge**

WUN S. CHAO<sup>1</sup>, JAMES V. ANDERSON<sup>1</sup>, and DAVID P. HORVATH<sup>1</sup>

<sup>1</sup>*Wun Chao, Research Molecular Geneticist, James Anderson, Research Chemist, and David Horvath, Plant Physiologist, USDA, Agricultural Research Service, Biosciences Research Laboratory, Plant Science Research, P.O. Box 5674, Fargo, ND 58105-5674.*

## **Abstract:**

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**

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<sup>1</sup>*Katheryn M. Christianson\* and Rodney G. Lym, Research Specialist and Professor, Plant Sciences Dept., North Dakota State University, Fargo, ND 58105. \*Presenter.*

### **Abstract:**

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

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### Abstract:

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 X 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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## Wyoming Assessment Project and remote sensing of leafy spurge

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### Abstract:

In the Wyoming component of the TEAM Leafy Spurge Assessment Project, large mixed-species releases (3,000 each of *A. nigriscutis* and *A. lacertosa* per site) resulted in not only significant, but very large reductions of leafy spurge in just two years. In contrast, non-release sites showed constant or increasing levels of leafy spurge during the three years of this study. Flea beetles were effective in reducing leafy spurge in all habitat types including riparian areas of very dense leafy spurge, wooded areas, and open upland areas. Flea beetles also effectively reduced leafy spurge on all aspects and soil textures. *A. lacertosa* was observed in greater numbers than *A. nigriscutis* on almost all of the release sites. In addition, *A. lacertosa* appeared to be more effective in controlling leafy spurge in a wide variety of conditions, with the largest crater sizes, and therefore the most rapid control occurring in cooler, moister riparian and north and east facing sites.

A fundamental research need in leafy spurge management and invasive plant management as a whole is cost-effective, large-scale mapping of plant populations. We acquired hyper spectral Airborne Visible / Infrared Imaging Spectrometer (AVIRIS) data over a 25 square-mile study area in Crook County, Wyoming on July 6, 1999. In 1999, we used an ASD FieldSpec spectroradiometer to collect ground calibration and reflectance data of leafy spurge, other vegetation, and soils. These spectra were used to perform spectral mixture analysis on the AVIRIS scene. A major advantage of this technique is that it can effectively “unmix” a pixel and provide an estimate of the areal extent of leafy spurge within the pixel. With its hyper spectral capabilities, AVIRIS provides the best resolution (spectrally, radiometrically, and spatially) for detecting and mapping leafy spurge.