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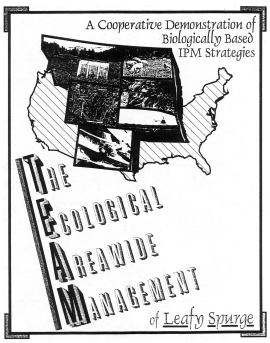

The Ecological Areawide Management of Leafy Spurge[1]

A Cooperative Demonstration of Biologically Based IPM Strategies

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[1] Cover (inserted above) Photos courtesy of Fremont Co. (WY) Weed & Pest, Theodore Roosevelt National Park, USDA APHIS-Bozeman, MT. Cover design by Valerie Farquhar, USDA-APHIS, Bozeman, MT.

TEAM Leafy Spurge Proposal

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The Ecological Areawide Management (TEAM) – Leafy Spurge

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Project Summary

Leafy spurge (*Euphorbia esula*) infests close to 5 million acres of land in at least 29 states. This invasive perennial weed overruns and destroys grazing lands for cattle and horses, degrades wildlife habitat and wildlife-associated recreation, decreases rangeland plant diversity, and reduces land values. Infestations on grazing lands and wildlands in Montana, North Dakota, South Dakota, and Wyoming alone are estimated to cost $144 million annually. Leafy spurge cannot be eliminated nor controlled by any single agency or management method. A collaborative, areawide program is absolutely essential to solving this weed problem.

Research indicates that integrated pest management (IPM) with a strong biological control component is the key to long-range management of leafy spurge. However, practical, comprehensive IPM information regarding leafy spurge has not been compiled for land managers.

The Ecological, Areawide Management (TEAM) – Leafy Spurge project will demonstrate precision targeting of practical, integrated leafy spurge management strategies for state, federal, and private land managers. Demonstration sites will be established in varied habitats along the Little Missouri River drainage, which begins in Wyoming and drains areas of Montana, South Dakota, and North Dakota. Public and private landowners in this area are highly motivated to manage this weed, and, in some cases, they have already organized community grazing or biological control programs.

A five-part approach to the TEAM Leafy Spurge demonstration project is proposed: 1) An extensive **operations** phase will demonstrate integrated leafy spurge management strategies; 2) **Assessments** of leafy spurge distribution and socio-economic factors related to management will be conducted; 3) **supporting research** will focus on insect-pathogen combinations, new grazing rotations, range ecology, inventory methods, and the life history of leafy spurge; 4) **technology transfer** will be encouraged; and 5) efficient **program management** will be ongoing.

Project objectives are:

- To develop and integrate sustainable leafy spurge management methods in a broad demonstration project with national implications and applicability;
- To form long-term partnerships among federal, state, and private land managers;
- To transfer to land managers economically and ecologically proven technologies to manage leafy spurge.

Keywords:

Leafy spurge, *Euphorbia esula,* biological control, IPM, weed management, range ecology.

The challenge

In 1978, a USDA Office of Environmental Quality Activities study team issued the report *Biological Agents for Pest Control: Status and Prospects.* Most of the report's major conclusions are as true today as they were 18 years ago, and are applicable to integrated weed management strategies in general. The study's major findings included the following:

- Information on pesticide alternatives is not easily available;
- More research is needed to improve *a priori* predictions of success; to develop production, storage, and application techniques; and to assess the impacts of use;
- Users need better technical assistance;
- Mechanisms are necessary to coordinate federal and state agencies, the private and the public sectors.

These issues – and more – are addressed by the TEAM Leafy Spurge project in a demonstration of practical management strategies.

Leafy spurge (*Euphorbia esula* L.), a Eurasian native, is one of the most pernicious rangeland weeds to invade the United States. A deep-rooted, long-lived perennial weed, leafy spurge displaces native vegetation, reduces cattle grazing and wildlife habitat, decreases rangeland plant diversity, and reduces land values. Today, more than 5 million acres in the United States and Canada are infested with this distinctive weed.

Leafy spurge was first recorded in the United States in 1827 in Massachusetts. It gained attention in the northern Great Plains and Northwest in the early 1900's. Leafy spurge is not considered a particularly invasive or troublesome weed in its native habitat because it has a host of natural enemies that control its population. However, the natural enemies did not accompany the plant on its overseas trip – and leafy spurge has spread unimpeded since it arrived.

The plant

Leafy spurge begins growing rapidly in early spring, getting a head start on native plants nearby. Shoots grow from crown and root buds, as well as from seeds. Stems can grow up to 32 inches tall. A pair of yellow-green, heart-shaped leaves surrounds the small green flowers, which usually appear by mid-July. A milky latex sap flows throughout the plant. This sap can cause skin irritations in humans and mouth irritation in grazing cattle and horses.

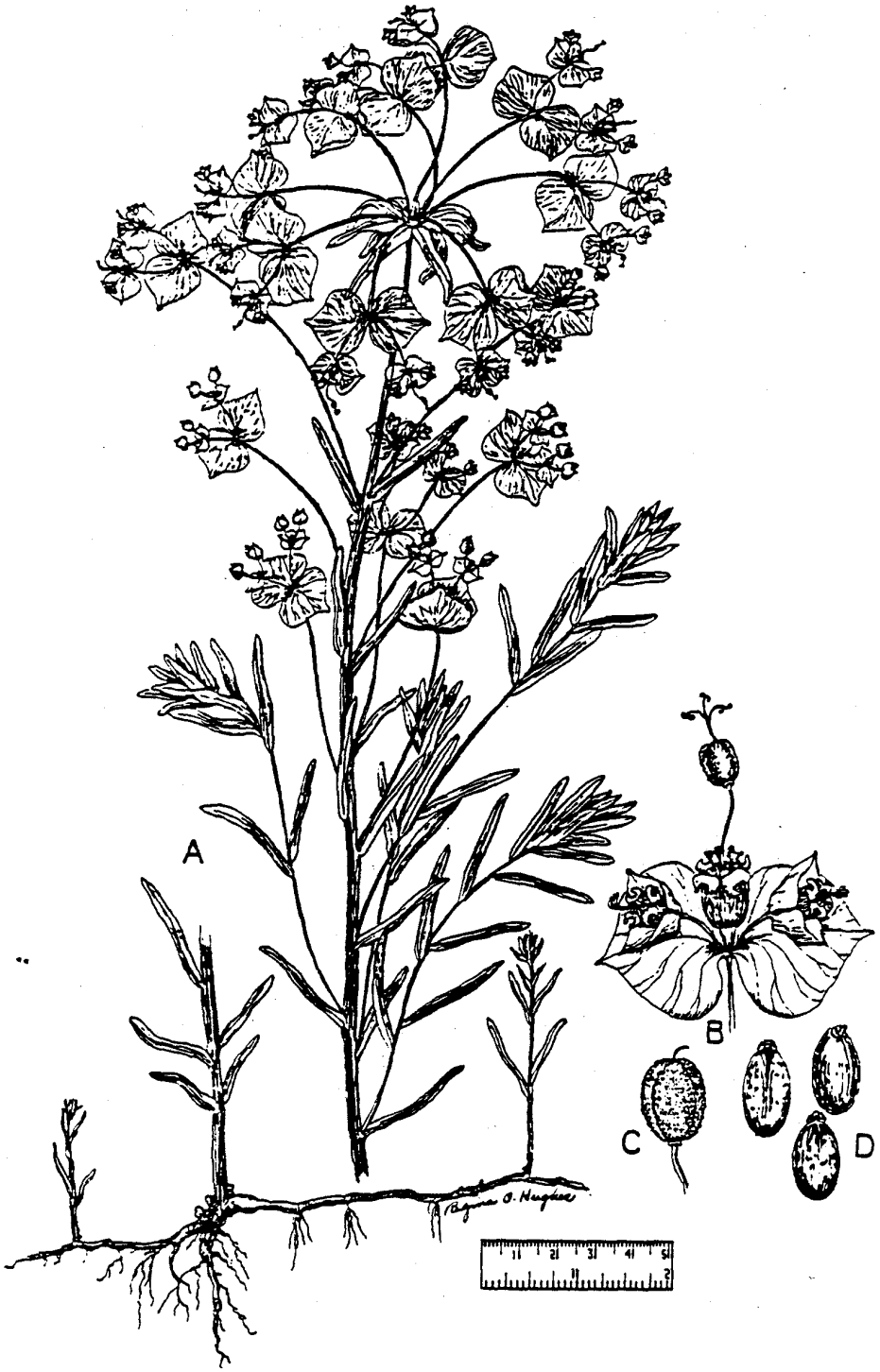

Figure 122. ***Euphorbia esula*** **L. Leafy spurge. A, Habit-× 0.5; B, flower cluster-× 2.5; C, capsule-× 2.5; D, seeds-× 6.**

LEAFY SPURGE

A deep and extensive root system makes leafy spurge extremely difficult to manage. Roots can grow 26 feet deep and can extend horizontally 15 feet per year. The thick-barked roots enable leafy spurge to survive repeated drought, grazing, and herbicide applications.

Leafy spurge thrives on many soil types and in a variety of habitats and climates. It often dominates river bottoms and lowlands – areas of great ecological importance to the semi-arid rangelands of the West. Dense stands of leafy spurge also can be found on the prairies, along roadsides, and up steep mountain slopes. The number of acres of leafy spurge-infested land has doubled about every 10 years.

Leafy spurge readily replaces native plants in disturbed soils, and is clearly related to a decline in the abundance of the dominant species in native prairies. Its threat to rare and endangered plants such as the prairie fringed orchid has been documented.

Economic issues

Left unattended, leafy spurge overruns untilled habitats and jeopardizes the biological integrity of grasslands and woodlands. Infestations on grazing lands and wildlands; result in an estimated direct annual impact of $40.5 million in Montana, North Dakota, South Dakota, and Wyoming alone. Secondary impacts could be as high as $89 million per year and represent the potential loss of 1,433 jobs.

Rural economies stagger under the effects of leafy spurge. When it infests grazing lands, leafy spurge reduces cattle grazing capacity, and therefore, reduces livestock sales, land values, and ranchers' incomes. Secondary impacts are seen in the region's loss of agriculture-related business.

This weed affects wildlands by degrading wildlife habitat and wildlife-associated recreation. In this rural four-state area, eliminating leafy spurge on wildlands could add 174 jobs and $9.8 million in business activity.

Recently, the economics of treating leafy spurge with herbicides have been studied. Conclusions indicate that herbicide treatments could be justified when applied to small infestations. However, as infestations become larger and more established, economic returns diminish quickly, and in many cases treatments cost more than the land is worth or could produce. Herbicides alone cannot provide long-term positive returns from leafy spurge control in many situations in the Great Plains.

Feasibility

The goal of the TEAM Leafy Spurge program is to devise and demonstrate practical leafy spurge management strategies that can be applied to the common habitats and land uses of the Upper Great Plains. Current management efforts can be summed up as "as little of this, and a little of that," depending on the landowner's preferences and budget. The TEAM Leafy Spurge project represents the first large-scale, systematic study and demonstration of alternatives. Land managers will have an opportunity to see different strategies in real-life settings, and adapt techniques to address their specific leafy spurge problems. This program is designed to be compatible with and expand upon current tech-

nologies. Results will be adaptable to varied sites, and the implementation is expected to have long-term benefits.

The TEAM Leafy Spurge program

A five-part approach to the TEAM Leafy Spurge demonstration project is proposed:

Operations: An extensive *demonstration* of integrated leafy spurge management strategies is central to this project. Varied habitats along the Little Missouri River drainage will be selected for precision-targeting of integrated weed management strategies. Hands-on field days and tours will highlight the demonstrations. Project updates and results will be regularly published electronically and in academic and popular journals.

Assessment: An accurate *inventory* of leafy spurge is necessary to provide information on the extent of the problem today, as well as a baseline to which infestation data can be compared periodically. Aerial and ground surveys will help determine specific habitats to which specialized management strategies may be applied. This project will also provide mapping specialists an opportunity to develop and test new GIS/GPS imaging techniques.

A study of the *socio-economic factors* associated with leafy spurge also will be conducted as part of the assessment phase. What are the costs and benefits of various management methods? This question and others will be answered at the conclusion of this five-year project.

Supporting research: Leafy spurge *research* will provide inputs to develop a decision-making model for the management of leafy spurge. Revegetation studies are needed to better understand what plants are likely and able to replace leafy spurge. The combined effects of insects and pathogens on leafy spurge are promising and require more study. New biological control agents to fill specific ecological niches are needed, as are determinations of establishment requirements of the agents. Grazing can be an effective leafy spurge management tool that must be developed as an alternative for land managers. New inventory methods are needed to monitor infestations more accurately and more economically. These issues will be addressed in this project.

Technology transfer: *Technology transfer* will be encouraged. Private landowners and public land managers must have the knowledge to recognize leafy spurge and the tools to manage infestations immediately. This information can be passed along in many formats appropriate to various audiences: Field tours, video documentation, Extension bulletins, training programs, World Wide Web databases, books, CD-ROMs, and symposia.

Program Management: The TEAM Leafy Spurge project will draw together the resources of state, federal, and local agencies and organizations to demonstrate an integrated approach to manage leafy spurge. Frequent, effective communication will be vital to the success of this multidisciplinary, geographically dispersed project. A full-time *Project Coordinator* will be required to promote cooperation among affiliates and to facilitate the TEAM Leafy Spurge project. The Coordinator will organize regular meetings of project participants, produce annual project reports, and produce a final, five-year evalua-

tion report. As time permits, the Coordinator will assist with leafy spurge education and awareness activities.

Project objectives and work plan

A. Operations

> **Operational objectives:** To demonstrate precision-targeting of integrated weed management strategies appropriately applied to varied habitats; to document the effects of integrated strategies; to draw together local, state, and federal agencies with private landowners in a cooperative project.

Little Missouri River drainage: The Little Missouri River drainage was chosen because it comprises a range of habitats and land uses as it flows through several states. Leafy spurge is found throughout most of the area. This area will provide ample numbers of sites to demonstrate leafy spurge management in heavily infested areas, in sporadically infested areas, and in uninfested areas where prevention is the key. In addition, land in the drainage is used in many ways, including for farming, grazing, wildlife habitat, and recreation. This poses a challenge for many land managers, and an opportunity for the TEAM Leafy Spurge program to demonstrate alternatives.

It is expected that many groups will be involved and will contribute matching and in-kind financial, physical, and educational resources necessary to implement the Little Missouri River integrated management demonstration sites. Through the efforts of the North Dakota Department of Agriculture, among others, many groups are already involved in leafy spurge projects along the river and its tributaries. These cooperators will be encouraged to expand into multi-jurisdictional, large-scale efforts that offer everyone a better opportunity to manage the infestation in a cost efficient, ecologically sound manner.

B. Assessment

> **Assessment objectives:** * Inventory – To demonstrate GIS/GPS technology; to evaluate and document existing flora; to help select appropriate management demonstration sites; and to provide baseline data with which to periodically compare vegetational changes over five years. * Socio-economic effects – To discover the most cost-effective strategies for managing leafy spurge in different situations; to quantify the effects of leafy spurge in financial terms; to better understand the social factors that affect acceptance of weed management programs.

Inventory: The development of effective and coordinated noxious weed management strategies at the national, regional, or local level depends upon accurate information concerning the extent, distribution, and dynamics of the problem species.

Aerial photography and satellite imageries hold promise for inventorying weed species. In this project, USDA-ARS researchers will use the aerial photographic mapping approach developed at Theodore Roosevelt National Park in Medora, ND (Anderson *et*

al. 1996) to inventory leafy spurge populations across four 6,500-ha intensive study sites located in Montana, Wyoming, North Dakota, and South Dakota. This local-scale mapping effort will be conducted during the first year of the project to develop an inventory baseline, and again in Year 4 of the project to assess change. Its objectives will be to: map the extent of leafy spurge within each region; evaluate the robustness of the procedure between different regions; and determine the adequacy of the information source for monitoring change and evaluating the effectiveness of various leafy spurge control efforts.

Regional-scale mapping will be conducted as part of the research component of this project.

Mapping results will be considered when sites are chosen to demonstrate various leafy spurge management strategies.

GIS/GPS technology will be explained and demonstrated to land managers as part of regular field days and tours. Results of mapping efforts will be displayed.

When collected by various agencies and organizations, weed inventory information is seldom in compatible formats. This proposal will promote the standardization of weed – and, specifically, leafy spurge – mapping and inventory information. ARS will adopt and encourage the use of the Greater Yellowstone Area (GYA) guidelines. These standards have already been adopted by the State of Montana and are being adopted by the USDA Forest Service. The GYA guidelines provide for a small set of standardized core information so that information can be shared or compiled across land ownerships and state boundaries. This approach emphasizes common data standards rather than the creation and maintenance of centralized databases.

Site assessments: Our objective is to assess the integrated leafy spurge management demonstrations in a manner that will provide information necessary to allow better management decisions in the future. Land managers must be able to predict the results of selected management practices before they can make wise decisions. Assessment will involve quantifying the plant community before and after weed management strategies are implemented. Data analysis will allow the prediction of the resulting plant community based on the initial plant community and management procedures applied. Management procedures will include:

- Biological control: Biological control agents (insects) will be released in appropriate areas. Insects in the genus *Aphthona* have been shown to be effective. The insects will be released as adults; subsequent oviposition by the females and larval feeding and development in the leafy spurge root system impacts plant vigor. Insects used in the demonstration area will be collected from previously established populations in North America.

  Assessment of naturally occurring pathogens present in the soil and in the larval feeding lesions on leafy spurge roots will be identified and monitored. After insect establishment has been confirmed, soil samples with leafy spurge roots will be examined and feeding lesions by larval *Aphthona* spp. will be sampled for identification of specific pathogens.

- Chemical (herbicides): Herbicides known to be effective in the control of leafy spurge will be applied at label rates according to best information from manufacturer and research community.
- Cultural: Assessment of native grasses as a competitive plant against leafy spurge will be tested. Grass competition and development studies will be assessed from natural grass populations and seeded grass stands in leafy spurge dominate plant communities. Use of differing seeding methods, fertilizers, and fire may be used as a component of these studies.
- Grazing: Utilization of sheep, cattle, and goats as grazers on leafy spurge will be assessed by standard methods.
- Combinations: Grazing and herbicides, grazing and insects, insects and pathogens, insects and herbicides, burning and herbicides, cultivation and reseeding.

Sampling: Prior to implementing a management strategy, data will be measured at each site using a technique that captures the natural variation in the existing plant community. At each site, several transects will be established throughout the area. Each transect will be subdivided into 20 two-by-five dm (Daubenmire) frames. Density by species and cover by species will be determined in each plot each year through image analysis of the Daubenmire frames. Each site's grazing capacity, measured in terms of Animal Unit Months (AUMs), will be determined annually. Percent bare ground and litter will also be determined. Biomass by species will be collected across gradients of leafy spurge from several randomly located plots throughout each demonstration area. The soil seedbank will be determined by collecting 30 randomly located soil samples before seed drop. Photo points will be established to document vegetation changes.

Treatments involving the release of biological control agents will include additional sampling. Each area will be sampled using standardized insect sweep net sampling techniques, and insects counted to determine establishment, population expansion, and development. Soil samples will be collected to determine the number of larvae in the soil and leafy spurge root biomass. Samples will also be processed to identify naturally occurring pathogens in the soil and changes in the microflora over time. All data will be recorded and held in a centralized data base that will include GPS determination of sites, pre- and post-treatment data. Additionally, historical information regarding the site and physical information about the location will be included in the data base. Data will be recorded on the USDA-APHIS Field Insectary Site Preliminary Information Sheet (FISPIS). Remote imagery may be used to monitor the impact of control strategies on the demonstration sites.

Treatments involving grazers will include soil core samples to determine leafy spurge root biomass. Additionally, changes in root development or shift in structure within the soil profile will be monitored as a result of differing grazing regimes.

Treatments involving herbicides will include samples for soil and water residues and microflora changes within the soil will be sampled and monitored annually.

Analyses: Data will be incorporated into multiple regression models using either linear or non-linear regression. Coefficients of determination, sums of squares and residuals

will be evaluated to determine the most suitable models. Regression will be conducted to characterize the plant community. Independent variables are density, biomass, and cover of all species before treatment. Dependent variables will be density, biomass, and cover of all species after implementation of the management strategy. Data will also be regressed using time as the dependent variable. These data will provide validation of the results predicted by the decision-making tool.

Socio-economic effects: Three studies of economics and sociology related to leafy spurge are proposed.

1. A study to assess the economic impact of leafy spurge reduction and range restoration. Gains in the regional economy associated with leafy spurge reductions will reflect alternative assumptions regarding the rate at which control technologies are adopted, and the rate at which rangeland grazing capacity recovers after control has been achieved. These scenarios will illustrate the potential payoffs from programs to speed adoption of control technologies and restoration of grazing capacity.

2. A study to evaluate costs and benefits of biological control strategies (*including grazing*) *and combinations of biological and chemical control strategies, and to develop an economic decision model.* Costs and benefits will be evaluated under various environmental situations and will include grazing land and wildlands. Analyses of specific control strategies and combinations will serve as the basis for a microcomputer decision model that will evaluate the least-cost and/or most profitable control strategies. The user-friendly model will be designed to be usable on a wide range of IBM-compatible computers. It will be similar to the Microcomputer Economic-Demographic Assessment Model (Leistritz *et al*. 1994).

3. A study to evaluate managerial, institutional, and social factors that may inhibit implementation of various control strategies and to develop approaches to counteract those factors, and to assess the impact of the demonstration program on attitudes and perceptions of landowners, land managers, and local decision-makers. The ultimate success of this project will depend on the extent to which control strategies are adopted by private land owners and public land managers. This aspect of the project will develop recommendations to improve the acceptability of selected control strategies among this population. Data will be collected through periodic interviews, surveys, and focus-group meetings.

C. Supporting research

> **Research objectives:** To better understand the biology of leafy spurge and the ecological implications of infestations; to improve existing management strategies and develop new approaches; and to refine inventory methods to more accurately and economically monitor leafy spurge.

Research will focus on six areas:

1. Insect-pathogen associations on leafy spurge: Soilborne diseases of leafy spurge have reduced stand density in rare natural epidemics observed in the Northern Plains. Evidence indicates that soilborne pathogens are the principal cause of spurge root bud

and shoot necrosis and eventually plant mortality where and when stands decline naturally. Pathogenic strains of three *Fusarium* spp., *Rhizoctonia solani, Pythium* spp., and *Agrobacterium tumefaciens* are consistently associated with especially rapid decreases in leafy spurge density when root-attacidng insect biological control agents (such as *Aphthona* spp.) are established. Scientists have evidence that the pathogens may enter the plant through wounds caused by insect feeding.

The strains of pathogenic species vary in virulence and possibly rhizosphere fitness and exhibit fairly narrow host ranges. These variations in virulence may help explain the failure of root-attacking insect biological control agents to establish and the failure of established insects to impact spurge density.

Evidence suggests that rhizosphere populations of soilborne pathogens of *Euphorbia* spp. are higher in European soils than in U.S. soils. European levels are approached in the United States only at sites where insect biological control agents are established and reducing stand density.

Studies of the means by which populations of highly virulent, narrow host range strains may be established, maintained, and become dispersed are needed.

Recent innovations are increasing opportunities for using microbes in biological control. A new (facile) process, dubbed STABILEZE, employs sucrose and silica products to promote stabilizing, granulating, storing, and applying microbes to weed targets.

The objective of this study is to broaden research on pathogens that have been demonstrated to affect leafy spurge, to discover how to ferment greater quantities, and to test various formulations for effective applications in the field.

2. Ecological barriers for the establishment and population increase of flea beetles on leafy spurge:

Habitat associations of flea beetles: The habitat associations of five flea beetle species will be characterized for leafy spurge infestations occurring from dry to very moist sites in the U.S. (70 sites across 11 states). Their relationships with particular chemical and/or physical properties of the soil, chemical properties of the spurge roots/foliage, levels of plant productivity and other factors will be determined from multivariate analysis of information that largely exists in an APHIS-PPQ data base. This information will help guide the release of flea beetle species in the appropriate types of habitats in the future, and thus improve their chances for establishment and impact on leafy spurge in the U.S.

Genetic variability of leafy spurge: Leafy spurge represents a genetic, chemical, and morphological mosaic, and as a consequence considerable taxonomic confusion exists. Furthermore, it has long been suspected that this high degree of variability may be responsible for the lack of flea beetle establishment or population increase at some of the leafy spurge release sites.

Two studies will assess the role of leafy spurge genetic variability in flea beetle establishment. In one, leafy spurge seed from release sites where flea beetles have and have not established will be planted in a common-garden. After suitable plant growth, flea beetles will be exposed to the common-garden plants and their performance on the different accessions monitored. Failure of the beetles to propagate on any of the accessions would indicate a genetic component to insect resistance and conversely, successful beetle

propagation on all accessions would indicate leafy spurge genetic variability is unimportant to beetle establishment.

In a second study, modern molecular genetic techniques culminating in a phylogeographic (i.e., phylogeny + geography) analysis will be used to reconstruct the invasion and post-colonization history of leafy spurge. North American and European leafy spurge accessions are available for this study and homologous DNA variants of known sequence will provide the phylogenetic information. By correlating the results of this study with the first, we will be able to quickly identify insect-resistant biotypes throughout the North American range of leafy spurge. Also, the identity of the European source population(s) will be known from this study; this is critical information for designing future overseas work on bioagents of leafy spurge.

Ecological amplitude and potential range of leafy spurge: Because leafy spurge is able to infest dry, moist, and wet sites across the U.S, the question is often posed: "How much of the U.S. is susceptible to attack by leafy spurge?" The answer to such a question is of critical importance for predicting the potential range and economic damage of leafy spurge. In order to address this question the relative abundance of leafy spurge will be correlated with chemical and physical properties of the soil, aspect of the site, elevation, average moisture levels, levels of plant productivity, and other factors (from the 70 release sites mentioned above) to determine which factors are most strongly correlated with the presence of leafy spurge. Geographic areas within the U.S. that contain these most important factors can then be used to identify potential areas of spurge infestation.

3. Grazing: Grazing is one of the most effective components of an integrated management plan for leafy spurge. North Dakota State University researchers are looking at the long-term effects of grazing combinations of cattle and sheep on leafy spurge-infested land. The economics of this strategy will be quantified, as well as its impact on plant communities and its integration into traditional, small-scale cattle ranching operations.

Questions remain concerning the most effective seasonal timing for grazing and the degree of utilization of leafy spurge that effectively harms the plant without negatively affecting the remaining plant community or performance of the grazing animals. University of Wyoming researchers are considering the impact of grazing treatments on other biocontrol agents, i.e., flea beetles (*Aphthona* spp.), and on the native plant community. Researchers will assess biomass, leafy spurge density, plant community composition and productivity, flea beetle abundance, and grazing animal performance relative to levels of herbivory treatment. Similar research is being conducted at Colorado State University.

At Montana State University, research has focused on combining intensive livestock grazing and associated desirable plants with herbicides. Effects on non-target vegetation and the resultant post-grazing plant communities are being studied.

The objective of this research component is to support grazing studies and to synthesize their results into practical guidelines for grazing management of leafy spurge.

4. Inventory methods: Weed species like leafy spurge (*Euphorbia esula*) are difficult to assess because the area infested is large, the types of ecological systems impacted are diverse, and the population expansion is rapid. Therefore, a careful evaluation of potential information sources is necessary to ensure that relevent and timely information is

obtained at a minimum investment. The proposed inventory program is designed to examine satellite imagery, aerial photography, and aerial videography as data sources for leafy spurge inventory and assessment.

Regional-scale analysis will evaluate the ability of satellite systems to identify and map major infestations ot leafy spurge across large areas. One scene from the Indian IRS-1C satellite system will be acquired over existing study areas in Crook County, WY, where extensive on-the-ground vegetational inventories have been taken. Standard spectral analysis will be used on the satellite image to identify plant communities composed predominantly of leafy spurge. On-the-ground data will be compared with satellite analyses to determine classification accuracy. This work will be coordinated with Dr. David Kazmer and Dr. David Legg of the University of Wyoming, as well as with the Upper Midwest Aerospace Consortium Remote Sensing Working Group.

Additional research at the regional scale will evaluate the combined use of digital videography and global positioning systems (GPS) for developing regional leafy spurge distribution maps. The study site will be an area 16 km by 80 km along the Little Missouri River. Forty flightlines will be flown perpendicular to the river at 500 m above ground level (AGL). The digital video system will acquire images encoded with location estimates from a GPS every 500 m. Each image will be photointerpreted to determine whether leafy spurge exists within the scene. The presence or absence of the weed within the georeferenced images will be used to determine the percentage of the area infested and spatial distribution. The objective of this study is to develop an assessment procedure useful in determining the amount and distribution of leafy spurge over major areas of a state.

5. Fire, herbicides, and reseeding: Fire and selected herbicides will be used to improve establishment of diverse mixtures of native grasses and legumes on leafy spurge-infested rangelands. Once established, the perennial native species will effectively compete with and suppress the leafy spurge, thus reducing the need for additional herbicide input. In this way, reliance on herbicides with potential adverse environmental consequences can be reduced.

Experiments will be established at leafy spurge rangeland sites in Nebraska. Results may be applied to demonstration sites on the Little Missouri drainage.

6. Life history of leafy spurge: The objective of this study is to gather the life history information necessary to develop a computerized decision-making management tool for leafy spurge. Understanding the biology and ecology of leafy spurge is central to its management. Decision-making tools must be based on our understanding of how weed populations change over time and how each management option alters that change. Thus, knowledge of the life history of leafy spurge is critical to developing a management decision-making tool that is based on ecology, science and technology, and economics. For example, Sheley and Larson (1994) studied the life history of yellow starthistle, and Maxwell and Sheley (1997) developed an educational model to help students and managers understand integrated yellow starthistle management. This model is adaptable to leafy spurge and could be used as a basis for a decision-making tool; however, information about the life history of leafy spurge is needed. Information that would be collected includes: leafy spurge population dynamics, the number of seeds in the seedbank, the num-

ber of seeds that germinate, the number of germinations that become juvenile plants, the number of juveniles that mature and produce seeds, the number of seeds produced, and the number of viable seeds that fall to the ground.

D. Technology transfer

> **Technology transfer objectives:** To educate land managers about leafy spurge and integrated management methods through field tours of the TEAM Leafy Spurge demonstration areas, through the presentation of programs about the demonstration areas, and through the development of informational products such as a computerized leafy spurge management decision-making tool.

Managers recognize that education, outreach, and technology transfer are major components of any successful integrated weed management plan. Awareness of the seriousness of leafy spurge is central to providing the impetus to develop and implement a weed management plan. Technology must be transferred to ensure that the most economically viable and ecologically sound integrated weed management strategies are adopted. Once state-of-the-art information becomes available, land managers can implement sustainable strategies for managing leafy spurge.

Field tours: Frequent field tours and demonstrations (particularly in Years 3-5) will allow land managers to see firsthand the effects of different weed management strategies. Hands-on training can be incorporated into the tours. Explanations and discussions will further enlighten participants.

Videography: The demonstration areas will be systematically videotaped annually (at least) to document vegetative changes. This visual archive will be used to supplement oral presentations about the project at meetings, conferences, and symposia held outside the project area. A multimedia program about the USDA project will be compiled at the conclusion of the five-year demonstration.

World Wide Web: A TEAM Leafy Spurge homepage on the World Wide Web will be developed and maintained. This page will provide a brief description of the project, a description of ongoing research, recent research results, and links to associated WWW sites.

Decision-making tool: A significant amount of information regarding the management of leafy spurge exists. However, the information is scattered throughout the scientific literature in a form that is very difficult to interpret and apply toward management. A major goal of this project is to compile this information into a decision-making tool usable by all land managers. The tool will incorporate our understanding of leafy spurge ecology, science and technology, and economics to provide managers information in a user-friendly, interactive system. New information will be easily incorporated into the model.

Networking: The coordination of the TEAM Leafy Spurge project necessitates effective communication among agencies, organizations, and individuals. This project will encourage and stimulate the development of integrated leafy spurge management pro-

grams in many states, focusing particularly on states that border major leafy spurge infestation areas. New partnerships and programs will be created as a result.

E. Program management

> **Program management objectives:** To coordinate the work of all involved agencies, organizations, and individuals; to keep records, produce timely reports, and organize the information produced by the project; to coordinate technology transfer efforts; and to promote continued cooperation of the partners in the management of invasive weeds.

Project coordinator: A project coordinator will be designated to facilitate the TEAM Leafy Spurge program. Good communication is essential to the successful coordination of the many facets of this program. The Project Coordinator will be responsible for this task.

Liaison committee: A liaison committee comprised of representatives of collaborating agencies and organizations will be established. This committee will advise the principal investigators (ARS and APHIS) as the TEAM Leafy Spurge program is developed, and will assist in the implementation of critical program components. This liaison committee essentially will form the “team" of TEAM Leafy Spurge.

Site-specific management technologies

Current leafy spurge management options

Biological: Biologically based weed management strategies have been accepted as the core of long-term, integrated weed management plans.

Twelve classical biological control insects have been introduced into the United States for control of leafy spurge. Some agents are immensely effective in specific habitats, and some are more effective in combination with additional biologically based or other management methods. Additional Eurasian exploration and research is needed to find insects that thrive in shady sites, riparian areas, and very sandy soils.

Pathogenic biological control studies have shown promising results. Some results indicate that soilborne plant diseases are strongly associated with attacks on leafy spurge by root-feeding insects. The effect of combining insects and pathogens is of great interest to researchers today.

Chemical: Herbicides applied repeatedly have been shown to control leafy spurge topgrowth and gradually decrease its root system. Herbicides commonly used to control leafy spurge include 2,4-D, dicamba, glyphosate, and picloram. Picloram, dicamba, and 2,4-D are selective herbicides that control broadleaf weeds, while glyphosate is nonselective and controls both grass and broadleaf weeds. Combinations of herbicides sometimes provide increased control. Dichlobenil suppresses leafy spurge growth under trees; fosamine can be used adjacent to water. Small patches of leafy spurge can be eliminated with a persistent herbicide program, but large areas require additional control methods.

Grazing: The milky latex within leafy spurge has been reported to cause skin inflammation, weakness, scours, and even death when ingested by some grazing animals. The toxin has produced inflammation and loss of hair on the feet of horses that walked in freshly mowed stubble after haying. Cattle, particularly, seem to avoid leafy spurge-infested sites.

However, goats and sheep seem to tolerate leafy spurge and, in the case of goats, even prefer it. Sheep will consume leafy spurge up to 50% of their diet, although consumption can vary from one sheep to the other. In one study, angora goats did an excellent job controlling the spread of leafy spurge. After two years of grazing, leafy spurge stem counts were significantly reduced while grass production increased. This greatly improved forage for cattle during the summer and fall months.

Other: Some perennial grass species can effectively compete with leafy spurge and afford some control; effectiveness of species varies by region. Reseeding rangeland with a mixture of grass and shrubs may provide more competition than reseeding with a single species. These strategies are often combined with an early herbicide treatment of leafy spurge to allow the competing plants to establish.

Integrated pest management: Research indicates that combining herbicide treatments with biological control agents increases leafy spurge control. Studies are underway at North Dakota State University (NDSU) to determine the most advantageous timing of herbicide treatments when biological control insects are involved, and the resulting plant populations when leafy spurge is removed from a site by herbicides, by biological control agents, and by both together.

Combinations and interactions of competitive grasses, fertilization, herbicides, and biological control agents are also being studied at NDSU to find a solution for leafy spurge infestations on sandy soils where single-method treatments are ineffective.

Herbicides have also been combined with goat grazing; initial results indicate that effectiveness of control depends on grazing intensity and timing of herbicide treatments.

A management strategy that integrates herbicides, fire, and reseeding with competitive native grasses has been developed to reclaim leafy spurge-infested rangelands in the central Great Plains. This strategy restores native tallgrasses on degraded rangeland sites without tillage, improves the value of the rangeland to livestock producers, and decreases the dominance of leafy spurge. Research is needed to refine and adapt this management strategy to different environments.

Proposed leafy spurge management

Varied habitats in the Little Missouri drainage will be selected to demonstrate different management strategies:

Habitat	Management strategy	Justification
Upland prairie	biological control*	Low cost, long-term strategy
	biological control × sheep × cattle	Practical option for local ranchers
	herbicides**	Standard for comparison
	containment (herbicides on periphery only)	Low-cost method of keeping leafy spurge in check
Riparian areas and woody draws	*Oberea* (biological control)	Demonstrate effects of one of the few insects that thrives near water
	biological control × sheep	Positive interaction reported
	biological control × sheep × fosamine	Experimental; included for comparison
	sheep grazing	Proven method for suppression
	sheep × cattle	Practical option for local ranchers
	sheep × burning	Burn to revive woody vegetation; sheep to suppress leafy spurge
	fosamine (herbicide)	Herbicide that's safe to use near water
	Landmaster™ (glyphosate + 2,4-D)	Herb. registered for riparian areas
Flat, tillable areas near crops	cultivation × reseeding	Proven method of revegetation
	herbicides	High production areas justify more inputs
	herbicides × burning	Bum to revive prairie plants; herbicides to contain leafy spurge
Uninfested areas of native vegetation – all ecosystems	prevention (spot treatments if necessary)	Demonstration of native species and environments

*Unless noted otherwise, "biological control" = *Aphthona* beetles

** Unless noted otherwise, "herbicide" = Tordon™ = picloram

Demonstration sites

Little Missouri River: The Little Missouri River ecosystem is invaded with the deep-rooted perennial weed leafy spurge. Many of the large-scale infestations along this river and its tributaries continue to displace native plant species that are important to the ranching economy of the region, as well as to the biological diversity of the ecosystem.

The existing Little Missouri Weed Management Area will integrate 17 years of research results into 16 demonstration sites within this ecosystem. Successes and failures will be monitored, on-site tours will be offered, permanent and portable interpretive displays will be developed, and findings will be published.

The drainage: The Little Missouri River flows north from its source near Devil's Tower, WY, and drains areas of four states: northeastern Wyoming, northwestern South Dakota, southeastern Montana, and southwestern North Dakota. Two major tributaries – Little Beaver Creek and Beaver Creek – originate in Montana and join the river in North Dakota. The Little Missouri meets the larger Missouri River at Lake Sakakawea in west-central North Dakota. The Little Missouri and its tributaries drain about 4,750 miles in North Dakota. For the most part, the river is free-flowing and is considered to have the unique characteristics necessary for a National Wild and Scenic River designation.

Theodore Roosevelt National Park: The Little Missouri River flows through the north and south units of Theodore Roosevelt National Park. In collaboration with USDA-ARS, North Dakota State University, and other entities, the National Park Service has instituted an intensive leafy spurge management program within the park's boundaries, including satellite mapping and large-scale releases of biological control agents. Many of the findings from the Theodore Roosevelt National Park project can be applied to the Little Missouri River area in general. In turn, many of the results of this five-year Little Missouri project will be applied to the park's ongoing program.

The land: Privately and publicly owned lands intermingle along the river; the U.S. Forest Service owns about 30 percent. The predominant land use is cattle grazing. Where the land can be tilled, small grains and forage crops are grown and there is an incidental amount of irrigation. Hunting is an important recreational activity along the river, as well as canoeing, horseback riding, and hiking.

Local weed management efforts: Six North Dakota counties are affected by the Little Missouri River. Each county administers an autonomous noxious weed program funded with local mill levies. Five of the six county weed boards receive state funding for a landowner-assistance program, and three are involved in cooperative projects through the state's Weed Innovation Network (WIN) grant program. All of the counties have biological control programs for leafy spurge. In 1995, these counties reported 60,000 acres of leafy spurge; 24,000 acres were treated with herbicides. Collectively, the counties spent $379,000 and treated 40 percent of acres reported. (It should be noted that some of the counties do not compile or report the acres of infestation on federal land.)

Partnerships and collaborations

USDA-ARS and USDA-APHIS

This project will be co-chaired and overseen by USDA-ARS and USDA-APHIS in partnership. Both agencies have many years of experience in leafy spurge research and implementation. Both agencies have valuable contacts and resources. Together they make a powerful team to tackle the leafy spurge problem on a national basis. A liaison committee comprised of key partners will advise and assist ARS and APHIS in the ongoing development and implementation of this program.

Proposal collaborators

Those who have been involved in the development of this grant proposal include:

Co-Chairmen		
Dr. P.C. Quimby, Jr.	USDA-ARS	Sidney, MT
Dr. Lloyd Wendel	USDA-APHIS	Mission, TX
USDA-ARS		
Tony Caesar	Plant pathologist	Sidney, MT
Neal Spencer	Entomologist	Sidney, MT
Gerry Anderson	GIS/GPS Specialist	Weslaco, TX
Janet Petroff	Communications	Bozeman, MT
Robert Masters	Range Scientist	Lincoln, NE
USDA-APHIS		
Robert Richard	Entomologist	Bozeman, MT
Richard Hansen	Entomologist	Bozeman, MT
Extension Service		
Roger Sheley	Montana State University	Bozeman, MT
Jerry Marks	Missoula County	Missoula, MT
Dan Duerre	Golden Valley County	Beach, ND
University		
Robert Nowierski	Montana State University	Bozeman, MT
Rodney Lym	North Dakota State University	Fargo, ND
David Kazmer	University of Wyoming	Laramie, WY
Larry Leistritz	North Dakota State University	Fargo, ND
Tim Faller	NDSU Ag Experiment Stn	Hettinger, ND
Scott Kronberg	South Dakota State University	Brookings, SD
State Departments of Agriculture		
Cindie Fugere	North Dakota	Bismarck, ND
Barbra Mullin	Montana	Helena, MT
Harold Stepper	Montana	Helena, MT
Other agencies		
Jim Olivarez	U.S. Forest Service	Missoula, MT
Rita Beard	U.S. Forest Service	Denver, CO
Hank McNeel	Bureau of Land Management	Billings, MT
Roger Andrascik	National Park Service	Medora, ND
Other state representatives		
Lars Baker	Fremont Co. Weed & Pest	Lander, WY

Grassroots collaboration

The Little Missouri River offers a unique opportunity to implement the integrated technologies that university and Federal researchers have developed. Land managers such as the U.S. Forest Service and the National Park Service are willing to participate and have access to professional staff capable of gathering data for this type of project. Private landowners welcome the opportunity to work beside public land managers to control leafy spurge. University researchers welcome the opportunity to apply their knowledge to a large-scale project.

A coordinated, grassroots effort will be mounted to communicate and educate all affected parties about the potential to join this project. Town meetings will be held at locations along the river. An informational letter, as well as follow-up phone calls will invite people and their agencies to participate. Many face-to-face contacts have already been made and all have shown interest and enthusiasm for the idea of managing leafy spurge in a large-scale project.

(*See Appendix 1 for a collection of collaborators' letters of support for this project.*)

Potential collaborators

Who	What
USDA Forest Service	Manages much of the land in the Little Missouri drainage; promotes weed-free land use practices; supports training of local land managers.
USDA Natural Resources Conservation Service	Teaches land management practices to farmers and ranchers; facilitates CRP program; promotes weed-free land use practices.
USDA National Park Service	Manages nearby Theodore Roosevelt Nat'l Park; provides experience in managing leafy spurge in a Badlands environment.
USDI Bureau of Land Management	Manages much land in the Upper Midwest and West; promotes weed-free land use practices; supports training of local land managers.
USDI Bureau of Indian Affairs	Manages nearby land; promotes weed-free land use practices; supports training of local land managers.
USDI Fish & Wildlife Service	Manages resource areas to benefit fish and wildlife; considers threatened and endangered species; promotes healthy ecosystems.
USDI Bureau of Reclamation	Manages lands throughout the U.S.; employs weed management strategies.
Department of Defense	Manages lands throughout the U.S.; employs weed management strategies.
U.S. Army Corps of Engineers	Publishes how-to weed management manuals and CD-ROMs; manages lands throughout the U.S.; employs weed management strategies.
Federal Interagency Committee on the Management of Noxious and Exotic Weeds (FICMNEW)	Coordinates weed management efforts among federal agencies as an advisory group.
North Dakota Dept. of Agriculture	Encourages implementation of best leafy spurge management strategies; conducts weed management training; funds local leafy spurge management programs.
Montana Dept. of Agriculture	Funds leafy spurge research (particularly biological control) and local management programs; encourages implementation of best leafy spurge management strategies; conducts weed management training.

Wyoming Dept. of Agriculture	Promotes wide distribution of insect biological control agents on leafy spurge; encourages implementation of best leafy spurge management strategies; conducts weed management training;.
South Dakota Dept. of Agriculture	Encourages implementation of best leafy spurge management strategies; conducts weed management training.
Montana State University	Researches leafy spurge management, particularly biological controls; Extension Service conducts weed- related educational programs and publishes educational materials.
North Dakota State University	Researches leafy spurge management, particularly herbicides used alone and in combinations with other methods.
South Dakota State University	Researches leafy spurge management, particularly grazing.
University of Wyoming	Researches leafy spurge management, particularly herbicide use and grazing.
University of Nebraska	Researches leafy spurge management, particularly burning and reseeding.
Western Weed Coordinating Committee	Coordinates weed management efforts among state and federal agencies in the West; develops and implements action plans.
Western Society of Weed Science	Serves as a clearinghouse for academic weed scientists in the West; hosts annual meeting at which project results can be presented.
North American Weed Managers Association	Provides support and training for on-the-ground weed managers; publishes NAWMA newsletter.
Weed Science Society of America	Hosts annual Leafy Spurge Symposium; publishes Leafy Spurge News newsletter. Serves as a resource for weed scientists; publishes project results;. Hosts annual meeting at which project can be presented.
International Organization of Biological Control – Weeds Working Group	Publishes project results; hosts annual meeting at which project can be presented.
Entomological Society of America	Serves as a resource for scientists involved with insect biological controls; publishes project results; hosts annual meeting at which project can be presented.
American Phytopathological Society	Publishes project results; hosts annual meeting at which project can be presented.

Private landowners	Implements leafy spurge management strategies; provides feedback on practicality and effectiveness.
Grazing associations	Promotes healthy grazing practices and improved rangeland conditions.
Cattlemen's groups	Promotes healthy cattle-grazing practices and improved rangeland conditions.
Wool Growers	Promotes healthy sheep-grazing practices and improved rangeland conditions.
Outdoor recreation groups	Promotes a healthy, weed-free, outdoor environment for multiple uses: hunting, canoeing, horseback riding, hiking.
Preservationists	Work to preserve native species and weed-free natural environments.
Alternative farming groups	Promotes less herbicide use and low-input farming practices.

Anticipated program benefits

Within five years, the TEAM Leafy Spurge project will:

- Demonstrate precision-targeting of integrated leafy spurge management strategies in varied habitats, with a better understanding of rangeland ecology;
- Transfer this technology to state, federal, and private land managers, expecting that Integrated Pest Management will begin to be implemented on leafy spurge infestations nationwide;
- Understand the costs and benefits – financial and otherwise – of different management strategies;
- Quantify the economic impact of leafy spurge and range restoration;
- Begin to incorporate leafy spurge research funded through this grant into the knowledge base and continually improve management methods;
- Improve satellite mapping and inventory techniques for more economic monitoring of vegetational changes;
- Develop leafy spurge management databases, information, and other tools to expedite the implementation of integrated management methods;
- Begin to reduce leafy spurge infestations on the Little Missouri drainage using integrated weed management techniques.

- Establish ongoing partnerships among land managers in the northern Great Plains, expecting that those partnerships will provide a foundation for future work in broader geographical areas and on broader problems;
- Contribute significantly to the global research of sustainable integrated pest management, especially as it relates to weeds, and stimulate continued IPM research and implementation nationwide;
- Encourage IPM training for Extension agents and state and federal land managers.

Facilities and equipment

- ARS Laboratory, Sidney, MT

  Includes a fully equipped laboratory, 10 remote-access weather stations, state-of-the-art computer communications equipment, insect-rearing facility, portable equipment for collecting and redistributing biological control agents, several 4×4 vehicles.

- ARS Laboratory, Weslaco, TX

  Includes laboratory and computers for GPS and GIS mapping and image analysis, and aircraft.

- APHIS Laboratory, Bozeman, MT

  Includes a fully-equipped laboratory, computer communications equipment, insect-rearing facilities, portable equipment for collecting and redistributing biological control agents, several 4×4 vehicles.

- ARS Laboratory, Lincoln, NE

  Includes weed science laboratory and field equipment for herbicide applications, reseeding, and site assessments.

- National Park Service and Forest Service

  Insectaries of biological control agents are established on NPS and USFS land near the Little Missouri River drainage.

- NDSU Agricultural Experiment Station, Hettinger, ND

  Includes livestock facilities such as portable fencing, portable watering devices, and vehicles for transporting livestock.

- University facilities

  Cooperators at universities in North Dakota, Montana, Wyoming, and South Dakota will have access to computer communication systems, laboratories, field equipment, and 4×4 vehicles.

Budget

	PHASE I		PHASE II		
	Year I	Year 2	Year 3	Year 4	Year 5
Operations					
Demonstrations	0	15,000	260,000	270,000	270,000
Equipment	40,000	25,000	20,000	10,000	10,000
Supplies	20,000	20,000	20,000	20,000	20,000
Field technicians	40,000	40,000	50,000	50,000	50,000
Subtotal	100,000	100,000	350,000	350,000	350,000
Assessment					
Inventory	200,000	200,000	100,000	100,000	100,000
Socio-economic	100,000	100,000	100,000	100,000	100,000
Subtotal	300,000	300,000	200,000	200,000	200,000
Supporting Research					
Insect/pathogen	25,000	25,000	25,000	25,000	25,000
Ecological barriers	40,000	40,000	40,000	40,000	40,000
Grazing	50,000	50,000	55,000	55,000	55,000
Inventory methods	40,000	40,000	40,000	40,000	40,000
Fire (in combinations)	20,000	20,000	20,000	20,000	20,000
Spurge life history	25,000	25,000	25,000	25,000	25,000
Subtotal	200,000	200,000	205,000	205,000	205,000
Technology Transfer					
Field tours/meetings	25,000	20,000	20,000	30,000	30,000
Videography	20,000	20,000	20,000	20,000	30,000
WWW/networking	20,000	15,000	15,000	15,000	15,000
Decision-making tool	35,000	45,000	45,000	35,000	25,000
Subtotal	100,000	100,000	100,000	100,000	100,000
Program Management					
Project coordinator	65,200	65,200	70,000	70,000	70,000
Meetings, travel	30,000	30,000	30,000	30,000	30,000
Communications/utilities	25,000	25,000	25,000	25,000	25,000
Publications/postage	20,000	20,000	20,000	20,000	20,000
Subtotal	140,200	140,200	145,000	145,000	145,000
TOTAL	$840,200	$840,200	$ 1,000,000	$ 1,000,000	$ 1,000,000

Personnel

Principal investigators:

Dr. P.C. Quimby, Jr. – USDA-ARS, Sidney, MT

Dr. Lloyd Wendel – USDA-APHIS, Mission, TX

Implementation responsibilities:

A. Operations – Lloyd Wendel (APHIS, Mission, TX) will have overall responsibility, in cooperation with selected partners, e.g., state Departments of Agriculture, Forest Service, Bureau of Land Management, National Park Service, and private landowners.

B. Assessments – ARS will have overall responsibility in cooperation with APHIS and selected partners.

- Gerry Anderson (ARS, Weslaco, TX) will lead the program on remote sensing for inventory, in cooperation with David Kazmer and David Legg (Univ. WY).
- Robert Masters (ARS, Lincoln, NE) and Robert Richard win co-lead the program on sampling and analysis, in cooperation with Richard Hansen (APHIS, Bozeman, MT), Roger Sheley (MT State Univ., Bozeman) and Rodney Lym (ND State Univ., Fargo).
- Larry Leistritz (ND State University, Fargo) will lead the program on socio-economic effects.

C. Supporting Research – P.C. Quimby, Jr. (ARS, Sidney, MT) will have overall responsibility, in cooperation with selected partners.

- Insect/pathogen associations – A.J. Caesar and N.R. Spencer, (ARS, Sidney, MT) will be co-leaders in this part of the program.
- Ecological barriers – Robert Nowierski (MT State Univ., Bozeman) and David Kazmer, (Univ. WY, Laramie) will be co-leaders in this part of the program.
- Grazing – Timothy Faller (ND State Univ. AES, Hettinger) will assume the lead in this research, in cooperation with Scott Kronberg (SD State Univ.).
- Inventory methods – Gerry Anderson (ARS, Weslaco, TX) will bear the responsibility of leading this research, in cooperation with David Kazmer and David Legg (Univ. WY, Laramie).
- Fire, herbicides, and reseeding – Robert Masters (ARS, Lincoln, NE) will lead this research, in cooperation with Roger Sheley (MT State Univ., Bozeman), Rodney Lym (ND State Univ., Fargo), and Carolyn Hull-Sieg (US Forest Service, Rapid City, SD).
- Spurge life history – Roger Sheley (MT State Univ., Bozeman) and Rodney Lym (ND State Univ., Fargo) will be co-leaders of this research.

D. Technology Transfer – Neal Spencer (ARS, Sidney, MT) will have overall responsibility, in cooperation with all TEAM Leafy Spurge partners.

E. Program Management – ARS and APHIS will select a Project Coordinator, with advice from a Liaison Committee of key partners.

Time commitments: It is estimated that ARS and APHIS personnel will average 20% of their time on this project; university personnel will spend 10-20% of their time on this project. A Project Coordinator will spend 100% of his/her time on this project. Other cooperators (state Departments of Agriculture, private landowners, other state and federal agencies) will spend an appropriate amount of time to fulfill the project terms.

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Appendix 1

Letters of support

United States Department of Agriculture
Forest Service
Custer National Forest
2602 1st Avenue North
P.O. Box 2556
Billings, MT 59103

File Code: 2150

Date: March 11, 1997

USDA
Agricultural Research Service
Beltsville, Maryland

To Whom It May Concern:

As a partner in the Little Missouri River TEAM Leafy Spurge project, we strongly support the effort. The out-come from infestation inventory, integrated pest management site demonstrations, economic analyses, and technology transfer activities will benefit this agency. Many other federal, state, and private partners and land managers will also benefit from the knowledge gained in the management of Leafy Spurge.

Thank you for your consideration of the TEAM Leafy Spurge proposal submitted by Northern Plains Agricultural Research Service.

Sincerely,

NANCY T. CURRIDEN

Forest Supervisor

cc: Neal R. Spencer, ARS

MONTANA STATE UNIVERSITY
EXTENSION SERVICE

Department of Plant, Soil and Environmental Sciences

Leon Johnson Hall
P.O. Box 173120
Bozeman, MT 59717-3120

Telephone (406) 994-4601
Fax (406) 994-3933

March 10, 1997

To Whom It May Concern:

I am writing in support of the TEAM Leafy Spurge proposal submitted USDA Agricultural research Service.

As it is proposed, this project will provide a badly needed example of a cooperative effort in tackling noxious weeds across political and jurisdictional boundaries. We have an opportunity here to pool our resources and expertise to develop practical management strategies for one of the most troublesome weeds we've ever encountered.

The focus on practical, on-the-ground management, and the attention to rangeland ecology and long-term effects of management strategies are particularly attractive int his proposal. In addition, the supporting research ties in well with work being conducted at Montana State University.

I wholeheartedly support – and look forward to working with – TEAM Leafy Spurge.

Sincerely,

Roger L. Sheley

Extension Noxious Weed Specialist

NDSU

DEPARTMENT OF AGRICULTURAL ECONOMICS

North Dakota State University
P.O. Box 5636
Fargo, North Dakota
58105-5636

Tel. 701.231.7441
Fax 701.231.7400

March 10, 1997

USDA Agricultural Research Service
Beltsville, Maryland

To Whom It May Concern:

This letter is in support of the Team Leafy Spurge IPM Project, which will establish demonstration sites along the Little Missouri River Drainage. Our research team in the Department of Agricultural Economics at North Dakota State University has been engaged in assessing the economic effects of leafy spurge in the Northern Plains region since 1989. Our research has helped to document what many range managers and ranchers have known for some time – that leafy spurge is an extremely serious problem in this region. We have estimated the annual direct impacts of leafy spurge in the four-state region of Montana, North Dakota, South Dakota, and Wyoming to total $40 million. The secondary impacts could be as high as $89 million annually and represent the potential loss of almost 1,500 jobs to the regional economy.

The Team Leafy Spurge project will contribute to the solution of this serious problem by (1) developing sustainable leafy spurge management methods, (2) forming long-term partnerships among federal, state, and private land managers, and (3) transferring to land managers economically and ecologically proven technologies to manage leafy spurge. As partners in this effort our economic research team will (1) evaluate costs and benefits of alternative biocontrol and chemical control strategies and develop an economic decision model for selecting control strategies and combinations of strategies, (2) evaluate managerial, institutional, and social factors that may influence implementation of various control strategies and develop approaches that may make some control strategies more acceptable, and (3) assess the economic impact of leafy spurge reduction/range restoration. We are very committed to this project, which we see as having the potential to have a major regional impact.

Sincerely,

F. Larry Leistritz

NDSU Distinguished Professor

United States Department of the Interior

NATIONAL PARK SERVICE
Theodore Roosevelt National Park
P.O. Box 7
Medora, North Dakota 58645

IN REPLY REFER TO:

N50

March 11, 1997

Mr. Raymond I. Carruthers
Mr. Robert M. Faust
National Program Leaders Biological Control
U.S. Department of Agriculture
Agricultural Research Service
Bldg. 005, Rm. 220
BARC-W
Beltsville, MD 20705

Dear Mr. Carruthers and Mr. Faust:

There is need for a feasible, long-term solution to the management and control of leafy spurge in the Little Missouri River drainage. The National Park Service is responsible for the preservation, protection, and management of resources on lands under its jurisdiction. Theodore Roosevelt National Park has been a partner and collaborator in the management of leafy spurge in the Little Missouri River drainage for over six years. The park now wishes to lend its support and assistance to The Ecological Areawide Management (TEAM) leafy spurge demonstration project. This three-year project will include an inventory of the infestation, economic analyses, and significant technology transfer activities.

Objectives of the TEAM leafy spurge project are: 1) to develop sustainable leafy spurge management methods; 2) to form long-term partnerships among federal, state and private land managers; and 3) to transfer to land managers economically and ecologically proven technologies to manage leafy spurge. Biological control agents may offer an environmentally acceptable management option as one component of an integrated weed management program for controlling noxious weeds and other non-native plants on NPS lands

Under separate cover we have provided Geographic Information System (GIS) maps of leafy spurge management actions in the park. Enclosed are some publications and reprints on Theodore Roosevelt National Park's specific situation involving exotic or non-

native invasive plants such as leafy spurge. Leafy spurge (*Euphorbia esula* L.) is a troublesome plant on the Northern Great Plains. Current research shows that this species is a serious invader into the park's South Unit. This aggressive invasion has displaced many native plant species. In addition to destroying the rich species diversity unique to the badlands, significant ecological impacts are resulting.

Leafy spurge was first reported in the park in 1968. In 1970, an estimated 13 ha. of the park's South Unit were infested. The infestation increased to 162 ha. between 1975 and 1983, and was conservatively estimated at 283 ha. in 1986. Infestations are currently estimated at 702 to 1,690 ha. Intensive management is required to reduce and contain these infestations while comprehensive and integrated approaches are needed to restore the habitat. GIS technology has been utilized to map and develop various types of Integrated Pest Management (IPM) control techniques for the park. Leafy spurge is managed on a watershed sub-basin level.

Park managers see the advantage of IPM programs that utilize a variety of techniques to manage exotic plant problems such as biological control, herbicides, and use of prescribed fire. This ARS project will helped foster interagency/private cooperation in the management of leafy spurge locally. It will also provide national and regional benefits as a demonstration project for the much large problem of leafy spurge in the Northern Great Plains. Through joint cooperative efforts a strategy can be developed for managing different levels of infestation within identified watershed basins. Implementation will require a serious commitment of financial resources over an extended period of time.

Our partners in this battle are our neighbors. With their assistance we might stand a chance of slowing down the spread of leafy spurge. This noxious weed knows no jurisdictional boundaries. The park hopes that with the united efforts of its partners inside and outside the park there is a chance that leafy spurge's free rein over the prairie will come to an end. It will be many years before the plant is controlled and it is possible that it will never be totally eradicated. Nevertheless, no action today will only led to a larger problem for tomorrow.

If you have any questions, please contact Roger Andrascik, Resource Management Specialist at (701) 623-4466.

Noel R. Poe

Superintendent

Enclosures

UNIVERSITY OF WYOMING

Department of Plant, Soil, and Insect Sciences
College of Agriculture

P.O.Box 3354
Laramie, WY 82071-3354
Phone: (307) 766-3103
Fax: (307) 766-5549

March 11, 1997

TO: To Whom It May Concern,
USDA Agricultural Research Service,
Beltsville, Maryland.

FROM: David J. Kazmer
Asst. Professor, Dept of Plant, Soil and Insect Sciences
Wyoming Weed and Pest Council, *ex-officio* member

RE: Support for the TEAM Leafy Spurge Proposal

Leafy spurge is the most damaging of the 18 weed pests listed on the State of Wyoming's Noxious Weed List. It currently infests over 100,000 acres of Wyoming rangeland and has an estimated direct impact within the State of over 1 million dollars per year.

Since 1994, over 6.7 million *Aphthona* flea beetles have been released or redistributed within the State. The impact *Aphthona* is starting to have on substantive leafy spurge infestations has served as motivation for this effort, with the hope that biological control will prove to be the cornerstone technology for integrated control of leafy spurge. Consequently, strong support is present for components of this proposal that: a) identify the limitations of the current biological control technology, b) study how other control measures can augment or cover the deficiencies of the biological control component, and c) remove the limitations of the current biological control technology by studying and introducing new biological control agents.

Participants in the Wyoming *Aphthona* redistribution effort include private land owners and managers, Weed and Pest Districts, Conservation Districts, the state and national forest services, the National Park Service, the Bureaus of Land Management and Indian Affairs, USDA/APHIS/PPQ, University research and extension staff, and local resource councils and environmental groups. These same individuals would be eager participants in a promising area wide implementation program and could likely provide resources comparable to what they already have for the *Aphthona* program. Biological control activities are coordinated on a state-wide basis through the Wyoming Biological Control Steering Committee.

Ongoing, instate leafy spurge research programs that parallel research foci of the proposal include herbicide and competitive planting studies (Drs. Tom Whitson and Mark Ferrell, Univ. of Wyoming) and sheep/goat grazing studies (Dr. Mike Smith, Univ. of Wyoming). County extension agents actively participate in these research programs.

Significant concern has been expressed over the demonstration component of the TEAM Leafy Spurge proposal. One concern is that the Little Missouri River drainage extends only about 15 miles into one Wyoming County and much of this terrain is difficult to access. Establishment of demonstration plots strictly within this drainage could not and would not be well-supported. Moreover, such plots would not be representative of the major habitats infested by leafy spurge in Wyoming. Secondly, establishing new demonstration plots including new biocontrol release sites is not well-supported. It is clear that if the *Aphthona* releases are going to result in significant, large-scale suppression of leafy spurge, the time required for this suppression will certainly exceed 5 yr. Consequently, data collected from newly-established demonstration plots in the first 5 yr would be biased towards showing negative results for current biological control technologies relative to other control technologies. Without a long-term commitment (> 5 yr) to the demonstration component, the value of undertaking this work is highly questionable.

Simple alternatives for the demonstration component include the use of demonstration sites that represent the full range of habitats infested by leafy spurge and where possible the use of previous biocontrol release sites to minimize the time-scale of the study.

USDA Agricultural
Research Service
Beltsville, Maryland

To Whom It May Concern:

I am a rancher in Western North Dakota and have been fighting a leafy spurge problem for many years. Having a main drainage run through my land and into the Little Missouri River has been difficult to try to control this noxious weed. With the large acreage of infestation and the value of land so low, I can no longer afford to use chemical as a major tool to control leafy spurge.

Five years ago a program called the Badlands Leafy Spurge Program was started and its focus was using an IPM Philosophy. This included bio-control, grazing, mowing, and chemicals. Bio-control has taken the lead for me along with the grazing of the sheep. Chemicals are used in certain areas, especially outside areas to keep leafy spurge from spreading.

Any program that could enhance what we in Western North Dakota have started, I would very much support. The people involved in the Badlands Leafy Spurge Program have for the first time seen progress with the help of the IPM Philosophy we have adopted. Other entities have taken this same approach in addressing the leafy spurge problem they have. These include the Forest Service and the Theodore Roosevelt National Park in our area.

USDA-ARS in Sidney, Montana has been an active and supportive entity in our program and this has been a positive effect for us to have an ARS scientist work by our side to help us in controlling leafy spurge.

Your support in the Little Missouri Watershed Project would be appreciated.

Sincerely,

Dennis Dietz
Box 247
Sentinel Butte, ND 58654

USDA Agricultural
Research Service
Beltsville, Maryland

To Whom It May Concern:

Leafy Spurge is a major concern of mine, as I'm a rancher in Western North Dakota, who has been fighting this noxious weed for several years. Located in the badlands and having rough terrain and a major drainage way run through my land and into the Little Missouri River has caused some problems for me. Due to this criteria and cost of chemical this is a prohibitive tool for me to use on a large area of infestation.

The Badlands Leafy Spurge Program, which was started five years ago looked at an IPM approach of which bio-control, chemicals, grazing, and mowing are a part of their focus. The bio-control approach had developed faster with chemical used in smaller areas. Many have gone to perimeter spraying due to factors mentioned above. The grazing of the sheep has also shown progress used along with the bio-control.

A program that could help in what we have established in the Badlands Leafy Spurge Program using the IPM approach, I would highly support. For the first time, those of us in this program can finally feel like we are making headway toward controlling this noxious weed. Others involved such as the Theodore Roosevelt National Park and the Forest Service have taken this IPM approach in addressing their problem with leafy spurge.

USDA-ARS out of Sidney, Montana was an active member in our program and it has been a positive impact for us to have a scientist out in Western North Dakota.

I hope you will consider fully supporting the Little Missouri Watershed Project so all of us along this watershed can get rid of the leafy spurge problem.

Sincerely,

Roger Meyer
P.O. Box 126
Medora, ND 58645

USDA Agricultural
Research Service
Beltsville, Maryland

To Whom It May Concern:

Leafy Spurge has become a major concern of mine for the past few years. I ranch in the Western edge of North Dakota and have been fighting this noxious weed for several years. My land is located in not far from the Little Missouri River and leafy spurge is found near the creeks and some of the major drainage areas that drain into the river. This has caused a problem for me as it is not only hard for me to spray because of the rough terrain, but also because of the drainage areas. I am spraying what I can, but the cost of chemical has made it harder to keep up with this. The land value is low and to spray large areas is impossible at this point. The perimeter is the best I can do to try to keep this under control.

A project called the Badlands Leafy Spurge Program was put into effect five years ago. Its major focus was an IPM Philosophy of which included chemicals, grazing, mowing and bio-control. The bio-control has been the most popular with the chemicals used in some selected areas.

A program that could help us with what I have mentioned above, I would be very supportive of. I and several others who are a part of the Badlands Leafy Spurge Program feel like we are making advancement in controlling this noxious weed. Along with us the Forest Service and Theodore Roosevelt National Park have become active in fighting leafy spurge.

Having an ARS scientist out of the USDA-ARS center in Sidney, Montana had given us a very positive attitude. This center has given us support and has been very active in this part of the country.

The Little Missouri River Watershed Project would be very helpful and I hope we can have your support as well.

Sincerely,

Cliff Obrigewitch
HC1 Box 16
Sentinel Butte, ND 58654

USDA Agricultural
Research Service
Beltsville, Maryland

To Whom It May Concern:

Living and ranching in Western North Dakota has made me look at my land in a new way. Leafy spurge is a major problem in this area and it has taken over many of the draws and drainage areas. There is a major drainage that runs through my land and into the Little Missouri River. This has caused big problems for me as it is impossible for me to spray these areas. The outside areas are all I can take care of. The larger areas can no longer be sprayed because of the cost of chemical makes this impossible for me. To buy my land over and over is just not feasible for me or anyone else.

Thanks to the Badlands Leafy Spurge Program that was started five years ago, ranchers in this area have had a positive effect on us. This program focused on an IPM approach in which chemicals, grazing, mowing, and bio-control are the major factors and bio-control has been the best motivator for us with chemicals being used in areas where is can be feasible.

To be able to support a program like the Little Missouri River Watershed project in which contributing to what we have started would be of great interest to me. Seeing more people and entities like the Forest Service and the Theodore Roosevelt National Park Service become active in addressing this problem has been a major step forward for us in the area. The progress we have made with the help of the Badlands Leafy Spurge Program has given us a better feeling for a brighter outcome.

The USDA-ARS office in Sidney, Montana has been helpful and active in this part of the United States and to have an ARS scientist out in the area has had a positive impact.

I hope you will support a project to help control leafy spurge along the Little Missouri Watershed.

Sincerely,

Brian Durham
HC1 Box 8
Sentinel Butte, ND 58654

USDA Agricultural
Research Service
Beltsville, Maryland

To Whom It May Concern:

I am a rancher in Western North Dakota and leafy spurge is a big problem for me. Located on the edge of the badlands and having one of the main drainage ways run through my land and into the Little Missouri River, I have major concerns. Due to this drainage it is difficult for me to spray leafy spurge. Perimeter spraying is all I can do due to the cost of chemical and the value of land being so low. Chemical prohibits me to spray the large acres of infestation, which I have.

A program in our area called the Badlands Leafy Spurge went into effect and focused on an IPM Philosophy. The IPM approach consisted of grazing, bio-control, mowing, and chemicals. Chemicals are being used in selected areas and the bio-control has been the fastest growing and most effective for us. Grazing of sheep, which my neighbors and myself use, along with the biocontrol has also had a positive outcome in controlling leafy spurge.

A program that could enhance the adaption of what I have mentioned would be highly supported by me. The producers who are in our program feel we are making progress toward controlling leafy spurge for the first time ever. The Forest Service and the Theodore Roosevelt National Park Service have also become very active in addressing the fight against leafy spurge.

An ARS scientist, who is out of the USDA-ARS office in Sidney, Montana has had a positive impact on us out in Western North Dakota. This office has been very active and supportive in the Badlands Leafy Spurge Program.

I hope we can count on your support for the Little Missouri Watershed Project.

Sincerely yours,

Dale Maus
HC1 Box 19
Sentinel Butte, ND 58654