TechLine

Information About Invasive/Noxious Plant Management

July, 1997

"It takes two to speak the truth — one to speak and another to listen."

Thoreau, 1849

Welcome to the New TechLine

This newsletter supplies technical information to public land managers, fish and wildlife specialists, ecologists, botanists, rare plant specialists, range and resource specialists, weed supervisors, cooperative extension, and others who are charged with managing noxious or invasive plants.

The goal of TechLine is to make it easier for you to obtain the necessary information for you to manage noxious weeds or invasive vegetation. In each issue, *TechLine* will publish summaries of innovative research studies and integrated weed management projects.

Through the *Weed Management Resource Library,* you may obtain complete copies or additional information on every subject that appears in *TechLine*. All aspects of noxious weed and invasive plant management are presented. We know that rarely is any one method of management successful. Success is nearly always the result of integrated management programs.

Each issue will also profile a public land noxious weed or invasive plant management program. Many of you are already involved with or managing successful programs. The development of an integrated, comprehensive, and carefully planned management program has been a key ingredient in your success.

We want to answer your technical questions, so *TechLine* solicits your input and feedback. If you have a successful weed technique or program you would like to share with your colleagues—we welcome them. Please call us toll-free at the *Weed Management Resource Library* at 1-800-554-WEED (9333) with your suggestions, comments, and input. Welcome to *TechLine*.

Inside TechLine

Weed Management Resource Library 1-800-554-WEED (9333)

The *Weed Management Resource Library* (WMRL) contains a wide variety of information resources to improve your noxious and invasive plant management. The Library provides you with quick, convenient access to as many resources as possible in one location.

A Library catalog lists the resources, along with a brief description of each piece of information and how it fits into a complete weed management program.

In the near future, the *Weed Management Resource Library* will be on the Internet for those with computer access. Until then, noxious weed and invasive plant managers can call the Library toll-free at 1-800-554-WEED (9333).

There is no charge for using the Library. However, users may be asked to provide follow-up information explaining how they used Library materials and the effectiveness of the resource. The Library expands continuously. It is updated whenever new resources are developed and proven effective. The Library serves as a network to place you in touch with other managers and experts. For instance, if you are interested in talking with managers who have controlled noxious weeds in a waterfowl refuge area, you simply call the 800 number and we will provide you with the names and phone numbers of fish and wildlife people with this experience. In this way, the Library serves as a central clearinghouse of weed management knowledge and expertise. We may not have all the answers, but we can put you in contact with someone who has experience in your area of interest.

Of course, we encourage library users and other vegetation management professionals to share their knowledge when they discover a technique or a useful tool that might help others. In this respect, the Library is really YOUR Library and will be as useful as you make it.

Sample of Items in the Weed Management Resouce Library include:

- Research studies on the impacts of noxious and invasive weeds
- Study on biological invasions as global environments change
- Successional weed management strategies for rangeland study
- Research studies to help you complete EISs and EAs
- Weed awareness videos
- Weed ID and educational slide sets
- Weed ID postcards
- A list of weed management experts from across the region
- An awareness and education "how-to" booklet
- A mapping guidelines booklet
- A prevention program "how-to" booklet
- A monitoring and evaluation "how-to" booklet
- A "how-to" weed awareness weed ID kit including news releases and weed line drawings that are camera-ready for newsletters, brochures, and other awareness-raising uses
- University economic studies detailing the impacts of weeds
- Copies of state weed laws
- Herbicide guides, research, and product comparison studies
- Calibration and training aids
- Biological and non-chemical control options
- ... and many other resources

Squarrose knapweed

Cooperative Effort Gains Success Against Invasive Plant Infestation

In 1928, the first sighting of squarrose knapweed, *Centaurea virgata*, was documented in central Utah. In 1954, about 20 land management partners, including the BLM's Fillmore District, discussed what to do with approximately 300 to 500 acres of squarrose then infesting the area. Quarantines and eradication were mentioned, but the conclusion reached was that they should not do anything drastic. They would study the plant and try to keep it from spreading further, but for the next 21 years, it was not a consistent or coordinated effort. By 1991, nearly the same coalition of land management partners at the county, state, and federal level ***(see box on page 4)*** began forming a partnership to support an action plan against 150,000 acres of squarrose knapweed infesting 8 million acres in central Utah.

"This history simply illustrates how invasive vegetation like noxious weeds will not go away without some type of consistent and coordinated management input," says Pat Fosse, BLM assistant area manager in Fillmore, UT. Fosse, with the assistance of Lori Armstrong, BLM botanist for the Richfield District, leads the partnership team that has inherited the squarrose problem. This project, the Squarrose Knapweed Demonstration Weed Management Area (DWMA), is one of four areas in the U.S. created last year..

The squarrose DWMA varies from Colorado Plateau terrain comprised of pinon juniper and sagebrush to Great Basin terrain comprised of Salt Desert shrub-type species. Elevations range from 4,000 to 7,500 ft. and annual precipitation varies from 7" to 14".

"Loss of diversity and the related degradation in wildlife habitat, soil erosion, and forage result from unmanaged infestations of squarrose knapweed," Fosse says. "Mule deer and livestock do not utilize squarrose unless there is no other green vegetation available. Squarrose becomes a monoculture that does not support a diverse mix of wildlife, including antelope, deer, birds, rabbits, coyotes, or rodents, etc. When the bottom of the food chain consists of a diverse plant community, it can support a diverse ecosystem. When it consists of a monoculture, it cannot."

Biologicals released on the Squarrose Knapweed DWMA

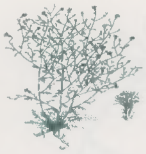
Root beetle —*B. fausti*
Moth — *Agapeta zoegana*
Seed-feeding weevil — *Larinum minutus*
Root boring beetle — *Sphenoptera jugoslavica*
Seedhead gall fly — *Urophora affinis quadrifiasciat*

Pat Fosse, BLM, Fillmore, UT, examines squarrose knapweed infestations that exploded from 200 acres to 150,000 acres in the past 40 years.

Soil erosion increases in infested areas because the squarrose is a taprooted plant without shallow or fibrous roots to hold soil. Resultant losses in forage have reduced some grazing allotments.

The Little Sahara Recreation Area is a popular off-road vehicle site within the DWMA. Users come from metropolitan areas mostly in Utah, but also from other western states. Most people who use the area for vehicle recreation do not perceive of squarrose deterring their enjoyment, Fosse explains. However, the public that uses the area for hiking, nature and wildlife viewing and understands eco-

See "BLM" on page 4



"BLM"
Continued from page 3

system diversity is alarmed about the changes caused by the knapweed.

Program goals and methods

Fosse says one DWMA goal, along with public education and infestation containment, is "through integrated weed management practices reduce the infestation, both population and acreage, to a level where biological control, along with proper management, will keep the weed in check within the ecosystem". Eradication is not attainable today. Their highest priorities for herbicide treatment are infestation source areas such as sheep trails, vehicle and railroad rights-of-way, camping areas (developed and undeveloped), and edge of infestation areas.

Integrated management includes insect releases, plus vehicle regulation, herbicides, and post-burn management. Releases of seedhead flies, seedhead weevils, gall flies, and root boring beetles have occurred for the past four years, according to Fosse ***(see box on page 3)***.

"In August of 1995, about 30,000 acres in the area burned in the Little Sahara complex fire," Fosse details. "We had a Type I interagency team here, which included people and resources from more than 10 states. To prevent them spreading the weed back to their home states, we washed all vehicles, including undercarriages, before they were demobilized from the fire. The Incident Commander (IC) was very cooperative in helping us achieve this objective."

During 1996, 12 of 15 identified high priority areas received herbicide treatments of Tordon* 22K herbicide and 2,4-D at various times. Approximately 13,284 acres have been treated with herbicides within the DWMA. Tordon 22K was applied at 1 pt./acre or 1.5 pt./acre with 2,4-D rates at 1 qt./acre in all treatments, except fall. Fosse says they are still experimenting with the best timing and Steve Dewey, Utah State University weed specialist, has numerous plots on the DWMA to help define treatment options. Larger treatments are initially made from the air, with follow-up spot treatment applied by ground rigs.

On June 12, 1996, 1,100 acres that burned the previous summer, called the "Death Creek fire", were treated with 1 pt./acre of Tordon 22K and 1 qt. of 2,4-D, according to Fosse. No rain fell on the area from June until September 16th. When the area was examined in the fall, the treatment looked unsuccessful. Partners and researchers speculated that UV sunlight broke down too much herbicide due to the lack of rainfall. But re-examination on May 1, 1997, showed that approximately 90% of the squarrose knapweed plants were controlled. All treatments last fall in burns (approx. 8,000 acres) achieved a 90% or better control rating this spring, Fosse explains.

Fosse says they could find no negative impacts on other vegetation due to the treatments. In test plots with Curtail* herbicide at 5 pt./acre, Tordon 22K at 1 pt./acre, 1.5 pt./acre, or 2.0 pt./acre, all treatments appeared to give equal control of squarrose. The Curtail treatments were more selective on forbs than the Tordon 22K. The highest rate of Tordon 22K (2 pt./acre) produced some yellowing of other vegetation and slowed grass growth slightly, but these were short-term effects and did not negatively affect this vegetation long-term. Of the treatments evaluated, Tordon 22K at 1.5 pt./acre provided the most consistent control.

Fosse concludes there are advantages to removing canopy (dead previous year's growth) to increase the amount of herbicide intercepted by green new growth under the canopy.

"We intend to demonstrate which methods and actions most effectively and efficiently helped us atttain our goals. We also intend to demonstrate how cooperation and partnerships benefit all partners and agencies involved. And to show how the synergy created through successful partnerships allows more innovation, creativity,

Partners in the Squarrose Knapweed Demonstration Weed Management Area

These partners contributed funds, manpower, or equipment to DWMA management activities. Each group contributes according to its own resources. Management objectives are prioritized and resources divided to most efficiently and effectively achieve objectives by a Planning Team comprised of coalition representatives.

Utah Weed Control Assn.	APHIS/ARS
DOD Dougway Proving Ground	Juab County
Farm Services Administration	Millard County
Private Landowners	Tintic School Dist.
U.S. Fish and Wildlife Service	Vernon City
Union Pacific Railroad	Eureka County
USDA Forest Service	Utah Farm Bureau
Bureau of Land Management	Utah County
Utah Department of Agriculture	State Lands Dept.
Cooperative Extension Service	Twooela County

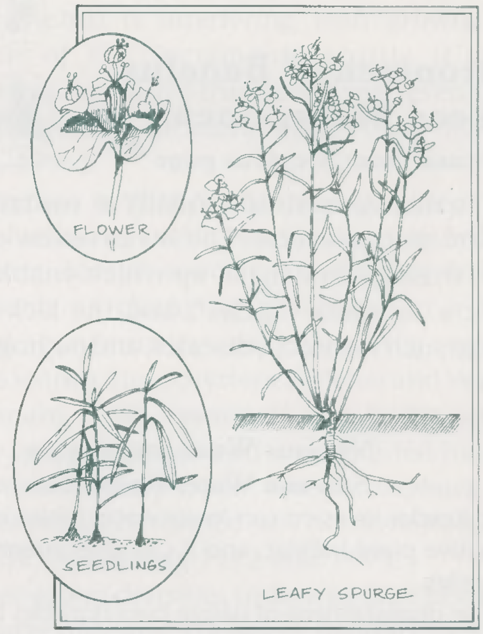
Utah Department of Transportation
Utah Division of Wildlife Resources
Natural Resources Conservation Service

*Trademark of DowElanco
Tordon 22K is a federally Restricted Use Pesticide.

Environmental Benefits of Weed Management

By Celestine Duncan
Weed Management Services
Helena, MT

Land managers involved with controlling weeds on public lands must be able to discuss weed management issues and concerns with the public. This includes information on the importance of managing non-native species, management techniques, and an assessment of health and environmental information associated with various methods. **This *TechLine* article is a summary of the complete paper. To obtain a complete copy, please call the Weed Management Resource Library at 1-800-554-WEED (9333).**



Exotic Plant Impacts on Species Diversity and Native Plant Habitat

- ❒ The introduction and spread of non-native plants threaten biological diversity of native plant communities and can alter ecosystem processes such as intensity and frequency of fire, hydrologic cycles, and soil erosion rates.
- ❒ Invasion of cheatgrass (downy brome) in the Intermountain West has increased the frequency of fires from once every 60 to 110 years to once every 3 to 5 years. This has changed plant diversity by reducing native shrub communities.
- ❒ Native species have been displaced by invasions of spotted knapweed and leafy spurge. As weed infestations increase, the abundance and diversity of native species decline.
- ❒ Native plant communities in Glacier National Park, Theodore Roosevelt National Park, the Bob Marshall Wilderness, and Rocky Mountain National Park are threatened by weed invasion.
- ❒ Altamont Prairie Preserve in South Dakota is no longer managed as native prairie by The Nature Conservancy because of invasion by leafy spurge. The site is now used to study the effectiveness of grazing animals (goats and sheep) for controlling leafy spurge and prairie restoration.
- ❒ Wetland vegetation is endangered by purple loosestrife invasion. The displacement of native vegetation by this weed has caused serious reductions in waterfowl and aquatic furbearer productivity as breeding habitats are degraded.
- ❒ The status of rare and threatened plants such as bulrush, dwarf spikerush, bog turtle, Sacramento thistle, sapphire rockcress, and Colorado butterfly plant are further imperiled by weed invasions.

This paper reviews current literature on:

1. Impacts of exotic plants on the ecosystem
2. Response of plant communities to weed invasion and herbicide treatments

Although invasions of exotic plant species occur worldwide, this review is limited primarily to problem species in the western United States. Invasions by non-native plants degrade biological communities and threaten survival of native species world wide. These plants, commonly known as "weeds" or "exotic species", use water, nutrients, and sunlight that would normally be utilized by native species, thus altering communities and ecosystems (Herbold and Moyle, 1986; Randall, 1995). Dewey and Torell (1991) defined a weed as any plant that interferes with the management objectives for a given area of land at a given point in time.

Once a plant has been classified as a weed, it attains a "noxious" status only by legislation. Noxious weeds, as defined by law, are plants of foreign origin that can directly or indirectly injure agriculture, navigation, fish or wildlife, or public health. More than 500 weeds are designated as noxious by either weed or seed laws in the United States and Canada (Lorenz and Dewey, 1988).

Most weeds are not native to the areas in which they are a problem. In a survey conducted on The Nature Conservancy managed lands, 237 plants were listed as problem species. Of these, 197 were not native to the area in which they were troublesome (Randall, 1995).

Most weeds were either introduced for their perceived

Continued on next page

Environmental Benefits of Weed Management

Continued from previous page

value to man, or unintentionally as contaminants in feed and seed products. The invasiveness of weeds is due to their genetic make-up which enables them to exploit a resource "niche", and the lack of natural enemies such as insects, diseases, and pathogens (Story, 1992).

Noxious Weed Impacts on Soil and Water Resources

- ❐ Saltcedar invasion can lower water tables influencing native plant habitat, and it can alter stream flow cycles.
- ❐ The displacement of native bunchgrasses by spotted knapweed substantially increases surface water run-off and sediment yield (soil loss). For example, an additional 18 tons of soil would be lost from a 500 acre spotted knapweed infested rangeland in western Montana during an average 30 minute rainfall event, compared to a similar site occupied by native bunchgrass.

The spread of noxious weeds has been considered analogous with a biological wildfire. As with wildfire management, a variety of treatments or techniques are available for management of weeds. These include prevention, early detection, timely control (biological, physical, chemical, or cultural), and site rehabilitation (Dewey et. al., 1995). The selection of respective control methods is influenced by land management objectives; effectiveness of the control technique on the target species; environmental factors; land use; economics; and the size of weed infestations (Lacey, C., 1991). An integrated weed management (IWM) approach that gives equal consideration of all management tools, including herbicides, is critical for managing extensive weed infestations.

A. Impact of Exotic Plant Species on the Ecosystem

Species Diversity and Native Plant Habitats

The introduction and spread of non-native plants threaten biological diversity of native plant communities and can alter ecosystem processes. For example, annual plants introduced into California grasslands have replaced native bunchgrasses, and downy brome (*Bromus tectorum L.*) has altered ecosystem processes and changed structure and function of plant communities in the Intermountain West (Mack, 1981; Randall, 1996).

Downy brome invasion has increased the frequency of fires from once every 60 to 110 years to once every 3 to 5 years on millions of acres of rangeland in the Great Basin (Whisenant, 1990). The high frequency of fire has eliminated native shrub communities (Randall, 1996).

Many weeds out-compete native species, change community structure, degrade or eliminate habitat for native animals, or provide food and cover for undesirable non-native animals (Kurz, 1995; Randall, 1996). Spotted knapweed (*Centaurea maculosa Lam.*) and diffuse knapweed (*Centaurea diffusa*) are recognized as serious invaders in the western U.S., infesting over 10 million acres in 9 western states and 2 Canadian provinces (Lacey, C. 1989). Invasion of spotted and diffuse knapweed into undisturbed native bunchgrass communities is well documented (Myers and Berube, 1983; Tyser and Key, 1988; Bedunah and Carpenter, 1989; Lacey, et.al., 1990). As spotted knapweed increases, cover of more desirable but less competitive grasses and forbs is significantly reduced, sometimes as much as 60 to 90 percent (Harris and Cranston, 1979; Bucher, 1984;).

In Glacier National Park, spotted knapweed reduced species richness and the frequency of six native species during a three year period. In addition, seven species classified as "rare" and "uncommon" at the beginning of the study were not present three years later. These results suggested that spotted knapweed was capable of spreading into natural fescue grasslands and altering plant community composition (Tyser and Key, 1988).

Cryptogamic ground crust may also be impacted by spotted knapweed. This crust, which is composed of small lichens and mosses and commonly covers undisturbed soil surfaces, is important for soil

Economic Impacts of Noxious Weeds

- ❐ Noxious weeds have a substantial economic impact on states' economies and may cause potential job losses. However, the economic impact of most noxious weeds is not well documented.
- ❐ Economic impacts of leafy spurge in Montana, North Dakota, South Dakota, and Wyoming total $129.5 million annually, and represent the potential loss of 1,433 jobs.
- ❐ Economic impacts of knapweed infestations on grazing land and wildland in Montana are about $42 million annually, which could support 518 full-time jobs.
- ❐ If knapweed infested all lands highly susceptible to invasion in Montana (34 million acres), the economic loss to the state would be $155 million.

stabilization, moisture retention, and nitrogen fixation (Rychert and Skujins, 1974, Anderson et. al., 1982). Tyser (1992) compared a native fescue grassland site to one invaded by spotted knapweed in Glacier National Park. Results of the study indicated that the cryptogam ground cover within the spotted knapweed infested site was only 96% less than the native fescue grassland site.

Other noxious weeds such as yellow starthistle (*Centaurea solstitalis*), sulfur cinquefoil (*Potentilla recta*), and Dyers woad (*Isatis tinctoria L.*) have been found to reduce establishment and growth of more desirable species (Evans and Chase, 1981; Rice et.al., 1994; Callihan et al, 1989). Yellow starthistle is especially trouble-some because it aggressively colonizes a variety of sites, and is responsible for a neurological disorder called "chewing disease" in horses (Kingsbury, J.M. 1964). In California, acreage infested by the weed increased from 1.2 million acres in 1958 to 7.9 million acres in 1985 (Maddox et. al. 1986). Yellow starthistle is also a serious problem in Oregon, Washington, and Idaho where 1.2 million acres were reported infested in 1988 (Lacey C., 1989).

Exotic weeds are recognized as serious problems on lands managed by federal, state, and private entities for wilderness or wildland values. When weeds invade and expand into a wilderness environment, the "naturalness" of the area is degraded and scientific values of once biologically diverse landscapes are impaired (Asher and Harmon, 1995). Examples of weed invasion in natural areas are found in most states. Leafy spurge has also successfully established and is increasing its range in rough fescue communities of Glacier National Park and has invaded the remote Danaher Creek area of the Bob Marshall Wilderness (Bedunah, 1992).

Wetland sites are also susceptible to invasion by exotic weeds. Purple loosestrife (*Lythrum salicaria*) was introduced in northeastern North America by the early 1800's. By 1940 it was established in the Pacific Northwest and had spread into the Great Plains (Thompson et. al, 1987), and now infests all states north of the 35th parallel, except Alaska. The weed forms dense infestations which displace native species including those that provide food and cover for many waterfowl and other wildlife (Thompson et. al., 1987).

Limited information is available on the impact of weeds on rare and threatened plants and animals. Dense infestations of purple loosestrife imperil endangered species, such as bulrush (*Scirpus longii*) in Massachusetts (Coddington and Field, 1978), dwarf spikerush (*Eleocharis parvula*) in New York (Rawinski, 1982), and the bog turtle *(Celmmys muhlenbergii)* in the northeastern U.S. (Thompson, 1987). Teazel (*Dipsacus sylvestris*) is interfering with growth and germination of the Sacramento thistle (*Cirsium vinaceum*), a federally-listed threatened species endemic to the Sacramento Mountains in New Mexico (Huenneke, 1996).

Impact on Wildlife Habitat Quality

The introduction of exotic plants influences wildlife by displacing forage species, modifying habitat structure such as changing grassland to a forb-dominated community or changing species interactions within the ecosystem (Belcher and Wilson, 1989; Bedunah, 1992; Trammell and Butler, 1996). Use of leafy spurge infested and non-infested habitats by deer (*Odocoileus spp.*), elk (*Cervus elaphus*), and bison (*Bos bison*) were studied in Theodore Roosevelt National Park, ND during 1992 and 1993.

Fecal pellet-group densities indicated that bison use of leafy spurge infested grassland habitats averaged 83% less than for non-infested sites. Deer pellet-group densities, normally highest within creeping juniper-

Continued on next page

Noxious Weed Impacts on Wildlife Habitat Quality

- ❒ The introduction of exotic plants impacts wildlife by reducing forage, modifying habitat (i.e. replacing a grass community with forbs), or changing how a species interacts within its environment.
- ❒ Bison and deer use of habitat infested with leafy spurge was 82% and 70% lower respectively than for non-infested habitat. This causes animals to use non-infested areas more heavily, intensifying stress on these sites and increasing their susceptibility to invasion by non-native species.
- ❒ The use of herbicides to remove spotted knapweed from an elk winter range in Montana changed elk distribution patterns resulting in a 266% increase in elk use. This change in elk distribution reduced grazing pressure on adjoining private lands.
- ❒ Spotted knapweed invasion of bunchgrass sites in western Montana reduces available winter forage for elk as much as 50% to 90%. Since a highly productive foothills site in western Montana can produce an average of 1,800 lbs per acre, forage (grass) loss from spotted knapweed can be as high as 1620 lbs. per acre.
- ❒ Purple loosestrife invasion of wetland sites degrades habitat for aquatic furbearing animals and waterfowl species. Degradation to these habitats from exotic species is a special concern because of the additional loss of wetland from urban, agricultural, and industrial uses.
- ❒ Displacement of native vegetation by exotic species significantly changes bird species composition and small mammal populations.

Environmental Benefits of Weed Management

Continued from previous page

little bluestem habitat, were reduced 70% by infestations of leafy spurge. Use of browse in green ash and chokecherry habitat during summer and winter was reduced an average of 32% by infestations of leafy spurge. Trammell and Butler (1996) conclud-ed that the reduction in native ungulate use of leafy spurge-infested sites may be attributed to lower forage production in infested sites as well as simple avoidance.

Spotted knapweed also influences elk and deer foraging behavior and population distribution (Hakim, 1979). In western Montana, herbicides were used to remove spotted knapweed from a 272 acre winter range site on Three Mile Game Range. Subsequent elk foraging behavior (trend counts and feeding craters) on spotted knapweed-infested and non-infested winter range was compared for 4 years (Thompson, 1996). Elk walked indiscriminately within knapweed-infested and non-infested sites, but foraged almost exclusively in the grass stand where knapweed was removed.

In addition, elk use increased an average of 266% after knapweed was removed from the site. Redistribution of a portion of the area elk population to the treated site may have benefited the entire herd by reducing competition for limited resources in other areas (Thompson, 1996). Spotted knapweed invasion of bunchgrass sites in western Montana reduces elk winter forage 50 to 90% (Bedunah and Carpenter, 1989). Guenther (1989) found that although knapweed was common on a mule deer (*Odocoileus hemionus*) winter range in Montana, the plant was not detected in the deer's diet.

Soil and Water Resources

Exotic plant species that alter hydrologic cycles, sediment deposition, erosion, and other ecosystem processes can cause serious ecological damage (Vitousek, 1986). Salt cedar (*Tamarix chinensis L.*) which invade wetland and riparian areas in the Southwest U.S. are responsible for lowering water tables at some sites (Horton, 1977). This reduces or eliminates surface water habitats required by native plants. Salt cedar infestations also trap more sediments than stands of native vegetation, thus altering the shape, carrying capacity and flooding cycle of water courses (Blackburn, 1982).

Tap-rooted weed species can also increase erosion rates as they invade grasslands. The influence of spotted knapweed on surface runoff and sediment yield was

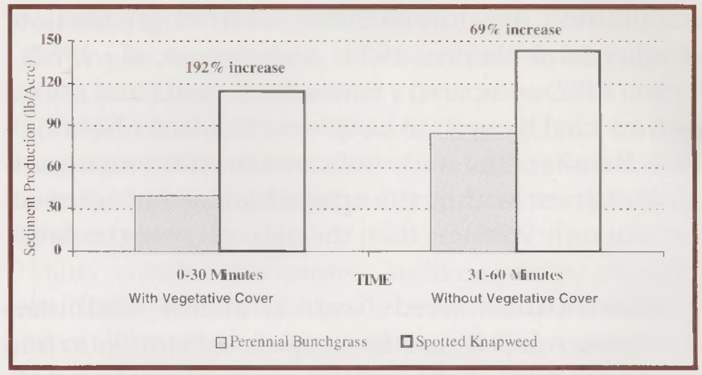


Figure 2: Sediment yield on grass-dominated and spotted knapweed dominated plots subjected to two consecutive simulated rainfall periods. The initial 30-min period was on the unaltered site to measure the effect of vegetative cover plus soil surface characteristics. Vegetative cover was removed before the second 30-min period to measure the effects of surface characteristics alone (Lacey et. al. 1989).

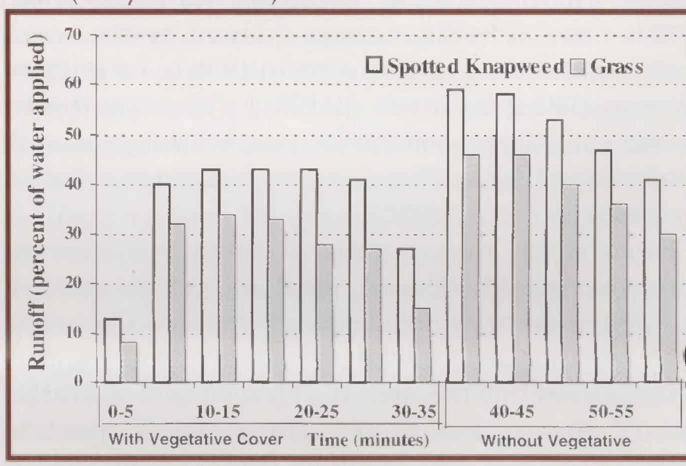


Figure 3: Surface runoff from 12 grass-dominated and 12 spotted knapweed-dominated plots at various time intervals during 2 consecutive 30-min simulated rainfall periods. Vegetation was clipped and removed from the plot after the first 30 min rainfall period.

determined under simulated rainfall conditions near Garrison, MT (Lacey et al, 1989). Surface water runoff and sediment yield (soil erosion) were measured during a 30 min. simulated rainfall event on 12 paired plots.

One plot of each pair was in a bunchgrass community whereas the other was dominated by spotted knapweed. Runoff was 56% higher and sediment yield was 192% higher on spotted knapweed plots compared to bunchgrass plots during the initial 30 minute simulated rainfall period ***(Figures 2 and 3 on page 8)***. The study concluded that spotted knapweed invasion onto bunchgrass rangelands of western Montana was detrimental to the protection of soil and water resources (Lacey et. al., 1989)

Economic Impacts of Noxious Weeds

There is limited information on economic impacts of noxious weeds on range, pasture, and wildland sites. The most thorough study was conducted by economists at North Dakota State University (Leitch et. al., 1994). They reviewed economic losses caused by leafy spurge in the upper Great Plains including states of Montana, North and South Dakota, and Wyoming. Economic impacts caused by leafy spurge to ranchers and landowners include reduced income from lower grazing capacity, lost livestock sales, and reduced grazing land values as a result of infestations. In 1993, grazing capacity lost to leafy spurge infestations in the four state area would have supported a herd of about 90,000 cows, which could generate about $37.1 million in annual livestock sales.

The direct loss of $37.1 million generated about $82.6 million in secondary impacts to the region's economy. Total direct and secondary impacts were $119.7 million or about $163/lost animal unit month (AUM).

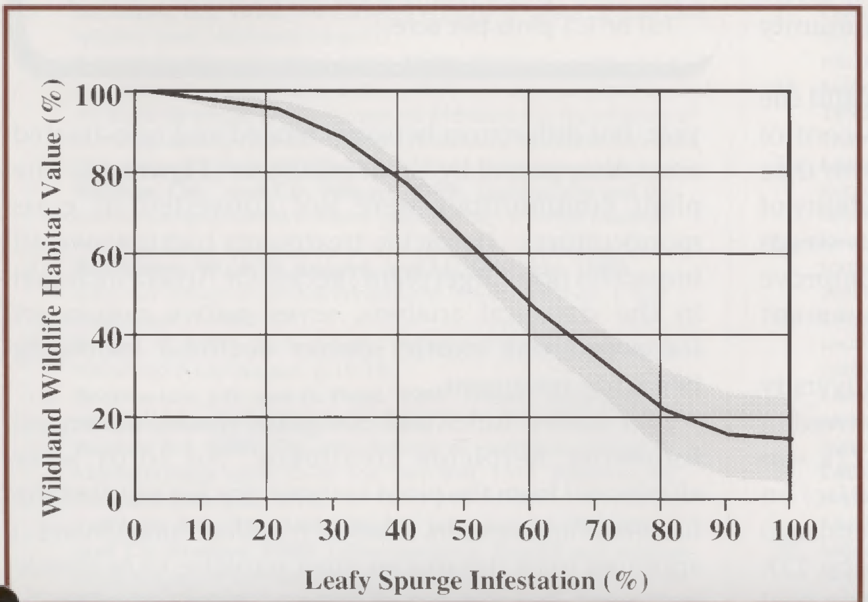


Figure 4: Estimates of reduced wildland wildlife habitat value caused by various leafy spurge infestation rates (Leitch et.al., 1994) *Shading along the function indicates uncertainty associated with the relationship.

Economic Impact on Wildlands

In addition to impacts to grazing lands, the study also estimated impacts of leafy spurge on wildlands from changes in wildlife habitat and soil and water conservation benefits. Degradation of habitat was assumed to reduce wildlife related expenditures in each state ***(Figures 4 at left)***. Nearly $3.4 million in direct economic impacts result from slightly less than 1% infestation level of leafy spurge.

Eliminating leafy spurge on wildlands could add 174 jobs and $9.8 million in business activity in the four-state area. The study concluded that direct and secondary economic impacts of leafy spurge infestations on grazing land and wildland in the four-state area are about $129.5 million and represent the potential loss of 1,433 jobs.

A similar economic study also estimated impacts of knapweed on wildlands based on changes in wildlife habitat which would affect wildlife-associated recreation expenditures and soil and water conservation benefits ***(Figure 5 on page 9)***. Total direct impacts on Montana's economy from infested wildland are about $3.093 million annually or $3.95 per infested acre. The study concluded that direct and secondary economic impacts of knapweed infestations on grazing land and wildland in Montana are about $42 million which could support 518 full time jobs in the state's economy.

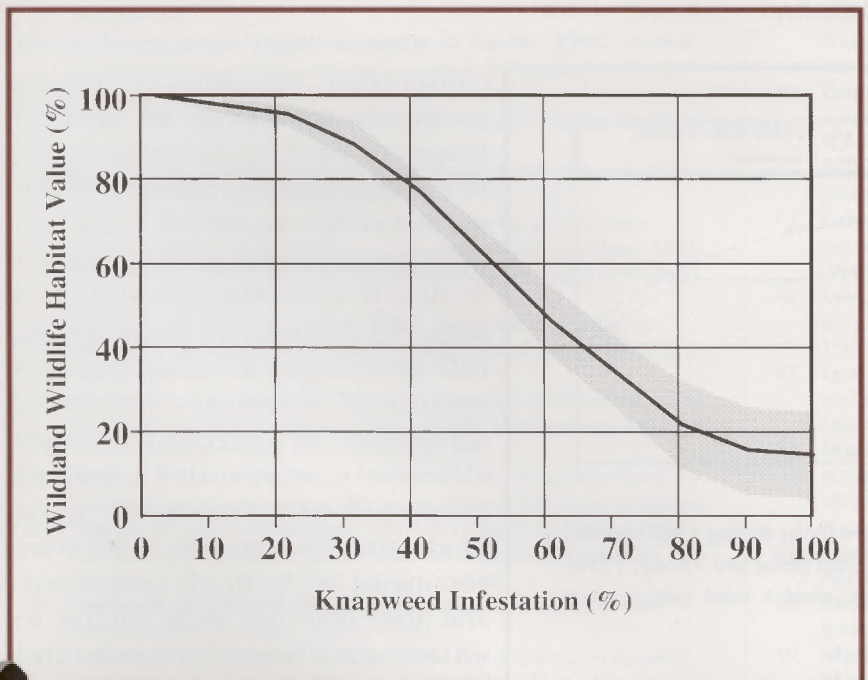


Figure 5: Estimates of reduced wildland wildlife habitat value caused by various knapweed infestation rates* (Hirsch and Leitch, 1996) *Shading along the function indicates uncertainty with the assumed relationship.

B. Response of Plant Communities to Picloram Treatments

Picloram (Tordon* 22K herbicide) is an important tool for managing noxious and exotic weeds on range and pasture sites. It is the most effective herbicide for controlling leafy spurge, the knapweed complex, sulfur cinquefoil, and other deep-rooted perennial

Continued on next page

*Trademark of DowElanco
Tordon 22K is a federally Restricted Use Pesticide.

Environmental Benefits of Weed Management

Continued from previous page

noxious or exotic weeds (Lym and Messersmith, 1985, Rice et.al., 1994, Lacey et.al., 1995, and Asher and Harmon, 1995). The herbicide is selective for broadleaf weeds, removing them from the plant community while allowing grasses to remain.

There is concern from some land managers and the general public that the use of herbicides to control noxious weeds may adversely effect native forbs thus creating grass "monocultures". However, the ability of land managers to selectively remove noxious weeds from plant communities and maintain or improve community diversity is a critical management consideration.

A recent study monitored plant community diversity following herbicide treatment of spotted knapweed in western Montana (Rice et.al., 1992). Tordon 22K was applied at the rate of 1 pint per acre (0.25 lb ai/ac) on four sites, two were grassland habitat types and two were forest habitat types. Applications of Tordon 22K were made in the spring to measure the effect on cool season plant species and again on separate plots in mid-summer to measure the effect on warm plant species.

Plant community diversity declined slightly the first year, but differences between treated and non-treated areas disappeared by the second year (***Figure 6***). The plant communities were not converted to grass monocultures. Herbicide treatments had low overall impact on non-target plant species. Of 70 taxa included in the statistical analysis, seven native non-target forbs and one exotic species declined following herbicide treatment.

Two native forbs and six grass species increased following herbicide treatment. No forbs were eliminated from the plant community as a result of the herbicide application. Yarrow (*Achillea millefolium L.*) appeared to be the species most sensitive to herbicide treatment, but was not eliminated from any of study sites. Researchers concluded that herbicide application is a useful management technique on sites where the conservation of native communities is a goal (Rice and Toney, 1996).

Response of Plant Communities to Tordon* 22K (picloram) Treatments

- ❒ Herbicide applications are a useful management technique on sites where conservation of native plant communities is a goal.
- ❒ Application of Tordon 22K at 0.5, 1.0 or 1.5 pints per acre did not convert native plant communities to grass monocultures.
- ❒ No forbs were completely removed from the plant community after treatment with Tordon 22K at 0.5, 1.0 or 1.5 pints per acre.

A second study measured plant community response following herbicide treatment of spotted knapweed on three elk winter ranges in western Montana. Tordon 22K was applied at the rate of 0.5, 1, and 1.5 pints per acre (0.125, 0.25, and 0.375 lb. ai/ac) to spotted knapweed infested sites. The influence of herbicides on native perennial forbs and grasses was measured two years following application. All herbicide treatments effectively controlled spotted knapweed and increased grass production. No native forbs were eliminated by herbicide treatments, and forb densities were similar to untreated plots (Bedunah and Carpenter, 1989).

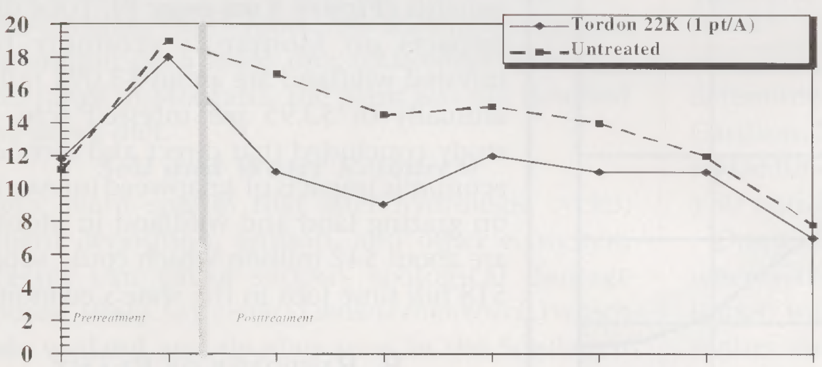


Figure 6: Total canopy cover of cool and warm native forbs during 1988 to 1992 in untreated and herbicide-treated plots across four sites (Rice and Toney, 1996). [Warm = warm season plant canopy measurements; cool = cool season plant canopy measurements.]

Year and Season

1988	1989	1990	1990	1991	1991	1992	1992
warm	cool	cool	warm	cool	warm	cool	warm

Literature Cited

1. **Achuff, P. L. and L. Schassberger. 1991**. Weeds and rare native plants in Montana. Montana Academy of Sci., Eastern Montana College, Billings, Montana.
2. **Anderson, D.C., K.T. Harper, and R.C. Holmgren**. 1982. Factors influencing development of cryptogamic soil crusts in Utah deserts. J. Range Management 35: 180-185.
3. **Andrascik, R.J. 1994**. Process for developing a leafy spurge strategic management plan within Theodore Roosevelt National Park. Leafy Spurge News 16 (3):5.
4. **Asher, J. E. and D. W. Harmon. 1995**. Invasive exotic plants are destroying the naturalness of U.S. wilderness areas. International Journal of Wilderness 1(2):35-37.
5. **Bedunah, D.J. 1992**. The complex ecology of weeds, grazing and wildlife. West. Wildlands 18:6-11.
6. **Bedunah, D. and J. Carpenter. 1989**. Plant community response following spotted knapweed (*Centaurea maculosa*) control on three elk winter ranges in western Montana. In: Proceedings of the knapweed symposium; Ap. 4-5; Bozeman, Montana. Montana State Univ. Ext. Bull. 45.205-212.
7. **Belcher, J.W. and S.D. Wilson. 1989**. Leafy spurge and the species composition of a mixed grass prairie. J. Range Manage. 42:172-175
8. **Blackburn, W., R.W. Knight, and J.L. Schuster. 1982**. Saltcedar influence on sedimentation in the Brazos River. J. Soil Water cons. 37:298-301.
9. **Bright, C. 1995**. Bio-invasions: the spread of exotic species. Worldwatch July/August. p.10-19.
10. **Brotherson, J.D. and D. Field. 1987**. Tamarix: impacts of a successful weed. Rangelands 9:110-112.
11. **Bucher, R.F. 1984**. The potential cost of spotted knapweed to Montana range users. Coop. Ext. Serv. Bull. 1316. Bozeman, MT: Montana State Univ. P.18.
12. **Callihan, R.H., F.E. Northam, J.B. Johnson, E.L. Michalson, and T.S. Prather. 1989**. Yellow starthistle. Biology and management in pasture and rangeland. U. of Idaho Publ. Ser. 634. p. 4.
13. **Cheater, M. 1992**. Alien Invasion. Nature Cons. Sept./Oct. 25-29.
14. **Chicoine, T.K., P.K. Fay, and G.A. Nielsen. 1988**. Weed Science 34:57-61.
15. **Coddington, J. and K.G. Field. 1978**. Rare and endangered vascular plant species in Massachusetts. Committee for Rare and endangered Species of the New England Botanical Club, Cambridge, MA.
16. **Dewey, S. A., M. J. Jenkins, and R. C. Tonioli. 1995**. Wildfire Suppression-A paradigm for noxious weed management. Weed Technology 9:621-627.
17. **Duffey, E., ed. 1988**. Special issue: Biological invasions of nature reserves. Biol. Cons. 44(1&2): 1-135.
18. **Evans, J.O., and R.L. Chase, 1981**. Dyers woad control EL-199. Utah State Ext. Serv., Logan, Utah.
19. **Fertig, W. 1996**. Census of Colorado butterfly plant (*Gaura neomexicana ssp. Coloradensis*) on F.E. Warren Air Force Base, 1995. Prepared for the US Air Force by Nature Conservancy, 1604 Grand Ave. Laramie, WY. p 23.
20. **Griffith, D. and J. R. Lacey. 1991**. Economic evaluation of spotted knapweed (*Centaurea maculosa*) control using picloram. J. Range Manage. 44:43-47.
21. **Guenther, C.E. 1989**. Ecological relationships of bitterbrush communities on the Mount Haggin Wildlife Management Area. MS Thesis, Montana State Univ., Bozeman, MT.
22. **Hakim, S.E.A. 1975**. Range condition of the Threemile Game Range in western Montana. MS thesis. Univ. of Montana, Missoula.
23. **Harris, P. and R. Cranston. 1979**. An economic evaluation of control methods for diffuse and spotted knapweed in western Canada. Canadian J. of Plant Sci. 59:375-382.
24. **Herbold, B. and P.B. Moyle. 1986**. Introduced species and vacant niches. Am. Nat. 128:751-760.
25. **Hirsch, S. A. and J. A. Leitch. 1996**. The impact of knapweed on Montana's economy. Ag. Econ. Report No. 355. p. 23.
26. **Horton, J.S. 1977**. The development and perpetuation of the permanent tamarisk type in the phreatophyte zone of the Southwest. p. 124-127 in R. R. Johnson and D.A. Jones, eds. Importance, preservation and management of riparian habitat: a symposium. Techn. Rep. RM-43 U.S. For. Serv., Fort Collins, CO.
27. **Huenneke, L. F. 1996**. Ecological impact of invasive plants in natural resource areas. In Proceedings, Western Society of Weed Sci. 49: 119-121.
28. **Kingsbury, J.M. 1964**. Poisonous Plants of the United States and Canada. Prentice-Hall Inc., Englewood Cliffs, NJ.
29. **Kurz, G. L. 1995**. Ecological implications of Russian knapweed (*Centaurea repens L.*) infestation: Small mammal and habitat associations. M.S. thesis. Dept of Rangeland Ecology, Univ. of Wyoming. p.63.
30. **Lacey, C. 1989.** Knapweed management: a decade of change. In: Proceedings of the knapweed symposium; p. 4-5; Bozeman, Montana. Montana State Univ. Ext. Bull. 45.1-6.
31. **Lacey, C. 1991**. Noxious weed management strategies. p. 75-84. In Lynn F James, John O. Evans, Michael H. Ralphs, R. Dennis Child, eds. Noxious Range Weeds. Westview Press.
32. **Lacey, C., J.R. Lacey, P.K. Fay, J.M. Story, and D.L. Zamora. 1995**. Controlling knapweed on Montana rangeland. Montana State Univ. Coop. Ext. Circ. 311. p.17.
33. **Lacey, J. R. and B. E. Olson. 1991**. Environmental and economic impacts of noxious range weeds. p. 5-16. In L. F James, J. O. Evans, M. H. Ralphs, R. D. Child, eds. Noxious Range Weeds. Westview.
34. **Lacey, J.R., C.B. Marlow, and J.R. Lane. 1989**. Influence of spotted knapweed (*Centaurea maculosa*) on surface runoff and sediment yield. Weed Technol. 3:627-631.
35. **Lacey, J., P. Husby, and G. Handl. 1990**. Observations on spotted and diffuse knapweed invasion into ungrazed bunchgrass communities in western Montana. Rangelands 12(1):30-32.
36. **Lacey, J. R., R. Wallander, and K. Olson-Rutz. 1992**. Recover, germinability, and viability of leafy spurge (*Euphorbia esula*) seeds ingested by sheep and goats. Weed Tech. 6:599-602.
37. **Lacey, J.R. 1987**. The influence of livestock grazing on weed establishment and spread. Montana Academy of Sci., Eastern Montana College, Billings, Montana.
38. **Lajeunesse, S., R. Sheley, R. Lym, D. Cooksey, C. Duncan, J. Lacey, N. Rees, M. Ferrell. 1995**. Leafy spurge biology, ecology and management. Montana State Univ. EB 134. p.25.
39. **Lesica, P. and J.S. Shelly. 1991**. Endangered, threatened and sensitive vascular plants of Montana. Montana State Library.
40. **Lesica, P. 1991**. The effect of the introduced weed, *Centaurea maculosa* on *Arabis fecunda*, a threatened Montana endemic. Montana Natural Heritage Program, State Library, Helena, MT.
41. **Leitch, J. A., F. L. Leistritz, and D. A. Bangsund. 1994**. Economic effect of leafy spurge in the upper Great Plains: Methods, models, and results. Ag. Econ. Rept. No.316. p.7.
42. **Loope, L.L. 1992**. An overview of problems with introduced plant species in national parks and biosphere reserves of the United States. p. 1-28 in C.P. Stone, C.W. Smith, and J.T. Tunhison, eds. Alien Plant Invasions in Native Ecosystems of Hawaii: Management and Research. Univ. of Hawaii Coop. Park Studies Unit, Honolulu.
43. **Lorenz, R.J. and Dewey,1988**. S.A. In The Ecology and Economic Impact of Poisonous Plants on Livestock Production. pp. 309-336. Westview Press, Boulder, CO.
44. **Lym, R. G. and D. R. Kirby. 1987**. Cattle foraging behavior in leafy spurge (*Euphorbia esula*)-infested rangeland. Weed Tech. 1:314-318.
45. **Lym, R.G. and C.G. Messersmith. 1985**. Leafy spurge control and improved forage production with herbicides. J. Range Manage.38:386-391.
46. **MacDonald, I.A.W., F.J. Kruger, and A.A. Ferrar. 1986**. The ecology and management of biological invasions in Southern Africa. Proc. of the National Synthetic Symp. on the Ecology of Biological Invasions. Oxford University Press, Capetown.
47. **Mack, R.N. 1981**. Invasion of *Bromus tectorum L.* into western North America: an ecological chronicle. Agroecosystems 7:145-165.
48. **Maddox, D.M. 1979**. The knapweeds: Their economic and biological control in the western states. USA Rangelands 1:139-140.
49. **Maddox, D. M., Rouhollah Sobhian, Donald Joley, Aubrey Mayfield, and David Supkoff. 1986**. New biological control for yellow starthistle. Calif. Agri. Nov.-Dec. p.4-5.
50. **Malecki, R.A., B. Blossey, S.D. Hight, D.Schroeder, L.T. Kok, and J.R. Coulson. 1993**. Biological control of purple loosestrife. BioScience 43:680-686.

See "Literature Cited" on page 12

Literature Cited

Continued from page 11

51. **Maxwell, J. F., R. Drinkwater, D. Clark, and J. W. Hall. 1992**. Effect of grazing, spraying, and seeding on knapweed in British Columbia. J. Range Manage. 45:180-182.
52. **McKnight, B.N., ed. 1993**. Biological Pollution: the Control and Impact of Invasive Exotic Species. Ind. Acad of Sci., Ind. 261 p.
53. **Myers, J. H. and D. E. Berube. 1983**. Diffuse knapweed invasion into rangeland in the dry interior of British Columbia. Can. J. Plant Sci. 63:981-987.
54. **Randall, J.M. 1995**. Assessments of the invasive weed problem on preserves across the US. Endangered Species Update 12 (4&5): 4-6.
55. **Randall, J.M. 1996**. Weed control for the preservation of biological diversity. Weed Tech. 10(2):370-393.
56. **Rawinski, T.J. 1982**. The ecology and management of purple loosestrife (*Lythrum salicaria L.*) in central New York. M.S. Thesis, Cornell Univ., Ithaca, 20 pp.
57. **Rawinski, T.J. and R. A. Malecki. 1984.** Ecological relationships among purple loosestrife, cattail and wildlife at the Montezuma National Wildlife Refuge. NY Fish and Game Journal.31:81-87.
58. **Rice, P.M. and J.C. Toney. 1996**. Plant population responses to broadcast herbicide applications for spotted knapweed control. Down to Earth 51 (2):14-19.
59. **Rice, P.M., D.J. Bedunah, and C.E. Carlson. 1992**. Plant community diversity after herbicide control of spotted knapweed. For. Serv. Intermountain Res. Stn. Res. Pap. N460: 1+
60. **Rice, P.M., C.A. Lacey, J.R. Lacey, and R. Johnson. 1994**. Sulfur cinquefoil biology, ecology and management in pasture and rangeland. Montana State Univ. EB109. 9p.
61. **Roche, C. T. and B. F. Roche, Jr. 1988.** Distribution and amount of four knapweed (*Centaurea L.*) species in eastern Washington. Northwest Sci.62(5):242-253.
62. **Rychert, R.C., and J. Skujins. 1974**. Nitrogen fixation by blue-green algae-lichen crusts in the Great Basin desert. Soil Science Society of america Proceedings 38: 768-771.
63. **Selleck, G.W., R.T. Coupland, and C. Frankton. 1962**. Leafy spurge in Saskatchewan. Ecological Monographs. 32(1):1-27.
64. **Sheley, R., M. Manoukian, and G. Marks. 1996**. Preventing noxious weed invasion. Rangelands 18(3):100-103.
65. **Story, J. M. 1992**. Biological control of weeds: selective, economical and safe. Western Wildlands 18(2):18-23.
66. **Thompson, M. J. 1996**. Winter foraging response of elk to spotted knapweed removal. Northwest Sci. Vol.70(1):10-19.
67. **Trammell, M. A. and J. L. Butler. 1995**. Effects of exotic plants on native ungulate use of habitat. J. Wildl. Manage. 59(4):808-816.
68. **Tyser, R. W. 1992**. Vegetation associated with two alien plant species in a fescue grassland in Glacier National Park, Montana. Great Basin Nat. 52 (2): 198-193.
69. **Tyser, R. W. and C. H. Key. 1988**. Spotted knapweed in natural area fescue grasslands: An ecological assessment. Northwest Sci. 62:151-160.
70. **Vitousek P.M., L.L. Loope, and C.D'Antonio. 1995**. Biological invasion as a global change. p. 216-227 In S.J. Hassol and J. Katzenberger, eds. Elements of change 1994. Aspen Global Change Institute, Aspen, Colorado.
71. **Vitousek, P.M. 1990**. Biological invasions and ecosystem processes: towards an integration of population biology and ecosystem studies. Oikos 57:7-13.
72. **Vitousek, P.M. 1986**. Biological invasions and ecosystem properties: can species make a difference? p163-176. In H.A. Mooney and J.A. Drake eds. Ecology of Biological Invasions of North America and Hawaii. Springer-Verlag, New York.
73. **Whisenant, S.G. 1990**. Changing fire frequencies on Idaho's Snake River Plains: ecological and management implications. p.4-10. In E.D. McArthur, E.V. Romney, S.D. Smith, and P.T. Tueller, eds. Proceedings -Symposium on cheatgrass invasion, shrub die-off, and other aspects of shrub biology and management. Las Vegas, NV. 1989. For. Serv. Intermountain Res. Stn. Gen. Tech. Rep., INT-276.
74. **Wilson, S.D. and J.W. Belcher. 1989**. Plant and bird communities of native prairie and introduced Eurasian vegetation in Manitoba Canada. conservation Biology 3:39-44.

354-02-001 (7/97 AgW)

Techline
c/o Ag West Communications
2305 Nottingham Court
Fort Collins, CO 80526