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Using beetles and remote sensing to battle leafy spurge on Wyoming rangelands

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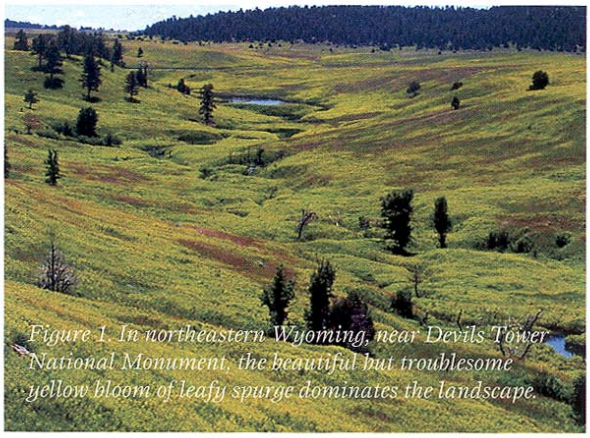
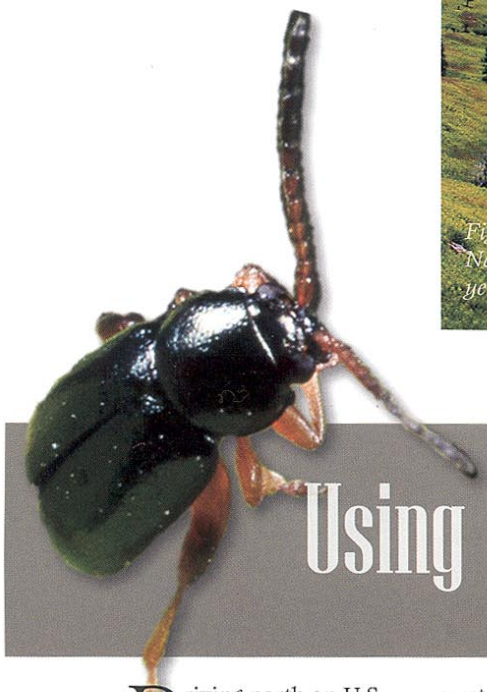


Figure 1. In northeastern Wyoming, near Devils Tower National Monument, the beautiful but troublesome yellow bloom of leafy spurge dominates the landscape.



Using beetles and remote sensing to

Amy Parker Williams, Ph.D. Candidate, Department of Botany

Driving north on U.S. 14 from Moorcroft, Wyoming, toward Devils Tower, you travel through wide-open rangelands. To the right stretches the blue expanse of Keyhole Reservoir, and up ahead the land rises in forested hills. A few more miles as the highway climbs up from the prairie, and you enter the northwestern edge of the Black Hills. After passing through the small town of Carlile, you head west on Cabin Creek Road; it winds along its namesake, a tributary of the Belle Fourche River. A dusty drive down this county road puts you in the heart of leafy spurge country. The view out the pickup truck window is a wide expanse of rolling prairie with forested ravines and ridges. In June, this landscape is dominated by the bright yellow of leafy spurge in full bloom (Figure 1).

The problem

Leafy spurge (*Euphorbia esula* L.) is the bane of ranchers in northeastern Wyoming. This plant has taken over millions of acres of western grazing land, not only in Wyoming, but also in Montana, Idaho, North Dakota, South Dakota, and Alberta, Canada. Habitats commonly affected include rangelands, pastures, and riparian corridors. It often forms dense stands that displace native vegetation and forage plants. Leafy spurge also contains a milky latex that is an irritant to the mouth and digestive system of cattle and horses. Infestations of leafy spurge destroy the quality of grazing lands for cattle and horses, degrade the forage base and structure of wildlife habitat, decrease plant diversity, and reduce land value.

Biological control

Figure 2. Left to right: (1) Healthy leafy spurge has a characteristic bright yellow-green color. (2) An adult black flea beetle (A. lacertosa) on a leafy spurge plant. (3) Adult flea beetles feed on and damage the above ground portions of the plant, (4) while larval beetles attack the root system. These two modes of attack lead to eventual death of the plant and, over several years, to large-scale control of leafy spurge.

Figure 3. A dense riparian leafy spurge infestation in 1998 (top) prior to release of beetles. Two years later (bottom), leafy spurge has been reduced in a 21.9 yard diameter "crater" surrounding the marker post. Each year, the impact of the beetles will continue to move outward from the initial release site as they attack additional leafy spurge plants.

battle leafy spurge on Wyoming rangelands

David J. Kazmer, Assistant Professor, Department of Renewable Resources

Herbicides have been used on leafy spurge for many years. They are successful in controlling the spread of infestations and in catching new infestations before they become established; however, because of the remarkable ability of leafy spurge to resprout from its extensive root system and spread over large acreages of rangeland, herbicide use is neither cost-effective nor practical on large, well-established infestations.

Fortunately, biological control using insects has become a highly effective tool for controlling leafy spurge on rangelands and along riparian corridors. Two species of flea beetles (*Aphthona nigriscutis* and *A. lacertosa*) are having a huge impact on leafy spurge in northeastern Wyoming. Introduced from Eurasia, the native home of leafy spurge, the flea beetles feed on the leaves and roots of leafy spurge and, over time, kill the plant (Figure 2).

Research jointly conducted by the UW Departments of Renewable Resources and Botany and the USDA Agricultural Research Service (USDA-ARS), and funded by USDA-ARS and the Wyoming Space Grant Consortium, sought to determine the rates at which the flea beetles impact leafy spurge and if these rates varied with slope, slope aspect, habitat type, and topographical position. In 1998, 3,000 *A. nigriscutis* and 3,000 *A. lacertosa* were released at each of 77 research sites in a 25 square-mile area in Crook County. Another 32 Crook County locations, where no beetles were released, served as control sites.

By summer 2000, two years after the research began, the dramatic impacts of the flea beetle releases were apparent. The average canopy cover of leafy spurge at the center of the release sites was reduced from 47 percent in 1998 to 12 percent in 2000, whereas no significant changes in canopy cover were observed on the control sites (Figures 3 and 4). Researchers noted that the average area over which this impact was observed increased from about 60 square yards in 1999 to more than 500 square yards in 2000.

At this time, researchers also noted that the black flea beetle, *A. lacertosa*, was nearly three times more abundant than the brown flea beetle, *A. nigriscutis*, and was most likely responsible for the greater part of the results (Figure 5). Given that most biological populations increase at geometric or exponential rates in the presence of abundant resources, researchers expect these impacts to be much greater in 2001 and beyond.

Significantly, the im-

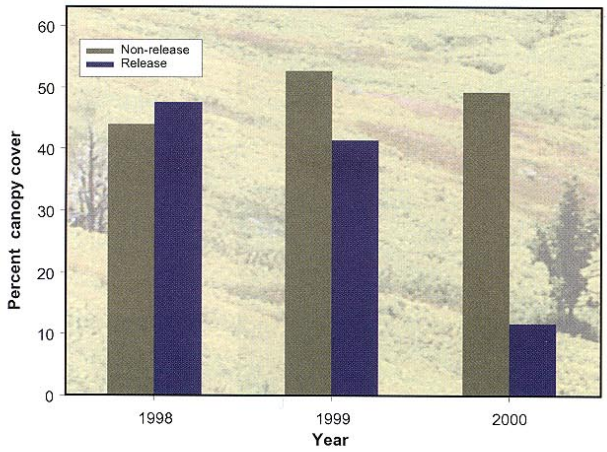


Figure 4. Percent cover of leafy spurge on release and non-release sites.

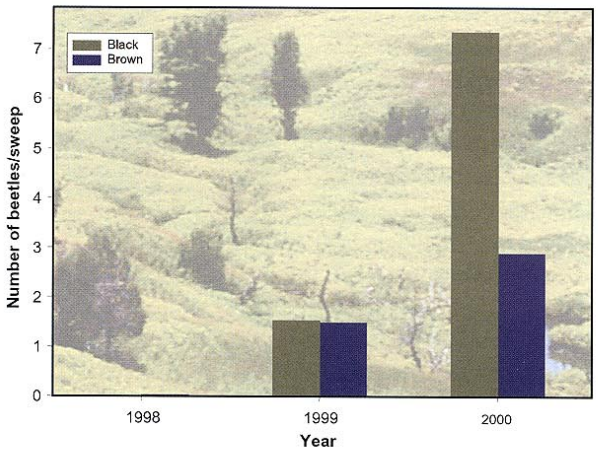


Figure 5. Number of Aphthona flea beetles on release sites.

pacts of the flea beetles do not appear to vary with slope, slope aspect, habitat type (prairie or woodland) or topographical position (upland, draw, or riparian). This suggests that, at least in Crook County, the flea beetles will be able to suppress the vast majority of leafy spurge infestations. Moreover, the release sites had good regrowth of perennial forage grasses with the decline in leafy spurge cover. Recovery of the grazing potential of leafy spurge infested lands appears imminent.

Results such as these, combined with the availability of the two species, have stimulated interest on the part of private and public land managers in obtaining flea beetles. Crook County Weed and Pest District personnel collected more than 6 million flea beetles in 2000 and moved them to new sites across Wyoming. Also in 2000, another 16.5 million flea beetles were collected and moved to new sites in Montana, Wyoming, and the Dakotas by The Ecological Area-wide Management (TEAM) Leafy Spurge Project. (TEAM Leafy Spurge is a collaborative effort involving private, local, state, university, and federal entities and is funded through USDA-ARS.)

All signs indicate that the biological control program against leafy spurge will be a major success. Unlike most other pest management tactics, successful biological control results in long-term, self-sustaining, area-wide suppression of the target pest with few, if any, undesirable side effects. Despite the need for an initial investment in the research and development of biological control agents, these properties of successful biocontrol provide extremely favorable long-term economic cost-benefit ratios, estimated by some to be as high as $31 returned for each $1 invested.

But when will there be successful leafy spurge control at appreciable spatial scales? This is a difficult question, as most current studies providing quantitative data on leafy spurge and other invasive plants are of relatively short duration and encompass small spatial scales. New tools are needed to facilitate research at greater spatial and temporal scales without excessive cost.

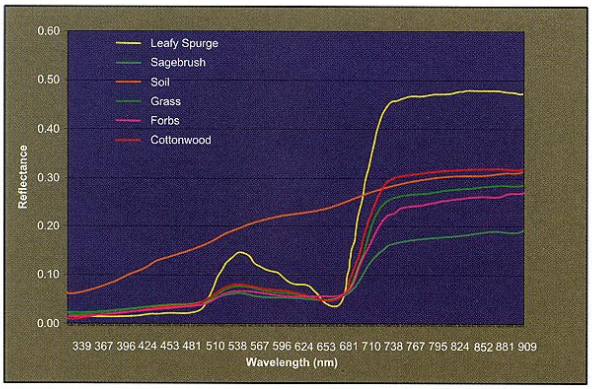


Figure 6. Field reflectance spectra of leafy spurge and other vegetation.

Remote sensing of leafy spurge

Recent advancements in remote sensing technology may provide these research tools. The key to using airborne or satellite imagery to detect and map a single

plant species, such as leafy spurge, lies in the ability to distinguish the target species from other kinds of green vegetation. Newer, "hyperspectral" sensors offer hope in this vein. Relative to sensors that provide limited color information (i.e., 4 broad measures of reflectance representing the blue, green, red, and near infrared portions of the color spectrum), hyperspectral or "many color" sensors provide much more data (i.e., up to 256 reflectance measures spanning the blue to middle infrared regions of the spectrum). This information helps detect subtle differences among green plant species.

Researchers in the Departments of Renewable Resources and Botany are now investigating the use of hyperspectral sensors to distinguish leafy spurge from other green plants. The first step was to employ a ground-based spectrometer held over leafy spurge and other vegetation in the field. The spectrometer took detailed measurements of the reflectance signatures, or color, of the vegetation. Researchers knew that if it was not possible to distinguish leafy spurge under these ideal conditions, then it was unlikely that leafy spurge could be distinguished in higher altitude imagery. Fortunately, during the May and June bloom, leafy spurge has a unique spectral signature that allows its quantitative separation from other vegetation (Figure 6).

With that result in hand, researchers obtained high-resolution imagery of about 25 square miles in Crook County from an instrument called the Airborne Visible/Infrared Imaging Spectrometer (AVIRIS). In essence, AVIRIS provides a hyperspectral, digital picture of the ground. The AVIRIS picture contains 256 bands of color information for each pixel measuring 21.9 by 21.9 yards on the ground. As with the ground-based spectrometer, leafy spurge has a unique signature in the AVIRIS imagery. Moreover, techniques were developed to calculate the percent cover of leafy spurge in each pixel (Figure 7). These advances allow both the extent and abundance of leafy spurge to be mapped. This is a truly powerful step forward.

Digital maps of leafy spurge distribution and extent are being constructed based on the AVIRIS data collected in 1999. With repetition of the mapping in a few years and integration of the maps into a Geographic Information System (GIS), researchers and land managers can quantitatively describe patterns of leafy spurge spread and assess the effectiveness of biocontrol at large scales. This information holds tremendous value for leafy spurge control programs and also shows promise for future applications to other weed species throughout the Western region.

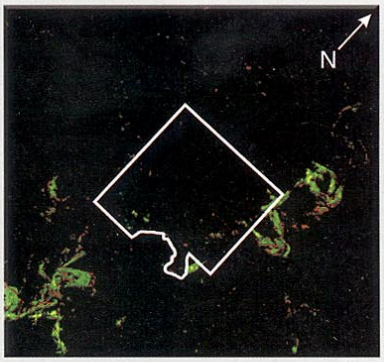


Figure 7. Top right: Airborne Visible/ Infrared Imaging Spectrometer (AVIRIS) image of the Devils Tower National Monument (white boundary) area. The image is a false color composite with green vegetation appearing bright red, leafy spurge appearing orange, conifer forest appearing black, and soil and exposed rock appearing bluish white. Notice the boulder field and shadow of Devils Tower in the center of the image. Most leafy spurge in this area follows the floodplain and tributaries of the Belle Fourche River, which runs across the bottom half of the image from left to right.

Bottom: Map of leafy spurge distribution and density. For reference, this image covers the same area as the color composite above. Remote sensing techniques allow researchers to map infestations of leafy spurge and also estimate the density of the infestation. Colors correspond to leafy spurge abundance: yellow – very high; bright green – high; dark green – moderate; brown – low; and black – none.