Mapping Leafy Spurge and Spotted Knapweed Using Remote Sensing

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Introduction

Invasive nonnative plants are threatening the biological integrity of North American rangelands and the economies supported by those ecosystems. Spatial information is critical to fulfilling invasive plant management strategies. Traditional invasive plant mapping has utilized ground-based hand or GPS (Global Positioning System) mapping. The shortfalls of ground-based methods include the limited spatial extent covered and the associated time and cost. Mapping vegetation with remote sensing covers large areas and maps can be updated at an interval determined by management needs. The objective of the study was to map leafy spurge and spotted knapweed using finely delineated color (hyperspectral) imagery (16.4-ft and 9.8-ft resolution) and assess the accuracy of the resulting maps.

Experimental Protocol

The imagery covered two sites in Madison County, Montana; each site was approximately 2,528 acres. The leafy spurge site was located about 10 miles southwest of Twin Bridges at the southern end of the Highland Mountains. Leafy spurge primarily occupied drainage bottoms and surrounding hillsides and was distributed with native vegetation in low- to high-density infestations and occasionally grew in dense monocultures. The spotted knapweed site was located in the northern foothills of the Gravelly Range and included the town of Virginia City and areas due west and south. Spotted knapweed infestations tended to be mixed with other vegetation and had a higher percentage of bare soil exposed than the leafy spurge site. The hyperspectral imagery was obtained in August 1999 using the Probe-1 sensor. The images were recorded from an average altitude of 8,200 ft with the Probe-1 site ground resolution of 16.4 ft. In August 1999, crews collected ground reference data of the target invasive species and associated vegetation using GPS receivers that had an accuracy of 6.7–16.4 ft after differential correction. Infestations ranged from 7 to 606 yards^2 and samples were split randomly into two equal sets: a) those used to differentiate between species and b) those used to compare GPS map points of infestations with image map points. Images were georeferenced to a digital orthophotoquad. Two different methods of GIS (Geographic Information System) analysis, classification tree analysis (CTA), and fuzzy set theory were used to classify the hyperspectral imagery and to adapt for over-classification of target species, respectively.

Results and Discussion

Although healthy vegetation exhibits similar reflectance properties, differentiation between species is possible due to plant structural characteristics, leaf area and geometry, surface construction, water content, and in the visual spectral range, pigmentation. Target species map accuracies were 61 percent for leafy spurge and 74 percent for spotted knapweed with the application of CTA alone (Fig. 1). The application of fuzzy set theory resulted in substantial increases in overall accuracies (especially with leafy spurge), without impairing accuracy of associated vegetation. The accuracies increased to 82 and 86 percent for leafy spurge and spotted knapweed, respectively. This is comparable to the highest ground-based mapping accuracy levels. Application of the fuzzy set theory overcomes several problems that have been noted in the past with mapping invasive species using airborne digital imagery.

Management Implications

This study provided valuable information about applying airborne hyperspectral imagery for mapping invasive species. Operational and practical methods were applied to classify the imagery. Given the time and cost required to perform intensive ground surveys, the tradeoff of lower accuracy might be worthwhile in situations where an estimation of infestation distribution over large areas will assist timely implementation of invasive plant management objectives. However, the use of fuzzy set analysis enables accuracies comparable to ground surveys.

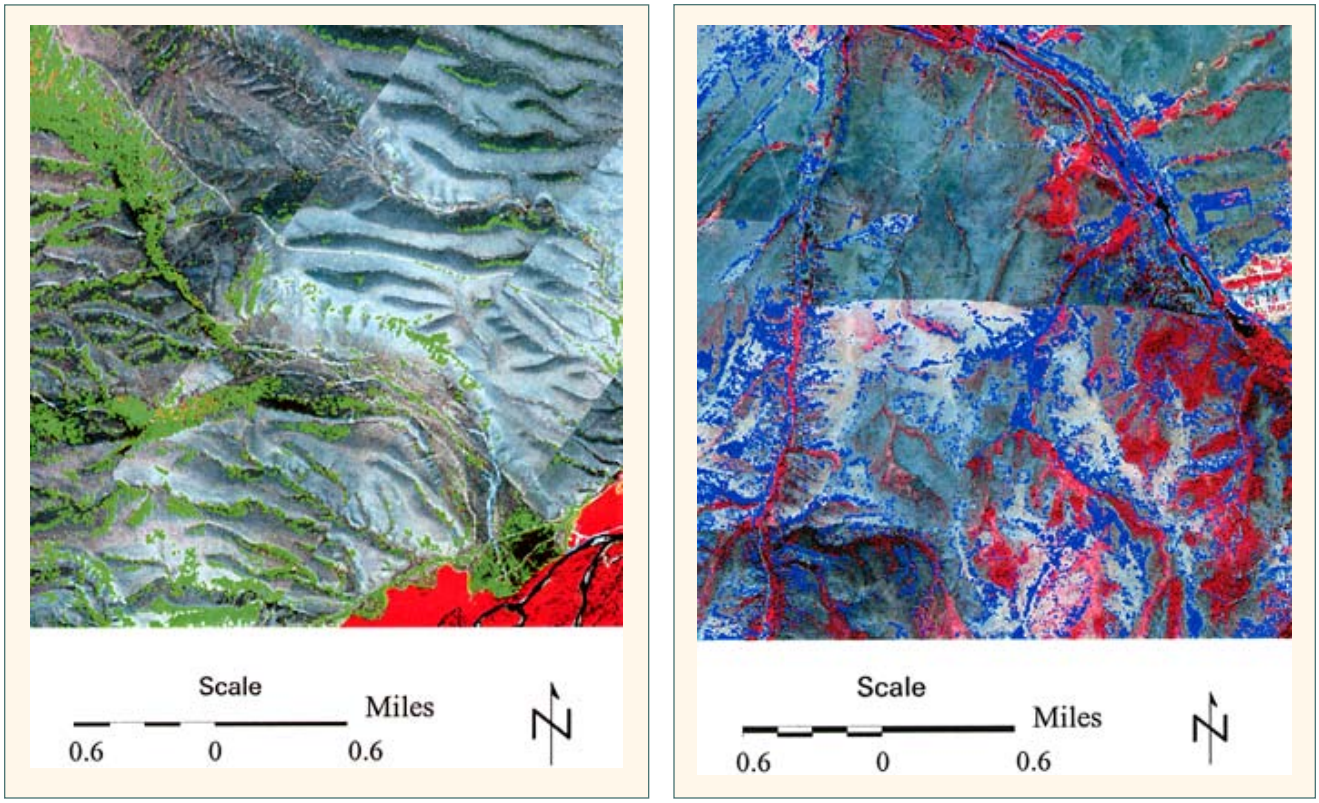

Figure 1. (Left) Classification of leafy spurge overlaid on hyperspectral imagery. Bands 24 (784 nm), 16 (662 nm), and 9 (555 nm) are displayed as red, green, and blue. (Right) Classification of spotted knapweed overlaid on hyperspectral imagery.