Evaluating the Costs and Benefits of Alternative Weed Management Strategies for Three Montana Landscapes

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Executive Summary

Invasive plant species management at the landscape scale in the Western U.S. is generally based on fine-scale experience and arbitrary decisions ("rules of thumb") with limited understanding of long-term outcomes across broad areas or over long periods. Range managers are often faced with dilemmas in applying limited resources to the control of invasive plants across a complex landscape, and few tools are available to guide real-world decision making across large landscapes. Due to uncertainty about invasive plant management across large areas and over long periods, research and demonstrations have generally focused on the refining control techniques at fine scales (e.g. small patches of weeds or experimental plots), rather than prioritization across thousands of acres. In order to develop the best strategies to maintain landscape values and prevent the spread of invaders, quantitative tools are needed to compare the effectiveness of various management strategies at different spatial scales and over several decades.

Computer models have been used to evaluate alternative management strategies of invasive species, while accounting for uncertainties related to actual landscapes, weed ecology, and management strategies. We used a spatially explicit simulation model to model the spread of leafy spurge and spotted knapweed and the effects of management actions in three Montana landscapes – the Centennial Valley (CV), Rocky Mountain Front (RMF), and Montana Glaciated Plains (MGP). We compared several management strategies under a variety of budget constraints to evaluate the long-term advantages of different approaches, identify appropriate resource allocation levels, and assess costs and benefits of strategies within an economic analysis framework.

This summary provides highlights from our full report (Frid et al. 2011) which should be consulted for further details and explanation. The report and additional resources are available at http://conserveonline.org/workspaces/montanaweedmodel.

Methods

We created state and transition models with the Vegetation Dynamics Development Tool (VDDT) and ran 40-year spatial simulations in the Tool for Exploratory Landscape Scenario Analyses (TELSA). Spatial data inputs for the simulations included vegetation types, current weed distribution, spatial restrictions on management actions, and features influencing the probability of new invasions. All inputs for the model were based on published literature, data from the landscape, and/or input from managers and experts in the landscapes. We incorporated a range of values for the rate at which weeds spread across the landscape over time, which was a key uncertainty among the model parameters. We used a 30-year time series of weed management and spread data from the RMF to calibrate the model.

To evaluate varying levels of weed management budgets, we ran simulations over a range of treatment levels with a management strategy that prioritized treatment of small patches over large patches. The simulations ranged from no management (zero budget) to unlimited management (unlimited budget), with up to four intermediate budget levels.

To compare the effect of alternative management strategies, we ran simulations at the mid-level budget ceiling with several alternative management scenarios:

1. Improving control success rates
2. Prioritizing large infestations instead of small infestations
3. Treating new infestations when they first appear instead of four years after establishment
4. Focusing all available treatment resources on 1/3 of the landscape each year on a rotational basis
5. Delaying the onset of management

We compared total area invaded at the end of the simulations to assess the impact of various management strategies on weed spread and cover on the landscape. We also evaluated the economic costs and benefits of the strategies, by accounting for the damages caused by weeds over time, as well as the costs associated with implementing management. For damages, we only considered loss of grazing value. This resulted in conservative estimates since we did not account for losses associated with crop productivity, local economies, wildlife, or native species.

Results

Regardless of landscape or invasive plant species modeled, simulations demonstrated that without treatment, noxious weeds substantially increased. Most management actions were effective at reducing the area infested in all three landscapes over the 40-year period, though the areas treated and infested ranged widely among the various management scenarios. Economic analysis of treatment costs and grazing losses suggested that some strategies resulted in positive net present values over the 40-year period, while others were not economically viable.

Early detection and control of small patches was the best performing strategy based on our evaluation metrics of total area invaded and economic benefits. Strategies that detect new infestations as soon as they appear provided additional benefits in the CV, while increasing control success provided additional benefits in the RMF. Strategies that either targeted large patches or delayed management resulted in poor economic performance while providing only marginal improvement over no management in terms of areas invaded after 40 years.

Management implications

Our model provided a useful way to assess the relative performance of alternative management strategies and varying budget levels across broad spatial scales in terms of ultimate area invaded, long-term treatment requirements, landscape grazing values, and benefit-cost ratios. To meet long-term goals for their landscape, managers need to pursue strategies that are both ecologically effective and economically justified. The model results provide several insights for achieving that success.

The early detection and small patch control strategies consistently outperformed large patch strategies, as well as most other strategies. Despite these results and previous recommendations for early detection and rapid response programs, managers are often mandated to focus on large infestations where weeds are well-established and highly visible. Small infestations do not present an immediate loss of productivity and are often more remote and time-consuming to control. Consequently resources are directed toward locations where, based on our model results, treatment is less beneficial and long-term success is less likely. Our model results support the reallocation of resources to an effective early detection and treatment strategy.

Our results also indicate managers should avoid delaying management or applying inconsistent treatment over time. In these cases, weed populations outpace management efforts and can reinvade previously treated areas, ultimately leading to a greater area invaded with greater economic costs. Preventative actions that reduce weed dispersal distances and spread rates will lower ultimate invasion levels and long-term management costs.

For landscapes with relatively few existing infestations of noxious weeds, managers should dedicate resources to detecting and controlling new infestations as early as possible to prevent the development of established populations. For invaded landscapes where large noxious weed infestations already exist, early detection and control remains a foundational strategy managers should also work to maximize treatment success. At the broadest scale, resources should be allocated to landscapes with lower infestation levels and thus greater potential for long-term management success and return on investment, rather than highly invaded landscapes.

References

Frid, L., D. Hanna, N. Korb, B. Bauer, K. Bryan, B. Martin, and B. Holzer. 2011. Evaluating the Costs and Benefits of Alternative Weed Management Strategies for Three Montana Landscapes. Prepared by The Nature Conservancy of Montana, Helena, MT and ESSA Technologies Ltd., Vancouver, B.C., 56 pp. + appendices. Available at http://conserveonline.org/library/evaluating-the-costs-and-benefits-of-alternative