

# Adaptive Management in EBIPM

## A Key to Success in Invasive Plant Management

By A. Joshua Leffler and Roger L. Sheley

Preventing invasion by nonnative or undesirable plant species and controlling ongoing invasion are two key management issues on rangelands worldwide. Invasive species cause considerable ecological and economic cost, including lost biodiversity and reduced productivity. Invasive plants cause approximately \$5 billion in direct losses to ranchers and range managers each year.<sup>1</sup>

Despite the ecological and economic costs of invasive plant species, few widely effective solutions to these problems have been developed. Tools to address the problem such as grazing strategies, herbicide applications, prescribed burning, and rangeland seeding have only limited success, failing as often as succeeding because invasive plant management is much more complex than merely reducing weed abundances.<sup>2</sup> It is becoming clear that numerous biological and nonbiological factors determine if invasive species management can be successful.<sup>3</sup>

Successful management of invasive plants on rangelands depends on considering how various management tools alter the underlying ecological processes that maintain the dominance of the undesired plant species on the landscape. Ecologically Based Invasive Plant Management (EBIPM) was developed to improve the probability of success of establishing and promoting a desired plant community. It provides a rubric for managers to decide whether Site Availability, Species Availability, or Species Performance is in disrepair and which ecological principles should guide the repair of proper ecological functions.<sup>4</sup> However, invasive plant management is not a one-time event; it requires ongoing inputs and adjustments. To successfully manage invasive plants, actions and monitoring within the EBIPM framework need to be incorporated into the adaptive management cycle.<sup>5,6</sup>

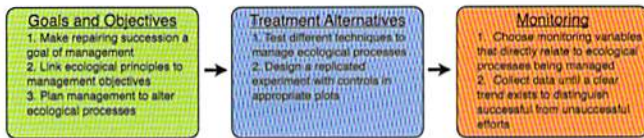
Adaptive management is often defined as “learning by doing”;<sup>6</sup> management actions are continuously improved by incorporating the results of monitoring. This allows managers to recognize which tools and strategies worked and which did not in a systematic manner. Incorporating EBIPM principles into the adaptive management cycle can further improve the odds of successfully controlling invasive plant species. To do so, monitoring needs to specifically examine how management actions alter causes of plant community change.

### Adaptive Management

Adaptive management is the process of using monitoring to iteratively improve management decisions and examine different management alternatives.<sup>5,6</sup> Adaptive management is used within rangeland management because rangelands are complex systems<sup>2</sup> and our knowledge of them is always incomplete. Every pasture differs in soil type, water-holding capacity, and management history among other things. Abiotic and biotic factors, including nutrient availability and precipitation, along with management scheme interact to produce the local plant community. These interactions can result in unforeseen outcomes to management actions, with treatments not always yielding the desired outcome. Adaptive management is important because new information is always being learned, and these discoveries need to be incorporated into management actions.

Land managers can use the adaptive management process to decide among various treatment alternatives to address their objectives on their land. Adaptive management is a scientific process where controlled, replicated plots are used to test different treatment options. Data are collected from these plots, and conclusions are drawn from the treatments tested. Adaptive management incorporates management objectives, monitoring, analysis of data, and decision making about refinements in technique. Adaptive management is also not a one-time event, but an ongoing process that iteratively improves the results of management actions. All adaptive management programs have a similar series of steps:<sup>6</sup>

- 1) *Set measurable goals and objectives for the adaptive management cycle.* Goals are statements of final products or what we want achieved, such as reduced invasive species presence on the landscape. Objectives are concrete steps along the way to our goals. Setting goals and objectives is best accomplished with the input of multiple stakeholders when appropriate.
- 2) *Collect information on the proposed site and treatments on similar sites.* Knowing information contained in an ecological site description such as climate, soils, and potential plant community will allow a manager to design treatment alternatives. Knowing what others have done will greatly assist in eliminating treatment alternatives that have been tried and failed.



**Figure 1.** EBIPM should be incorporated throughout the adaptive management process, but its influence should be most apparent in setting Goals and Objectives, designing Treatment Alternatives, and planning the Monitoring that will take place during the cycle.

- 3) *Develop the adaptive management plan.* Researchers and managers select which alternative management schemes will be tested based on likelihood of success and management goals, and then a monitoring plan is designed. This design will define the scale of the treatments, replication of sampling, study plot sizes, proper location of control areas, and protocols for data collection.
- 4) *Seek stakeholder input and incorporate stakeholder concerns.* Adaptive management cannot be conducted in a vacuum, but instead it must encompass alternative management strategies that will be tested regionally with different stakeholders from diverse groups.
- 5) *Adjust the plan to incorporate stakeholder comments.* Widespread support for a management plan is key to its success. Consequently the concerns of the larger community need to be seriously considered. Certain management alternatives may need to be incorporated or controversial alternatives may need to be dropped to gain widespread support for actions on public land.
- 6) *Implement the management plan.* Management actions are determined according to the plan and should be conducted for several years. Actions can often take several growing seasons to have a significant effect, and even the best plans can fail in poor years. A long-term perspective is critical.
- 7) *Collect and analyze monitoring data.* Monitoring data need to be collected on a regular basis for several years. Data should be collected in a rigorous manner until a measurable change occurs or until there is a clear difference between management alternatives. Ideally, data should be analyzed for significance with basic statistical tests when the manager or other stakeholders have the expertise. While significance at  $P < 0.05$  might not be achieved, trends toward the desired goal can be evaluated.
- 8) *Draw conclusions and update the plan.* In the final step, what was learned from the adaptive management cycle is incorporated into the management plan. Alternatives that did not work can be dropped, those that succeeded can be expanded, and new alternatives that were not previously considered can be included. These steps should be repeated with each cycle, ultimately improving management.

### Adaptive Management and EBIPM Are Well Suited to Be Used Together

It is our opinion that by incorporating EBIPM into adaptive management stakeholders will improve the odds of suc-

cessfully controlling invasive plants on rangelands. EBIPM should be explicitly incorporated throughout the adaptive management process (Fig. 1). Two goals should be measurably improved ecological health and repaired causes of succession that were identified in Rangeland Health Assessment (see Vasquez et al., "Integrating a Rangeland Health Assessment With Successional Management: A Synergistic Approach to EBIPM," this issue).<sup>7,8</sup> Objectives should incorporate ecological principles such as reduced frequency of disturbance benefiting long-lived perennial plants. For example, although the ultimate goal may be to control invasive plant species, setting an objective of increasing seed production of perennial grasses gives the manager a set of processes (e.g., reproduction) to build the plan around and associated principles (e.g., more seed presents more opportunities for establishment) for planning treatments.

The various alternatives developed in the third step of the adaptive management plan should incorporate ecological principles described in EBIPM literature.<sup>4</sup> If through Rangeland Health Assessment<sup>7,8</sup> a manager determines that Site Availability and Species Availability are in disrepair, a prudent plan would incorporate alternative disturbance scenarios and/or alternative seeding methods or seed mixtures. If Species Performance appears more of an issue, alternative methods of stressing the undesirable species might be appropriate.

Most importantly, the adaptive management plan should dictate measurements on variables that directly inform the ecological processes that are being repaired. Although it may be tempting to base most of the monitoring effort on site indicators that are closely tied to the final goal (i.e., a more desirable plant community), monitoring measurable indicators associated with specific ecological processes could be more informative over the near term. A desirable plant community is an emergent property of a healthy ecosystem and may be realized only once significant repair has occurred, possibly many years following treatments. Measurable indicators associated with important ecological processes, however, may show an improving trend much sooner. This indication of improved ecological condition informs managers that they are on the "right track" toward success.

Once EBIPM is incorporated into the monitoring phase of the adaptive management plan, the cycle proceeds through the remaining steps. The difference is that following the EBIPM guidelines gives the manager a set of data from which to draw conclusions that is both responsive—it indicates change toward a goal rather than just indicating if the goal has been achieved—and linked to ecological processes that cause plant community change in a desired direction.

### Designing a Successful Monitoring Regime

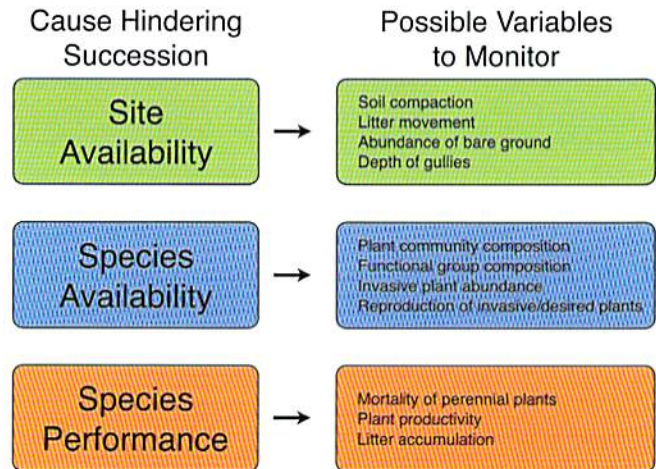
The most crucial component of EBIPM in adaptive management is a plan for monitoring variables that will indicate progress toward objectives and goals. A good monitoring program is set up as a good scientific experiment.<sup>9</sup> It includes several crucial components:

- 1) *Choose the right location for treatment alternatives.* Landscape variation can have a considerable influence on treatment success. It is important to choose sites for different treatments that are as similar and as uniform as possible. If the landscape is topographically complex, make sure all alternatives will experience the same level of complexity.
- 2) *Select an appropriate plot size.* While plot size is partially determined by the land available, the number of treatments, and replication, plots need to be of adequate size for the treatment. At the early stages, small plots might be appropriate, but ultimately treatments need to be tested over larger areas. Plots for different treatments should be similar in size, but plots need not be square, they can follow contours of the landscape.
- 3) *Replicate the treatment alternatives.* If a treatment is attempted in only one area, a manager cannot know if success or failure is likely in other locations. Replication is repeating the treatment alternatives in both space (different locations) and time (different years).
- 4) *Randomize the treatment alternatives.* Assign treatment alternatives randomly to study plots, and do not select or predetermine which plot will receive which treatment. Random assignment removes unintended personal bias with regard to sites and treatments.
- 5) *Use control plots.* Control plots allow managers to determine if a treatment alternative actually had an effect, or if the observed change was due to outside forces such as weather. Control plots are those where no treatment was applied. Controls should be part of the landscape that could be treated, not simply areas that were not treated (i.e., a rocky area that could not be accessed with a rangeland drill). Controls need not be managed; however, they cannot have any of the new treatments that are being tested.

Selecting appropriate variables to monitor is just as critical as good experimental design. Good adaptive management incorporates monitoring variables that indicate measurable progress toward the objective. EBIPM suggests that these variables should be closely linked to ecological processes. The 17 indicators from Rangeland Health Assessment<sup>7,8</sup> can help guide selection of monitoring variables, and EBIPM can point the way toward a select set of variables that are most closely linked to the ecological processes in disrepair at a given location. For example, if Species Availability is the primary cause of retarded succession because seed of desired plants is not abundant, then treatments to improve reproduction should be implemented and measurements of plant reproduction should be made. Similarly, if Species Performance hinders succession, variables related to productivity should be monitored (Fig. 2).

### Concluding Remarks

Given the impact of invasive species on rangelands worldwide, it is safe to say that many attempts at managing this problem have not been successful and new thinking about the problem is necessary. Combining EBIPM and adaptive



**Figure 2.** Selection of variables to monitor should be directly related to the causes of succession that are in disrepair. The indicators of Rangeland Health and how they relate to succession management can be useful in planning how to collect data.

management gives land managers more opportunities to effect change on rangelands worldwide and improved success has already been demonstrated. Treatments to restore rangelands infested with spotted knapweed (*Centaurea maculosa*), sulphur cinquefoil (*Potentilla recta*), and cheatgrass (*Bromus tectorum*) have been developed with the aid of EBIPM and adaptive management. In a case study, treatment combinations including disking, seeding, and watering over a series of experimental plots yielded improved condition on 66% of the trials by maximizing establishment of desirable plants.<sup>10</sup>

EBIPM is not a solution to the problem of invasive plants on rangelands. Rather, it is a step-by-step process built within a framework of organizing principles for improving management actions and increasing the odds of achieving management goals. Managing invasive plants on rangelands is best accomplished by incorporating ecology, the fundamental science of how plant communities change through time. Although adaptive management is the best way to manage in the face of uncertainty, adaptive management can be made more powerful and responsive by incorporating EBIPM into management goals, alternative management scenarios, and monitoring.

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