Symposium

Distinct Roles of Surveys, Inventories, and Monitoring in Adaptive Weed Management

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Abstract: Ambiguity exists in the use of the terms “survey,” “inventory,” and “monitoring” as related to adaptive weed management. Misunderstanding can lead to poor planning and inefficient use of limited budgets. Adaptive weed management includes developing an objective-based weed management plan, implementing the plan, monitoring to measure progress toward objectives, evaluating the plan or practices, making any necessary adjustments, and then repeating the cycle. Monitoring involves the repeated collection and analysis of site-specific data to evaluate progress toward management objectives. Surveys and inventories are field searches to determine the location and relative abundance of weeds on a landscape scale. Surveys are representative samples of an overall weed population, whereas inventories attempt to account for all weed infestations or individual plants within a specified area. Weed surveys and inventories are as basic to preserving land health as medical exams are to maintaining human health, and weed maps are as vital to land managers as X-rays are to medical professionals. Weed surveys are especially critical for success in early detection and rapid response. Area-wide weed surveys or inventories should be conducted as part of planning long-term weed management strategies and control tactics. Attempts to survey and monitor weeds simultaneously can result in data ill suited to the objectives.

Additional index words: Definitions, invasive, inventory, monitoring, survey.

OBJECTIVE

During the past 6 yr, Utah State University field crews have conducted numerous invasive weed surveys and inventories on tens of thousands of hectares of western wildlands in support of weed management programs by the Bureau of Land Management, Forest Service, National Park Service, and Utah Division of Wildlife Resources. It has been our experience that considerable ambiguity exists in the use of the terms “survey,” “inventory,” and “monitoring” as they relate to adaptive weed management. This can lead to misdirected planning and inefficient use of limited budgets. The theme of the session in which this paper was presented was “managing invasive plants with limited resources.” It is our observation that avoiding costly mistakes should be the first and most important approach to getting more from a limited weed budget. It is our intent to review and hopefully clarify key differences between these basic terms as they apply specifically to invasive weed management and point out the importance of performing each in proper sequence.

TERMS AND DIFFERENCES

Adaptive resource management has been described by Elzinga et al. (1998) as a cyclic process in which: (1) specific resource objectives are developed to describe desired outcome conditions, (2) a management plan is created and implemented to meet those objectives, (3) resource response is measured (monitored) periodically to determine whether the objectives have been met, and (4) management practices are adapted if objectives are not reached. In other words, adaptive management is a continual stepwise cycle of “plan (or adjust plan)—manage—measure—evaluate.” Adaptive weed management follows the same steps, i.e., development of an objective-based weed management plan, implementation of the plan, monitoring to measure the effectiveness, evaluating the plan or practices, making any necessary adjustments, and then repeating the cycle.

Monitoring is a key element of adaptive weed management (USDI-NPS 1996). A statement shared among successful ranchers in northern Utah is “You can’t man-
age what you can’t (or don’t) measure.” It is meant as a reminder that a good vegetation monitoring program is essential for effective management of land and livestock, and we believe it applies equally well to successful weed management. As defined by Elzinga et al. (1998), monitoring is “the collection and analysis of repeated observations or measurements to evaluate changes in conditions and progress toward meeting a management objective.” Generally, this form of monitoring is conducted at regular intervals at representative site-specific locations and is designed to detect relatively small changes with time (Barbour et al. 1999; Winward 2000). Monitoring methods range from simple photo points to collecting detailed data in fixed plots or along permanent transects (Coulloudon et al. 1999; Moore and Chapman 1986).

Elzinga et al. (1998) also point out that the term monitoring is sometimes used in a general sense to describe a broad variety of data gathering activities, including inventories and surveys. This creates the potential for confusion over two very important but different aspects of a weed management program; i.e., (1) conducting landscape-scale weed surveys or inventories upon which to build and implement an overall weed management strategy and (2) the collection of precise site-specific monitoring data to evaluate the effectiveness of weed management practices or measure the ecological effects or spread of uncontrolled invasive weeds. Without making a clear distinction between monitoring and surveys or inventories, land managers are likely to become frustrated in designing operations to meet both objectives and provide useful data in the most efficient manner possible.

Weed surveys and inventories can be described as single point-in-time observations or searches to determine the occurrence (location and abundance) of one or more weed species within a delineated management area (NAWMA 2003). The goal in a survey is to sample a representative portion of a greater weed population; whereas the objective of a weed inventory is to account for the entire population of a targeted plant species within a defined geographic area (Moore and Chapman 1986; Pugnaire and Valladares 1999). The distinction between a weed survey and a weed inventory is analogous to the difference between a poll and a census. A census is intended to account for all persons within an entire targeted population. In a poll, a subgroup of the total population is sampled with the hope of obtaining information representative of the whole.

An expectation to detect every individual plant of a targeted species with 100% assurance in a landscape-scale inventory is highly unrealistic, if not impossible. And even if possible, an inventory to find every single individual weed may not be worth the enormous amount of time and money that would be required (Kuchler and Zonneveld 1988; NAWMA 2003; USDI-USGS 1994). Instead of searching for every single weed plant, planners might set a minimum detectable patch size representing an early stage of invasion (perhaps 1/100 to 1/10 ha), large enough to detect with confidence, but small enough for eradication to be feasible. The intent should be to resurvey the same area often enough that single weeds or patches smaller than the minimum detectable patch size missed in the previous survey will not grow into patches too large to eradicate by the subsequent survey. This type of search could still be considered an inventory if it is clearly stated what is being searched for (including the minimum patch size), and if coverage is area wide and thorough enough to achieve the desired detection confidence level. However, an inventory of all weed patches equal to or greater than 1/10 acre in size is still technically a survey of all weeds because it was not designed to detect isolated individual plants.

In early phases of weed detection and mapping, or when it is not feasible to inventory an entire management area for targeted weeds, representative “exploratory or reconnaissance” surveys of the area may provide a suitable alternative (Kuchler and Zonneveld 1988). There are a number of survey types and patterns to choose from, including random, stratified, transect, and grid options (Barbour et al. 1999; Coulloudon et al. 1999; Pugnaire and Valladares 1999). In the case of invasive weeds introduced primarily by human-related activity, it might make sense to choose those areas first that are most frequently visited or most drastically disturbed, such as roads, campgrounds, trail heads, or areas of heaviest livestock concentration. In other words, those areas with the greatest probability of new introductions or successful weed establishment should be searched first, beginning with the sites of highest visitation, working down the list to less and less likely sites, and finishing with a few cross-country searches into areas of least human visitation or disturbance. The process of prioritizing and searching areas for indications of new invasive weeds is very similar to what is termed an “initial” or “scratch” search conducted by modern search-and-rescue teams trying to locate a missing person (May 1973).

A stratified survey within a large management area
could actually include some inventories of certain sub-units. For example, if a survey involves searching for all targeted weeds within a 30-foot right-of-way on both sides of all paved and gravel roads, and within all campgrounds in the entire management unit, then technically an inventory of those sub-units has been performed. But, if only a fraction of the hiking trails are searched, and only a small percentage of all road-less and trail-less lands are inspected, the overall operation is still a survey.

Results of weed surveys and inventories are normally presented in the form of maps. Accurate weed-distribution maps play an essential role in developing weed management strategies and setting control priorities. It is our opinion that weed surveys are as vital to good land health as medical exams are to good human health, and that weed-distribution maps are just as essential to weed program planning and execution by land managers as X-rays are to the work of an orthopedic surgeon. It is impossible to develop an effective and efficient weed control plan without knowing the identity, location, and relative abundance of the weeds. Weed surveys are especially critical for success in early detection and rapid response efforts.

Major differences between weed surveys, inventories, and monitoring include scale, intensity (detail—precision), and reproducibility of results. Monitoring usually involves repeated measurements of individual plants, plots, or points at the same location using methods that allow statistically meaningful comparisons between time periods. Surveys and inventories are generally conducted and interpreted on a landscape scale with considerably less detail and precision. A weed survey or inventory provides a single point-in-time assessment or “snapshot” of the location and overall abundance of a weed population and supplies the basic information upon which to develop weed management strategies. Because of differences in surveyors, design, sampling methods, and other field procedures, data comparisons between surveys or inventories conducted at different times may be of limited value, even at the landscape scale. They might be used to show change in overall weed distribution or total infested acres with time but probably would not be sufficiently precise to measure changes in the size or density of individual weed patches.

**POTENTIAL MISTAKES**

To be optimally successful, the steps of adaptive weed management must be implemented in the prescribed sequence as described above. Launching an elaborate and potentially expensive assault against an invading weed force requires that planners first obtain good reconnaissance information. In other words, an area-wide weed inventory or survey should be conducted before developing specific weed management strategies and initiating control tactics.

One of the most basic mistakes made by some weed managers is to reverse the order of what could be termed “diagnosis and treatment.” In other words, some well-intentioned land managers may attempt to control weed invasions without first determining the identity, distribution, or relative abundance of the invaders. To illustrate the folly of this approach, try to imagine a doctor treating an injury or illness without first diagnosing the problem or a search-and-rescue mission being initiated without first gathering all available facts and maps (May 1973). Yet the same faulty logic is applied if weed control efforts are initiated without first conducting an adequate survey or inventory.

Adaptive weed management, similar to any other science-based process, requires clearly defined methods matched to specific objectives. Weed surveys, inventories, and monitoring, each involves gathering data from plant populations but can differ markedly in purpose and procedure. For example, the primary objective of a weed survey might be simply to produce area-wide distribution—abundance maps to guide the development of local weed management priorities and strategies across a broad landscape, whereas monitoring might be needed to determine the relative aggressiveness or ecological effects of an invasive species within a local native plant community. Field measurements also might be taken to evaluate the effectiveness of site-specific weed management methods or to support development of computer models to identify preferred habitats and to predict potential spread of invasive species.

In each of these examples, the failure to set clear objectives, or failure to properly match objectives with methods, can lead to inefficiency or collection of ill-suited data. For example, the simple goal of a wildland weed survey might be to determine the location and relative abundance of specific invasive species, while covering as much land area as possible with the limited dollars available. Collecting more data than required can slow down the fieldwork considerably and cause a reduction in the amount of land that can be surveyed.

Performing surveys and monitoring in reverse sequence or trying to accomplish both simultaneously in a single operation can be a mistake. Monitoring is the third step in adaptive weed management, yet in an effort to save money, some land managers may be tempted to

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combine it with the general weed surveys normally conducted as part of step one—before management planning objectives have been fully determined.

As noted previously, the purpose of monitoring is to measure progress toward management objectives, and the specific method of monitoring should be carefully matched to those objectives. This cannot be done if objectives have not been defined clearly. Elzinga et al. (1998) point out that the necessary type and intensity of monitoring often will not be known until a survey or inventory is completed. They note that the types of data collected during surveys may be similar to those collected during monitoring and might be useful for developing a future monitoring study, but the data may not be useful for monitoring itself. We discourage attempts to consolidate mapping and monitoring, even though it may appear to be more cost efficient. We believe it would be better to first conduct an area-wide survey or inventory covering the greatest area of land in the least amount of time and with least cost possible; and then use that information to determine the most logical locations for establishment of long-term monitoring sites.

The terminology and methods used by many weed managers and researchers are expanding as the disciplines of population biology, plant ecology, and traditional weed science merge around the issue of invasive plants (Sakai et al. 2001). Rejmanek et al. (2002) noted growing confusion in the use of ecological terminology in recent literature, calling it “sloppy” and blaming it on “newcomers to the burgeoning field of invasion ecology ignoring existing terminology.” However, some traditional ecological terms, if applied directly to the perspectives and needs of weed managers, may not fit perfectly and might need either clarification or modification.

It is hoped that a better understanding of the terms reviewed here and their critical role in adaptive weed management will help managers and administrators of public lands to communicate more clearly and enjoy even greater success in stopping the spread of invasive weeds.

LITERATURE CITED


