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Science Versus Political Reality in Delisting Criteria for a Threatened Species: The Mexican Spotted Owl Experience

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The Mexican spotted owl (*Strix occidentalis lucida*) was listed as a threatened species under the Endangered Species Act (ESA) in April 1993 (USDI 1993). Concomitant with the listing of the owl, a recovery team was appointed to develop a plan to recover the owl, allowing for its removal from the list of threatened and endangered species. The recovery plan—"the plan"—was completed and accepted by the U.S. Fish and Wildlife Service in 1995 (U.S. Fish and Wildlife Service 1995).

In developing the plan, the recovery team assembled and reviewed all existing information on the ecology of the Mexican spotted owl, existing forest conditions and trends, and potential threats to the owl. Existing information provided a baseline understanding of owl biology and habitat correlates, which provided a basis for the general management recommendations contained within the plan. However, little reliable data were available to assess the status and trend of the owl population or owl habitat.

Consequently, considerable uncertainty existed in whether or not implementation of those recommendations would provide for adequate habitat now and into the future to support a persistent owl population. Rather than recommend cessation of all management activities that constituted possible but uncertain effects,

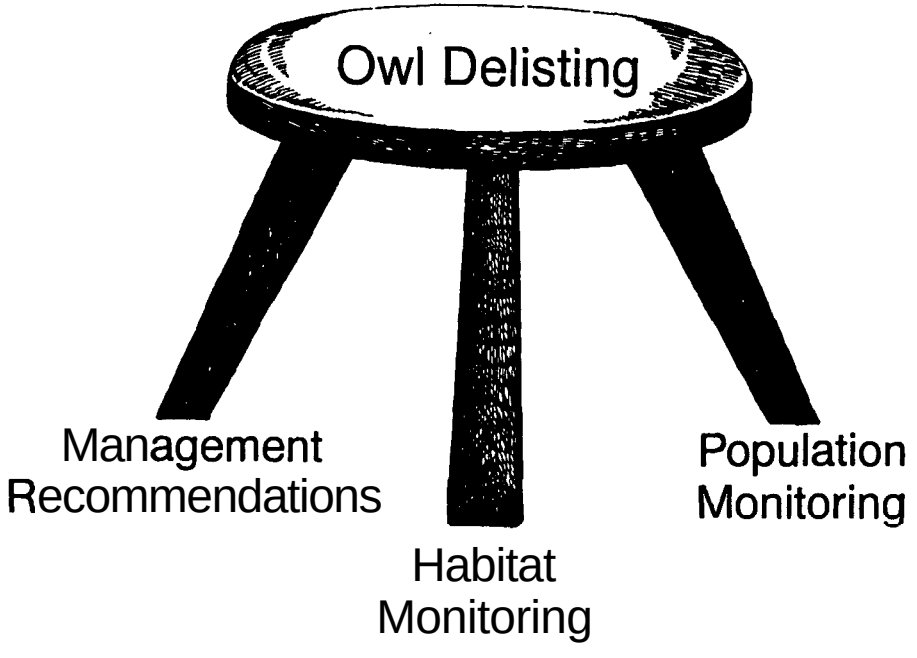

Figure 1. Conceptualization of the Mexican spotted owl recovery plan (USDI 1995) as a three-legged stool (from USDI 1995).

the recovery team developed a more flexible plan that was contingent upon an adaptive philosophy. Therefore, the team characterized this plan as a three-legged stool (Figure 1), with management recommendations, habitat monitoring and population monitoring representing the legs of the stool. Like a stool, if any one of the legs were removed, the recovery plan could fail. This concept was reinforced in the delisting criteria contained within the plan, two of which required strong evidence for stable or increasing habitat and population. Thus, the plan was firmly rooted in the concepts of adaptive management (Walters 1986), whereby efficacy of the management recommendations needed to be actively tracked and adjusted depending on the results of monitoring.

The recovery plan recommendations were formally accepted in an amendment to the Forest Plans for all 11 National Forests in the southwestern region (U.S. Forest Service 1996). Despite this formal adoption, and although the plan was based on the best available science, resource agencies have not completely embraced the recovery plan. Reasons for failure to adopt the plan are numerous, and all need not be detailed here, but much of the opposition centered on reluctance to conduct the monitoring of Mexican spotted owl populations required in the recovery plan. Primary objections concerned the time and money required to implement and conduct the population monitoring required for delisting of the species by the recovery plan.

The objective of this paper is to describe the scientific basis underlying the population monitoring proposed in the recovery plan, steps required for implementation of this program and perceived obstacles to its implementation. Implicit to this objective is a very basic question about whether management of wildlife resources should be based on best available science and reliable knowledge. Prior to addressing this objective, however, we present some relevant background on the Mexican spotted owl and the recovery plan.

Background

Ecology of the Mexican Spotted Owl

Our intent here is to present salient points about the owl that were key considerations in developing management recommendations: detailed reviews of various aspects of the owl's ecology are provided in the recovery plan (U.S. Fish and Wildlife Service 1995). Although the Mexican spotted owl occupies a broad geographic range extending from Utah and Colorado south to central Mexico, it occurs in disjunct localities that correspond to isolated mountain and canyon systems. The current distribution mimics its historical extent, with the exception of its presumed extirpation from some historically occupied riparian ecosystems in Arizona and New Mexico. Of the areas occupied, the densest populations of owls are found in mixed-

conifer forests, with lower numbers occupying pine-oak forests, encinal woodlands, rocky canyons, and other habitats. Habitat-use patterns vary throughout the range of the owl and with respect to owl activity. Much of the geographic variation in habitat use corresponds to differences in regional patterns of vegetation and prey availability. Forests used for roosting and nesting often exhibit mature or old-growth structure; they are uneven-aged, multi-storied, of high canopy closure, and have large trees and snags. Little is known about foraging habitat, although it appears that large trees and decadence in the form of logs and snags are consistent components of forested foraging habitat. The quantity and distribution of owl habitat, as well as of areas that can be expected to support the necessary habitat correlates in the future, are poorly understood. Assessment of habitat quantity and distribution are among the recovery plan recommendations.

With the exception of a few studies of owl demography, little is known of the population ecology of the Mexican spotted owl. The recovery team recognized the limitations of existing data and the inferences that could be drawn from them. Consequently, the team reviewed and re-analyzed those data (White et al. 1995) to estimate population parameters needed for the development of a design that would provide more rigorous and defensible estimates.

Recovery Plan Management Recommendations

As noted above, the recovery plan is cast as a three-legged stool, with management recommendations as one of the three legs. Three levels of management are provided under the general recommendations of the recovery plan: protected areas, restricted areas and other forest and woodland types (Figure 2). Protected areas include all recently occupied nest or roost areas, mixed-conifer and some pine-oak forests with greater than 40 percent slope, where timber harvest has not occurred in the past 20 years, and all legally administered reserved lands (e.g., wilderness). Protected areas receive the highest level of protection. Active management within protected areas should be solely to alleviate threats of catastrophic, stand-replacing fires by using a combination of thinning small trees (less than 22 cm dbh) and prescribed fire.

Restricted areas include mixed-conifer forests, pine-oak forests and riparian areas not included in protected areas. Guidelines for restricted areas are less specific and operate in conjunction with existing management guidelines. Management for the owl should focus on maintaining and enhancing selected restricted areas to become replacement nest and roost habitat, and abating risk of catastrophic fire in much of the restricted habitat. The amount of restricted area to be managed as replacement habitat varies with forest type and location, but ranges between 10 to 25 percent of the restricted area landscape.

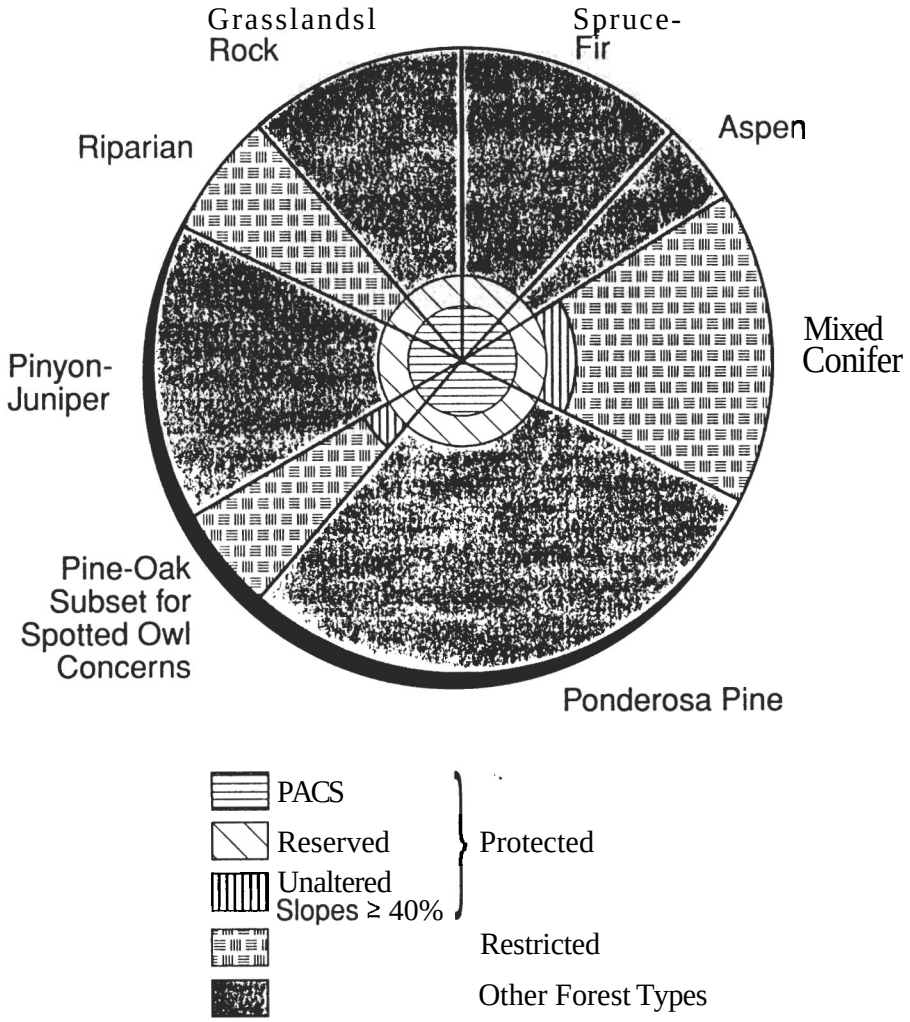

Figure 2. Generalization of the management strategies in the Mexican spotted owl recovery plan (from USDI 1995).

Thus, between 75 to 90 percent of restricted areas can be managed to address other resource objectives.

No specific guidelines are provided for other forest and woodland types outside of protected areas. These other forest and woodland types were primarily ponderosa pine (*Pinus* ponderosa) and spruce-fir (Picea spp./*Abies* spp.) forests, and pinyon-juniper (*Pinus* spp./*Juniperus* spp.) and quaking aspen (*Populus tremuloides*) woodlands. However, some relevant management of these vegetation types may produce desirable results for owl recovery, including management for landscape diversity, mimicking natural disturbance pat-

terns, incorporation of natural variation in stand conditions, retention of special habitat elements such as snags and large trees, and appropriate use of fire.

In addition, some guidelines proposed were related to specific land uses, such as grazing and recreation that apply to all management areas. The team recognized that effects of such activities on spotted owls are not well known, thus advocated monitoring potential effects to provide a basis for more specific recommendations, where warranted.

The recovery team divided the range of the Mexican spotted owl into 11 recovery units—6 in the United States and 5 in Mexico (Figures 3 and 4) (Rinkevich et al. 1995), because aspects of owl ecology, biogeography and management practices varied geographically. Recovery units were based primarily on physiographic provinces and biotic regimes, but perceived threats to owls or their habitat, administrative boundaries and known patterns of owl distribution were also considered in designating recovery units. Three of the U. S. recovery units, Upper Gila Mountains, Basin and Range-East, and Basin and Range-West, include the core populations within the subspecies range (Ward et al. 1995).

By and large the management recommendations in the recovery plan allowed resource agencies considerable latitude in designing and implementing activities. The general philosophy of the team was to protect spotted owl habitat where it existed, and to enhance habitat where appropriate. Whether or not the management recommendations are successful in meeting these objectives could only be measured through habitat and population monitoring, the other two legs of the stool. Without monitoring, there would be no empirical and objective basis for determining whether management guidelines led to desired outcomes, whether plan recommendations need reevaluation in an adaptive management context, or whether the owl should ultimately be delisted.

Delisting Criteria

Delisting the Mexican spotted owl will require meeting five specific criteria (USDI 1995:76-77). Three of these criteria pertain to the entire United States range of the owl, and two are recovery-unit specific. The three range-wide delisting criteria are:

(1) the populations in the Upper Gila Mountains, Basin and Range–East and Basin and Range–West recovery units (the "core" populations) must be shown to be stable or increasing after 10 years of monitoring, using a design with a power of 90 percent to detect a 20 percent decline with a Type I error rate of 0.05;

(2) scientifically-valid habitat monitoring protocols are designed and implemented to verify that (a) gross changes in macrohabitat quantity across the U.S. range of the Mexican spotted owl and (b) microhabitat modifications and trajectories within treated stands meet the intent of the recovery plan; and

(3) a long-term, range-wide management plan in the U.S. engaged to ensure appropriate management of the subspecies and adequate regulation of human activity over time.

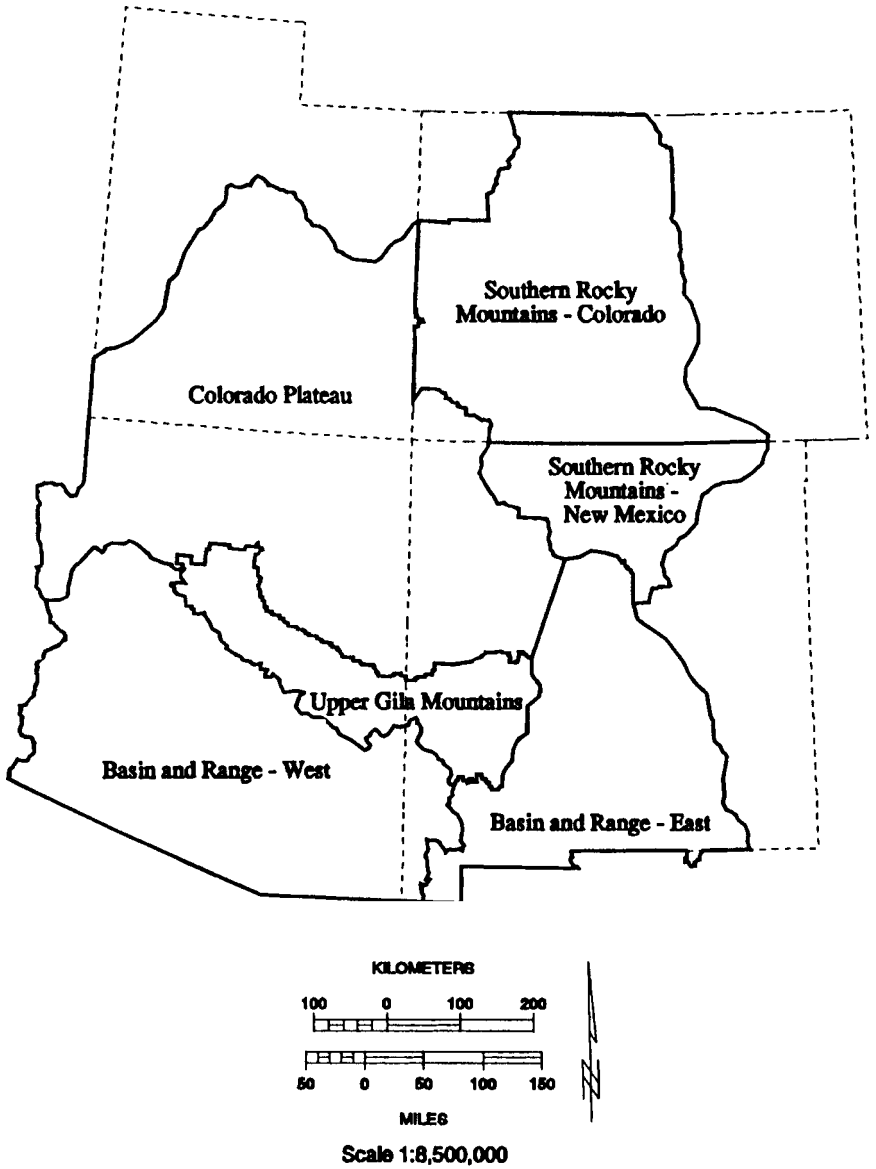

Figure 3. Recovery units designated in the Mexican spotted owl recovery plan for the United States (from USDI 1995).

Once these three criteria have been met, delisting may occur in any of the 11 recovery units that meet the final two criteria:

(4) threats to the Mexican spotted owl within the recovery unit are sufficiently moderated and/or regulated; and

(5) habitat of a quality to sustain persistent populations is stable or increasing within the recovery unit.

Implicit to the philosophy underlying these delisting criteria is the need for reliable, defensible data to (1) assess population status, (2) assess habitat trends, and (3) develop long-term management guidelines. Without such information, the recovery team felt that risks to the threatened owl would be too great to recommend a liberal management regime. As an example of the team's philosophy, we detail the population monitoring approach presented in the recovery plan, and discuss ramifications of failure to implement population monitoring.

Figure 4. Recovery units designated in the Mexican spotted owl recovery plan for Mexico (from USDI 1995).

Population Monitoring

Rationale

The Mexican spotted owl was listed without quantitative knowledge of the population size or trend (USDI 1993). Because no one can reliably estimate how many owls are required for a viable population, the proposed monitoring program focuses on estimating both abundance and population trend. If results of population monitoring indicate that the U. S. population is stable or increasing over the next 10 to 15 years (assuming 10 years prior to delisting followed by 5 years after delisting as required by the ESA), the team is willing to accept that the current population will remain viable in the foreseeable future, given that threats to the population do not re-occur. That is, the team considers evidence that the existing population is maintaining itself as evidence that the population size is ample to persist.

Because the bulk of the Mexican spotted owl population inhabits the Upper Gila Mountains, Basin and Range–East, and Basin and Range–West recovery units (Ward et al. 1995), and because these three recovery units are centralized in the subspecies's range and thus provide the best candidates for assuring the subspecies's persistence, the team felt that considerable monetary savings could be achieved by assuming that population trends these three recovery units represented trends for the population as a whole. Owl populations in the other three U.S. recovery units are lower in density and more widely dispersed, making the cost high and logistics difficult for effective population monitoring. Given the small proportion of the U. S. population that would be monitored in these recovery units, the decision was made to monitor only the three primary recovery units.

The recovery team developed the population delisting parameters using the following justification. The annual rate of change of the population within a recovery unit is $\lambda = N^{t+1}/N^{t}$. A population is stationary if $\lambda = 1$, decreasing if $\lambda < 1$, and increasing if $\lambda > 1$. A 20 percent reduction in the population over a 10-year period implies a value of $\lambda = 0.978$ (i.e., $\lambda^{10} = 0.8$). Because the Endangered Species Act requires a review of the delisting criteria five years after delisting, $\lambda = 0.98523 = 0.8^{(1/15)}$ for a 15-year period To conclude that a population is stationary, the null hypothesis that $\lambda = 1$ must not be rejected. Thus, the 95-percent confidence interval on λ must include 1. The team wanted to ensure that the width of this confidence interval was narrow enough so that failure to detect a decline would only happen if the population was actually declining at a slower, less vulnerable rate. Thus a Type II error rate of 0.10

was used with $\lambda = 0.978$ for delisting after 10 years. That is, the probability of accepting a false null hypothesis of $\lambda = 1$ is 0.1.

For this statistical evaluation of trend in the Mexican spotted owl population, the Type II error rate is more important than the Type I error rate. A Type I error would mean that we mistakenly conclude that the population is declining when in fact it is stable or increasing. Such a mistake would be costly in that unnecessary measures would be taken to reverse the non-existent downward trend. In contrast, a Type II error would mean that we conclude the population is stable or increasing when in fact it is declining. Persistence of the population could be in danger, because measures would not be taken to correct the decline. Thus, the recovery plan emphasizes that a low Type II error rate of $\beta = 0.10$ (power is $1-\beta = 0.90$) must be met to delist the species.

The time span for monitoring and the amount of change required to detect a population decline are related. The time span for monitoring of 10 years prior to delisting and an additional 5 years after delisting allows 70 to 83 percent of the population at the start of monitoring to have been replaced, based on the mean life span of adult owls computed with an observed adult survival rate of 0.8889 (SE = 0.0269) (White et al. 1995). Further, 10 to 15 years would allow the spotted owl population to be subjected to considerable variation in environmental (such as weather) and other extrinsic factors that might influence demographic parameters and population trend. Based on the observed adult survival rate of 0.8889, two years of no recruitment would result in a 21 percent population decline. However, observed recruitment data suggest that two consecutive years of total failure of recruitment are unlikely (White et al. 1995), and adult survival rates are relatively constant across years. Thus, a 20 percent decline over a 10-year period likely indicates the population is truly declining, and is not the result of normal temporal variation in recruitment and adult survival rates.

The choice of a Type II error rate of 0.10 is somewhat arbitrary, but this value interacts with the choice of the amount of decline that is to be detected over the 10-year period. For a given sampling effort, we could specify that a 15 percent change is detectable with 67 percent power, or that a 25 percent change is detectable with a 94 percent power. All are approximately equivalent with respect to sampling effort. Power of 90 percent for a 20 percent decline over 10 years "positions" the curve of statistical power relative to the size of the decline.

Sampling Design

The monitoring program suggested in the recovery plan involves surveying a number of randomly selected sample quadrats throughout the area of interest to estimate changes in Mexican spotted owl population using mark-recapture estimators. Trends in abundance based on this sample are then evaluated relative to the delisting criterion from the recovery plan, given a sufficient sample of quadrats to meet the power requirements.

Based on their evaluation of all previous efforts to monitor populations of spotted owls, especially the methodologies and ideas discussed in Noon et al. (1993), the recovery team recommended:

(1) Surveying for owls on sample quadrats approximately 50 to 75 squared kilometers in size, randomly scattered throughout selected portions of the owls range;

(2) Capturing and color banding all owls located so that individuals could be uniquely identified;

(3) Surveying each quadrat four times, marking and/or resighting owls on each survey, to estimate probability of capture/resighting and size of the breeding population on each quadrat; and

(4) Estimating abundance of owls using capture-recapture models for closed populations (Otis et al. 1978) and analytical features contained in program MARK (White and Burnham in press).

The field methodology needed for collecting monitoring data has been validated by May et al. (1996). The next step for implementing this monitoring program requires that a pilot study be conducted to allow estimation of detection and capture probabilities and the variance in owl density among quadrats. This information will be used to determine the number of quadrats required to satisfy the precision requirements in the delisting criterion. Other issues that will be addressed with the pilot study are the effectiveness of several proposed stratification schemes based on habitat, owl density and elevation, plus the overall feasibility of such large-scale sampling. The expected cost to survey 30 randomly selected quadrats in one recovery unit is approximately $1 million. Once the pilot study is complete, the survey methods will be expanded to include the three recovery units with high owl densities. We anticipate that full execution of the monitoring program will require additional samples and more funds than required for the pilot study.

At the Crossroads: Should Wildlife Management be Science-based Rather than Budget-based?

Management of wildlife has become a paradox in recent times. However, wildlife science has grown exponentially over the past 50 years, especially since passage of the ESA (1973) and the National Forest Management Act (1976). Great strides have been made in the study of wildlife populations (McCullough and Barrett 1992, Thompson et al. 1998) habitats (Vemer et al. 1986, Morrison et al. 1998), and numerous other subject areas. Not only have

these advances increased basic knowledge about selected species, but they have also provided more sophisticated, rigorous, and defensible approaches for addressing wildlife-related questions. Clearly, the need to base management of natural resources, including wildlife, on the best available science is the rhetoric espoused by nearly every resource agency in North America. Yet there appears to be a certain reluctance within these agencies to fully embrace new scientific approaches to monitor and manage wildlife. This stems partly from budget concerns in that more rigorous scientific approaches usually require greater funds to acquire the data needed, but also from institutional resistance to initiating change within many resource-management agencies. We submit that the situation with the Mexican spotted owl in the Southwest illustrates this paradox quite clearly.

There are several advantages of the population monitoring program in the Mexican spotted owl recovery plan. The procedure is scientifically defensible and will provide accurate and precise estimates of population trend. It will also provide an objective criterion for delisting the species according population trend. If the population trend meets the criterion, legal disputes surrounding management and delisting of the owl should be avoided or at least minimized. Alternative monitoring methods, such as night time call indices or direct counts that lack corrections for detection probability, do not provide the scientific rigor to detect real trends in population levels. Currently, promise of a rigorous monitoring scheme has permitted a more flexible management regime; without population monitoring many management activities that might otherwise be enjoined.

A disadvantage of the population monitoring program is that management agencies have not embraced it, primarily because of the cost (roughly more than $1 million per year) and lack of tradition in conducting such large-scale research. Much of the explanation for the high cost of the monitoring program rests with the characteristics of the species. The owl is nocturnal and occurs in low densities throughout its range. Time required to travel, survey, detect, and capture owls in widely spaced territories is expensive. Because of the specialized techniques required to monitor this species, the surveys that will be conducted generally are not useful for providing incidental information on other species, such as goshawks (*Accipiter gentilis*) However, the estimated cost for monitoring Mexican spotted owls is considerably less than the $3.5 million per year ($25.7 million from 1989-1995) spent by state and federal agencies to recover the peregrine falcon (*Falco peregrinus*) or the $8.5 million per year ($59.4 million from 1989-1995) spent to recover the bald eagle (*Haliaeetus leucocephalus*) (U.S. Fish and Wildlife Service 1989-1995). Given the likelihood of fixed or declining budgets, initiating population monitoring is meeting resistance within the agencies because it will require re-orienting priorities towards Mexican spotted owl monitoring. Population monitoring may also limit money that can be used for habitat monitoring and habitat improvement for owls, and for management and monitoring of other threatened and endangered species. From a biological perspective, discovering that the Mexican spotted owl population is declining through monitoring will not provide strategies on how to reverse the decline. Information about a declining population, however, may provide a trigger for the initiation of more conservative management actions and for research specifically designed to understand causes of population declines (USDI 1995:116-120). A more sophisticated design that concurrently monitors trends in population growth and environmental factors could accelerate our understanding of factors that regulate owl populations (Franklin 1997). Although the joint monitoring approach would save time over the long term, it would require additional funds over the short term. However, resistence to funding population monitoring indicates that financial cost rather than technical ability is a significant barrier to obtaining reliable and decisive information.

In summary, gathering the kinds of defensible scientific information necessary for delisting the Mexican spotted owl costs more than management agencies have been able or willing to spend to date. Although these agencies appeal for high-quality information, their budgets and expertise are not keeping up with progress in wildlife science, namely the use of modem methods to monitor populations, and the need for experimental studies to realize cause-and-effect relationships (Romesburg 1981).

Clearly, the wildlife profession has reached a crossroads in the management of wildlife resources, and it is not a decision for us alone to make. The Mexican spotted owl serves as one high-profile example of this decision point. Relevant questions that the wildlife profession needs to address are:

- Should or can the best available science be brought to the forefront in managing wildlife?
- What are the obstacles, and are they real or perceived?
- If the best science cannot be applied to wildlife management, what are the potential risks to the conservation of species, and are those risks acceptable?

As representatives of a profession, we must ask ourselves if we are desiring information beyond society's ability or willingness to pay. Similarly, the American society must clearly define at what level and at what cost they are willing to conserve our natural resources. Failure to adequately address these issues has led and will continue to lead to gridlock in natural resources management. Without adequate data upon which to base sound management policy, we stand a high probability that more and more important natural resource decisions will be made by federal judges.

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