How Good Are Endangered Species Recovery Plans?

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Science should be able to guide management actions intended to help species that are at risk of extinction. One of the best ways to ask whether science is doing this job in conservation is to examine the implementation of the US Endangered Species Act (ESA). The ESA's ultimate goal is to recover listed species (NRC 1995). As part of the recovery process, the ESA requires the US Fish and Wildlife Service (USFWS) or the National Marine Fisheries Service (NMFS) to develop recovery plans for all listed species, unless the agency determines that a recovery plan will not promote the conservation of a particular species (16 USC 1533[f][1]). Recovery plans are the central documents available to decisionmakers and serve as guides for the management and recovery of threatened and endangered species. Because these plans play a critical role in endangered species management, we undertook a systematic and quantitative analysis of recovery plans to evaluate the extent to which scientific principles and analyses were used when designing strategies for species recovery, and whether the presence of solid science was measurably correlated with indicators of plan effectiveness.

Here we present analyses that test four major hypotheses concerning factors we expected, a priori, to influence the effectiveness of recovery plans, as measured by trends in species status (e.g., improving, stable, or declining):

1. Revised plans would be more effective than plans that had never been revised.
2. Recovery plans developed by a diverse group of authors would be more effective than those written only by federal employees.
3. Plans in which recovery criteria (or goals) were explicitly linked to a species' biology would be more effective than those without such links to biology.
4. Multispecies plans would be more effective than single-species plans, because multispecies plans must adopt a broad view of threats and be more integrative.

Hypotheses 1, 2, and 4 were motivated largely by USFWS policy initiatives based on the veracity of those propositions. The USFWS and NMFS issued joint policies addressing the

> THE EFFECTIVENESS OF RECOVERY PLANS FOR ENDANGERED SPECIES CAN BE IMPROVED THROUGH INCORPORATION OF DYNAMIC, EXPLICIT SCIENCE IN THE RECOVERY PROCESS, SUCH AS STRONGLY LINKING SPECIES' BIOLOGY TO RECOVERY CRITERIA

diversification of expertise and background of participants in plan development (USFWS 1994a) and the development of ecosystem plans where multiple listed species, or species that are candidates for listing, co-occur (USFWS 1994b). In addition, official USFWS Recovery Planning Training courses stress that recovery plans should be revised whenever there is significant new information or changes in a species' status (Debby Crouse [USFWS], personal communication, 2001). Hypothesis 3 represents what we considered the most central query regarding the value of science in recovery planning.

Our approach, like that of traditional studies of plant or animal populations, was to collect attribute data on a sample of individuals drawn from the "population" of approved recovery plans. We gleaned generalizations by examining the aggregated data for patterns of covariation among plan attributes or by asking whether there were marked differences among subgroups of the population. Statistical analyses were

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used to determine whether observed patterns in the data were significant (i.e., unlikely to be attributable to sampling error or recording/observation error). The key advantage to this approach was its power to detect statistically significant population-level patterns and trends among individual-level data on plan attributes.

Using a detailed questionnaire to characterize recovery plans

The first step in our analysis was to draw a random post-stratified sample of recovery plans for the 931 listed species for which the USFWS had primary responsibility as of 1998. The sample plans were selected to produce a reasonable number of plans in key groupings, defined by year of plan completion, taxon, single-species versus multispecies plans, and unrevised versus revised plans. Completion dates of the sample plans ranged from 1977 to 1998. The plans covered 85 plant and 96 animal species. We included species from 100 single-species plans, 29 multispecies plans, and six ecosystem recovery plans. Last, plans for 68 species had been revised while those for 113 species were unrevised at the time of our review. Our sample represented nearly 20% of all listed species for which a recovery plan had been approved as of December 1998.

The second step in our analysis was to develop a data collection method that would consistently and comprehensively characterize the attributes and content of individual recovery plans so that we could draw reliable generalizations about recovery plans as a group. To standardize effort and to minimize subjectivity, we used a detailed questionnaire that asked reviewers to record specific data about each plan. First, the queries solicited general descriptive information about the plan, such as plan length, length of time between listing and completion of the recovery plan, composition of the recovery team, and number of species covered by the plan. The questionnaire then solicited detailed data regarding available information on the species' biology and natural history, threats to the species, prescribed management actions, monitoring protocols, plan administration and implementation, and criteria against which recovery is measured. The questionnaire was developed in a graduate seminar at the University of Washington, and then refined and finalized at a workshop hosted by the USFWS and attended by conservation biologists, managers and scientists from the USFWS, academic scientists, and representatives of environmental organizations and private business.

The questionnaire required reviewers of a recovery plan to consider more than 2600 specific questions about the attributes and content of that plan. Only information contained in the recovery plan and the original listing document for the species was used to determine the response to each question. This restriction standardized the scope of the review. To limit subjectivity and facilitate quantitative analysis of the data, answers to the questions were coded according to a list of standardized responses appropriate to each question (e.g., yes or no; a set of categorical responses, such as taxonomic group; or a series of ordered factors that reflected relative ranking or magnitude, such as the intensity of a threat to a species). Some questions required a count or tabulation, and others required a descriptive response. Special response codes were also available for all questions in the event that a question was not applicable or not answerable for a particular recovery plan. Questions were focused to reduce potential ambiguity, though some subjectivity was unavoidable for queries about qualitative attributes. (The questionnaire and the database of responses on which our analyses are based are on the Internet at *www.nceas.ucsb.edu/recovery*.)

The job of reviewing the sampled recovery plans and collecting data with the questionnaire was accomplished through a collaboration of 20 graduate seminars at 19 universities across the United States (a total of more than 325 researchers) during the first half of 1999. Each seminar group reviewed five to 10 recovery plans and submitted their data for incorporation in a single large database.

To calibrate data collection for their subsamples of plans and to clarify ambiguous or vague questions, seminar participants at the different universities first reviewed the recovery plan for the Hawaii tree cotton (*Kokia drynarioides*). Responses from this first application of the questionnaire suggested that overall data collection was consistent and well calibrated: Responses to 37% of the questions were at least 94% consistent (i.e., no more than one university recorded a different response), and responses to 68% of the questions were at least 75% consistent (i.e., at least 14 of 18 universities recorded identical responses). For the analysis of data from the sampled recovery plans, we excluded questions that yielded highly inconsistent responses. For example, we discarded a series of questions about the expected costs of recovery tasks because recovery plans did not uniformly present economic projections, making consistent data collection difficult and meaningful comparisons impossible. (For a more detailed description and discussion of recovery plan review methods and data consistency, see Hoekstra et al. forthcoming.)

Adopting USFWS trend categories as measures of plan effectiveness

To identify "effective" attributes of recovery plans, we selected a measure of plan effectiveness and assessed our sample recovery plans against it. The definitive measure would be recovery itself, but too few species have recovered enough to allow delisting to be the benchmark (only 11 species had been delisted as of 2000 [USFWS 2000a]). We therefore quantified plan effectiveness according to the "trend" category—improving, stable, declining, extinct, or unknown—that USFWS assigns to each listed species in biennial reports to Congress, which are required under the ESA. According to the latest report (issued in May 1999 and current as of 1996), 44% of the species covered in our sample of recovery plans were classified as either stable or improving; the remainder were either declining, extinct, or unknown (USFWS 1999). We expected that the status trends of species with more effective recovery plans would more likely be stable or improving than declining. This difference should be more apparent for older recovery plans that have had more time for implementation than for recent plans that may not have yet effected measurable improvements in species' status. For all of our analyses, plans that were completed during or before 1990 were considered "early" and those completed after 1990 were considered "recent." This division was selected because 1990 marked implementation of new regulations amending the recovery planning process.

Using these trend data—or any other index, for that matter—as measures of recovery plan effectiveness underscores the importance of basing these assessments on the most rigorous possible foundation. The assignment of species to a particular trend category often reflects little more than the judgment of a species expert or other USFWS personnel; nevertheless, it represents the best estimate available. Additionally, many factors besides the recovery plan may contribute to the trend in a species' status, such that a species may persistently decline despite having a scientifically sound recovery plan. If more quantitative and carefully documented trend data were placed biennially in a national database for threatened and endangered species, less equivocal measures of plan effectiveness could be defined and more refined analyses could be conducted. For example, we would have liked to analyze whether a species' trend category had improved (e.g., been upgraded from declining to stable) after completion of a recovery plan. Unfortunately, biennial reporting of species trends was initiated only in 1990, allowing too little time (at most 6 years) to register improvements and too few data with which to perform such an analysis.

Recovery plans have not improved with revision

One aspect of effective recovery planning is the ability to adjust course in response to new information or changed conditions. Thus, when new information becomes available or in response to a change in a species' status, plan revision could obviously improve plan effectiveness. Among all plans, species with revised recovery plans were significantly more likely to show an improving status trend than were species for which plans remained unrevised (Figure 1a, $G = 10.1$, $p < .01$). However, recovery plans that had been revised were generally older than unrevised plans, so the improvement in status trend could have been an artifact of plan age. The general pattern persisted when recovery plans completed after 1990 were excluded from the comparison, but it was not statistically significant (Figure 1b, $G = 0.68$, $p = .71$), suggesting that—contrary to our expectation—time, not plan revisions, was associated with improved species status trends. One explanation may be that recovery plans revisions are a response to, rather than a cause of, changes in species' status (D. Crouse [USFWS], personal communication, 2001). Furthermore, although revised recovery plans included more information on species biology and threats, they did not show improvements in how that information informed management actions, monitoring protocols, or recovery criteria (Harvey et al. forthcoming). Thus, the expected benefits of plan revisions are not being realized in practice.

Nonfederal participation in recovery plan development has a positive impact

As previously mentioned, in 1994 the USFWS and NMFS issued a joint policy officially endorsing diversification of interests and expertise among those participating in recovery plan development (USFWS 1994a). This policy could improve the effectiveness of recovery plans by ensuring that concerns of affected parties are addressed and thereby promoting a broader base of support for plan implementation. To test that assumption, we compared status trends of species whose plans were written solely by federal employees against trends of species whose plans were written by groups that included

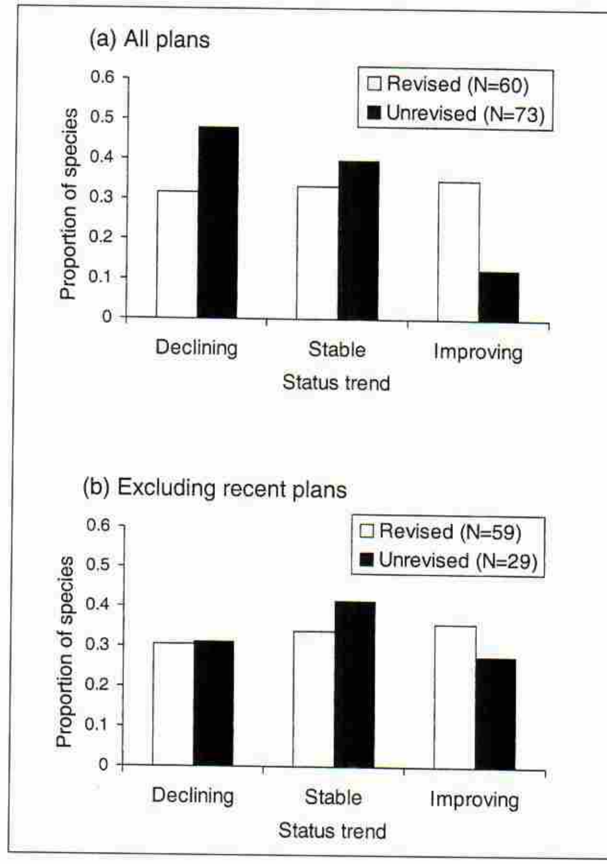

Figure 1. Frequency distributions of status trend categories for species covered by revised versus unrevised recovery plans. Species for which status trends were unknown or extinct were excluded. Figure 1a represents data for all recovery plans in our sample. Figure 1b excludes status trend data for recent recovery plans (those approved after 1990). Among all recovery plans, species covered by revised recovery plans appeared significantly more likely to have improving status trends ($G = 10.1$, $p < .01$), but the difference disappeared when recent plans were excluded from analysis ($G = 0.68$, $p = .71$).

nonfederal participants. Among all recovery plans, species covered by plans written with nonfederal participants were much more likely to exhibit improving status trends than species for which plans had been written only by federal employees ($G = 6.45, p < .04$). However, the difference in trend was only marginally significant among earlier plans (Figure 2a, $G = 5.17, p < .08$) and not significant among recent plans (Figure 2b, $G = 1.40, p = .50$). Nonetheless, these results are consistent with our expectations regarding the influence of nonfederal participation in plan development and the relative magnitude of that effect in early versus recent plans. No other feature of plan authorship had such a strong impact on the apparent effectiveness of recovery plans. Moreover, this was not simply a matter of more authors yielding better plans, because there was no relationship between the number of authors and status trends. One possible explanation for this pattern is that participation by nonfederal parties, particularly academic scientists, promotes incorporation of the most up-to-date scientific information into recovery plans (Gerber and Schultz forthcoming).

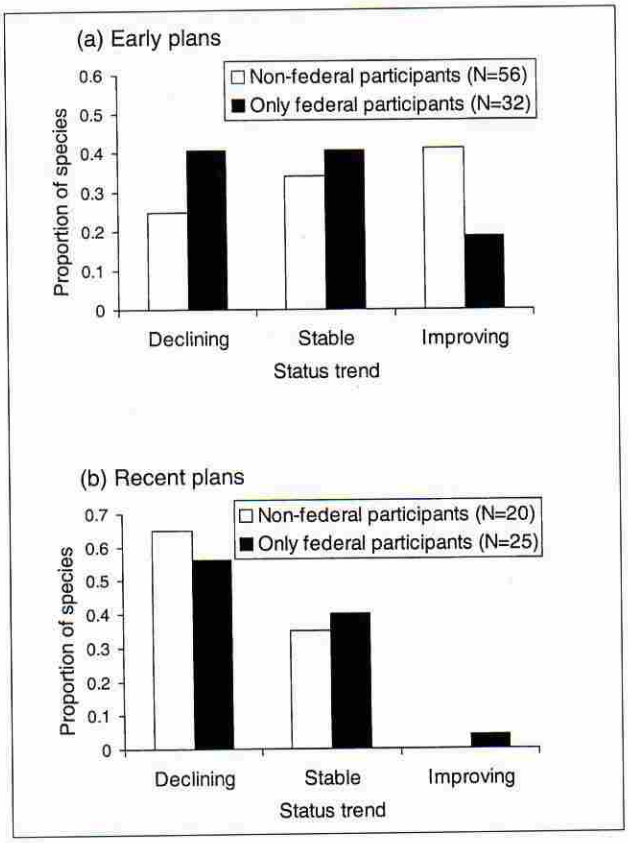

Figure 2. Frequency distributions of status trend categories for species whose plans were developed with nonfederal participants versus plans developed only by federal employees. Species for which status trends were unknown or extinct were excluded. Figure 2a represents data for early recovery plans (those approved during or before 1990). Figure 2b represents data for recent recovery plans (those approved after 1990). Among early recovery plans, species covered by plans developed with nonfederal participants appeared more likely to have improving status trends, though the difference was only marginally significant ($G = 5.17, p < .08$). There was no difference in species' status trends among recently approved recovery plans developed with or without nonfederal participants ($G = 1.40, p = .50$).

The value of linking recovery goals to species biology

Recovery plans that are tailored to a species' biology should be more effective. To test this hypothesis, we explored how well biology is incorporated into recovery plans. One indicator of how well recovery plans incorporate biological information and understanding is the extent to which recovery goals for a species are related to the species' natural history and ecology. We expected that recovery plans in which recovery criteria were clearly linked to species' biology would be more likely than others to be associated with improving species status trends.

To quantify how clearly recovery goals were linked to species biology, we calculated an aggregate "linkage score" for each reviewed recovery plan. For each of 15 possible recovery metrics (e.g., population size, population trends, range size, habitat quality), plan reviewers ranked the influence of biological information as unclear, somewhat clear, or very clear based on the material presented in the recovery plan. No rank was given if a criterion was not used in the plan.

If all recovery criteria in a plan were ranked as "unclear," that plan was assigned a "no linkage" score. If at least one of the criteria in a plan was ranked as "somewhat clear" or "very clear," the plan was assigned a "some linkage" score. We then compared status trends for species whose recovery plans had "no linkage" versus "some linkage" between recovery criteria and species' biology. Among earlier recovery plans, "some linkage" scores were significantly associated with improving species status trends (Figure 3a, $G = 6.35, p = 0.04$), strongly suggesting that clear connections between species' biology and recovery goals could contribute to recovery plan effectiveness. "No linkage" scores may be an unavoidable consequence of a lack of relevant biological information (e.g., Kareiva et al. 1999), and such a limitation may also make it less likely that a species' status can be improved. This reasoning only reinforces our conclusion that clear links between species biology and recovery goals are critical for effective recovery planning (see also Gerber and Hatch n.d.).

Surprisingly, among recent plans, the association between linkage and species' status trends was marginally significant in the opposite direction: Species whose plans had better linkage scores were more likely to be declining (Figure 3b, $G = 5.47, p < 0.07$). Considering that recent plans had relatively little time in which to effect substantial improvements in species' status, we interpreted this result as a positive indication that recovery plan authors emphasized links to species biology in tougher cases—that is, where species were more likely to exhibit declining trends. Time will tell whether this

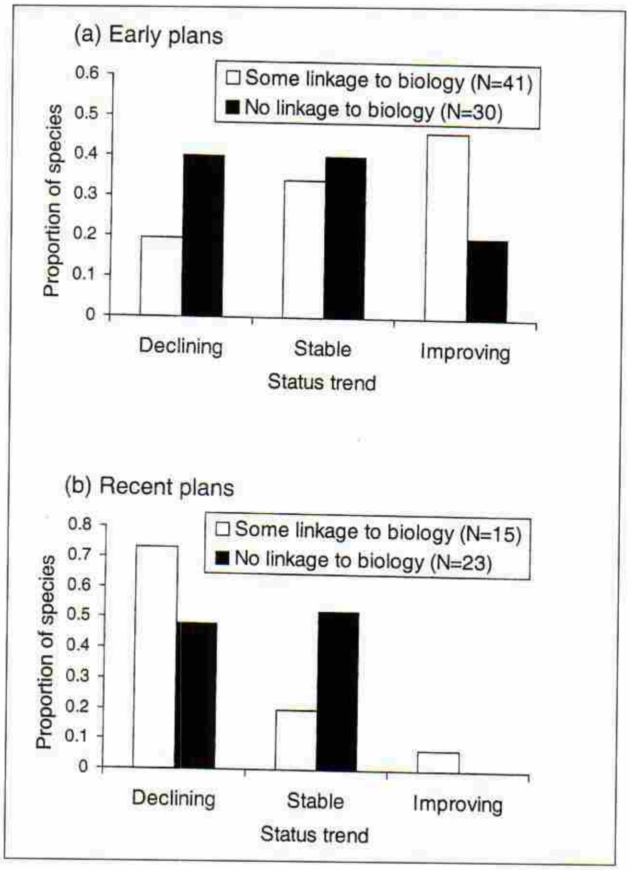

Figure 3. Frequency distributions of status trend categories for species whose plans had better versus poorer links to species biology. Species for which status trends were unknown or extinct were excluded. Figure 3a represents data for early recovery plans (those approved during or before 1990). Figure 3b represents data for recent recovery plans (those approved after 1990). Among early recovery plans, species whose plans had better links to biology were more likely to have improving status trends (G = 6.35, p = .04). Among recent recovery plans, the pattern was marginally significant but in the opposite direction (G = 5.47, p < .07). We interpreted this as a positive indication that greater attention was paid to biological links in recovery plans for declining species.

interpretation is borne out by improved species status trends in the future.

Multispecies plans are less effective than single-species plans

Another result that contradicted our expectations concerned the effectiveness of multispecies versus single-species recovery plans. Increasingly, the USFWS has developed recovery plans that address multiple species simultaneously (USFWS 1994b). This policy transition makes intuitive sense when listed species co-occur in a geographic area, are taxonomically related, or face similar threats, because a multispecies or ecosystem-based recovery plan can coordinate and integrate recovery efforts efficiently. However, our analysis revealed that, among earlier plans, species covered under multispecies plans were almost four times less likely to exhibit improving status trends than were species covered by single-species plans (Figure 4a, $G = 15.1, p < .001$). There was no significant difference in status trends between more recent single-species and multispecies trends (Figure 4b, $G = 1.46, p = .48$), suggesting that the former pattern is not an artifact of multispecies plans covering species with poorer status trends. These results do not necessarily mean that multispecies and ecosystem plans are inherently ineffective. The effectiveness of these plans may be limited because less time and money is spent per species. If this in turn reduces the linkage between recovery goals and the biology of individual species, one would expect species to fare less well. Thus, as multispecies and ecosystem

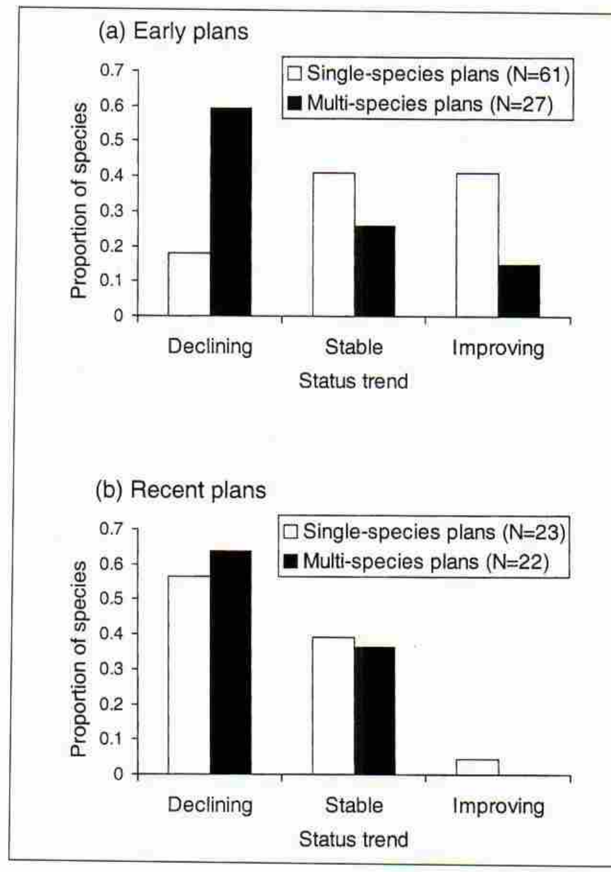

Figure 4. Frequency distributions of status trend categories for species covered under single-species versus multispecies recovery plans. Species for which status trends were unknown or extinct were excluded. Figure 4a represents data for early recovery plans (those approved during or before 1990). Figure 4b represents data for recent recovery plans (those approved after 1990). Among early recovery plans, species covered under single-species recovery plans were more likely to have improving status trends (G = 15.1, p < .001). There was no difference in species' status trends among recently approved single-species and multispecies recovery plans (G = 1.46, p = .48).

plans are developed, careful attention must be paid to ensure that efficiency is not achieved at the expense of thoroughness or explicit science.

Management actions are not sufficiently monitored

In addition to testing hypotheses regarding plan effectiveness, we evaluated how consistently recovery actions were monitored. Other studies of endangered species management plans concluded that monitoring protocols are often not clearly described or designed (James 1999, Kareiva et al. 1999). Recovery plans typically propose from one to a dozen different management actions. We asked what fraction of management actions was to be monitored to determine whether the actions had desired effects. For each of 24 categories of management action, the questionnaire asked whether or not the effects of the management actions were to be monitored. For our analyses, we lumped the 24 management action categories into five broader classes. If any management actions within a class were to be monitored, we considered the whole class of actions to be monitored. On average, only 55% (± 3% standard error, or SE) of the management action classes in a plan were monitored. Given uncertainty about the effectiveness of many different management actions and the clarion call by scientists and policymakers alike for adaptive management (Smallwood et al. 2000, USFWS 2000b), this figure is disturbingly low. One cannot possibly know whether management is working and whether it needs to be adaptively altered unless its effects are monitored.

Plans take too long to complete, and longer plans are not more effective

During our analyses we also summarized some key plan attributes to describe the "population of recovery plans" approved by USFWS. From these summaries, we concluded that recovery plans take a long time to write, and that length of time is growing. We calculated the lag time between the date a species was listed under the ESA and the date of recovery plan approval. Plans completed during or before 1990 had an average lag time of 3.1 years (± 0.2 SE), whereas plans completed after 1990 had an average lag time of 5.1 years (± 0.5 SE).

Another interesting finding was that plans varied enormously in their number of pages (range: 14 to 432 pages, mean = 104 pages ±7 SE). However, lengthy plans were by no means more likely to be effective. In fact, plans for species with declining status trends averaged more than 1.5 times the length of plans for species with improving or stable status trends. One interpretation of this pattern is that species in greatest peril (and thus least likely to exhibit an improving status trend) may require longer plans to provide sufficiently detailed guidance for management and recovery. Alternatively, longer plans may simply take longer to write and may, as a consequence of undisciplined writing, include unneeded management actions (Schemske et al. 1994). Thus, writing a longer plan could be counterproductive because it delays implementation and clouds prioritization of management actions. Clearly the trade-offs between (a) providing necessary detail to link biology and recovery goals and (b) producing a succinct document in a timely manner need to be carefully considered case by case during recovery plan development.

Human impacts and the challenge of improving recovery plans

Species endangerment occurs for many reasons, but analysis after analysis suggests that human-caused habitat loss is the primary factor putting species at risk of extinction (see, e.g., Wilcove et al. 1998, Czech et al. 2000). Furthermore, both human populations and resource consumption continue to increase, suggesting that pressures on endangered species are likely to get worse, not better, and that successful recovery of species threatened with extinction will become increasingly difficult.

Protecting threatened species is a matter of choice. Conservation biology can identify those choices that should yield the greatest benefits to species at the lowest cost to humans. It does not require any science to conclude that if we reduced the human population and halted human economic development, we could probably recover many species. In the real world, however, we need science for recovery planning because such simple solutions are not available. Instead, we must establish practical, yet biologically valid, recovery plans that reverse downward trends in the populations of endangered species while the world experiences an upward trend in the human population and its collective impacts.

Our analyses suggest several ways in which the science of recovery planning could be improved. First, the opportunities for adaptive management when recovery plans are revised must be seized. Clearly, plans that remain unrevised run the risk of becoming irrelevant as time passes and species' status changes. But it is equally tragic for plans to be revised without capitalizing on improved information and understanding, which should promote more effective recovery planning. Second, the newly promulgated policy endorsing diversification of participants in recovery plan development should be vigorously pursued. We suspect that involvement of diverse participants encourages greater investment in the planning process and greater commitment to effective implementation, both of which ultimately promote eventual improvements in species' status. Third, recovery criteria must be clearly linked to species biology to ensure that recovery plans are appropriately suited to each species' situation. Plans that simply invoke general platitudes of ecology or conservation biology are not likely to succeed. Finally, the policy encouraging development of multispecies and ecosystem-based recovery plans should be scrutinized to ensure that promised efficiencies do not come at the expense of insightful analysis and strategy. To achieve both efficiency and effectiveness, we think, requires enough funding and personnel resources for the recovery planning process to ensure that each species in the plan gets adequate attention. Unfortunately, there are no data that enable us to quantify planning expenditures and thereby test this assertion.

Many scientists have commented on the presumptive failings and weaknesses of recovery plans (Tear et al. 1993, Clark 1994, Schemske et al. 1994, Foin et al. 1998), but ours is the first study to analytically identify ways to improve recovery plan effectiveness. The lesson is clear: Statistical evidence shows that dynamic and explicit science can improve the recovery process. Perhaps more important, it is also clear from our analyses that a much finer resolution of the hypotheses posed would be possible if trend data for species were more quantitative and more reliably accurate. Recovery planning is a joint process involving federal and state agencies and private stakeholders. In this age of "government accountability," we ought to ask whether recovery plans are working. To do otherwise is irresponsible. Yet we can find out whether recovery planning efforts are working only if we collect better quantitative data on the population trends of threatened and endangered species.

Recovery plans are themselves experiments in management. As such, their success needs to be carefully monitored so that we can know when to delist species and learn which management actions work under different circumstances. Ultimately, effective use of science in individual recovery plans offers the greatest potential for successfully—and cost effectively—conserving and recovering threatened and endangered species.

Acknowledgments

This study was funded by the Society for Conservation Biology; the US Fish and Wildlife Service; and the National Center for Ecological Analysis and Synthesis, a center funded by the National Science Foundation (Grant DEB 94-21535), the State of California, and the University of California–Santa Barbara. The project director was Dee Boersma. Jeff Bradley, Debby Crouse, William Fagan, Jon Hoekstra, Peter Kareiva, Julie Miller, Gordon Orians, and Jim Regetz all made significant contributions to various parts of the project. A complete list of the more than 325 seminar and workshop participants who reviewed the recovery plans can be found at the Web site *www.nceas.ucsb.edu/recovery/acknowledgments*. Without their efforts, this paper could not have been written.

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