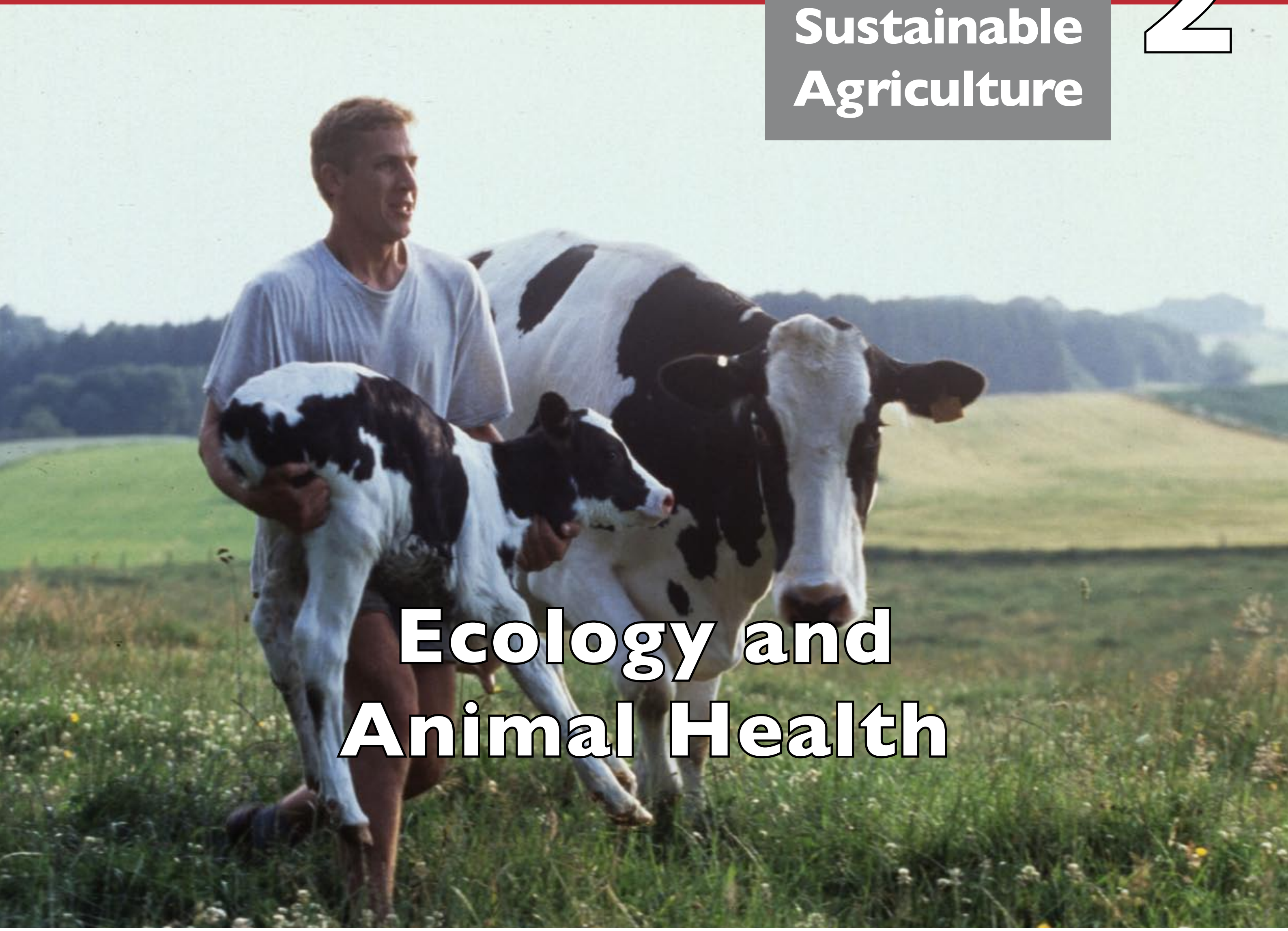
Ecosystem Health and Sustainable Agriculture 2



Ecology and Animal Health

Editors: Leif Norrgren and Jeffrey M. Levengood

Baltic University Press

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Facilitating Recovery of Threatened and Endangered Species

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Introduction

The global biodiversity crisis has been discussed at length in the natural resource conservation community. Despite this familiarity, however, the grim statistics remain alarming. Of those species groups that have been almost completely evaluated using the IUCN's Red Listing process – mammals, birds, amphibians, and gymnosperms – nearly 20% of all described species are classified as threatened with extinction (http://www.iucnredlist.org/info/stats, accessed May 2008). Moreover, the number of threatened species in each of these groups (with the exception of mammals) has increased since 1996. Most notable in this regard are the amphibians, which have seen a meteoric rise in threatened status in just the past few years. This revelation has emerged from an effort to catalogue the world's amphibian biodiversity and to assess the true threat posed by the fairly recent introduction of disease by chytrid fungus infection around the world (http://www.globalamphibians.org, accessed May 2008). We can draw only one conclusion from even a brief review of data such as these: An abundance of the world's species are threatened by mankind's activities on our planet, and the situation is getting worse.

We now focus our attention on the United States for a more in-depth look at the issue of endangered species identification and management. The Unites States Fish and Wildlife Service (USFWS) is the federal agency responsible for conserving, protecting, and enhancing fish, wildlife and plants and their habitats for the continued benefit of the American people. The Service's Endangered Species Program oversees the identification of threatened and endangered species within the country, as well as the process of developing strategies to prevent extinction of the species within its range. The primary tool to achieve this is the Unites States Endangered Species Act (ESA), which was originally drafted in 1973. The primary goal of the ESA is to protect threatened and endangered species to the extent that they are no longer endangered or threatened (NRC, 1995).

As of May 2008, the ESA has been used to list a total of 1,353 species (609 animals, 744 plants) as either threatened or endangered in the US. Effective conservation management of these taxa requires detailed guidelines for identifying the threats to species survival, and for specific actions that can be taken to minimize the impact of these threats. Within the context of the ESA, these guidelines are collectively knows as *recovery plans*. In 1978, the United States Congress amended the ESA to require that the USFWS (or its marine analog, the National Marine Fisheries Service) develop and implement recovery plans for all listed species. This amendment was received with great enthusiasm within the broad conservation community, as effective recovery of threatened and endangered species was now seen as a more tangible process.

Since the species listing process began in the late 1960's upon passage of a precursor law to the ESA, only nine listed species have been declared extinct. Despite this one measure of success, realization of the larger goal of broad species recovery has been problematic at best. As of May 2008, 19 species within the US have been reclassified from endangered to threatened (downlisted) and 15 species have been removed from the list altogether through active recovery (delisted). In contrast, as of the same date of analysis more than 250 species are candidates for addition to the endangered species list, with a few additional species currently being proposed for entering the listing process. Statistics like these have prompted many critics of the ESA to claim that the law facilitates adding species to the list, but does a poor job of creating conditions that are suitable to taking them off the list. More to the point, they doubt whether this piece of legislation – called by many the world's strongest conservation law – is effective enough to justify its continued use.

The goal of this chapter is to review the concept of endangered species recovery as defined within the context of the Unites States recovery planning process; to evaluate the strengths and weaknesses of this process; and to discuss ways in which endangered species recovery methodologies can be strengthened with existing tools used both within and, sometimes, outside the traditional professional conservation biology community.

What is a Recovery Plan?

The US Fish and Wildlife Service defines *recovery* as a process by which threats to a species' continued persistence are reduced or removed, thereby ensuring the long-term survival of the species in its wild habitat through population growth to more stable numbers. To recover a species, the Service will create a Recovery Team that is mandated to create a recovery plan, ideally within 2-3 years of the date of listing. Recovery plans provide a sort of guidebook that outlines the threats facing the species of concern, and specific management recommendations targeted at the federal, state, and/or local governmental level that will lead to mitigation of the identified threats. More importantly, additional recommendations are created that engage private citizens and organizations in the larger conservation effort. This is very important to the successful recovery of many endangered and threatened species in the United States, as significant portions of a species' habitat is often found on private land. Through this emphasis on public and private opportunities for action, USFWS strives to ensure a truly collaborative environment for fostering creative solutions to today's biodiversity conservation needs.

Ideally, a species recovery plan should serve the following purposes (USFWS, 2004):

- Delineate those aspects of the species' biology, life history, and threats that are pertinent to its endangerment and recovery.
- Outline and justify a strategy to achieve recovery.
- Identify the actions necessary to achieve recovery of the species.
- Identify goals and criteria by which to measure the species' achievement of recovery.

Recovery plans can also serve the following secondary functions:

- Serve as outreach tools by articulating the reasons for a species' endangerment, as well as why the particular suite of recovery actions described is the most effective and efficient approach to achieving recovery for the species.
- Help potential cooperators and partners understand the rationale behind the recovery actions identified, and assist them in identifying how they can facilitate the species' recovery.
- Serve as a tool for monitoring recovery activities.

- Be used to obtain funding for USFWS and its partners by identifying necessary recovery actions and their relative priority in the recovery process.

Interestingly, no agency or other entity is required to actually implement the recovery strategy or any of the specific actions defined in the recovery plan. In other words, *a recovery plan is a guidance document, and not a regulatory document*. However, the ESA is written so that the recovery plan is recognized as the central organizing tool for identifying and guiding the management activities required to facilitate endangered species recovery.

As will be discussed in more detail below, the rigor of a specific recovery plan is dependent in part on the breadth and depth of scientific and other information used in the analysis. Those responsible for writing the ESA recognized this, and included a section in the Act that authorizes revision of a recovery plan when new information surfaces or when a change in species status is warranted. This represents a practical application of the familiar adaptive management approach to conservation – an approach explicitly designed to promote flexibility in the identification of important species management guidelines when new information frequently arises.

Important Elements of a Recovery Plan
The following list highlights a subset of components that make up an effective recovery plan, listed in the intended order of their presentation as outlined in the USFWS Recovery Planning Guidance Document (USFWS, 2004):

- <u>Background Information on Species and its Habitat</u>
  This section provides the fundamental information on the species' description and taxonomy; conservation status; population trends and distribution; life history/ecology; and habitat characteristics. Taken together, this review of available literature should provide a single source of biological information on the species.

- <u>Designation of Critical Habitat</u>
  Section 3(5)(A) of the ESA mandates that critical habitat be designated for each species at the time of formal listing. Critical habitat is defined as "*…the specific areas…on which are found those physical or biological features essential to the conservation of the species and which may require special management considerations or protection…*" This section is to lay out the type and extent of critical habitat, and the date when it was designated.

- <u>Reasons for Listing / Threat Assessment</u>
  This critical plan element should summarize the causes of species decline, and should also provide detailed information of the sources of those threats causing the decline. For example, habitat destruction could be a major threat for a given species, with the destruction occurring through agroconversion, commercial logging, etc. Threats included here should be discussed in the context of the five listing factors identified by the ESA:
  - The present or threatened destruction, modification, or curtailment of a species' habitat or range.
  - Overutilization for commercial, recreational, scientific or educational purposes.
  - Disease or predation.
  - The inadequacy of existing regulatory mechanisms.
  - Other natural or manmade factors affecting its continued existence.

  This section should also include a threat assessment: A formal approach to identifying threats to the focal species, the sources of the threats, and their relative contribution to compromising the species' status in the wild. This assessment usually results in a table that summarizes information on each threat, and can be invaluable in providing a single consistent source of threat data to all stakeholders in a species recovery planning process.

- <u>Recovery Strategy</u>
  The Recovery Strategy presents a summary of the Recovery Program for the focal species, based on the Background information presented earlier in the plan. This summary should be limited to just a few short paragraphs and should identify the key facts and assumptions underlying the proposed Program, the primary focus of the recovery effort (i.e., invasive species control or disease management), the overarching objectives of the program, and the identification of and rationale for specific recovery units (subpopulations) if appropriate. While this section may be com-

paratively short, it is extremely valuable for linking the species biological and human social information to the details of the upcoming recovery program.

- Recovery Goals
  The long-term goals of the Recovery Program are specified here. Nearly all endangered species recovery programs have recovery (delisting) of the species as the ultimate goal. For those species formally listed as endangered, downlisting to threatened status can be listed as an intermediate goal to recovery.

- Recovery Objectives
  Each Recovery Goal can be subdivided into specific objectives that describe the condition necessary to achieving the Recovery Goal. For example, a Recovery Objective could be the maintenance of adequate breeding habitat to ensure high levels of reproductive success and, by extension, minimize inbreeding depression.

- Recovery Criteria
  In order to determine if a specific Recovery Objective has been completed, specific parameters must be fulfilled. These parameters are defined as Recovery Criteria. These criteria provide the targets by which progress towards achieving recovery can be measured. The criteria should be objective and measurable and, where appropriate, should be written in reference to the five listing factors described above.
  An example of Recovery Objectives and associated Criteria is given in Table 2.1.

- Recovery Program
  The Recovery Program section details the individual actions that are necessary to achieve the Recovery Objectives, and the monitoring programs required to track the efficacy of these actions. The actions described in this section should be action-oriented, and targeted to a level of detail that facilitates proper funding from the appropriate authorities. In addition, the narrative that describes the Program should include actions for conservation in the short-term – in other words, those that prevent extinction of the species within the next five to ten years – and those that lead to long-term recovery through downlisting or delisting. Recovery actions must also include specific actions to control each of the threats to the species identified in the Threat Assessment, as categorized under the five listing factors of the ESA.
  An example of actions included in a Recovery Program narrative is given in Table 2.2.

- Implementation Schedule and Cost Estimates
  Section 4 of the ESA explicitly states that recovery plans must include "…estimates of the time required and the cost to carry out those measures needed to achieve the plan's goal and to achieve intermediate steps toward that goal". The Implementation Schedule is designed to fulfill this need. Importantly, the Schedule must identify responsible parties to complete the individual actions, ideally so that management authorities can track the completion of the actions within the stated timeline. Each action is given a priority score from 1 (prevent extinction or irreversible decline) to 3 (achieve full long-term recovery) within the Schedule, and the actions are then listed in this order to clearly outline which actions must be taken more urgently.

An Evaluation of Endangered Species Recovery Plans: How Good Are They?

The Endangered Species Act has come under considerable scrutiny and outright criticism for many years. Finally, in the mid-1990's a number of proposals were introduced that would have dramatically restructured the Act – resulting in, among other things, an increased role for the recovery planning process and their associated recovery plans. In response to these proposals, many institutions were very interested in an evaluation of the rigor of recovery plans and their ultimate value to the conservation of biodiversity within the United States.

Unfortunately, such an independent assessment of recovery plans had not yet been conducted. In response to this identified need, the Society for Conservation Biology (SCB) proposed a comprehensive evaluation of endangered species recovery plans. This review would

Table 2.1. Example subset of Recovery Objectives and Criteria, adapted from the Recovery Plan for the Sierra Nevada Bighorn Sheep (approved September, 2007). Source: United States Fish and Wildlife Service, 2007.

Recovery Objective
Attain population sizes and geographical distribution of bighorn sheep in the Sierra Nevada that assure long-term viability of the overall population and thereby allow its delisting as an endangered species.
Recovery Criteria
Downlisting A minimum of 50 yearling and adult females exist in the Kern Recovery Unit (Great Western Divide), 155 in the Southern Recovery Unit (Olancha Peak to Coyote Ridge), 50 in the Central Recovery Unit (Mount Tom to Laurel Mountain), and 50 in the Northern Recovery Unit (Mount Gibbs and Mount Warren), for a minimum total of 305 females. The number of females is the limiting factor in reproductive output because one male can produce offspring with several females.
Delisting The minimum number of females required for downlisting per recovery unit has been maintained as an average for one bighorn sheep generation (7 years) with no intervention (i.e. population management, buffering populations through translocations, captive breeding, etc.). Herd status for delisting must entail at least three censuses, one at the beginning of the period (qualifying for downlisting), one at the end of the period, and one intermediate count for each herd unit. Maintaining this number of females over a generation should be sufficient to indicate that predation is managed and that the number of individuals within the population is large enough to promote regular use of winter range.

Table 2.2. Example text of actions comprising a Recovery Program narrative, adapted from the Recovery Plan for the Sierra Nevada Bighorn Sheep (approved September, 2007). Source: United States Fish and Wildlife Service, 2007.

1. Protect bighorn sheep habitat.
1.1 *Identify and acquire important habitat not in public ownership from willing landowners.*
1.2 *Maintain and/or enhance integrity of bighorn sheep habitat.*
2. Increase population growth by enhancing survivorship and reproductive output of bighorn sheep.
2.1 *Prepare and implement a management plan to temporarily protect Sierra Nevada bighorn sheep herds from predation losses, where needed, until viable herd sizes are reached.*
2.2 *Increase use of low elevation winter ranges.*
2.3 *Minimise probability of bighorn sheep contracting diseases causing mortality and morbidity.*
3. Increase the number of herds, and thereby the number of bighorn sheep.
3.1 *Develop and implement a strategy for translocations.*
3.2 *Develop sources of translocation stock.*
4. Monitor status and trends of bighorn sheep herds, their habitat, and threats to them.
4.1 *Develop and implement a monitoring plan for population abundance and distribution of bighorn sheep herds in the Sierra Nevada.*
4.2 *Monitor key predators in the vicinity of winter ranges.*
4.3 *Monitor vegetation structure and composition changes likely to affect bighorn sheep population parameters.*

be conducted by more than 300 researchers from 19 universities. The design of a detailed "data collection instrument", within which information from different recovery plans could be coded consistently for rigorous statistical analysis where appropriate, was a key component of the overall study.

A total of 181 recovery plans, spanning the full taxonomic and chronological history of the recovery planning process since its inception, were included in the final analysis (Hoekstra et al., 2002a). As many different people were involved in collecting and interpreting the recovery plan information, the data collection instrument was carefully calibrated from the outset to maximize the degree of data consistency across plans. Through this calibration, the researchers were able to confidently analyze the full set of recovery plan data across a wide breadth of questions, collectively designed to provide unique insight into the reliability and value of the plans in particular and of the recovery process in general.

The following is a summary of the important results to emerge from this analysis.

Influence of the Academic Conservation Biology Literature

Since the mid-1980's, the depth and scale of literature to come out of the academic conservation biology community has grown tremendously. But despite this growth of knowledge and understanding within the field, the stereotype of academics as intellectually and functionally separate from their action-oriented counterparts "in the field" grew stronger with each passing year. Consequently, there was real concern that this volume of work was having little if any impact on the practical recovery of endangered species. To evaluate the impact of this perceived schism, Stinchcombe et al. (2002) reviewed 136 recovery plans for any evidence of their evolution in response to the growing body of conservation biology literature.

Overall, as the amount of literature increased over time in four keys areas of conservation biology – population viability analysis (PVA), conservation genetics, metapopulation dynamics, and conservation corridors – recovery plans appeared to be incorporating this information more frequently. Specifically, more recovery actions were targeted toward collecting more detailed information in these areas, with greater priority given to the current or future application of methods in population viability analysis and conservation genetics. Actions related to metapopulation dynamics and conservation corridors was conspicuously absent from many plans. Therefore, while there appeared to some positive response to the growing academic literature, there is still considerable room for improvement. This may be difficult, since at the time of the publication only 34% of recovery plans making up the SCB database have academic scientists as members of the recovery team that wrote the plan. In order to utilize the academic community more effectively, the USFWS must actively encourage more direct participation in the recovery planning process by conservation scientists.

The Role of Population Viability Analysis (PVA) in Recovery Planning

Population viability analysis uses simulation models of species demography and ecology to predict the most likely response of a population to changes in its environment through harmful activities by humans or though active conservation management of threats that may impact it (Beissinger and McCullough 2002; Reed et al. 2002; Miller and Lacy 2003). The tool can therefore be extremely valuable for prioritizing future research or management efforts, although serious concerns have been expressed about its irresponsible use in the face of considerable gaps in our understanding of species biology. Despite limitations such as this, PVA can be a valuable tool for detailed threat assessment and the establishment of quantitative recovery criteria.

Morris et al. (2002) reviewed the SCB recovery plan database to determine the use of PVA throughout the history of the recovery planning process. Although there was a significant increase over time in the proportion of recovery plans that presented results of a PVA or called for the collection of data that would be required for a future PVA, less than 50% of all recovery plans approved in the time period 1991 – 2002 called for such an analysis as part of the general recovery process. Moreover, the types of data collection recommended in the majority of plans would facilitate only the most basic PVA to be conducted: the so-called count-based PVA that relies solely on census data over a period of years, instead of more detailed population demographic data. More complex PVAs would be possible for <25% of recovery plan species. In response to these findings, Morris et al. (2002) urged the USFWS to enhance appreciation of PVA among recovery team members and associated Service personnel; to encourage the direct use of PVA in more recovery plans; and to link population monitoring protocols more directly to the data required to conduct a detailed demographic analysis.

The Use of Recovery Criteria to Guide Endangered Species Recovery

A final amendment to the Endangered Species Act was added in 1988, requiring all recovery plans to include objective and measurable criteria for delisting endangered or threatened species. Gerber and Hatch (2002) studied recovery plans in the SCB database to assess the degree to which recovery criteria were employed over time. They found that more than 80% of studied plans include at least one quantitative recovery criterion, and that the number of such criteria increased significantly over time since 1990. Moreover, there appears to be a positive correlation between the number of recovery criteria for a given recovery plan and the current status of a species. In other words, species that are characterized as improving in status tend to have a larger number of quantitative recovery criteria. This suggests that the specification of clear quantitative recovery criteria facilitates the progress towards species recovery.

On the other hand, the authors also found that a relatively high percentage of recovery plans contained quantitative recovery criteria that had no clear relationship to information on the species' biology. Moreover, this observation appeared to increase in frequency for plans approved since 1990. On a more positive note, species that were seen as improving in status had criteria that were tied more closely to information on their biology, furthering strengthening the apparent relationship between well-defined recovery criteria and the species' chances for recovery. Taken together, the analysis points to the value of specifying detailed quantitative recovery criteria for all species that are the focus of a recovery plan.

The Treatment of Threats in Endangered Species Recovery Plans

Species recovery depends critically on the proper identification of threats and the specification of management actions designed to mitigate them. However, many threats are quite complicated to describe and address effectively. Lawler et al. (2002) assessed the identification of threats among recovery plans in the SCB database, and found that various types of basic information (magnitude, severity, frequency, timing) was lacking for 39% of all identified threats facing the species. However, threats that were better understood had more recovery actions identified for them compared to threats that were more poorly understood.

Perhaps the most alarming aspect of this assessment was the observation that 37% of all threats that were identified as impacting species were not directly addressed through associated recovery actions. This may be due to a lack of understanding the threats or, more problematically, may reflect a lack of internal consistency in the content of the plans (see below). Whatever the reason might be, the authors concluded that a lack of basic understanding of threats and their mode of impact on threatened and endangered species may be hindering our attempts at recovery.

Internal Consistency in Endangered Species Recovery Plans

In order to have a major impact on species conservation, a recovery plan must possess a clear logic that lays out the major threats to the species, the justification for specific recovery objectives, and the articulation of clear recovery actions that directly address the primary threats endangering the species. In other words, the recovery plan must be internally consistent. Brigham et al. (2002) studied entries in the SCB recovery plan database for evidence of internal consistency. Overall, the authors found relatively high levels of consistency across key areas within recovery plans: management actions often address primary threats and/or target important data gaps. However, a major failure in consistency revolves around population monitoring, where many plans recommend monitoring schemes that do not directly link to species threats or to the identified species recovery criteria.

Overall, this analysis indicates a comfortable level of consistency within the bulk of endangered species recovery plans. To address concerns that came to light in the analysis, the authors recommend that more careful thought be directed to the derivation of monitoring schemes so that critical analysis of threat mitigation can emerge. In addition, monitoring protocols must be more carefully tied to the recovery criteria so that progress towards recovery can be observed more efficiently.

Monitoring as a Component of Endangered Species Recovery Plans

Because of gaps in our knowledge of endangered species biology and ecology, our decisions around conservation management decisions are filled with uncertainty. Consequently, our ability to monitor progress towards recovery is a vital aspect of the full recovery process; we must give ourselves the opportunity to adjust our practices if necessary as new information comes to light about the species and the threats it may face. Therefore, it is very important to evaluate the degree to which we include monitoring as an explicit component of species recovery plans.

Campbell et al. (2002) reviewed the role monitoring plays among recovery plans making up the SCB database, focusing on the extent to which monitoring was proposed in the plans as well as the degree to which the proposed monitoring plans were implemented. They found that actions focusing on monitoring population trends were the most commonly proposed and implemented; actions involving monitoring species demography, habitat quality, and the impacts of predators or competitors or exotics were recommended must less frequently. There appeared to be a marked taxonomic bias in the rigor of proposed monitoring schemes, with mammals and birds receiving more detailed monitoring attention compared to invertebrates. As stated above, proposed monitoring schemes in many plans did not appear to be consistently associated with the primary threats identified for the species. Finally, based on the common emphasis on population-level monitoring within recovery plans, the authors recommended against an emphasis on focal species monitoring as this likely reduces the attention that could be directed to other valuable forms of monitoring, e.g. density and impact of exotics.

Critical Habitat Designations in Endangered Species Recovery Plans

The designation of critical habitat is now a requirement of the ESA, but as of 2002 less than 10% of all listed species had such a designation. At the time of this SCB-mediated review, the USFWS saw addressing the backlog of critical habitat designations the top funding priority for their endangered species program. Hoekstra et al. (2002b) reviewed the role that critical habitat designation plays in the recovery plan process. A review of the SCB recovery plan database revealed that the designation of critical habitat did not increase the availability of information on the focal species' habitat needs, and it did not increase the frequency with which habitat management was prescribed in species recovery actions. Additionally, recovery plans that included critical habitat designations were not more likely to have habitat-based recovery criteria, although they recommended a greater number of habitat monitoring programs.

In total, the authors concluded that critical habitat designations had negligible positive impact on individual species recovery planning processes. To address this important shortcoming, they recommended a more standards-based system for designating critical habitat that would more effectively account for the biological and ecological needs of the focal species. This would lead to critical habitat designation constituting parameters *x*, *y*, and/or *z* instead of simply confining critical habitat within specific spatial boundaries, such as elevational gradients or bounded segments of a river.

The Value of Multi-species Recovery Plans

As the biodiversity conservation community moves to a more ecosystem-centric management philosophy, recovery plans for multiple species within a given habitat system become more attractive. By the beginning of this century, more than half of all ESA-listed species were covered by multi-species recovery plans. Clark and Harvey (2002) evaluated these plans for their rigor and breadth of coverage of important topics related to biologically sound recovery. Multi-species plans typically have a poorer understanding of the biology of included species, tend to lack a consistent adaptive management approach, and have a lower probability of being revised over time. Perhaps most importantly, these plans do not appear to be successful at choosing groups of species based on similarity of threats – a characteristic explicitly encouraged in USFWS recovery planning guidelines.

Based on these findings, the authors conclude that multi-species recovery planning is not as effective as single-species planning processes, and recommend that the multi-species planning process be critically evaluated before employing it further. Specifically, development and implementation of a more robust threat similarity index is warranted.

Revising Endangered Species Recovery Plans

The USFWS encourages the revision of recovery plans in response to new knowledge or to new events on the ground, but there is no consistent criteria to decide when and how such a revision should take place. Harvey et al. (2002) evaluated the SCB recovery plan database and found that recovery plans for vertebrates are four times more likely to be revised than invertebrates or plants, assuming no critical habitat designations. Knowledge of species biology and status appears to improve after revision, as does information on the presence and magnitude of threats impacting the species. However, this new knowledge does not lead to improved recovery criteria or monitoring programs. Consequently, the authors recommend a more stringent protocol for recovery plan revision triggers, as well as improved methods for applying new information to the specification of better recovery criteria and monitoring efforts.

Factors Affecting Implementation of Endangered Species Recovery Plans

Of course, recovery plans will be meaningless unless implemented on the ground. In their analysis of the SCB recovery plan database, Lundquist et al. (2002) found an average of about 70% of all recovery actions had been either partially or fully implemented within a given plan, although this value varied from 0% to 100% implementation across plans. As expected given other information from this review, recovery plans for animals had a higher degree of implementation than those for plants. On the whole, terrestrial species had a lower degree of recovery plan implementation than their aquatic counterparts, and multi-species plans are implemented more slowly. Recovery plans from teams with a dedicated coordinator had a higher level of implementation, as did plans that explicitly identified conflict among stakeholders as an element of the larger species recovery landscape. This effect of "social process" suggests that inclusion of diverse stakeholder interests within a structured, hierarchical team approach will lead to a more positive recovery process.

This observation was strengthened by Hatch et al. (2002), who evaluated the jurisdictional landscape and its influence on recovery development and implementation. Coordinating landowner and management agency domains is one of the biggest challenges to recovery planning. The authors found that species residing on federal land are more likely to be improving in status than those found at least partly on private land, indicating the difficulties in implementing recovery strategies in situations where public and private interests may be in direct conflict. Specifically, they found that increasing federal jurisdiction over recovering species leads to greater recovery plan implementation through a larger and more diverse body of stakeholder comprising the associated recovery team. However, a point of diminishing returns exists where an excessive number of implementing agencies on the team can inhibit an efficient path to recovery.

In conclusion, it appears that the variation in recovery success can be explained more completely by differences in how the recovery plans are created and how they're implemented – not simply by differences in the types and magnitude of threats the species encounter in the wild. This implies that careful consideration must also be given to the human sociological component of endangered species recovery planning – something that a traditional academic training in conservation biology does not typically address.

The collective results from this important analysis can be distilled down to the essential elements given below (USFWS, 2004):

What is working with the recovery planning process?
- Species with recovery plans in place for longer time periods show more improvement in status
- Most recovery plans have a fairly high degree of implementation
- High priority recovery actions are more likely to be implemented

What is improving?
- Emphasis on monitoring species is increasing
- Recovery criteria are increasing in specificity
- Scientific tools, such as population viability analysis, adaptive management, and metapopulation analysis, are being used more frequently

What needs more improvement?
- Explicit addressing and monitoring of threats
- Diversity of contributors, while keeping diverse teams manageable
- Monitoring of species trends, threats, implementation, effectiveness of implementation, and recovery criteria
- Internal consistency of plans, i.e., connecting biological information to recovery criteria/actions
- Inclusion of new science and theories
- Elimination of taxonomic biases
- Prioritization of species' plans for implementation and revision
- In multi-species plans, addressing of individual species needs, revisions, and implementation
- Addressing of needs for critical habitat management, where designated

Some Thoughts on Improving the Species Recovery Process

The biological science of endangered species recovery, while complex in its own right, is often comparatively easy when pitted against the sociological environment surrounding recovery. Those people involved in the threatening activities are nearly always in conflict with those attempting to manage the impact of those activities. Moreover, it's not uncommon to see different Federal agencies in conflict over the same endangered species management program – even if both agencies are devoted to improving the status of the species. These institutional conflicts often combine with our individual tendencies to see the world only through our own eyes and not through those of others. This combination makes endangered species conservation in a diverse, multi-stakeholder domain extremely complex (Westley and Byers, 2003).

Species recovery planning cannot be done in a sociological vacuum. Some organizations, such as the IUCN's Conservation Breeding Specialist Group (CBSG), have combined quantitative conservation biology with the complexities of human social dynamics to create a highly effective decision-making process that explicitly incorporates the perspectives and needs of relevant stakeholders in a meaningful way (see Westley and Miller, 2003 for additional information). This process has been applied to a small number of species within the United States, and the US Fish and Wildlife Service has expressed a high level of satisfaction with the process and the product that results from it – essentially forming the core of a new species recovery plan or the revision of an existing plan. The broader adoption of stakeholder-inclusive processes such as this, when combined with rigorous scientific analysis of the available data including thoughtful application of PVA methodologies, can only serve to improve our ability to direct conservation of endangered species with greater efficiency and efficacy.

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