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*Contributed Paper*

# Assessing the impact of the U.S. Endangered Species Act recovery planning guidelines on managing threats for listed species

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**Abstract:** *The Endangered Species Act (ESA) of the United States was enacted in 1973 to prevent the extinction of species. Recovery plans, required by 1988 amendments to the ESA, play an important role in organizing these efforts to protect and recover species. To improve the use of science in the recovery planning process, the Society for Conservation Biology (SCB) commissioned an independent review of endangered species recovery planning in 1999. From these findings, the SCB made key recommendations for how management agencies could improve the recovery planning process, after which the U.S. Fish and Wildlife Service and the National Marine Fisheries Service redrafted their recovery planning guidelines. One important recommendation called for recovery plans to make threats a primary focus, including organizing and prioritizing recovery tasks for threat abatement. We sought to determine the extent to which results from the SCB study were incorporated into these new guidelines and whether the SCB recommendations regarding threats manifested in recovery plans written under the new guidelines. Recovery planning guidelines generally incorporated the SCB recommendations, including those for managing threats. However, although recent recovery plans have improved in their treatment of threats, many fail to adequately incorporate threat monitoring. This failure suggests that developing clear guidelines for monitoring should be an important priority in improving ESA recovery planning.*

**Keywords:** extinction, monitoring, recovery plan guidelines, threats, U.S. Fish and Wildlife Service

Evaluación del Impacto de las Pautas de Planeación de la Recuperación del Acta de Especies en Peligro de EUA sobre el Manejo de Amenazas para Especies Enlistadas

**Resumen:** *El Acta de Especies en Peligro (AEP) de los Estados Unidos fue promulgada en 1973 para prevenir la extinción de las especies. Los planes de recuperación, requeridos por las enmiendas de 1988, tienen un papel importante en la organización de estos esfuerzos para proteger y recuperar especies. Para mejorar el uso de la ciencia en el proceso de planeación de la recuperación, la Sociedad de la Biología de la Conservación (SBC) comisionó en 1999 una revisión independiente de los planes de recuperación de especies en peligro. A partir de estos hallazgos, la SBC hizo recomendaciones esenciales sobre cómo las agencias de manejo podrían mejorar el proceso de planeación de la recuperación, y con las cuales el Servicio de Pesca y Vida Silvestre de EUA y el Servicio de Pesqueras Marinas Nacionales reescribieron sus pautas de planeación de la recuperación. Una recomendación importante pedía que los planes de recuperación hicieran de las amenazas un enfoque primario, incluidos la organización y priorización de las tareas de recuperación para el abatimiento de amenazas. Buscamos determinar el alcance al cual los resultados de las recomendaciones de la SBC con respecto a las amenazas se incorporaron a estas nuevas pautas y si las recomendaciones de la SBC con respecto a las amenazas resultaron en planes de recuperación escritos bajo estas nuevas pautas. Las pautas de planeación de la recuperación incorporaron en general a las recomendaciones de la SBC, incluidas aquellas para el manejo de amenazas. Sin embargo, mientras los planes de recuperación recientes han mejorado en su tratamiento de las amenazas, muchos fallan en incorporar adecuadamente el monitoreo de amenazas.*

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*Esta falla sugiere que el desarrollo de pautas claras para el monitoreo debería ser una prioridad importante en el mejoramiento de la planeación de la recuperación de la AEP.*

**Palabras Clave:** amenazas, extinción, monitoreo, pautas de planes de recuperación, Servicio de Pesca y Vida Silvestre de EUA

## Introduction

The U.S. Endangered Species Act of 1973 (ESA) has been controversial since its passage; critics range from large nongovernmental organizations to private landowners (Doremus 2010). Many legal scholars and conservationists, however, revere the ESA as one of the most powerful and substantial U.S. environmental laws (Goble 2009). Part of this reverence stems from the perceived successes of the ESA. Some sources indicate that species that would otherwise be extinct persist today because of protections offered by the ESA (Taylor et al. 2005; Suckling et al. 2012). Critics nonetheless point toward the large discrepancy in the number of species listed each year relative to already-listed species that are never delisted (Doremus & Pagel 2001; Gerber 2003). Furthermore, the requirement that recovery plans must be written for all threatened and endangered species (unless the plan would not aid recovery) may be seen as burdensome (Crouse et al. 2002). Despite these critiques, recovery plans remain vital to species improvement (Taylor et al. 2005; Kerkvliet & Langpap 2007). Recovery plans coalesce important information about species recovery, including criteria dictating what represents recovery for the species, management actions for bolstering recovery, and key threats to the species that must be mitigated, including competitor species, negative human impacts, and climate change (Taylor et al. 2005). We analyzed the clarity and depth of recently drafted recovery plans, focusing specifically on the incorporation of key characteristics that correlate directly with species improvement and recovery.

A seminal study conducted in 1999 by the Society for Conservation Biology (SCB) provided the U.S. Fish and Wildlife Service with critical information on the characteristics of recovery plans most important for improvement. With support from the USFWS and in partnership with faculty and graduate students at 19 universities across the country, the SCB embarked on an ambitious review of 181 representative species' recovery plans—about 20% of the total number of plans at the time (NCEAS 2002*a*). The goal of the study was to determine which features of recovery plans contribute to an improving status for species, as determined by USFWS biannual reports to Congress, and to find potential discrepancies and inconsistencies common among plans (Brigham et al. 2002; Campbell et al. 2002; Clark et al. 2002). The study was the most comprehensive review of endangered species recovery plans ever completed, the findings of which were published in a special issue of *Ecological Applications* (volume 12, number 3) in 2002.

On many accounts, the study showed that recovery plans were improving with time (Clark et al. 2002). For instance, Gerber and Hatch (2002) found that more recently drafted plans included more quantitative data, and Harvey et al. (2002) reported that plan revisions were effectively incorporating updated species information. Despite these improvements, the SCB study highlighted several areas in need of improvement, including the treatment of threats to species (Lawler et al. 2002), more effective integration of key biological information, and reductions in taxonomic biases in plans (Table 1) (Clark et al. 2002). This last recommendation accompanied over a decade of lobbying by various critics for more equitable treatment of plant species under the ESA. In response to the bias of recovery efforts toward charismatic vertebrates, Congress amended the ESA in 1988 to prohibit the consideration of taxonomic classification in recovery planning (Schultz & Gerber 2002).

In response to these recommendations, the USFWS identified 10 action items that could be addressed more effectively by agencies responsible for managing these species—the USFWS and the National Marine Fisheries Service (NMFS) (Crouse et al. 2002). In 2004, in direct recognition of the SCB's recommendations and these action items, the USFWS and NMFS overhauled their recovery planning guidance document (NMFS 2010). In 2014, 10 years after the initial revision of the guidelines, we examined the extent to which these guidelines promote the implementation of SCB recommendations. We determined the extent to which the 1999 SCB study recommendations were integrated into the recovery planning guidelines and, in turn, the extent to which threat sections in recovery plans written under these new guidelines reflect SCB recommendations.

The extent to which U.S. agencies have implemented the SCB recommendations has important international implications, particularly for countries and organizations whose techniques may be similar to those in the United States, including the International Union for the Conservation of Nature's Save Our Species program and programs under Australia's Environment Protection and Biodiversity Conservation Act of 1999. Although the SCB study identified key indicators of success in recovery planning, identification of attributes is ineffective if they cannot be successfully integrated into recovery plans and management. If these characteristics were impracticable, the importance of the SCB's findings would be severely diminished. Alternatively, if these characteristics can be successfully incorporated into recovery plans, then the SCB recommendations can be made actionable in future

**Table 1. Society for Conservation Biology 1999 study recommendations and text in the U.S. (Fish and Wildlife Service and National Marine Fisheries Service) recovery planning guidelines that directly, partially, or insubstantially incorporate each attendant recommendation.**

| *SCB recommendation (reference)*[a] | *USFWS/NMFS guideline (recovery planning text)*[b] |
|---|---|
| New recovery planning guidelines (1) | direct appeal to SCB recommendations (1) |
| Provide guidance on drafting optimal recovery plans (1) | example recovery outline, example recovery strategy, and explicit plan writing instructions (2) |
| Bolster internal consistency with checklists of questions (1) | calls for improvement in internal consistency (1) specific checklists for various species assessments (3,4,5) |
| Improve and standardize revision process (2, 3, 4) | describes how to use and update plans and when to revise (6) |
| Reflect species-specific needs and information in plan length and structure (4) | maintain plan flexibility and address specific circumstances (7, 8) |
| Clearly define and justify management actions, recovery goals, and monitoring programs (1) | describes considerations and uses for management actions (9,10,11) |
| | prioritize actions in recovery strategy (12) |
| Keep authorship small yet diverse (4, 5, 6) | improve diversity of contributors, while maintaining small, manageable, expert-based teams (1,13,14) |
| Improve effect of prioritization on plan structure/ implementation (2, 3, 7) | prioritize species plans and actions within plans for implementation and revision (1,15) |
| Invest more in recovery coordinators (3, 5) | identify responsible parties and facilitate coordination (16) |
| | if necessary, employ coordinator (17) |
| Small, diverse committee to coordinate implementation (1) | includes responsible parties and possible coordinator, but no calls for committee (14,16,18)[c] |
| Invest in centralized databases (3,5) | no inclusion[d] |
| Maintain current, publicly available database of high-quality estimates of status trend (1) | none[d] |
| Track investment of resources and effectiveness on species recovery (1) | "Within the recovery action narrative, recovery actions should be stepped down to discrete actions that can be funded, permitted, or carried out independently" (5.1-22). (10) |
| Integrate and use biological information (1, 8) | More effectively connect biological information with recovery criteria and actions. (1) |
| | Identify sources and magnitude of uncertainties. (19) |
| Link species biology with important features of recovery plans, such as recovery criteria and actions (4, 8, 9, 10) | Make criteria specific and measurable. (20,21) |
| | Make realistic criteria that are defensible and grounded in good science. (21) |
| If possible, use quantitative criteria (10) | No focus on quantitative criteria[d] |
| Define management actions and goals that are more biologically justified (2) | "Identify any biological constraints or needs of the species that need to be considered in planning and management" (5.1-10). (22) |
| Use species-specific biology to select monitoring protocols (7, 8, 9) | inadequate discussion of use of biology to determine appropriate monitoring protocols (10)[d] |
| Collect information necessary to effectively monitor species (7) | little information on how collected information will or should influence monitoring (10)[d] |
| Incorporate population viability analyses (11) | "PVA should not be viewed as a replacement for criteria based on threats, but as a supplement to them" (5.1-18). (19)[c] |
| Monitoring must be a priority (1) | only 1.5 pages of guidelines (1,10)[c] |
| Monitor species status, threats, and implementation of recovery tasks (7, 8) | monitoring needed to address a number of different aspects of a recovery program (4.5-1) (10,23) |
| Develop an implementation monitoring system (1) | create a basic monitoring framework, including an action to create post-delisting monitoring plan (1,10,23) |
| Address how threats can be mitigated and alleviated (8, 12) | "Identification of, and strategies for dealing with the threats . . . should be central to the recovery plan and program" (1.3-1). (24, 25) |
| Invest in understanding factors that threaten species (12) | "Include species characteristics that make it vulnerable to and would allow it to recover from, environmental, demographic, and human-caused threats." (24) |
| Include and prioritize tasks to directly address threats, especially major ones (1, 8, 12) | include threats tracking table and threats assessment (25); include recovery actions for each of the identified threats to the species (10) |
| Address threats with monitoring and implementation tasks (7, 9) | briefly mentioned in implementation monitoring section (10, 26)[c] |

*Continued*

**Table 1. Continued.**

| *SCB recommendation (reference)*[a] | *USFWS/NMFS guideline (recovery planning text)*[b] |
|---|---|
| Include information on magnitude, timing, frequency, and severity of threats (12) | calls for information gathering and inclusion of a threats tracking table and threats assessment (4, 20, 25, 27) |
| Develop and implement plans equally across taxa (2, 3, 6, 7, 8, 13) | brief recognition of need to eliminate bias (1)[d] |

[a]*Key: 1, Clark et al. 2002; 2, Harvey et al. 2002; 3, Lundquist et al. 2002; 4, Boersma et al. 2001; 5, Hatch et al. 2002; 6, Gerber & Schultz 2001; 7, Campbell et al. 2002; 8, Schultz & Gerber 2002; 9, Brigham et al. 2002; 10, Gerber & Hatch 2002; 11, Morris et al. 2002; 12, Lawler et al. 2002; 13, Hoekstra et al. 2002.*

[b]*Key: 1, Box 1.0 – "2002 Society for Conservation Biology study of FWS recovery plans and its application to the NMFS recovery program" in NMFS (2010); 2, Appendix K – "Sample recovery outline," 5.1 – "Contents of a recovery plan," Box 5.1.9.2 – "Recovery action outline: Atlantic Coast population of the Piping Plover (*Charadrius melodus*)" in NMFS (2010); 3, Box 3.2.2-1 – "Prompt sheet for biological assessment" in NMFS (2010); 4, Box 3.2.2-2 - "Prompt sheet for threats assessment" in NMFS (2010); 5, Box 3.2.2-3; Box 3.2.3-1; Box 3.2.3-2 in NMFS (2010); 6, 3.3.5 – "Using/ updating the recovery outline" and 6.2 – "Modifying the recovery plan" in NMFS (2010); 7, 1.2 – "Legal and policy guidance for recovery planning" in NMFS (2010); 8, 1.4 – "Opportunities for streamlining and flexibility" in NMFS (2010); 9, 1.0 – "Purpose and overview" in NMFS (2010); 10, 5.1.9.3 – "Recovery action narrative" in NMFS (2010);11, 5.2.3 – "Incorporation of comments" in NMFS (2010); 12, 5.1.7 – "Recovery strategy" and 5.1.8.1 – "Recovery goals" in NMFS (2010); 13, 2.3.2.2 – "Use of NMFS biologists to write recovery plans" in NMFS (2010); 14, 2.3.3.2 – "Recovery team composition" in NMFS (2010); 15, 5.1.10 – "Implementation schedule and cost estimates" in NMFS (2010); 16, 2.3.1 – "Coordination" in NMFS (2010); 17, Appendix I – "Terms of reference for the Hawaiian Monk Seal" in NMFS (2010); 18, Appendix Q – "Example implementation schedule" in NMFS (2010); 19, 5.1.8.3 – "Recovery criteria" in NMFS (2010); 20, 5.2.1.2 – "Analysis" in NMFS (2010); 21, Box 5.1.8.3-1 – "When drafting recovery criteria, remember that they should be 'SMART'" in NMFS (2010); 22, 5.1.6.9 – "Biological constraint and needs" in NMFS (2010); 23, 4.5 – "Monitoring considerations" in NMFS (2010); 24, 1.3.2 – "The significance of threats in recovery planning"; see also Box 5.1.6.7 in NMFS (2010); 25, 5.1.6.7 – "Reasons for listing / threats assessment" in NMFS (2010); 26, 6.1 – "Implementation, monitoring, and information management" in NMFS (2010); 27, Appendix C – "Threats assessment" in NMFS (2010).*

[c]*Recommendation was partially incorporated.*

[d]*Recommendation was not addressed.*

recovery planning, both in the United States and elsewhere (Joseph et al. 2009).

We focused on threats for several reasons. First, many scientists recognize the key role threats play in species endangerment (Croxall et al. 2012; McClenachan et al. 2012) and the need for clear communication about these threats (Salafsky et al. 2008), particularly in recovery plans (McCune et al. 2013). Threats to species vary in severity, longevity, source, and impact and generally refer to anything that might threaten the recovery or sustained existence of the species. Explicit recognition and clear communication can lead to better threat management and abatement, which is a critical step in species recovery (Carwardine et al. 2012). Additionally, the treatment of threats was explicitly identified as deficient in the SCB review, which suggests providing more substantial information on the nature of threats and incorporating tasks for adequately monitoring threats would strengthen an insufficient area of planning. (Lawler et al. 2002; Table 1). Compared with all other SCB recommendations, the USFWS and NMFS guidelines most strongly emphasize the importance of addressing threats for the recovery of species (NMFS 2010). By focusing on threats, we sought to assess the extent to which the recovery planning guidelines have incorporated the recommendations of the 1999 SCB study and whether recent (2006–2012) recovery plans are adequately implementing these recommendations.

## Methods

### Review of Recovery Planning Guidelines

To determine the extent to which the SCB recommendations were incorporated into the USWFS recovery planning guidelines when they were redrafted in 2004, we first compiled a list of all key recommendations made from each of the 20 papers published under the SCB study (available at NCEAS 2002*c*). Recommendations made by SCB were considered key if they were strongly emphasized in a publication, explicitly recognized by the USFWS (Crouse et al. 2002), or included as final recommendations in the SCB summary paper (Hoekstra et al. 2002). We then reviewed the recovery planning guidelines and found sections that correlated with each SCB recommendation. If a recommendation had multiple sections or passages, the most relevant section was chosen (Table 1). We only considered recommendations to be explicitly recognized if parallel passages in the guidelines were actionable and specifically addressed how to incorporate the item into plans.

### Review of Plans to Analyze Current Features

In general, we followed methods used in the 1999 SCB study, which included a detailed survey of various attributes of each recovery plan. The SCB study centered on a data collection questionnaire with over 2500 specific questions about the information included in recovery plans (available in NCEAS 2002*b*). These questions were written as explicitly as possible and solicited answers meant to reduce subjectivity and to standardize the scope of the recovery plan review. The questionnaire covered the gamut of areas addressed by recovery plans, including prompting reviewers to answer questions on descriptive data and biological information about species, recovery actions and criteria, and other key species details (Kareiva et al. 1998; Harding et al. 2001).

Most questions required a standardized numeric response (e.g., 0 for no, 1 for yes; primary ecotype: 1,

tropical rainforest; 2, tropical deciduous forest, etc.). Negative response codes indicated when and why information was missing for each question. Some questions called for numeric answers to indicate a total quantity, whereas others asked for qualitatively descriptive answers. In this way, the questionnaire allowed for identification of relevant information in recovery plans; each question signified diverse information included in the plan. Questions could be answered using only information explicitly stated in the plan itself or in the species' listing document. The data were collected for each of 135 plans, patterns and trends were identified, and collective results were published. We used the same methods, although we slightly altered the questionnaire to better suit our goals.

### Developing the Questionnaire

We used the key recommendations from the SCB study to reform the original SCB questionnaire to fit our needs. Almost all original SCB threat questions were kept in the revised questionnaire (Table 2). Specifically, key characteristics of threats were still assessed, including the severity, magnitude, frequency, timing, and directness of threats (for detailed descriptions of these metrics, see Kareiva et al. [1998], Harding et al. [2001], and Lawler et al. [2002]). The most important difference between our questionnaire and the SCB questionnaire is that we asked each question about individual threats, whereas the SCB study generalized its questions to types of threats. For example, the SCB study asked for the highest priority of a particular threat type (e.g., non-native species), whereas we asked for the specific priority of each threat classified as a non-native species. By asking every question for each specific threat and not generalizing, our data were more discretized and nuanced than the SCB's data. These differences negated certain comparisons between the present study and the original SCB study but allowed us to ask more detailed questions than the SCB researchers. We also asked several questions related to particular directives in the guidelines that were not a direct result of the SCB study itself. For instance, the SCB study did not specifically recommend using threat-tracking tables, but the guidelines emphasize them as an important feature to include in plans when possible (Table 1).

### Data Collection

Because the SCB study showed that multi-species plans had particular problems that were not manifest in single species plans (Clark & Harvey 2002), we excluded multi-species plans from our study. The SCB study also included plans for both threatened and endangered species, but we used only endangered species plans so as to contain more consistent results for the smaller sample size. Finally, SCB researchers assumed a 2-year time lag in assessing the impacts of the 1988 amendments to the ESA. We used a similar approach in that we analyzed only plans written during or after 2006, to allow for a 2-year period after the guidelines were written for their incorporation into plan writing. Because the guidelines have since been edited 3 times (although not substantially), it is possible that more recent plans incorporate more of the recommendations. Of the 32 plans in this sample, 28 were coded and analyzed using our questionnaire. We identified 302 threats for the 28 species we considered.

All information used to answer questions about individual recovery actions was taken from the implementation schedule and the recovery action narrative, whereas information contained in each plan's section on threats was used to answer questions related to threats. One individual coded all plans for this study, ensuring higher consistency in responses for potentially subjective analyses. The SCB study, on the other hand, used multiple groups of individuals, and consistency was checked by comparing each groups' response to each plan. This method was not necessary here.

For monitoring tasks specifically, if the threat had more than one assigned monitoring task, we used the SCB methods (Campbell et al. 2002; Schultz & Gerber 2002) (i.e., the best answer to each question was coded). For instance, if the protocol for one monitoring task for the threat was not clearly linked to biology but the other's protocol was clearly linked to biology, the threat was counted as having monitoring clearly linked to biology. If the monitoring tasks called for monitoring of different subjects (focal species, associated species, or habitat), the category with the most information was counted. Admittedly, this method may have skewed these data; however, it appears as though not enough threats had more than one monitoring task to cause a serious problem (approximately 1 threat for every 5 plans).

### Analyses

To facilitate comparison of our results with those from the SCB study, we used statistical analyses similar to those used in the SCB study. For example, to identify potential taxonomic biases in the number of threats in plant versus animal plans, we used an independent samples *t* test, like in the SCB study, so our results would be comparable. In a few cases, our results were not directly comparable. In some instances, the units of analysis between the 2 studies were disparate. For example, in analyzing taxonomic bias in monitoring, the SCB study used the number of threats that were monitored, whereas we analyzed the percentage of threats with monitoring tasks. Similarly, some data analyzed in our study were at the species level, others were at the individual threat level, and others were at the plan level. The unit of analysis for each test is clarified in the results section. For all within-plan

**Table 2. Questions related to threats to species, possible answers to questions, and whether each question was included in the 1999 Society for Conservation Biology (SCB) study or came only from the government (U.S. Fish and Wildlife Service and National Marine Fisheries Service) recovery planning guidelines.**

| *Question* | *Answers* | *[*]Question origin* |
|---|---|---|
| Which category of the five listing factors does this threat fall into? | one of 5 factors | guidelines |
| Are biological characteristics directly used to determine what makes the species vulnerable to threats? | yes or no | SCB |
| How substantial a threat does the recovery plan identify the factor to be? (i.e. magnitude) | not a threat<br>minor<br>major | SCB |
| Are the effects of this factor historic, current, or anticipated? (i.e. timing) | historic<br>current<br>anticipated<br>multiple | SCB |
| How frequently does this factor affect the species? | never<br>once<br>repeatedly<br>chronic | SCB |
| When this factor affects the species, what is the severity of this effect? | light<br>moderate<br>intense | SCB |
| Does this factor have direct or indirect effects on the species? | indirect<br>direct<br>both | SCB |
| Does the spell out discuss the geographic scope of this threat? | yes or no | guidelines |
| Is this considered to be an intractable threat? | yes or no | guidelines |
| Is this threat explicitly linked to endangerment and recovery needs? | yes or no | guidelines |
| Is there recognition of uncertainty about this threat? | yes or no | guidelines |
| Is there an associated recovery action? | yes or no | SCB |
| Is there a monitoring task assigned to this threat? | yes or no | SCB |
| If there is a monitoring task for this threat, what is its priority? | 1,2,3 | SCB |
| If there is a monitoring task for this threat, what is its cost? | dollar value | SCB |
| What is the action monitoring? | focal species<br>associated species<br>habitat | SCB |
| Are the data to be collected through monitoring qualitative or quantitative? | qualitative<br>quantitative<br>both | SCB |
| How did biological information (either species-specific info or general principles) influence what is to be monitored? | unclear<br>somewhat clear<br>very clear | SCB |
| How did biological info (either species-specific or general principles) influence how monitoring is done (i.e. protocols)? | unclear<br>somewhat clear<br>very clear | SCB |
| Is there a responsible party listed for this monitoring action? | yes or no | guidelines |
| Is there a timeline for this monitoring action? | yes or no | guidelines |

[*] *The questions' content came from the SCB study; however, SCB asked about categories of threats, while we asked about each specific threat. For example, our question was, are the effects of this specific threat historic, current, or anticipated? Whereas, SCB's question was, are the effects of this type of threat historic, current, or anticipated? Another example is, for monitoring tasks for this threat, how will data be used and analyzed (our question) and for monitoring tasks of focal species, how will data be used and analyzed (SCB question)?*

comparisons, the Wilcoxon signed-ranks test was used because the paired data (minor vs. major threats, direct vs. indirect threats, etc.) were non-normally distributed between plans. For all comparisons between animals and plants, an independent samples $t$ test was used. For all tests, a $p$ value of $<0.05$ was considered significant. All tests were performed using IBM SPSS Statistics (version 22.0).

## Results

### Incorporation of the SCB Recommendations into Revised Guidelines

We found that the majority of key SCB recommendations are addressed in the new USFWS/NMFS guidelines. However, the guidelines lacked adequate discussion of investment in recovery coordinators and centralized databases, the use of quantitative recovery criteria, and monitoring techniques (Table 1). Monitoring in particular was not a central focus of any part of the guidelines; instead, discussions of monitoring were sparsely dispersed throughout in other relevant sections (such as sections on threats and recovery actions). Specifically, the revised guidelines did not offer directions for establishing monitoring protocols, identifying effective monitoring foci, or using species-specific biology to craft monitoring tasks. However, in response to SCB recommendations, the revised guidelines offered improved direction for better incorporating and addressing threats to species' survival, which has led to many improvements in the treatment of threats by recovery plans.

### Documentation of Threats

The percentage of threats we and Lawler et al. (2002) categorized as chronic was equivalent (Table 3). However, high and moderately severe threats were equal in frequency in our sample, whereas high severity threats dominated the SCB study (Table 3). Most threats occurred in multiple time frames (Table 3), at a rate one-third higher than the percentage in Lawler et al. (2002). A majority of threats were direct (57%) (Table 3).

Lawler et al. (2002) found that 39% of threats lacked information on at least one of the 4 key characteristics (severity, magnitude, timing, frequency) compared with 44% of threats in recent plans (Fig. 1). Severity information was missing the most often (17%), and 1% of threats lacked information on timing, reflecting the disparity found by Lawler et al. (2002) (30% to 5%, respectively). Major threats were also more fully documented than minor threats, and direct threats included more information overall than indirect threats (Table 3). Animals were also assigned more direct threats than plants (Table 3).

### Plan Consideration of Threats

Lawler et al. (2002) and Schultz and Gerber (2002), of the SCB study, showed that 37% of all threats had no associated recovery task, whereas we found that only 19% had no recovery task (Fig. 1). The maximum percentage of threats not addressed by a recovery task in a single plan was 57% (8/14), whereas the median was 12% across plans. There was also improvement in the percentage of major threats addressed by recovery tasks (Fig. 1), and animal threats mentioned in Lawler et al. (2002) and Schultz and Gerber (2002) no longer had more associated tasks than plant threats (Table 3). However, like Lawler et al. (2002), we found that more total threats were identified for animals than plants; however, we found a larger discrepancy between the taxa (Table 3).

The number of tasks that address major threats demonstrated an increase in the number of total tasks addressing major threats since the SCB study (i.e., Schultz & Gerber 2002). Major tasks were not prioritized more than minor tasks, whereas Brigham et al. (2002) found that plans were fairly consistent in prioritizing these tasks (Table 3). Before the new guidelines, Lawler et al. (2002) showed that incompletely documented threats were addressed by recovery tasks less often than fully documented threats (55% vs. 66%). We found that less-documented threats were addressed as often as well-documented threats (74% vs. 86%, Wilcoxon signed-ranks test $Z = -1.734$, $p = 0.083$). Additionally, the percentage of both types addressed by recovery tasks increased (Fig. 1).

### Monitoring of Threats

The percentage of threats with an assigned monitoring task almost doubled from that reported in Brigham et al. (2002) (Table 3). More major threats had monitoring tasks than minor threats, and more direct threats had monitoring tasks than indirect threats (Table 3). Campbell et al. (2002) and Schultz and Gerber (2002) found there was no taxonomic bias in the number of threats monitored and the number of monitoring tasks. Our findings were consistent with theirs; the percentage of threats with monitoring tasks did not vary between plants and animals for all threats or major threats (Table 3). However, animals had a greater percentage of monitoring tasks dedicated to focal species monitoring than plants (Table 3).

We found that 93% of all threats that are monitored had a clear biological basis for the focus of monitoring, whereas only 50% of monitored threats had a clear biological explanation for the monitoring protocol provided. For 35% of threats, it was unclear how monitoring protocols were influenced by biological information, and the influence of biology on monitoring protocols was even less prevalent in animals (Table 3).

### Threat-Linked Recovery Criteria

Across all plans, the median percentage of threats addressed by at least one recovery criterion was 89%, suggesting that recovery goals are adequately addressing species' threats. However, plant threats were more often addressed by recovery criterion than animal threats (Table 3).

**Table 3. Comparisons of Society for Conservation Biology (SCB) and our findings in studies of threat management in species' recovery plans.**

| *Finding* | *SCB study*[a] | *This study* |
|---|---|---|
| Number of threats per species ratio of animal to plant threats | 4.6 | 1[b] |
| Number of direct threats per species animals v. plants | | 7.15 vs. 3.62[b] |
| Percentage of threats with recognition of uncertainty animals v. plants | | average: 75 vs. 58[c] |
| Percentage of total threats classified as | | |
| severity: intense | 44 | 28 |
| magnitude: major | 49 | 35 |
| frequency: chronic | 76 | 78 |
| timing: multiple time frames | 63 | 39 |
| Average documentation of threats (out of 4) | | |
| major vs. minor | | 3.74 vs. 3.42[d] |
| direct vs. indirect | | 3.45 vs. 2.94[d] |
| Percentage of threats not addressed by recovery task | | |
| total | 37 | 19 |
| major v. minor threats | major > minor[d] | 18% vs. 9 |
| direct v. indirect threats | direct >indirect[d] | 18% v.18 |
| Number of recovery tasks per threat | | |
| median for major threats | 15 | 25 |
| animals vs. plants | animals > plants[b] | animals = plants |
| Number of threat recovery tasks per plan (median) | | |
| major v. minor | | 25.0 v. 9.0[d] |
| direct v. indirect | | 23.5 v. 0.5[d] |
| Prioritization of threat recovery tasks | | |
| major v. minor | major > minor[d] | major = minor |
| Percentage of threats monitored total | 26 | 51 |
| animals v. plants | animals = plants | animals = plants |
| major v. minor | | 75 v. 54[d] |
| direct v. indirect | | 56 v. 32[d] |
| Percentage of major threats monitored | | |
| animals v. plants | | animals = plants |
| Percentage of monitoring tasks for focal species | | |
| animals v. plants | | 42 v. 13[b] |
| Percentage of threats with monitoring protocol clearly linked with species biology | | |
| total | | 50 |
| animals v. plants | | 40 v. 72[b] |
| Percentage of threats addressed by a recovery criteria | | |
| animals v. plants | | 74 v. 91[b] |

[a] *Blank cells indicate no relation to SCB finding.*
[b] *Independent samples t test, $p < 0.05$.*
[c] *Independent samples t test, $p = 0.057$.*
[d] *Wilcoxon signed ranks test, $p < 0.05$.*

## Discussion

The SCB presented the USFWS with actionable, specific recommendations for the improvement of endangered species recovery planning. The USFWS strongly embraced these recommendations (Crouse et al. 2002) and adequately incorporated most recommendations into their recovery planning guidelines, indicating a tight connection between the newest set of guidelines and the emphases of recently drafted plans. In particular, the guidelines are clear that threats should be prioritized and adequately addressed in as much detail as possible by plans. This change in the guidelines has fostered improvement in several key areas. Several taxonomic biases have been eliminated (Table 3), threats are being more adequately described by biological information, more threats are being assigned recovery tasks, and minor threats are receiving more attention, in general. Still, several areas of disconnect between the guidelines and recent plans indicate potential areas for improvement in plan drafting.

Our results suggest important areas for future research and management. Major and direct threats are given more attention in plans than minor and indirect threats, respectively. This finding suggests that more resources are being dedicated to finding key information about major and direct threats. Though the number of actions to address major threats has increased, the prioritization of these actions remains comparable to actions for minor threats

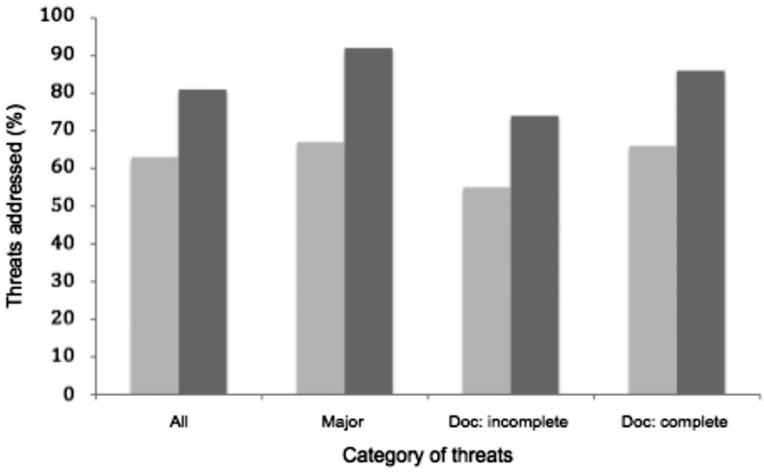


*Figure 1. For all reported threats to species across U.S. recovery plans in each category, percentages of threats addressed by a recovery task in the Society for Conservation Biology (SCB) study (Lawler et al. 2002) (light gray) and in our study (dark gray). The percentage of all threats included in recovery plans (1928 threats in total) that were addressed in the SCB study are reported. To allow comparison between the studies, we also report total percentages for all threats (out of 302 total threats). Complete documentation (doc) refers to inclusion of information on severity, timing, frequency, and magnitude categories for threats.*

despite prioritization of major threats being emphasized in the guidelines (Table 1). An increased number of actions without accompanying prioritization increases may not grant major threats the larger focus they may require. Additionally, as a result of this change in focus, it is possible that minor and indirect threats may be taken less seriously than is necessary. For instance, if more resources were dedicated to studying minor threats, more minor threats might be classified as major threats. This trade-off should be kept in mind and the consequences of relegating certain threats for the sake of focusing on others should be considered. Although it may be pertinent to address major threats more often than minor threats, it is not clear why indirect threats should be addressed less often than direct threats. Although it may be harder to address indirect threats (Horowitz & Jasny 2007; Halpern et al. 2008), it is nonetheless important to adequately consider them (Darst et al. 2013). A greater focus on indirect threats may facilitate broader awareness of the problems plaguing various species and enable more effective long-term planning for the species.

Though taxonomic biases seem to have been mitigated in other key areas of recovery planning, the basic attribution of threats to species may be indicative of their sustained presence (Table 3). It was apparent in the qualitative analysis that plant plans are generally less extensive than animal plans; for instance, on average, plant plans were much shorter than animal plans (65.5 pages vs. 131 pages). This difference in the number of threats materializes directly in the number of direct threats assigned to species. Either there are actually more direct threats to animals than to plants, which seem likely, or direct threats to plants are not being identified as readily and completely as those to animals. This disparity could be due to biases in the knowledge of threats to species or to the amount of information about threats being included in the plans. However, these biases may have foundations in a species' biology and may not be a major concern for recovery planning. Others have found inherent taxonomic biases in the listing process in other countries (Mooers et al. 2007; Walsh et al. 2013), and these biases are likely also prevalent under the ESA. Additional research on the disparities in the treatment of threats between different taxa's plans may illuminate some of these issues and clarify the source of these ostensible biases.

The overall monitoring of threats in recovery plans is still weak as a direct result of the lack of emphasis of monitoring in the recovery planning guidelines. Adaptive management for threats, which is specifically encouraged in the guidelines, cannot be adequately implemented without appropriate monitoring. The 2-fold increase in the total percentage of threats monitored (from 21% to 50%) is encouraging, but half of all threats still have no assigned monitoring task. Likewise, the total number of monitoring tasks is lacking and task protocols remain unclear, suggesting an inadequacy in threat monitoring that may reflect a larger problem in recovery planning. Further studies using the data acquired from recent plans should consider monitoring throughout the entirety of the plan to determine if the potential inadequacies discovered for threats reflects a pervasive problem in recovery plans.

Because the USFWS and NMFS recovery planning guidelines are still "interim" (USDI 2010), there is opportunity to restructure them to focus more substantially on monitoring. The successful incorporation of other key SCB recommendations could serve as a template for how to more adequately incorporate monitoring. Perhaps giving monitoring its own section in the guidelines and in recovery plans themselves would allow for more effective inclusion and prioritization of these tasks. These techniques were used to more adequately integrate other SCB recommendations and have greatly improved many areas of the recovery planning process. Many biases and inadequacies in the treatment of threats in planning for endangered species have been eliminated thanks to the focus of the guidelines on addressing them. Overall,

recovery planning is improving under the ESA, and this improvement can directly lead to more effective management of endangered species.

The improvements we identified can now be compared with the status of species, to ensure that the guidelines are maintaining the appropriate focus, as suggested by the SCB study. Although we could not examine the resultant effect on species with recent plans, because data are lacking, by following the SCB study recommendations closely, the agencies are likely on the right track toward improved recovery. Our results indicate that management under the ESA is improving and may be more successful at protecting listed species. Though certain areas of management under the ESA can be vastly improved, our findings suggest that the recent changes to the recovery-planning framework have successfully incorporated important changes in focus and planning technique. These changes in focus are instructive for planning prioritization both in the United States, including funding allocation (McCarthy et al. 2012), and elsewhere. We found that many SCB recommendations can be effectively incorporated into recovery plans. International recovery planning efforts could follow the USFWS' lead and begin incorporating some of these important planning characteristics into their recovery planning and species management regimes (Possingham et al. 2002). The SCB study recognized these planning changes as fundamental to the recovery of species, and other systems across the globe may benefit from following in the USFWS and NMFS footsteps by integrating these suggestions into their frameworks.

Although we focused only on threats to species, data were collected for many additional attributes of recovery plans. Further research could help to determine if other areas of plans have improved since the SCB study. Specifically, there has been a push to incorporate quantitative recovery criteria (Gerber & Hatch 2002; Schultz & Hammond 2003) and to improve prioritization and management of recovery actions by including adaptive management in plans (Crouse et al. 2002; Ruhl 2003). Additionally, with the current agreement by the USFWS to consider listing over 250 species by 2017 (USFWS 2011), research on how recovery planning could be more efficient and effective will play an important role in allowing listed species to gain protection and begin to recover. Finally, our data are relevant to applying structured decision making (Gregory et al. 2013) and other new approaches to the recovery planning process.

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