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THE SCOPE AND TREATMENT OF THREATS IN ENDANGERED SPECIES RECOVERY PLANS

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Abstract. The recovery of threatened and endangered species is complicated by the number, severity, and tractability of the threats facing each species. We investigated the nature and the treatment of threats in recovery plans for 181 threatened and endangered species. We examined the types of threats facing species, as well as the degree to which threats were understood and addressed. We found that >85% of all species faced at least four out of nine distinct types of threats. The most common threats were those related to resource use, exotic species, construction, and the alteration of habitat dynamics. Recovery plans lacked basic information about the magnitude, timing, frequency, or severity of 39% of all threats facing the 181 species. Likewise, 37% of all threats were not directly addressed with recovery tasks. Threats from pollution were more poorly understood than other threats, and threats from exotics were better addressed than other types of threats. Finally, we found that threats that were better understood were assigned recovery tasks more often than threats that were more poorly understood. Thus our results suggest that a lack of basic understanding of the nature of the threats facing threatened and endangered species may, in part, be undermining our recovery efforts.

Key words: *endangered species; Endangered Species Act; recovery plans; threats.*

Introduction

The Endangered Species Act (ESA) charges the U.S. Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service with developing recovery plans for all federally listed endangered and threatened species, except when the agency determines that a recovery plan would not promote the recovery of a species (U.S. ESA 1988). One crucial purpose of a recovery plan is to prescribe tasks to restore species' populations to viable, self-sustaining levels so that they can be removed from the endangered species list (USFWS 1990).

The recovery of threatened and endangered species depends on the identification and removal or amelioration of the factors threatening the existence of the species. For cases in which a single, relatively tractable, factor contributes heavily to the risk of extinction of a species, recovery may be feasible in a relatively short time frame. Species facing numerous or poorly understood threats, on the other hand, are likely to present greater challenges. The threats to endangered species have been identified in a number of studies, both in relation to their relative importance to different taxa (Schemske et al. 1994, Foin et al. 1998, Wilcove et al. 1998, Stein et al. 2000) and their geographic distribution (Dobson et al. 1997, Richter et al. 1997, Flather et al. 1998). We expanded on these studies by investigating the treatment of threats in recovery plans produced by the USFWS.

We briefly summarized the number and types of threats facing 181 threatened and endangered species. We then investigated the magnitude, timing, frequency, and severity of the threats. To assess the treatment of threats in recovery plans, we analyzed how the extent to which threats were understood and addressed varied with taxon, magnitude of threat, and mode of effect (direct or indirect). Finally, we investigated whether threats that were better understood in recovery plans were addressed more often with tasks to promote a species' recovery.

Methods

The data used here were extracted from a large database compiled during a comprehensive review of recovery plans for 181 species listed under the U.S. Endangered Species Act. Details regarding the general design and methodology of the recovery plan review

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TABLE 1. Threats to 181 threatened and endangered species as listed in a sample of USFWS recovery plans.

Types of specific threats	Specific threats	Percentage of species
Resource use	timber, ore, oil and gas, grazing, fishing and hunting, collection, other resource use	80
Exotic species	competition, predation, parasitism, pathogens, disease vector, habitat modification, other effects of exotic species	73
Construction	commercial, urban/suburban, rural, utilities, roads, other construction	71
Altered habitat dynamics	successional change, fire regimes, hydrodynamic regimes, agricultural regimes, other altered habitat dynamics	70
Agriculture	dryland herbaceous, irrigated herbaceous, dryland woody plants, irrigated woody plants, silviculture, aquaculture, other agriculture	48
Species interactions (non-exotics)	competition, predation, parasitism, prey, pathogen, other species interactions	46
Pollution	water point source, water nonpoint source, air point source, air nonpoint source, deposition, solid waste, toxins, acid precipitation, other pollution	44
Water diversions	dams, irrigation, flood control, groundwater extraction, wetland fill, dredging, other water diversions	41
Other factors	inbreeding depression, climate change, weather extremes, catastrophes, all other threats	62

Notes: Recovery plans were evaluated to determine which of the 59 threats listed in the middle column affected each species. The first column lists nine categories into which the 59 threats were grouped. The third column lists the percentage of species that faced at least one threat in each of the nine categories. The percentages in the right-most column do not sum to 100% because species often faced threats in multiple categories.

project are presented in Hoekstra et al. (2002). For each analysis described, we reference the unique alphanumeric codes that identify the specific columns of data extracted from the project database.

To describe the threats facing threatened and endangered species, evaluators recorded whether or not each species was affected by each of 59 threats (column M), which were aggregated into nine broader categories: resource use, exotic species, construction, altered habitat dynamics, (non-exotic) species interactions, agriculture, pollution, water diversions, and ''other factors'' (Table 1). Several of our analyses were based on these nine broad categories in lieu of the 59 individual threats. Hereafter, the 59 threats will be called ''threats'' and the nine categories will be referred to as ''types of threats.'' We tallied the percentage of the 181 species that faced at least one threat in each of the types of threats. We also counted the number of types of threats faced by each species. We compared the number of types of threats faced by plants and animals with a *t* test, and the number of types of threats faced by four different animal taxa (birds, fish, mammals, and invertebrates) with ANOVA. All analyses by animal taxon were done with these four taxa.

We investigated the nature of the threats facing threatened and endangered species with respect to their magnitude, timing, frequency, and severity. Evaluators classified the magnitude of each threat facing a species as either major or minor (col. P). This general classification attempted to describe the overall danger that a particular threat posed to a species. The timing of threats was coded as historic, current, anticipated, or multiple (a threat occurring over any combination of these time frames; col. Q). The frequency of threats was classified as one-time or chronic (col. R). Finally, the severity of each threat when it affected the species was classified as light, moderate, or intense (col. S). Although assessing the nature of threats clearly involves a certain degree of subjectivity, several steps were taken in the creation and use of the evaluation instrument to minimize such effects (see Hoekstra et al. 2002).

We also examined whether threats facing particular taxa or particular types of threats were disproportionately lacking information about their nature (i.e., magnitude, timing, frequency, and severity). For each species, we compiled the percentage of threats with complete information and used this as a response variable. Likewise, we compiled the percentage of threats with complete information for each of the nine types of threats for each species and used this as a response variable. Because the latter approach leads to a lack of independence among threat types, we calculated Spearman correlation coefficients for all pairs of threat types to assess the degree of dependence. Significant differences in the percentage of threats with complete information across the nine threat types suggest that some types of threats are intrinsically difficult to document. In contrast, significant correlations among threat types suggest that some plans are better documented, in general. We compared percentages both across taxa and across the nine types of threats, using Kruskal-Wallis tests.

We then investigated whether the extent to which different types of threats were addressed varied with the nature of the threat. Recovery plans typically define a series of numbered ''recovery tasks'' or actions to be implemented for the recovery of the species. These tasks should, in part, be designed to eliminate or ameliorate the threats facing the species. To assess whether

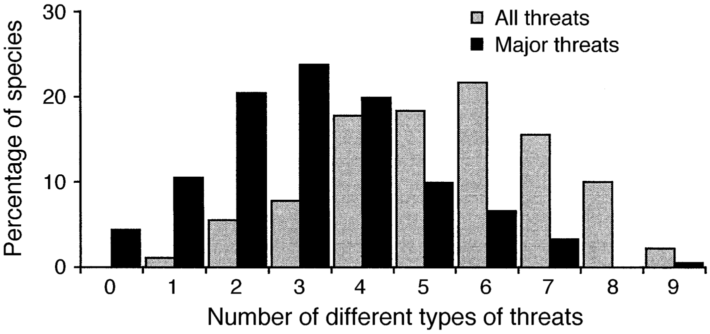

FIG. 1. The distribution of the number of different types of threats faced by threatened and endangered species, as identified by recovery plans. Species faced from one to nine different types of threats (see Table 1). The gray bars represent the number of all threats to threatened and endangered species, and the black bars represent the number of threats that were considered to have a major impact on the species.

threats were addressed with tasks, for each species, we calculated the percentage of threats with which a recovery task was directly associated (col. X). We compared the degree to which (1) major vs. minor threats, (2) direct vs. indirect threats (col. U), (3) different taxa, and (4) different types of threats were addressed with recovery tasks. For the comparison of major to minor threats, for each species, we computed the percentage of major and minor threats for which no recovery tasks were designated. We then tested the within-species differences in percentages with a Wilcoxon signed-ranks test. The comparison of the degree to which direct and indirect threats were addressed was done similarly. Using Kruskal-Wallis tests, we compared the percentages of threats addressed for each species both across taxa and across the nine types of threats. Again, because testing across threat types might not have provided independent samples, we computed Spearman correlation coefficients for the percentages of threats addressed in all pairs of threat types. If strong correlations existed between the percentages of threats addressed in each threat type, we would conclude that some recovery plan authors are more thorough or proactive than others, or that some species (i.e., higher profile species) are generally better addressed.

Finally, we tested whether threats that are better documented in recovery plans (i.e., threats with complete information in our analysis) are addressed with recovery tasks more often than threats that are more poorly documented. We used χ^2 tests to test for this association among all threats, and for each of the nine types of threats individually.

RESULTS

The threats

Approximately 85% of all species faced at least four out of nine different types of threats, two or more of which were considered to be major (Fig. 1). Plants faced fewer threats than did animals (on average, one less threat; $t = -3.4831$, df = 179, $P < 0.001$), but there were no differences in the number of threats among animal taxa ($F = 0.143$, df = 94, $P = 0.706$). The most prevalent threats were those related to resource use, exotic species, construction, and changes in habitat dynamics (Table 1), respectively threatening 80%, 73%, 71%, and 70% of all species examined.

Nature of threats

We tallied a total of 1928 threats affecting the 181 species reviewed. Examining the magnitude, timing, frequency, and severity of each of the 1928 threats showed that most threats were major (49%), chronic (76%), occurred in multiple time frames (63%), and were intense when they did occur (44%). However, 39% of all threats were lacking information about at least one of four aspects of their nature (magnitude, timing, frequency, or severity). More was known about the timing of threats (5% lacked information) than about the severity of threats (30% lacked information).

Although we found no difference in the degree to which threats were understood for different taxa (plants vs. animals, Kruskal-Wallis $\chi^2 = 1.55$, df = 1, $P = 0.214$; across four animal taxa, Kruskal-Wallis $\chi^2 = 5.26$, df = 3, $P = 0.137$), the nine types of threats were differentially understood. Threats related to pollution, species interactions, and ''other factors'' were less well understood than were threats related to construction, agriculture, and exotics. These differences appeared to be statistically significant (Kruskal-Wallis $\chi^2 = 26.21$, df = 8, $P = 0.001$). However, our correlation analysis indicated that of the 36 pairs of threat types, 89% were significantly correlated ($P < 0.05$), with correlation coefficients that ranged from 0.30 to 0.71 (81% of all pairs had correlation coefficients ≥ 0.40). These results suggest that pollution and species interactions may be more poorly understood than other types of threats, but some plans were generally better documented than others.

Addressing threats

Of all threats identified in recovery plans, 37% did not have associated recovery tasks. We found that major threats were addressed with recovery tasks more often than minor threats (Wilcoxon signed-ranks test $Z = -3.10$, $P = 0.001$); nonetheless, 33% of all major threats were not directly addressed with a recovery task. Of all threats, 34% were direct, 20% were indirect, and 37% were considered to affect the species both

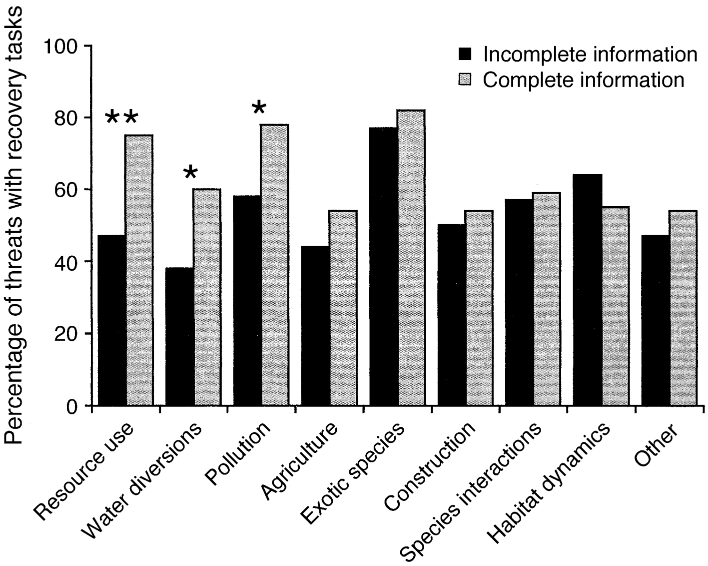

FIG. 2. The relationship between how well threats were documented and addressed in threatened and endangered species recovery plans and the type of threat. Bars represent the percentage of threats, with complete or incomplete information, that were assigned at least one task to promote the species' recovery. Evaluators assessed the nature of all threats cited in USFWS recovery plans for 181 threatened and endangered species. If a plan contained information about the magnitude, frequency, timing, and severity of a threat, complete information about the nature of that threat was said to have been provided. Otherwise, the information provided was said to have been incomplete. Asterisks above the bars depict the significance of χ^2 tests (*$P < 0.05$; **$P < 0.001$).

directly and indirectly (with the remainder ''unknown''). Interestingly, direct and indirect threats were addressed to a similar extent (Wilcoxon signed-ranks test $Z = -1.26$, $P = 0.897$). Threats to plants and animals were also addressed to a similar extent (Kruskal-Wallis $\chi^2 = 3.15$, df = 1, $P = 0.076$), as were threats to the four taxa of animals (Kruskal-Wallis $\chi^2 = 4.14$, df = 3, $P = 0.247$).

Recovery plans addressed different types of threats to different degrees (Kruskal-Wallis $\chi^2 = 39.82$, df = 8, $P < 0.001$). Threats from exotics were addressed more frequently than other threats (80% of the threats from exotics were addressed, compared to 50–67% for all other types of threats). Threats from construction, agriculture, water diversion, and ''other factors'' were least often addressed. However, testing across the nine types of threats did not provide independent samples, so we computed Spearman correlation coefficients for all pairs of threat types. Of the 36 pairs, 36% were significantly correlated ($P < 0.05$), with correlation coefficients that ranged from 0.23 to 0.47. These relatively weak correlations indicated that the degree to which threats were addressed was indeed threat-specific, and unlikely to depend on the recovery plan authors or species.

Threats that were better documented in recovery plans (i.e., threats with complete information in our analysis) were addressed with recovery tasks more often (66% addressed) than threats that were more poorly understood (55% addressed) ($\chi^2 = 21.14$, df = 1, $P < 0.001$). This differential varied with the type of threat and was strongest for threats related to resource use, water diversions, and pollution (Fig. 2). Ideally, each threat would be analyzed independently, but because species faced multiple threats, individual threats could not be considered independent samples. The bias due to such lack of independence should be manifest as plan dependence in the degree to which threats were addressed. However, the correlation analysis that we presented here provided little evidence for such a bias. Thus neither the general quality of a plan nor the effort put into the plan by its authors is likely to be driving the relationship that we found between the understanding of threats and the degree to which threats were addressed.

DISCUSSION

Most threats listed in recovery plans are chronic, have occurred over a long time period, and are intense when they do occur. In addition, most species face multiple major threats rather than single major threats. The recovery of species under such conditions is likely to be quite difficult. Some species with single major threats that have proven relatively feasible to address have shown signs of recovery. Both Bald Eagles (*Haliaeetus leucocephalus*) and Peregrine Falcons (*Falco peregrinus*) have recovered largely due to the banning of the pesticide dichlorodiphenyltrichloroethane (DDT). Likewise, gray wolves (*Canus lupis*) have been successfully reintroduced to Yellowstone National Park in the absence of hunting and trapping. Such examples of species facing a single major threat are, according to our analysis, rather unusual among threatened and endangered species.

Although the threats to species are usually known (Schemske et al. 1994, Tear et al. 1995, Wilcove et al. 1998), we found that basic information about the nature of these threats was often lacking in recovery plans. For example, plans often lacked information about whether threats were major or minor, when and how often they occurred, and how severely they affected the species when they did occur. With such a lack of information, assigning and prioritizing tasks to recover species is necessarily difficult.

Lack of knowledge regarding the nature of threats facing species is likely to be one of the factors contributing to the failure of plans to address threats with recovery actions. We found that roughly one-third of all major threats facing species were not specifically addressed with a recovery task. It is important to note that this is likely to be an overestimate of the percentage of unaddressed threats; only when a task directly addressed the threat in question was it recorded in the evaluation of the plans. Nonetheless, the fact that more poorly documented threats tended to be addressed less often than threats that were better documented suggests a potential weakness in recovery planning that warrants attention.

The complex nature of many threats is likely to make them difficult to both document and address in recovery plans. For example, controlling exotic species is proving to be a monumental challenge that requires a broad array of possible solutions, the results of which can be highly unpredictable (Cox 1999, Myers et al. 2000). In addition to understanding complex ecological systems, removing or ameliorating threats often requires understanding and addressing interrelated economic and social factors. For example, threats related to resource use, agriculture, water diversion, and construction often involve complicated issues of private land ownership (see Bean and Wilcove 1997). In these cases, recovery plan authors may be faced with additional challenges involving the ecological, economic, or social feasibility of assigning tasks for a species' recovery.

Money for the protection and recovery of threatened and endangered species is limited. Therefore, it would be prudent to set priorities clearly so that we can optimally use the funds available. Our analysis indicates that recovery plans currently do not document threats well enough to allow this. We recommend that more energy be expended early in the recovery process to understand the factors that threaten species. No matter how much ecological theory, natural history, and monitoring sophistication we bring to bear on threatened and endangered species recovery, the science will be squandered without detailed insight into the threats that are putting the species at risk.

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