Missing, delayed, and old: The status of ESA recovery plans

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Abstract
Recovery planning is an essential part of implementing the U.S. Endangered Species Act (ESA), but conservationists and government agencies recognize challenges with the current planning process. Using data from all U.S. domestic and transboundary ESA-listed species, we quantify the completeness, timeliness, age, and other variation among ESA recovery plans over the past 40 years. Among eligible listed taxa (n = 1,548), nearly one-fourth lack final recovery plans; half of plans have taken >5 years to finalize after listing; half of recovery plans are more than 20 years old; and there is significant variation in planning between agencies, and among regions and taxonomic groups. These results are not unexpected given dwindling budgets and an increasing number of species requiring protection, but underscore the need for systematic improvements to recovery planning. We discuss solutions—some already underway—that may address some of the shortcomings and help improve recovery action implementation for threatened and endangered species.

Keywords
Endangered Species Act, Fish and Wildlife Service, National Marine Fisheries Service, recovery planning

1 INTRODUCTION

The U.S. Endangered Species Act (ESA) is widely considered the strongest wildlife conservation law in the world. Recovery plans are a key part of the strength of the ESA, and detail the biology of ESA-listed species, the threats they face, and the actions needed to achieve the goals of preventing the extinction of and recovering the species (Schwartz, 1999; U.S. Congress, 1973, 1978, 1988). For example, species with recovery plans are more likely to have improving status than species without plans (Taylor, Suckling, & Rachlinski, 2005). The federal agencies responsible for implementing the ESA, the U.S. Fish and Wildlife Service (FWS) and National Marine Fisheries Service (NMFS; collectively, the Services), are required to develop recovery plans unless they find doing so would not promote the conservation of the species (e.g., for foreign-listed species).

Recovery plans have evolved significantly over the years. Perusing available plans (https://ecos.fws.gov), one observes that those from the 1980s are rarely more than several dozen pages in length while recent plans are more substantial. A significant part of the evolution of recovery plans was driven by detailed studies of recovery planning organized by the Society for Conservation Biology (SCB) in the late 1990s (see overview in Clark, Hoekstra, Boersma, & Kareiva, 2002). Informed by the SCB review, the Services developed their joint recovery planning handbook (NMFS & FWS, 2003), which has improved recovery plans by, for example, shifting the focus of recovery to threats (Troyer & Gerber, 2015). Because available data indicate the status of most ESA-listed species declined between 1990 and 2010 (Evans et al., 2016), species need plans with timely information to guide recovery efforts.

Although many aspects of ESA recovery plans have improved, practitioners recognize that significant challenges remain with the recovery planning process. For example, in NMFS’ (2016) public review of its recovery program, panelists and participants noted that too many species lack...
recovery plans; plans take too long to develop; plans remain unchanged for too many years despite new knowledge; and there may be too much variation in how recovery planning is implemented (NMFS, 2016). While these problems are known to exist, their extent has not been comprehensively quantified or estimates are dated. For example, Tear and colleagues (1995) reviewed recovery plans for 344 species (53% of 652 species listed as of 1991) and found that plant recovery plans took on average 4.1 years to complete while plans for animals took 11.3 years. Schwartz (2008) found that 15% of species lacked recovery plans in his broad review of the ESA. Since then, >350 species have been listed as threatened or endangered, new plans have been published, and other plans have been updated. Now, nearly a decade later and with a new batch of species likely to be listed in the coming decade (FWS, 2017), there is a need to understand and, as necessary, improve the status of ESA recovery planning.

Using data from the Services’ websites, we answered four questions about the history and status of ESA recovery plans:

1. How many species have final recovery plans, and how has that changed since 1978? Finalized recovery plans are the official position about what is needed for recovery. They can inform regulatory actions, such as Section 7 consultations, for example, through “recovery units” (FWS & NMFS, 1998) and in mitigation (U.S. Fish and Wildlife Service, 2008). Recovery outlines or draft recovery plans are useful, but are not official positions on recovery.

2. What is the average time from listing to an original final recovery plan? The Services’ 1994 recovery planning guidance stated that, “the Services will...develop recovery plans within 2-1/2 years after final listing” (FWS & NMFS, 1994). This goal is relevant because the longer a species goes without a recovery plan, the more likely it is to be neglected and recovery actions to remain uncoordinated. However, the Services and their conservation partners recognize that recovery planning often takes far longer than 2.5 years (e.g., >6 years for Cook Inlet beluga whale (Delphinapterus leucas; NMFS, 2016, Appendix C), in part because addressing these complex problems requires coordination among multiple parties (Crouse, Mehrhoff, Parkin, Elam, & Chen, 2002).

3. How old are recovery plans as of 2018? A significant challenge of current recovery planning is the difficulty of updating plans: revisions often require extensive and expensive work. But our knowledge of species and threats—consider the emergence of our understanding of climate change in the past decades—can change rapidly. A previous analysis found that revisions did not improve recovery criteria (Harvey, Hoekstra, O’Connor, & Fagan, 2002), but we anticipate that recovery will be more successful if plans contain up-to-date information beyond original recovery criteria.

4. How has recovery planning varied among FWS regions, between the Services, and among taxonomic groups? Systematic differences may be present in recovery planning given differences between the Services in funding, culture, and workload (e.g., Lowell & Kelly 2016), the high degree of independence of FWS regions, and taxonomic biases in conservation (e.g., Stein et al. 2002). Identifying patterns of differences can help focus attention to initiate, complete, or revise recovery plans.

We do not attempt to answer other important and interesting questions, such as whether the recovery criteria of newer or revised plans are scientifically better supported than those of older recovery plans. Our results show that both the extent of recovery plan coverage and the time required for recovery plan development, finalization, and revision are falling short of expectations set by the Services (FWS & NMFS, 1994). We discuss several solutions that can improve recovery planning for threatened and endangered species.

2 | METHODS

We collected all available recovery plan metadata by web-scrapping FWS’s ECOS website (https://ecos.fws.gov), recording all data in every table on each species’ page, and downloading all documents. Because listings occur on a species-by-location basis, we manually linked recovery plans to the listed entity when there were multiple locations (e.g., distinct population segments) that each require their own recovery plan. We refer to every listed entity as “species” for simplicity. NMFS does not provide tabular metadata for its recovery plans, so we manually curated data from its recovery plan website (https://www.nmfs.noaa.gov/pr/recovery/plans.htm). Many species have multiple documents listed in recovery plan tables even though those documents are often just related addenda; we used only the document that is the core plan rather than associated documents. We collected data for all domestic U.S. and transboundary listed species because foreign-listed species rarely warrant recovery plans.

To quantify completeness of plans (Q1), we simply tallied species listed in each year and recovery plans in each year. For the time-to-plan analyses (i.e., the time from listing to final plan; Q2), we included only final recovery plans and not subsequent revisions so as not to inflate the time period. Importantly, time-to-plan is right-censored data: we do not know the plan date for species lacking plans. While there are ways to estimate expected values, those methods require assuming stationarity (Qin & Shen, 2010), which is invalid for our data. Instead, we simply acknowledge that the time-to-plan estimates are likely biased low because of species that still
The cumulative number of listed species (black line), species with official recovery plans (gray dashed line), species with draft recovery plans (gray dotted line), and the number of species lacking recovery plans (red line) show distinct tempos. The number of species with plans correlates well with the number of listed species ($r = 0.864, p = 7.08e-5$). A concerted effort to increase the number of species with recovery plans in the mid-1990s and the low listing rate from 2001 to 2009 led to a decline in the number of species without recovery plans. That trend began reversing as the rate of listings increased again starting in 2009. (b) Recovery plans by year show a pulse of planning in the mid- and late-1990s. The greater the difference between the black line (number of species with plans) and gray line (number of plans), the greater the proportion of species covered by multispecies plans. There was a pulse of draft plan (dotted line) in 2010.

In contrast to the time-to-plan estimates, we included all species with official plans for estimating plan age (Q3) as of 2018-01-08 because the most recent plan revision date is known and the age is unbiased. We used Pearson’s correlation and general linear models (McCullagh & Nelder, 1999) for variance partitioning to understand variation among places and groups (Q4).

We used R for scraping, data management, and analyses (R Core Team 2017). The code for data preparation, model specifications, other analyses, and graphs can be found in the public GitHub repository at https://github.com/jacob-ogre/recovery_plan.overview, including an R vignette of all analyses. Data and code are archived at the Open Science Foundation under project “zwhv3” (https://doi.org/10.17605/OSF.IO/ZWHV3).

3 | RESULTS

3.1 | Species with and without plans

The number of domestic and transboundary-listed species has increased to 1,660 taxa (Figure 1a) since 1973. Of these, seven species were exempted from recovery planning and 105 taxa were listed less than 2.5 years ago, i.e., are newer than the Services’ target for plan development. We exclude these 112 species from subsequent calculations unless noted. Of the 1,548 species eligible for final recovery plans, we found 1,038 species had a final plan as of January 2018 and 131 had a revised plan ($n = 604$ official plans), leaving 379 species (24.5% of eligible species) without official recovery plans. Of the species lacking an official plan, 98 (6.3%) had a draft recovery plan or a recovery outline, leaving 280 species (18.1%) without any publicly available recovery guidance. Starting around 1980, the number of species with final recovery plans began increasing at a rate comparable to the listing increases (Figure 1a). A steep increase in the number of species with plans in the 1990s was associated with an increased emphasis by FWS on recovery planning and an increase in the number of multispecies recovery plans (Figure 1b, Figure S1). The rate of listing has outstripped recovery planning since that peak of recovery plan production, and the proportion of species listed each year that have a recovery plan has declined since 2000 (Figure 2).

3.2 | Time-to-plan

Using only data for species with final, nonrevised recovery plans, we found a median time-to-plan of 5 years, which was skewed toward longer times ($\bar{x} = 6.7$ years; Table 1;
The proportion of species with recovery plans by year begins to drop significantly starting with species listed around 2000. Points represent the proportion of ESA-listed species with recovery plans each year; line represents the spline-fit curve. Despite the decline, a high proportion of species listed between 2001 and 2009 had recovery plans (see Fig. 1) because very few species were listed during this time.

Figure 3a). Only 18.6% of species received a plan within 2.5 years of listing and 18.4% required ≥10 years (Figure 3b). The data include 53 species for which the time-to-plan was negative. These are not mistakes: species were included in existing multispecies plans that had already identified the species of concern before they were listed. Excluding these species from the calculations only slightly increased the average time-to-plan (\( \bar{\tau} = 7.06 \) years). Recognizing that species without final plans constitute right-censored data, the time-to-plan for species with plans has generally declined over the past four decades (year parameter \( \beta = -0.12, P = 4.56 \times 10^{-6} \); Figure 4). Last, species in multispecies plans had a time-to-plan approximately 1.4 years shorter than those in single-species plans (median 4.7 vs. 6.1 years).

### 3.3 Plan ages

The age distribution of current recovery plans is highly variable, with a median recovery plan age of 22.8 years \((n = 604 \) plans; Figure 5a). It is useful to examine both ages of plans (Figure 5b) and ages of plans on a per-species basis (Figure 5c): multispecies plans mean that the ages cluster on a per-species basis. As a result of this clustering, the median age of plans per-species is 20.5 years. As of January 2018, 10% of species have plans that are <10 years old, and 10% of species have plans that are >31.7 years old.

### 3.4 Plans by region, agency, and taxon

NMFS has a lower proportion of species with recovery plans than FWS, and FWS regions with fewer listed species tend to have a higher proportion of species with plans (Table 2). Time-to-plan varied across regions and between the Services \((F_{8,1029} = 21.74, P < 2.2 \times 10^{-16}, \text{multiple } R^2 = 0.145)\), with time-to-plan substantially longer for NMFS species than for FWS species (Figure 6a). Similarly, plan age varied across regions and between the Services \((F_{8,1029} = 32.8, P < 2.2 \times 10^{-16}, \text{multiple } R^2 = 0.197)\), but plans are substantially newer for NMFS species than for FWS species (Figure 6b). Time-to-plan and plan age were negatively correlated \((r = -0.361; t = -12.464, df = 1036, P = 2.2 \times 10^{-16})\).

We found substantial variation in plan completion among taxonomic groups (Table 3). None of the diverse taxonomic groups are complete, but some (e.g., reptiles and birds) have particularly high completion rates at 94 and 89% (respectively), while amphibians, insects, and snails (63, 60, and 65%, respectively) have noticeably low rates. Species in a few small groups—conifers and cycads (three species), lichens (two species), and arachnids (12 species)—all have official recovery plans. Time-to-plan is structured by taxonomic group \((F_{14,1023} = 17.03, P < 2.2 \times 10^{-16})\), but is driven by high time-to-plan for birds and mammals (Figure S2). Plan age also covaries by group \((F_{14,1023} = 5.62, P = 1.43 \times 10^{-10})\), but is highly variable within groups (Figure S3).

| Guide | Min  | Median | Mean  | Max  |
|-------|------|--------|-------|------|
| 1,038 spp. with final plans* | | | | |
| Listed date | 3/11/67 | 5/14/92 | 8/20/90 | 9/19/13 |
| Plan date | 3/17/80 | 7/29/97 | 4/22/97 | 10/13/17 |
| Years elapsed | –13.5 | 5 | 6.7 | 50 |
| 119 spp. with revised plans | | | | |
| Listed date | 3/11/67 | 10/28/75 | 8/07/76 | 5/13/10 |
| Plan date | 6/14/83 | 8/22/01 | 3/2/01 | 6/11/17 |
| 35 spp. with draft plans | | | | |
| Draft date | 9/30/84 | 9/30/97 | 1/11/04 | 6/26/17 |
| Years elapsed | –5.7 | 7.9 | 11.9 | 45 |

*These species include only those with a “Final” plan and does not include plan revisions (see text for details).
FIGURE 3  The median time-to-plan was 5.1 years, but skewed towards higher values (mean = 7 years). In (a), negative values indicate species with plans written before the species was listed under the ESA, typically in multispecies/ecosystem recovery plans. In (b), the line represents the percent of plans with time-to-plan less than X and shows only 19% of recovery plans have been completed within the Services' stated goal of 2.5 years; 20% have taken ten or more years.

4 | DISCUSSION

Recovery plans are one of the few requirements of the ESA that encourages forward planning (Schwartz, 2008) and play a critical role in guiding the actions of agencies, conservation partners, and the regulated community (Clark et al., 2002; Crouse et al., 2002). Significant progress has been made improving the quality of recovery plans: contemporary plans are far more detailed and science-based than many older plans (Troyer & Gerber, 2015). But the number of ESA-listed species in increasing and funding is widely recognized as insufficient and static or declining (Gerber, 2016; Lowell & Kelly, 2016; Negrón-Ortiz, 2014) have left the Services unable to develop recovery plans or keep them up-to-date. Here, we have shown that many ESA-listed species’ plans are missing, out-of-date, slow to develop relative to Services expectations (FWS & NMFS, 1994), or taxonomically biased, which informs how future recovery planning can be improved.

The first challenge we identified is the number of species without recovery plans. We found a quarter of eligible ESA-listed species currently lack an official recovery plan. This rate is less than half, 53% in 1991 (Tear et al. 1995), but substantially higher than the ~15% (n = 211) of species that lacked recovery plans in 2007 (Schwartz, 2008). The increased rate of listings since 2009 has outstripped the relatively constant rate of recovery plan completion during that period, creating the current gap. Time-to-plan is a complement of completeness: the longer the gap without plans, the lower the rate of completeness at any point in time. The NMFS recovery review panel recognized the problem of delays (NMFS, 2016), and our finding that recovery plans require twice the target set by the Services (5.1 vs. 2.5 years) underscores that issue.

The second and substantially different challenge of recovery planning is plan age. At a median age of >20 years and with 10% of plans ≥31.7 years old, hundreds of recovery plans are showing their age. Not only has our knowledge about these species likely advanced over these extended timeframes, but the biological status and threats have likely changed significantly. For example, the indigo snake (Drymarchon corais couperi) recovery plan was finalized in 1982, when poaching was identified as a significant threat. Today, habitat destruction in the Southeastern U.S. is clearly the leading threat.
FIGURE 5  The distribution of the ages of current recovery plans is complex and the range is wide (<1 year to >36 years old). Variation in the tempo of recovery planning is clear in the histogram of plan ages, e.g., the pulse of recovery plans from the mid-to-late 1990s is very evident (a). Half of all recovery plans are >19.5 years old, and 10% are 32.5 or more years old as of 2016. The shape of percentile curves (i.e., the line represents the percent of plans with time-to-plan less than X) varies slightly between the age of plans on a per-species basis (b) and the age of plans (c) because of the use of multi-species plans, especially in the 1990s.

TABLE 2  Distribution of species with and without recovery plans, between U.S. Fish and Wildlife Service regions (1-8) and the NMFS

| Region | No. with plan | No. eligible | Proportion with plan |
|--------|---------------|--------------|----------------------|
| 1      | 353           | 505          | 69.9                 |
| 2      | 120           | 159          | 75.5                 |
| 3      | 36            | 46           | 78.3                 |
| 4      | 316           | 363          | 87.1                 |
| 5      | 38            | 43           | 88.4                 |
| 6      | 40            | 61           | 65.6                 |
| 7      | 6             | 8            | 75                   |
| 8      | 220           | 295          | 74.6                 |
| NMFS   | 40            | 73           | 54.8                 |

(Breininger et al., 2012). Similarly, very few recovery plans consider climate change but almost all should (e.g., Povilitis & Suckling, 2010; Ruhl, 2008).

Addressing the challenges of recovery planning we have detailed here will require a combination of approaches. First, more funding is needed: a recent analysis found <25% of required recovery funding had been allocated annually from 1980 to 2014 (Gerber, 2016). The U.S. Congress and states need to significantly increase funding, and perhaps develop a dedicated revenue stream for ESA recovery (AFWA, 2016), akin to the Pittman-Robertson Act, which provides funding from firearm sales to state wildlife agencies. The Services should also look at recruiting resources beyond traditional funding. For example, professional societies and organizations such as Xerces Society and Partners for Reptile and Amphibian Conservation may be able to mobilize resources to help the Services complete missing insect and amphibian recovery plans. The Services may even be able to solicit funding for recovery planning, for example, from entities who benefit from the regulatory certainties arising from final recovery plans (Article S1). Regardless of the sources, this funding will need to be coupled with priority-setting—which plans need to be written or revised first—and expectation management, for example, through policy revision, as discussed further below, and public engagement.

Second, fundamental administrative changes underway at the Services will help address some issues in recovery planning. For example, FWS has developed their Recovery Planning and Implementation framework (RPI; Articles S2 and S3), which holds promise for making plans both faster to create and easier to update. (NMFS expressed its interest in RPI in its response to the recent recovery program review (Consensus Building Institute, 2016.) Under RPI, the traditional monolithic recovery plan is split into three parts: a Species Status Assessment (SSA) that is maintained as a “living document”; a short (10-20 pages) core recovery plan that contains mostly static content such as recovery criteria; and one or more Recovery Implementation Strategies that contain implementation details. With the adoption of RPI, SSAs are developed before listing decisions or as part of status reviews. This means a significant amount of recovery planning happens before the “formal” recovery planning period, and suggests
FIGURE 6 Variation in the time-to-plan (a) and plan age (b) is high between U.S. Fish and Wildlife Service (FWS) regions and between FWS and National Marine Fisheries Service (NMFS). Box plots show the median and interquartile range along with outliers, and violin plot overlays show the data density along the y-axis. Time-to-plan is strongly negatively correlated with plan age at the regional/Service level ($r = -0.84, p = 0.001$)

TABLE 3 Distribution of species with and without recovery plans by taxonomic group

| Taxonomic group       | No. with plan | No. eligible | Proportion with plan |
|-----------------------|---------------|--------------|----------------------|
| Amphibians            | 22            | 35           | 62.9                 |
| Arachnids             | 12            | 12           | 100                  |
| Birds                 | 85            | 97           | 87.6                 |
| Clams                 | 71            | 88           | 80.7                 |
| Conifers and cycads   | 3             | 3            | 100                  |
| Corals                | 2             | 6            | 33.3                 |
| Crustaceans           | 19            | 25           | 76                   |
| Ferns and allies      | 26            | 30           | 86.7                 |
| Fishes                | 126           | 162          | 77.8                 |
| Flowering plants      | 625           | 847          | 73.8                 |
| Insects               | 43            | 72           | 59.7                 |
| Lichens               | 2             | 2            | 100                  |
| Mammals               | 68            | 93           | 73.1                 |
| Reptiles              | 34            | 35           | 97.1                 |
| Snails                | 30            | 46           | 65.2                 |
that the formal planning timeline can be shortened. Last, the adoption of SSAs means FWS can keep key status information up-to-date.

Third, the Services should update their 1994 policy to build on the past >20 years of experience and take advantage of RPI, including points to address several of our findings:

- To provide early guidance, the required recovery outline should be publicized soon after the final listing rule. This should include preliminary recovery objectives and a list of needs for developing the full recovery plan.
- To help manage public engagement, which is part of planning but is likely part of the high time-to-plan (Crouse et al., 2002) we observed, the policy could state that an initial public meeting on the recovery plan will be scheduled, if warranted, within 6 months of listing.
- To allow early and continuous public engagement, even before the traditional 30- or 60-day formal comment period, interim recovery plan content should be posted online as soon as possible, and before the Federal Register notice of the draft plan.
- To encourage shorter time-to-plan, the policy can state that the draft recovery plan should be available within 1.5 years of listing, revised as necessary, and approved as final within 2 years of listing.
- Exemptions from the preceding deadlines should be allowed in cases of:
  - Scientific uncertainty, which, if ignored, could result in harm to the species,
  - Recovery actions already underway that would significantly change the content of the recovery plan.
  - Other reasons for which a species’ conservation would be harmed by adhering to the timeline.

This is not an exhaustive list of possible policy updates, but we believe it is a useful starting point for the Services to consider.

Species recovery is the ultimate goal of the ESA and planning is a central component of achieving that goal. Our analyses quantify some of the challenges of recovery planning to date. Some of our recommendations are being addressed while others need prompt attention. Closing the recovery planning and implementation gaps will require not only closing the funding gap (Gerber, 2016; Lowell & Kelly, 2016; Negrón-Ortiz, 2014), but also administrative and technological reforms.

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**SUPPORTING INFORMATION**

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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