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. We show that nearly 1/4 of eligible listed taxa (n = 1,548) 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 between agencies and among regions and taxonomic groups in planning. 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.

Introduction

The U.S. Endangered Species Act (ESA) is widely considered the strongest wildlife conservation law in the world. Recovery plans detail the biology of ESA-listed species, the threats they face, and the actions needed to recover the species (U.S. Congress 1978, 1988) and are a key part of the strength of the ESA. For example, species with recovery plans are more likely to have improving status than species without plans (Taylor *et al.* 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 is not warranted (e.g., for foreign-listed species).

Recovery plans have evolved significantly over the years. Perusing available plans (http://ecos.fws.gov), one observes that those from the 1980s are rarely more than several dozen pages in length while later plans are much 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 *et al.* 2002). Informed by the SCB review, the Services developed their joint recovery planning handbook (NMFS & FWS 2003, 2010), 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), there is a substantial need to ensure species have plans with timely information to guide their recovery.

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 spatial and agency 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 current 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. Further, final recovery plans can inform regulatory actions, such as section 7 consultations, e.g., through "recovery units" (FWS & NMFS 1998) and in mitigation (U.S. Fish and Wildlife Service, 2008). Recovery outlines or draft recovery plans are usually 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 *et al*. 2002).

3. *How old are recovery plans as of 2016?* 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 *et al*. 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 2012), 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 or original 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 expectation and need, and point to several solutions that can improve recovery outcomes for threatened and endangered species.

Methods

We collected all available recovery plan metadata by web-scraping FWS's ECOS website (http://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 (http://www.nmfs.noaa.gov/pr/recovery/plans.htm). Many species, especially in Hawaii, 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 species' 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 because we don't 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 almost certainly invalid for our data. Instead, we simply acknowledge that the time-to-plan estimates are likely biased low because of the species that still lack plans. 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 estimate 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 2016). The 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).

Results

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 1,037 had a final plan as of January 2018 and 130 had a revised plan (n = 602 official plans), leaving 381 species (24.6% of eligible species) without official recovery plans. Of the species lacking an official recovery plan, 98 had a draft recovery plan or a recovery outline, leaving 283 species (18.3%) 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 multi-species recovery plans (Figure 1b).

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).

Time-to-plan

Using only data for species with final, non-revised recovery plans, we found a median time-to-plan of 5 years, which was skewed toward longer times ($\bar{x}$ = 6.6 years; Table 1; 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: these species were included in existing multi-species 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 ($\bar{x}$= 7.06y). 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 = -0.12, $p = 4.56e^{-6}$; Figure 4).

Plan ages

The age distribution of current recovery plans is highly variable, with a median recovery plan age of 22.8 years (n = 602; Figure 5a). It is useful to examine both ages of plans (Figure 5b) and ages of plans on a per-species basis (Figure 5c): multi-species 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.

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 ($F_{8,1028} = 20.38$, $p < 2.2e^{-16}$, multiple $R^2 = 0.13$), 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 ($F_{8,1025} = 28.39$, $p < 2.2e^{-16}$, multiple $R^2 = 0.18$), but plans are substantially newer for NMFS species than for FWS species (Figure 6b). Time-to-plan and plan age were negatively correlated ($r = -0.837$; $t = -4.059$, $df = 7$, $p = 0.0048$).

We found substantial variation in plan completion among taxonomic groups (Table 3). None of the diverse taxonomic groups are complete, but some like reptiles and birds have particularly high completion rates at 94 and 89% (respectively), while amphibians, insects, and fishes (57, 60, and 69%, 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.

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 growing number of ESA-listed species and insufficient and static or declining funding (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 too many ESA-listed species' plans are missing, out-of-date, slow to develop, or taxonomically biased, which informs how future recovery planning can be improved.

198 The first challenge we identified is the number of species without recovery plans. We
199 found a quarter of eligible ESA-listed species currently lack an official recovery plan. This rate is
200 less than half the 53% in 1991 (Tear *et al.* 1995), but substantially higher than the ~15% (*n* =
201 211) of species that lacked recovery plans in 2007 (Schwartz 2008). The increased rate of listings
202 since 2009 has outstripped the relatively constant rate of recovery plan completion during that
203 period, creating the current gap. Time-to-plan is a complement of completeness: the longer the
204 gap without plans, the lower the rate of completeness at any point in time. The NMFS recovery
205 review panel recognized the problem of delays (NMFS 2016), and our finding that recovery
206 plans require twice the target set by the Services (5.1y versus 2.5y) underscores that issue.
207 How can this two-part challenge of completeness and time-to-plan be addressed? First,
208 more funding is needed: a recent analysis found <25% of required recovery funding had been
209 allocated annually from 1980-2014 (Gerber 2016). The U.S. Congress and states need to
210 significantly increase funding for ESA recovery. The taxonomic results suggest additional
211 funding might be coupled with targeted outreach to or by professional scientific societies whose
212 members can assist with recovery plans for particular taxonomic groups. For example, members
213 of Partners for Amphibian and Reptile Conservation members or affiliates could help with
214 amphibian and fish recovery plans; Xerces Society members or affiliates could assist with insect
215 plans. Increased funding should support developing recovery outlines and draft recovery plans,
216 which can effectively guide recovery work until plans are finalized. Draft plans can shape
217 regulatory decisions, e.g., when the Services delineate recovery units (FWS & NMFS 1998) that
218 are used in section 7 consultation (see SI Article S1), and recovery outlines can lay the
219 foundation for detailed planning. These interim tools should be a high priority for the 283 species

lacking any type of plan, the 105 species listed in the past 2.5y, and the hundreds of species that will likely be listed in the coming decade.

Forthcoming administrative changes may improve the completeness and timeliness of recovery plans. One promising route that FWS has been developing is their next-generation recovery planning framework, Recovery Planning and Implementation (RPI; see SI Articles 2 and 3). The central idea of this framework is to separate recovery plans into three components: a core that addresses the statutory requirements of recovery plans, a Species Status Assessment (SSA) that is regularly updated, and a recovery implementation strategy that provides more detail about recovery actions. FWS anticipates that future recovery planning will occur more quickly in part because the SSAs will be prepared during the listing analysis rather than after listing (G. Schultz, FWS, *pers. comm.*). NMFS expressed its interest in this model in its response to the recent recovery program review (Consensus Building Institute 2016).

The second and substantially different challenge of recovery planning is plan age, which is related to the SSA component of RPI. 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 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 at that time. Today, habitat destruction in the Southeastern U.S. is clearly the leading threat (Breininger *et al.* 2012). Similarly, very few recovery plans consider climate change but almost all certainly should (e.g., Ruhl, 2008, Povilitis & Suckling 2010).

Basic technologies like web-based collaboration tools can be leveraged to improve information flow that keeps recovery plans up-to-date. Adopting web-based recovery plans and

SSAs may help close the gap for the species lacking any guidance: the plans can more easily start as recovery outlines in the web-based framework, then be systematically updated until they are finalized. Because of the ease of updating, a web-based recovery plan might be updated every 20 days instead of 20 years. (The statutory requirements for recovery plans—recovery criteria, site-specific actions required, and estimated time and cost [U.S. Congress 1988]—will still require public review and comment before changing.) Importantly, web-based recovery plans offer the benefit of directly incorporating real-time data on other components of the ESA, such as section 7 consultations and section 10 conservation agreements, thereby placing permitting data directly in the context of recovery. To help ensure new and up-to-date plans change how conservation practitioners implement recovery actions—which Boersma *et al.* (2001) suggest may not happen—the Services may need to update their training and standard operating procedures.

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. Many of our recommendations are not new—the Services are moving in these directions—but the results underscore the importance of adopting these changes promptly. Closing the recovery planning and implementation gaps will still require closing the funding gap (Gerber 2016, Lowell & Kelly 2016, Negrón-Ortiz 2014), in addition to the administrative and technological reforms necessary to close the planning gap.

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Tables

Table 1. Summary statistics for time-to-plan and plan completion dates for final recovery plans.

guide	min	median	mean	max
*Spp. with final plans**				
Listed Date	3/11/67	5/15/92	8/27/90	9/19/13
Plan Date	3/17/80	7/29/97	4/17/97	10/13/17
Years Elapsed	-13.5	5	6.6	50
Spp. with revised plans				
Listed Date	3/11/67	10/28/75	8/25/76	5/13/10
Plan Date	6/14/83	5/12/01	2/18/01	6/1/17
Spp. with draft plans				
Draft Date	9/30/84	6/17/10	3/7/08	6/26/17
Years Elapsed	-5.7	0.2	5.3	45

* These 1,037 species include only those with a "Final" plan and does not include plan revisions (see text for details).

339 **Table 2.** The distribution of species with and without recovery plans, between U.S. Fish and
340 Wildlife Service regions (1-8) and the National Marine Fisheries Service (NMFS).

341

Region	# with plan	# eligible	Proportion with plan
1	356	505	70.5
2	122	159	76.7
3	37	46	80.4
4	320	363	88.2
5	41	43	95.3
6	40	61	65.6
7	6	8	75
8	220	295	74.6
NMFS	45	73	61.6

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344 **Table 3.** The distribution of species with and without recovery plans by taxonomic group.

345

Taxonomic group	# with Plan	# eligible	Proportion with plan
Amphibians	20	35	57.1
Arachnids	12	12	100
Birds	86	97	88.7
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	112	162	69.1
Flowering Plants	625	847	73.8
Insects	43	72	59.7
Lichens	2	2	100
Mammals	67	93	72
Reptiles	33	35	94.3
Snails	30	46	65.2

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348 **Figures**

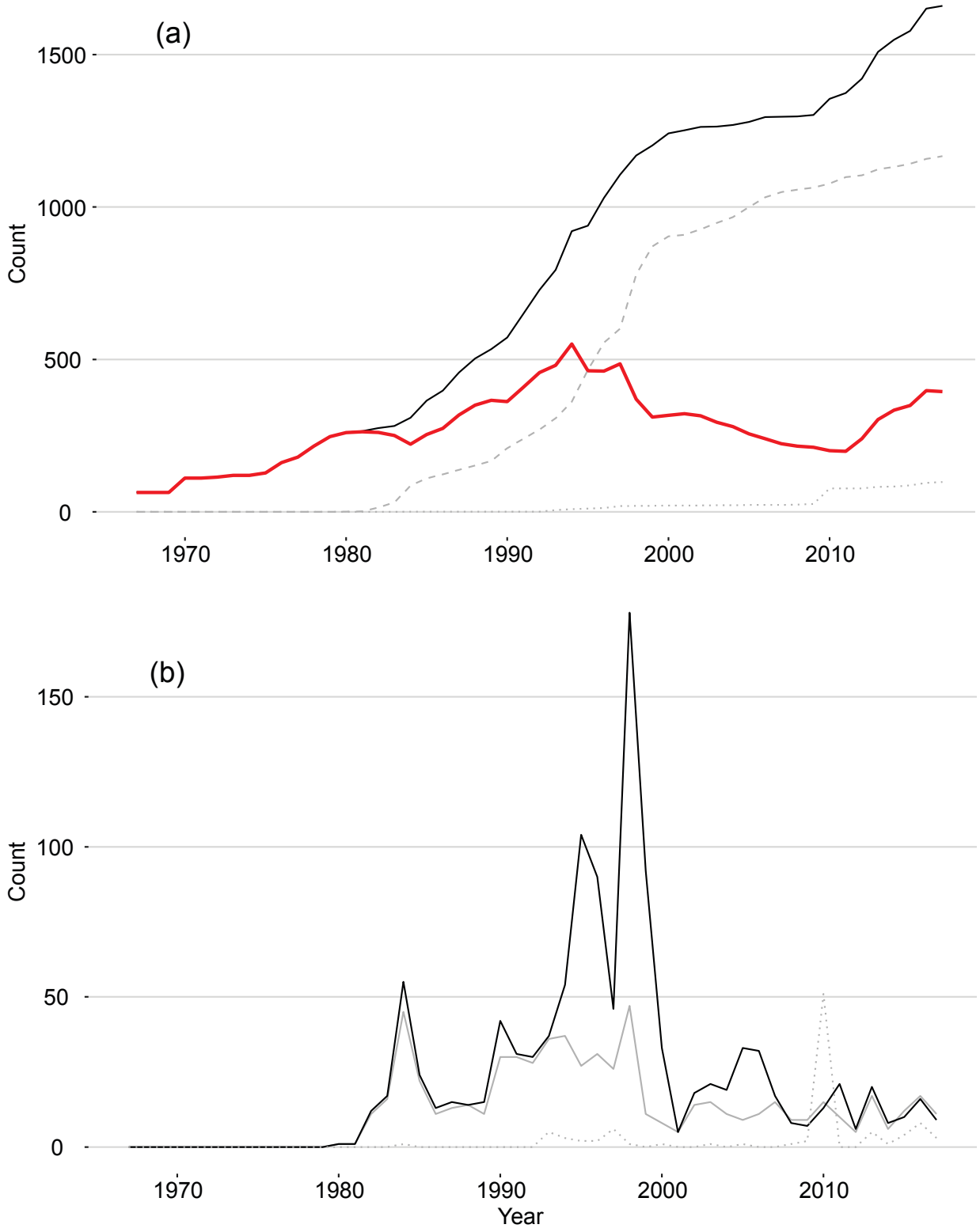

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Figure 1. Species listings and recovery plan completions show distinct periods of change over the past >40 years. (a) The cumulative number of listed species (black line), species with official recovery plans (gray dashed line), species with draft 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.

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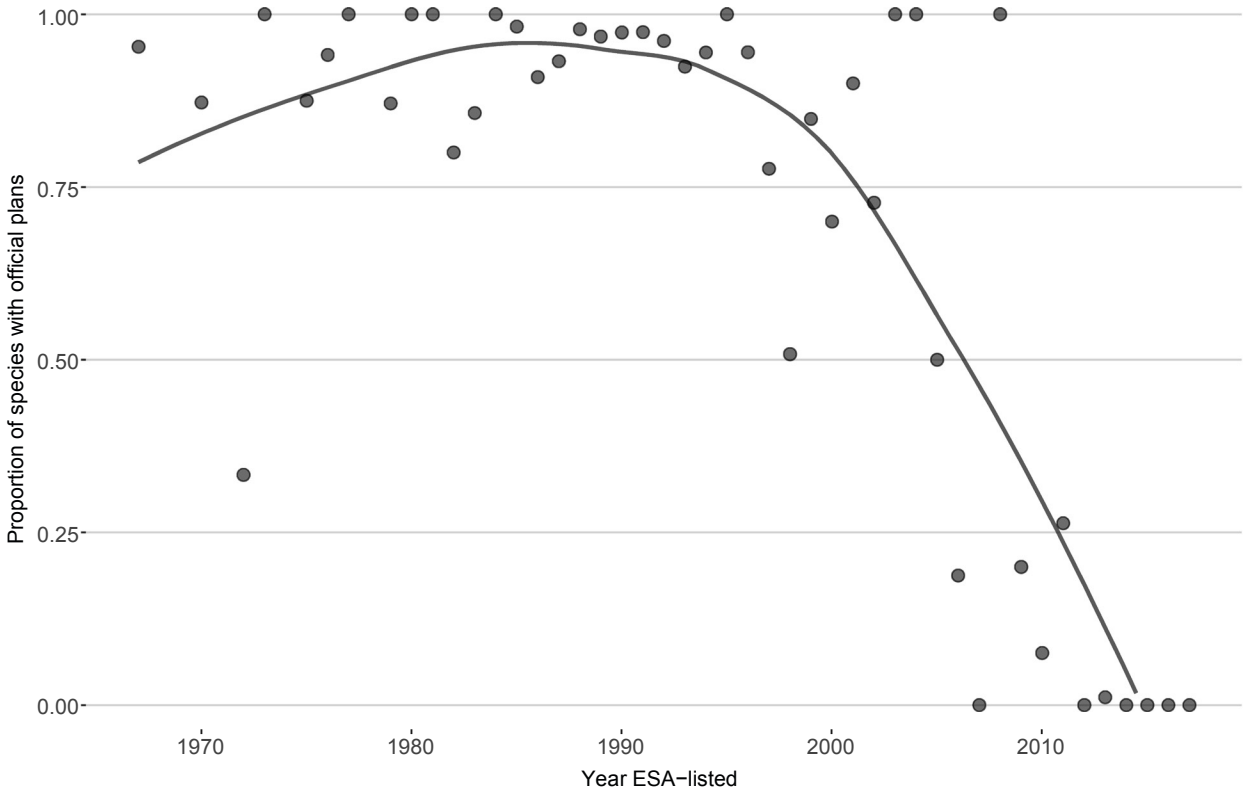

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365 **Figure 2. The proportion of species with recovery plans by year begins to drop significantly**
366 **starting with species listed around 2000.** Points represent the proportion of ESA-listed species
367 with recovery plans each year; line represents the spline-fit curve. Despite the decline, a high
368 proportion of species listed between 2001 and 2009 had recovery plans (see Fig. 1) because very
369 few species were listed during this time.

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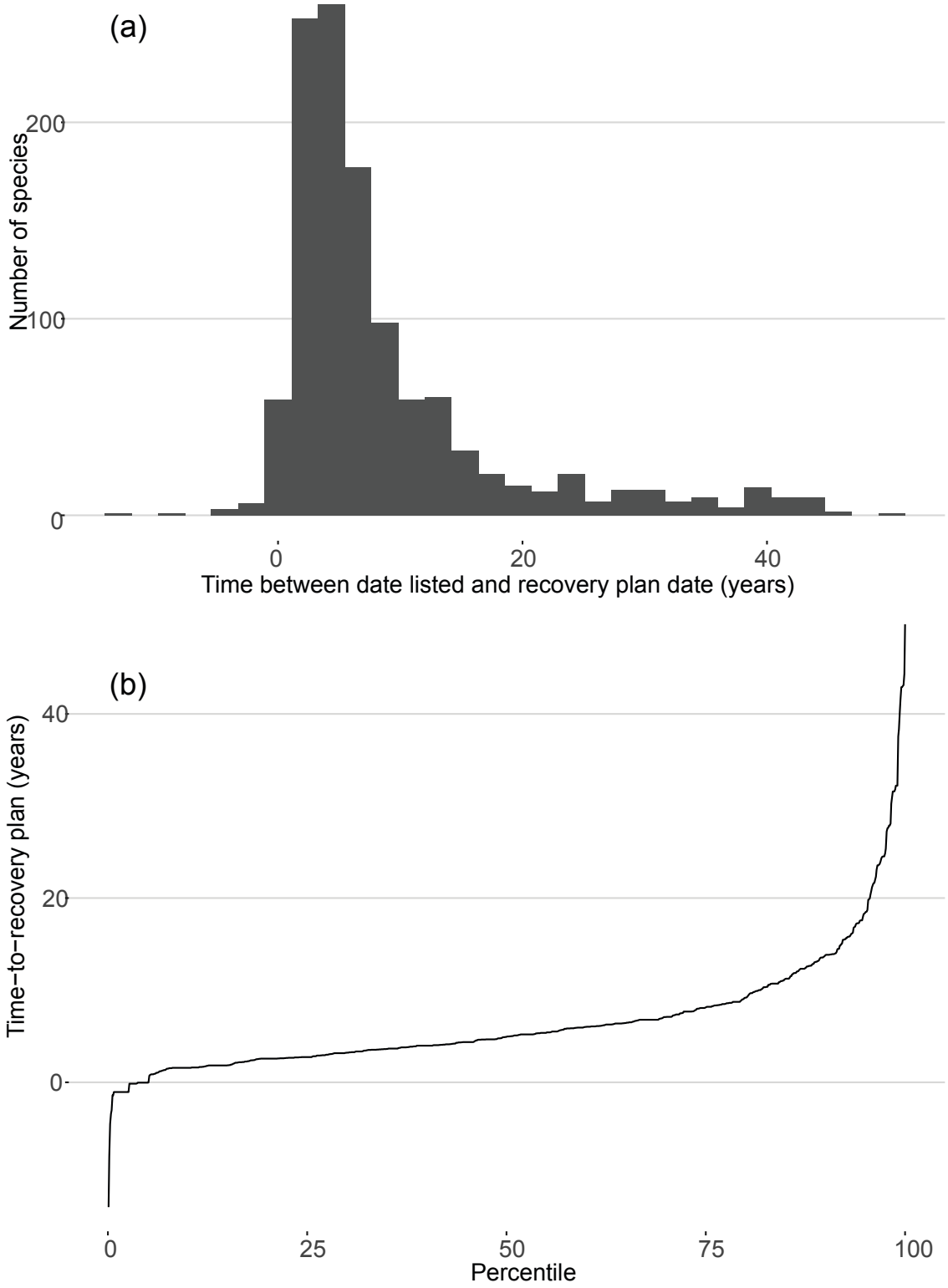
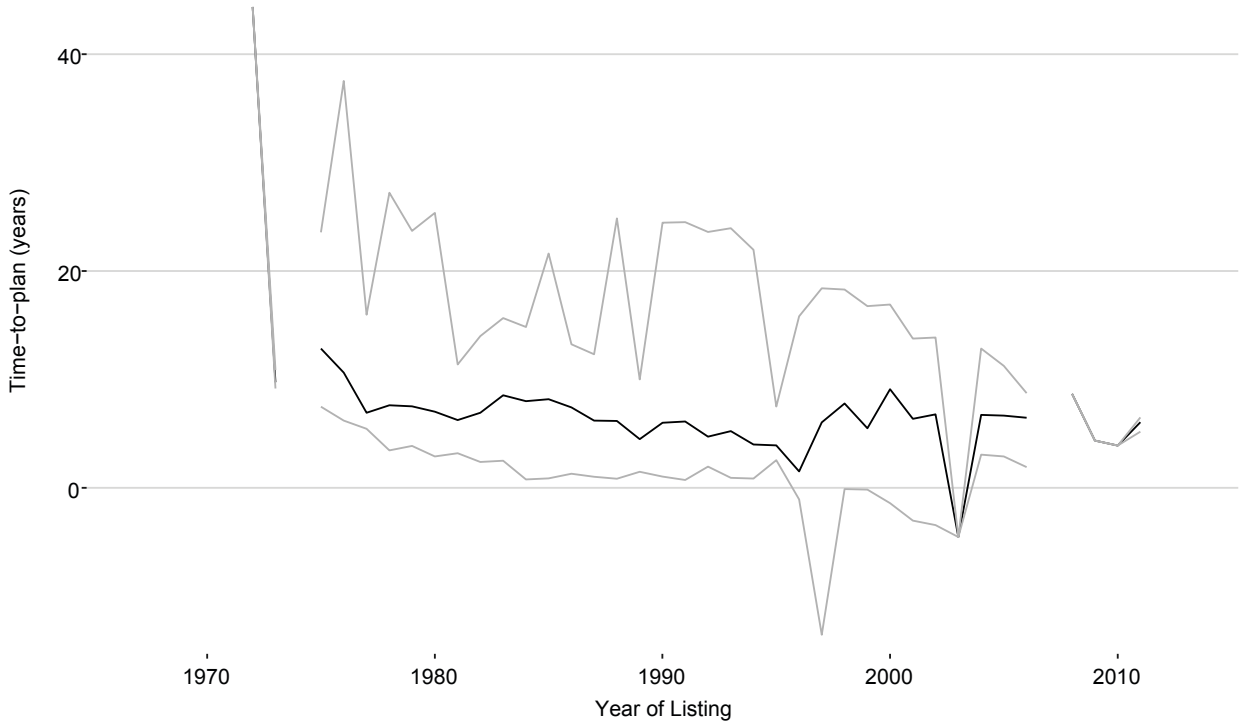


372
373 **Figure 3. The median time-to-plan was 5.1 years, but skewed towards higher values (mean**
374 **= 7 years).** In (a), negative values indicate species with plans written before the species was

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.



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380 **Figure 4. The mean time-to-plan (black line) has declined slightly through time.** The

381 maximum and minimum times-to-plan for each year are shown in light gray. Note that this trend

382 does not account for the right-censored species that do not yet have recovery plans.

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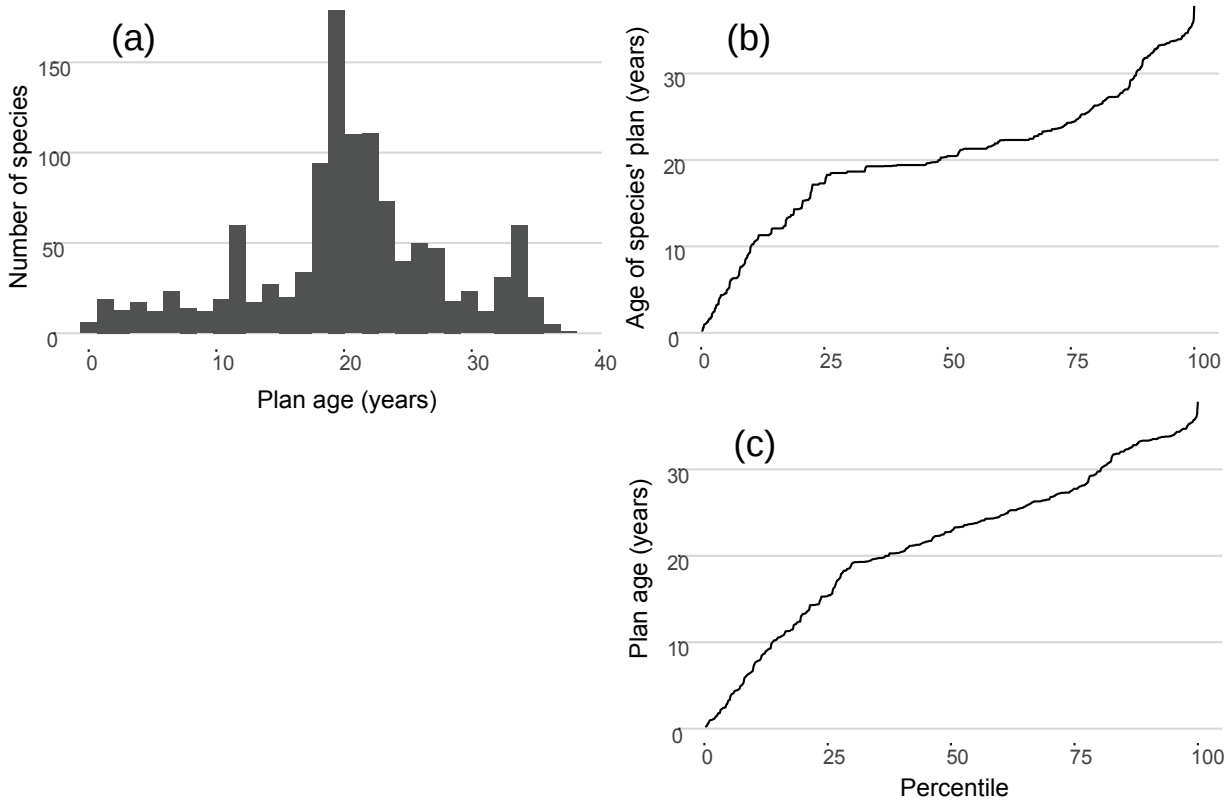

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386 **Figure 5. The distribution of the ages of current recovery plans is complex and the range is**

387 **wide (<1 year to >36 years old).** Variation in the tempo of recovery planning is clear in the

388 histogram of plan ages, e.g., the pulse of recovery plans from the mid-to-late 1990s is very

389 evident (a). Half of all recovery plans are >19.5 years old, and 10% are 32.5 or more years old as

390 of 2016. The shape of percentile curves (i.e., the line represents the percent of plans with time-to-

391 plan less than X) varies slightly between the age of plans on a per-species basis (b) and the age

392 of plans (c) because of the use of multi-species plans, especially in the 1990s.

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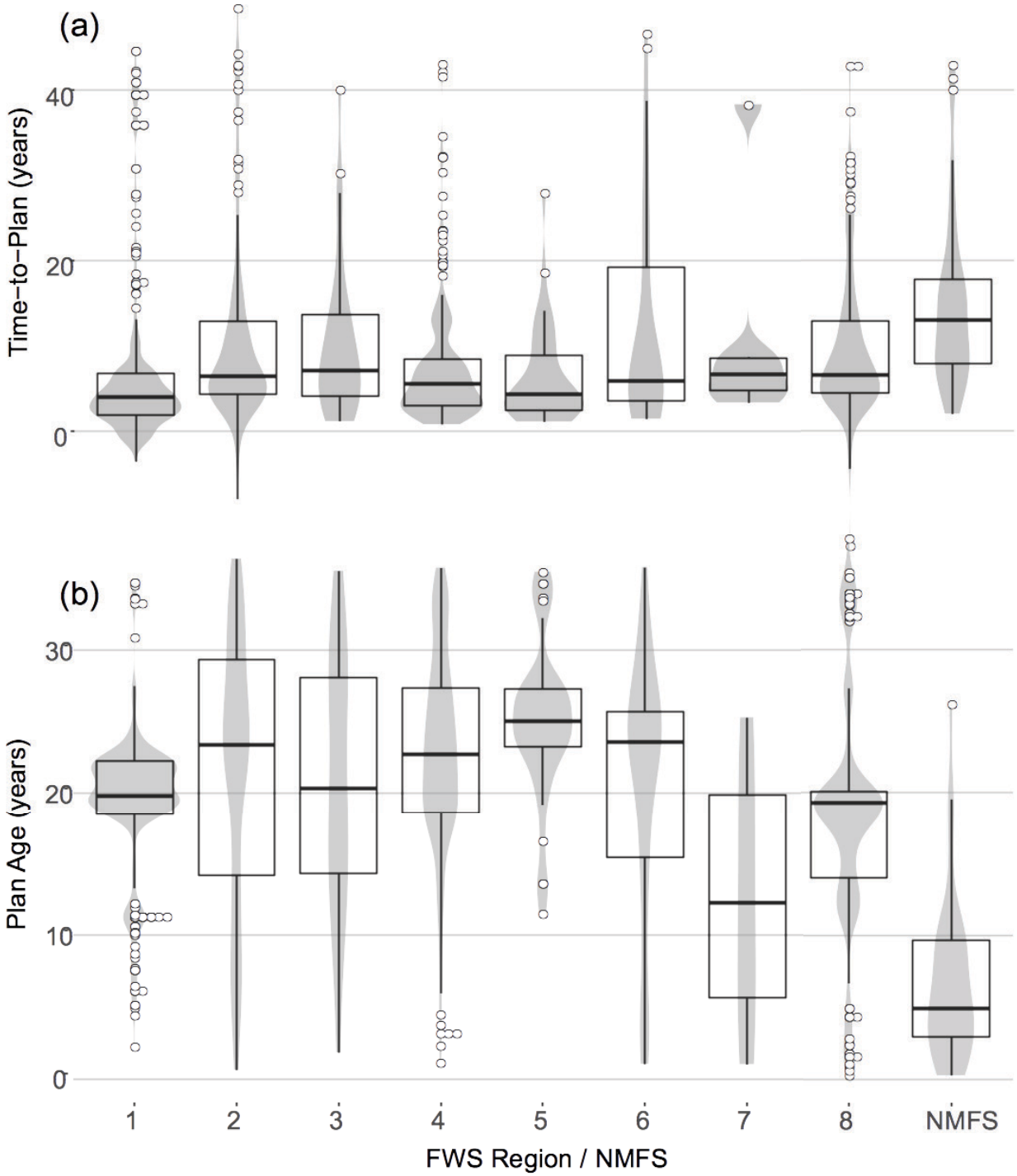

Figure 6. Variation in the time-to-plan (a) and plan age (b) is high between U.S. Fish and Wildlife Service (FWS) regions and between FWS and National Marine Fisheries Service (NMFS). Box plots show the median and interquartile range along with outliers, and violin plot

400 overlays show the data density along the y-axis. Time-to-plan is strongly negatively correlated

401 with plan age (r = -0.84, p = 0.001).