Species recovery in the United States: increasing the effectiveness of the Endangered Species Act

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Summary

The Endangered Species Act (ESA) has succeeded in shielding hundreds of species from extinction and improving species recovery over time. However, recovery for most species officially protected by the ESA – i.e., listed species—has been harder to achieve than initially envisioned. Threats to species are persistent and pervasive, funding has been insufficient, the distribution of money among listed species is highly uneven, and at least 10 times more species than are actually listed probably qualify for listing. Moreover, many listed species will require ongoing management for the foreseeable future to protect them from persistent threats. Climate change will exacerbate this problem and increase both species risk and management uncertainty, requiring more intensive and controversial management strategies to prevent species from going extinct.

In this Issue, we provide an overview of the ESA, summarize the causes and patterns of species endangerment in the United States, identify key successes and shortcomings of recovery programs, and discuss the following six broad strategies to increase the effectiveness of ESA implementation:

1. Establish and consistently apply a system for prioritizing recovery funding to maximize strategic outcomes for listed species.
2. Strengthen partnerships for species recovery by expanding collaboration among federal agencies, the states, and nongovernmental organizations and by developing incentives for private landowners.
3. Promote more monitoring and adaptive management for species recovery. Conduct targeted, efficient monitoring programs to assess species status and improve management strategies, and use adaptive management to deal with ecological complexity and uncertainty.
4. Refine methods to develop more objective, measurable recovery criteria based on the best available science.
5. Use well-established climate-smart conservation strategies such as increasing habitat connectivity and reducing nonclimate stressors; evaluate and consider using innovative climate adaptation strategies, including protecting potential future habitats, assisted colonization, and engineering new habitats.
6. Evaluate ecosystem-based approaches such as surrogate species and coarse ecological filters to develop methods that increase the efficiency of managing for recovery.

Cover photos: *Clockwise starting on the left: a) Haleakalā silversword b) Desert tortoise c) Schaus' swallowtail butterfly d) Bald eagle.*

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A NATIONAL COMMITMENT TO NATIVE SPECIES

"For one species to mourn the death of another is a new thing under the sun," wrote Aldo Leopold in *A Sand County Almanac*. Leopold deplored the loss of the passenger pigeon, gray wolf, grizzly bear, bison, and prairie flower as a waste of America's wildland heritage and a failure to observe the first principle of "intelligent tinkering"—namely, "to keep every cog and wheel." By the turn of the 20th century, market hunting and habitat loss, mainly to farmland, threatened countless species across the United States. Early conservationists such as George Bird Grinnell helped awaken a national awareness of—and outcry against—threats to America's wildlife.

Emergence of the Endangered Species Act

Leopold, Grinnell, and others looked to the states for wildlife protection, in accordance with traditions going back to medieval laws, which gave feudal lords ownership rights over game in their domains. On royal lands, the king appointed stewards who were responsible for maintaining deer, elk, boar, and other game in trust for the king. In the United States, the notion of royal trusteeship for game evolved into a public trust doctrine giving states the power to manage wildlife in the public interest.

The states traditionally relied on public trust doctrine to manage game species while largely ignoring nongame species. The steady loss of both led conservationists to turn increasingly to the federal government for help. In response, Congress passed a series of laws to protect wildlife, beginning with the Lacey Act of 1900, which regulated commercial animal markets. Other laws regulating the trade in animals and animal products followed, such as the Migratory Bird Treaty Act of 1918.

The Migratory Bird Conservation Act of 1929 further authorized the federal government to acquire habitat for conservation purposes, but habitat protection was constrained until the enactment of the Land and Water Conservation Fund Act of 1965, which provided funds to acquire habitat for fish and wildlife. The Endangered Species Preservation Act of 1966 authorized the listing of endangered species and a modest program to acquire additional habitat. In the years that followed, Congress continued to refine the law, with more comprehensive protections for endangered species and their habitats, culminating in the Endangered Species Act (ESA) of 1973—arguably the strongest piece of environmental legislation in history.

The need for New Strategies

The federal government and its conservation partners have now implemented the ESA for more than 40 years. They have had many successes, but the ESA has only partly fulfilled its conservation promise.

Critics point out that recovery efforts are focused disproportionately on charismatic species, to the detriment of others, particularly plants. Moreover, less than 2 percent of all species that have ever been listed (formally protected by the ESA as endangered or threatened) have recovered to the point where they qualified for delisting. Private landowners and businesses complain of infringements on property rights, which can yield perverse consequences such as efforts to discourage or eliminate listed species from private lands, sometimes described as "shoot, shovel, and shut up."

The ESA's defenders point to success stories such as the bald eagle, which went from 417 nesting pairs in 1963 to more than 11,000 in 2007. Other successes include such hallmarks of America's wildlife heritage as the gray wolf, whooping crane, peregrine falcon, grizzly bear, and gray whale. In fact, scientists estimate that the ESA has directly prevented the extinction of more than 200 species, and the longer a species is protected by the act, the more likely it is to increase in abundance and geographic distribution. Recovery takes time, and most species protected by the ESA have not been protected long enough to fully recover. After more than 40 years, the ESA remains essential to protecting species in the United States.

However, the ESA has not kept pace with rapid socioeconomic changes in the United States and advances in conservation science. Since 1973, the US population has grown by more than 50%, and gross domestic product has expanded from approximately $1.4 trillion to more than $16 trillion, resulting in multiple stressors to vulnerable species. At the same time, conservation biology has developed from its infancy into a sophisticated science. Today, scientists have much better data on the conservation status of species and the threats they face. They also have a better understanding of the monitoring and management needed to achieve and sustain species recovery. Although interpretation of the ESA continues to evolve via litigation in US courts, the act itself has remained fairly static. Fortunately, the ESA has proved flexible in its implementation, and there are many good options for increasing its effectiveness. In this paper, we discuss six key areas in which implementation could be improved to further species recovery.

SPECIES STATUS AND THREATS

Before discussing strategies to increase the ESA's effectiveness, we will provide an overview of the ESA and its implementation, discuss procedures and methods for determining whether species are endangered or threatened, outline where endangered and threatened species occur across the United States, and describe the greatest threats causing species to decline.

ESA OVERVIEW

Recovery of species that are endangered or threatened with extinction is a central goal of the ESA. The act instructs federal agencies to promote the recovery of listed species using "all methods and procedures which are necessary" to increase species abundance and conserve their habitats until "the measures provided pursuant to this Act are no longer necessary" (ESA sec. 3(3)). Recovery means that listed species no longer need the act's protection (ESA secs. 4(f)(1), 4(g)(1)).

The ESA describes the path to recovery as a linear process:

- The federal agencies that administer the act—the U.S. Fish and Wildlife Service (FWS) in the U.S. Department of the Interior and the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS) in the U.S. Department of Commerce (together known as the Services)—identify and assess the threats to a species to determine whether it is endangered or threatened. FWS has jurisdiction over terrestrial species and freshwater fishes; NMFS has jurisdiction over marine species and anadromous fishes.
- If the species is endangered or threatened, FWS or NMFS adds the species to an official list of endangered and threatened species (Figure 1).
- Listing triggers two overlapping types of conservation measures: extinction prevention and recovery actions.
- A tailored mix of conservation measures mitigates the threats that the species faces and, where necessary and appropriate, restores and enhances habitat and populations.
- The Services delist a species and consider it recovered when its abundance and geographic distribution is sufficient to sustain secure populations for the long term in the wild and the threats have sufficiently abated. After delisting, the species thrives on its own or under other regulatory protec-

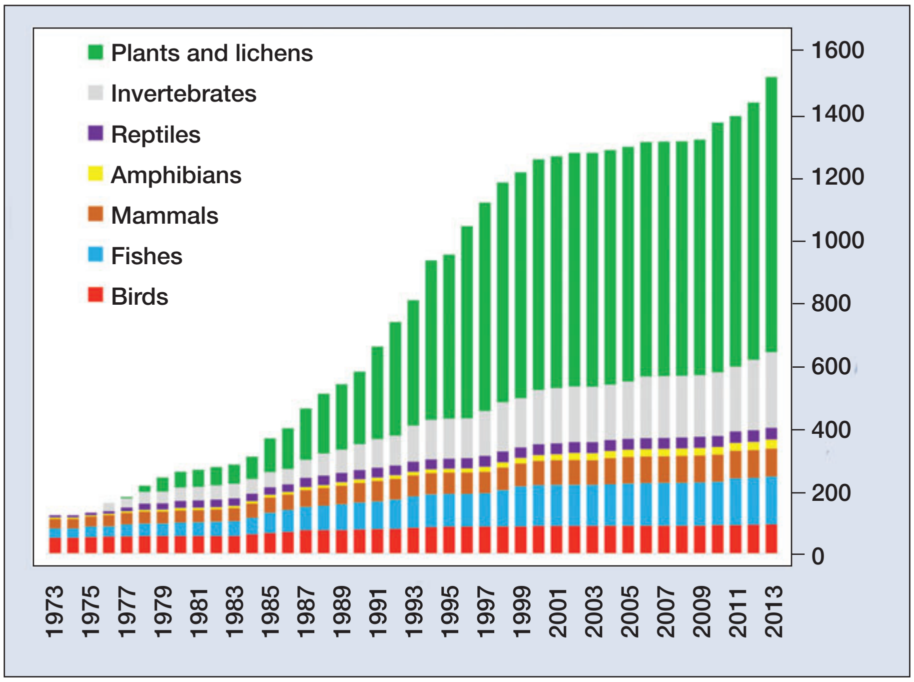


Figure 1. Endangered and threatened species listings by year for all U.S. states and territories. Listings include all species, subspecies, and distinct population segments of a species, minus delistings due to extinction, recovery, or new information not available at the time of listing. Listed at the end of 2013 were 93 birds, 152 fishes, 89 mammals, 29 amphibians, 37 reptiles, 240 invertebrates, and 871 plants and lichens.

tions. For example, after the bald eagle was delisted, it was still protected by the Bald and Golden Eagle Protection Act.

Listing Species

When evaluating a species for listing, the Services consider a host of factors but give special emphasis to (a) the actual or threatened destruction, modification, or curtailment of its habitat or range; (b) overutilization of the species for commercial, recreational, scientific, or educational purposes; (c) disease or predation; (d) the adequacy of existing regulatory protections; and (e) any other "natural or manmade factors that threaten its continued existence," such as small population sizes or threats due to climate change (ESA sec. 4(a)(1)).

According to the ESA, a species should be listed as "endangered" if it is "in danger of extinction throughout all or a significant portion of its range" (ESA sec. 3(6)) and as "threatened" if it is "likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range" (ESA sec. 3(20)). These terms are vague and clearly open to interpretation, but the crucial distinction is time (see Box 1). An endangered species is in danger of extinction now, a threatened species *in the foreseeable future*.

The ESA requires the Services to base listing decisions "solely on the best scientific and commercial data available" (ESA sec. 4(b)(1)(A)). However, any decision to list a species also requires a policy judgment regarding how much risk to that species is acceptable. Science can inform the decision by determining the degree of risk a species faces, but science alone cannot determine whether the risk is acceptable. Similarly, judgments about how much risk a species faces in the foreseeable future, while necessarily supported by science, can be influenced by social and political considerations. Stakeholders with divergent views about acceptable levels of extinction risk frequently mount legal challenges over whether species need to be listed, whether they are endangered or threatened, how much habitat represents a "significant portion" of a species' range, and other key elements of ESA implementation. Accordingly, interpretation of the ESA continues to evolve, one court case at a time.

Implementing Conservation Measures

Listing a species triggers ESA provisions intended to mitigate threats, stop the slide toward extinction, and improve the species' conservation status. The corresponding conservation measures are of two overlapping types: extinction prevention and recovery actions.

Extinction Prevention

The ESA is often likened to an emergency room, with requirements intended to prevent or slow a species' continued decline. One requirement is consultation. Any federal agency that proposes an action (including funding or permitting activities on private lands) that might affect a listed species must

Box 1. The Polar Bear Memo: Distinguishing between "Endangered" and "Threatened"

In 2010, FWS published a memo clarifying its decision to list the polar bear as threatened rather than endangered. The agency noted that climate change is diminishing the sea ice that the polar bear depends on, threatening it with extinction throughout all or a significant portion of its range in the foreseeable future. However, FWS judged that the bear was not yet on the brink of extinction.

FWS defined "foreseeable future" as "[t]he timeframe over which the best available scientific data allows us to reliably assess the effect of threats on the species." In determining that timeframe, the agency focused on projections of sea ice loss and the timespan covered by several generations of polar bears ("the optimal timeframe" for assessing the species' "response to population level threats"). Both timespans fell within 40 to 50 years, for an average "foreseeable future" of 45 years. The agency listed the polar bear as threatened because it was likely to become in danger of extinction within 45 years and no regulatory mechanisms were in place to effectively address the threat.

Polar bear and cubs.
Photo credit: Larry Master.

consult with FWS or NMFS to "insure" that the proposed action "is not likely to jeopardize the continued existence" of the species or "result in the destruction or adverse modification" of its critical habitat (ESA sec. 7(a)(2)).

Another provision prohibits any "person" (including government and business entities (ESA sec. 3(12)) from "taking" endangered animals. The ESA's definition of "taking" includes harassing or harming species as well as selling the species or their parts (ESA secs. 3(19), 9(a)(1)). By regulation, FWS has extended the prohibition against taking to all threatened animals unless it adopts alternative take regulations for a particular species. The prohibition against taking does not apply to endangered plants, which are protected principally from removal on federal lands or destruction in knowing violation of state law.

Most federal actions that result in a take do not "jeopardize the continued existence" of a listed species. For these actions, consultations with the Services include an "incidental take statement," which estimates the expected take of the listed species; federal actions that conform to the statement may proceed. Similarly, nonfederal entities can receive an "incidental take permit" if they develop and agree to implement a habitat conservation plan (ESA sec. 10(a)). Before issuing an incidental take permit, the Services must determine that the taking "will not appreciably reduce the likelihood of the survival and recovery of the species in the wild" (ESA sec. 10(a)(2)(B)(iv)). Although incidental take statements and permits include some safeguards for listed species, they often allow for continued population reduction and habitat degradation.

Recovery Actions

Listing also triggers affirmative recovery actions, such as mandatory recovery plans created by the Services "for the conservation and survival of [listed] species" (ESA sec. 4(f)). Recovery plans are essential documents for guiding future recovery activities. However, the ESA gives few guidelines for their preparation and content and does not specify a deadline for how soon after listing the Services must complete recovery plans. Funding limits and low priority for some species can cause significant delays. The Services are also required, with narrowly defined exceptions, to designate critical habitat (ESA sec. 4(a)(3)). Similarly, the ESA requires all federal agencies to implement "programs for the conservation of [listed] species" (ESA sec. 7(a)(1)), although judicial interpretation has given agencies discretion in carrying out this provision.

Other recovery actions are explicitly discretionary, such as deciding which actions to take to alleviate threats, protect habitats, and augment populations. The Services, for example, can translocate a species as an experimental population under the agencies' "conservation" authority (ESA secs. 10(j), 3(3), 7(a)(2)). Similarly, the Services can issue permits for activities that "enhance the ... survival of the affected species" (ESA sec 10(a)(1)(A)). Finally, the Services can use "activities associated with scientific resources management such as research, census, law enforcement, habitat acquisition and maintenance, propagation, live trapping, and transplantation" (ESA sec. 3(3)).

Delisting a Recovered Species

The Services can delist a recovered species after meeting the same procedural requirements for listing. They must evaluate the species' status in relation to the threats it faces, including habitat loss, overutilization, disease or predation, inadequate regulatory mechanisms, and any other natural or manmade factors affecting its continued existence.

The Services have considerable leeway in deciding when a species has recovered. For example, the ESA does not require the Services to base delisting decisions on recovery criteria given in recovery plans, and a 2012 court case upheld that recovery criteria are not legally binding. Although the Services agree with this view, some stakeholders contend that it creates false expectations and inconsistencies in delisting decisions. In addition, because the ESA requires the Services to make delisting decisions based on the best scientific data available (ESA sec. 4(b)(1)(A)), their methods for evaluating recovery status have changed as scientific methods have evolved. The Services sometimes use population viability analysis, a quantitative assessment of the probability of extinction based on several often-interacting factors, including demographic, environmental, and genetic mechanisms. More recently, the Services have begun to assess species according to the "3Rs"—the resiliency,

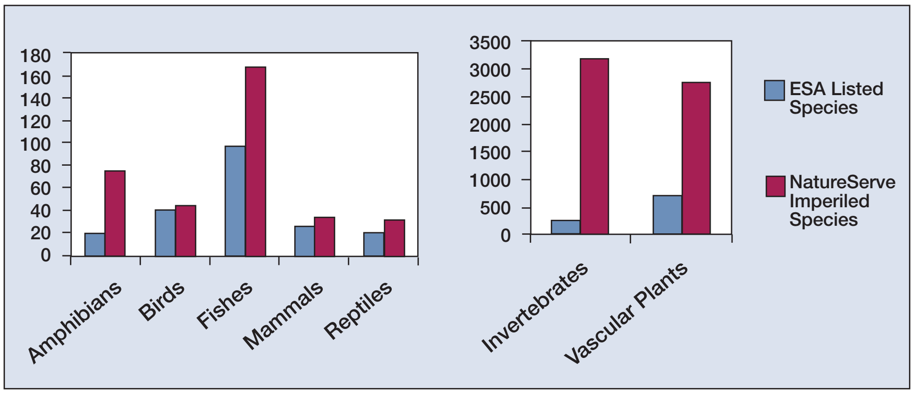


Figure 2. The number of species listed under the ESA compared with the number that NatureServe ranks as imperiled (as of the end of 2013).

redundancy, and representation of populations (see Box 2).

The Services currently define recovery in terms of sustaining secure populations of a species for the long term in the wild and abating threats. The size, number, and geographic distribution of populations must be large enough for the risk of extinction due to periodic threats such as drought or disease to be reasonably low, and regulatory or other conservation mechanisms must provide reasonable assurance that the species will not be placed at risk again.

Although the Services have the ultimate legal responsibility for listed species, state governments, tribal nations, nongovernmental organizations, academic researchers, and private landowners and businesses are all essential partners for species recovery. For example, the ESA requires the Secretary of the Interior to "cooperate to the maximum extent practicable with the states," including consultation before acquiring lands or waters "for the purpose of conserving any endangered species or threatened species" (ESA sec. 6(a)). In addition, treaties with American Indian tribes frequently grant them management authority over endangered and threatened species. In the Pacific Northwest, for example, several treaties guarantee tribes the right to fish in "usual and accustomed places," making the tribes comanagers of many of the region's imperiled salmon.

Box 2. The "3Rs" of Species Recovery

The 3R framework is a science-based approach that the Services currently use to help develop recovery criteria.

Resiliency: Local populations of a species are large enough, have sufficient genetic variation, and are sufficiently mixed with respect to the age and sex of individuals to persist in the face of periodic threats such as drought, wildfire, and disease.

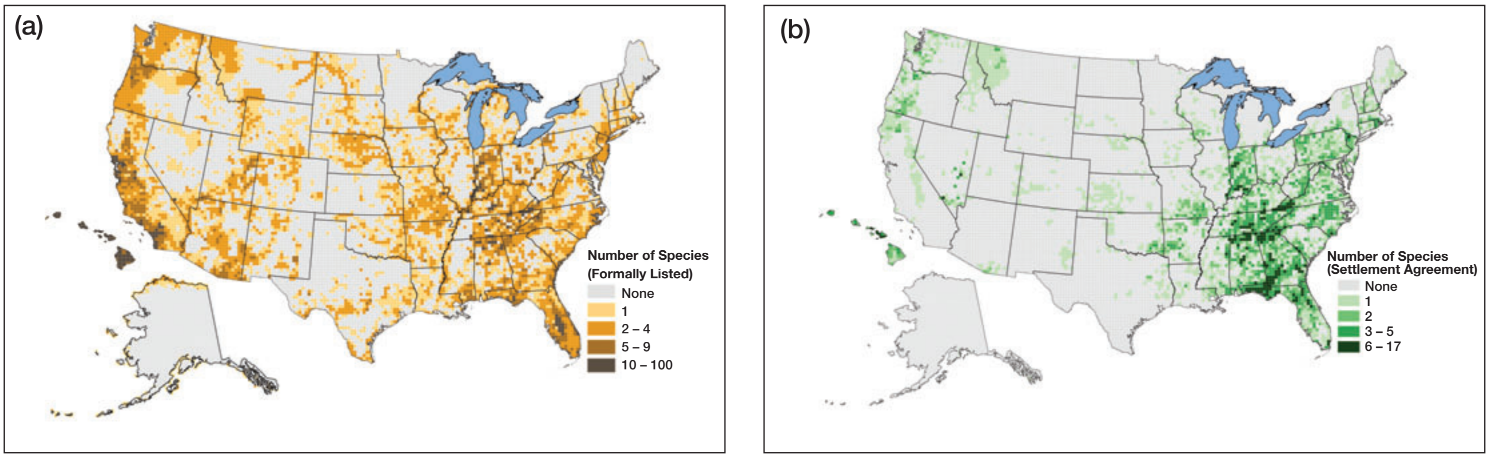
Redundancy: There are enough separate populations of a species to provide a margin of safety in case catastrophic events eliminate some populations.

Representation: There is sufficient genetic variation among populations of a species to conserve the breadth of the species' genetic makeup and its capacity to evolve and adapt to new environmental conditions.

Species Status Assessments and the Potential for New Listings

Nongovernmental scientific organizations also assess species and rank them according to their extinction risk. By far the most comprehensive list for the United States is maintained by the nonprofit organization NatureServe and its Natural Heritage Network, which tracks more than 28,000 species and 9,000 subspecies and other narrowly defined taxonomic groups in all 50 states and Puerto Rico. NatureServe evaluates species status in terms of three primary factors—rarity (i.e., relative abundance); threats (including their scope, severity, and immediacy); and trends (in population numbers, area of occupancy, and range size). NatureServe weights the three factors according to a strictly applied set of rules, making its species status rankings consistent and repeatable. NatureServe's species rankings also correspond closely to similar assessments made by other organizations, including the International Union for Conservation of Nature (IUCN) Red List rankings and American Fisheries Society rankings for aquatic species. And there is good concordance with listings under the ESA: approximately 90 percent of currently listed species are also considered imperiled by NatureServe. However, among the more than 28,000 U.S. species that NatureServe tracks, only about 20 percent of imperiled species (as ranked by NatureServe) are listed. The correspondence is good for birds, mammals, and reptiles, but the discrepancy is huge for most other taxa, including amphibians, fishes, invertebrates, and vascular plants (Figure 2). Taken together, these assessments suggest that there are many more species that probably should be listed under the ESA but are not currently listed.

Other assessments suggest that there is an even wider gap in the number of species that likely need protection under the ESA. The species assessed by NatureServe represent only about 19 percent of the plants, animals, and fungi described in the United States. The other 81 percent, mostly invertebrates, are generally too poorly known to determine their



conservation status. However, based on the number of described species, scientists estimate that the total number of known species at risk of extinction in the United States is at least 10 times the number of domestic species listed under the ESA.

Geography of Listed and Imperiled Species

The geographic distribution of U.S. listed species and imperiled species (as ranked by NatureServe) is far from uniform. Instead, there is considerable overlap among these species, many of which are concentrated in regional "hotspots."

Hotspots of Listed Species

We used contemporary species occurrence records maintained by NatureServe and its network of natural heritage programs to evaluate the geographic distribution of listed species. We found hotspots in Hawaii, in the southern Appalachian Mountains, in peninsular Florida, in coastal parts of the Southeast and eastern Gulf states, in California Mediterranean-climate regions, and in the Cascade and lowland mixed forests of the Pacific Northwest (Figure 3a). Since the late 1990s, scientists have consistently recognized these hotspots, despite variation in analytical methods and a substantial increase in the number of listed species (Figure 1). However, we also identified a new, emerging area of listed-species concentration associated with the interior highlands and plateau region of southern Missouri, northern Arkansas, western Kentucky, and southern Illinois and Indiana (Figure 3a). Many regions outside of these hotspots contain very few listed species. Overall, 54 percent of the U.S. land area has no listed species in NatureServe's databases.

The taxonomic composition of listed species varies among hotspots. Since 1994, plants have outnumbered animal species listed, and listed plants are concentrated in areas with high levels of endemic species—species that occur nowhere else—including Hawaii, the Mediterranean climates of California, and the Florida inland scrub. Invertebrates are a large part of the listed biota in some regions—insects in Hawaii and California and mollusks in the Southern Appalachians and interior highlands. Birds make up many of the listed species in Hawaii, peninsular Florida, and the southeastern Atlantic coast. Mammals are well represented in the arid Southwest, the dry steppe of the California Central Valley, the Southern Appalachians, and the interior highlands of the East. Amphibians and reptiles have fewer listed species than other vertebrates; the ones listed tend to be in the arid Southwest, California, and peninsular Florida. More species of fish receive ESA protections than any other vertebrate group, and listed fishes tend to concentrate in the arid Southwest, Pacific Northwest, and Southern Appalachians.

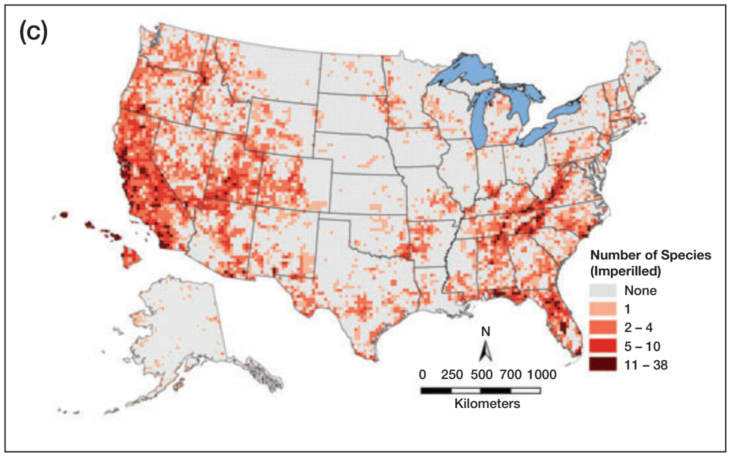


Figure 3. Geographic distribution of (a) listed species; (b) species involved in the settlement agreement; and (c) species that NatureServe ranks as imperiled but are not on map a or map b.

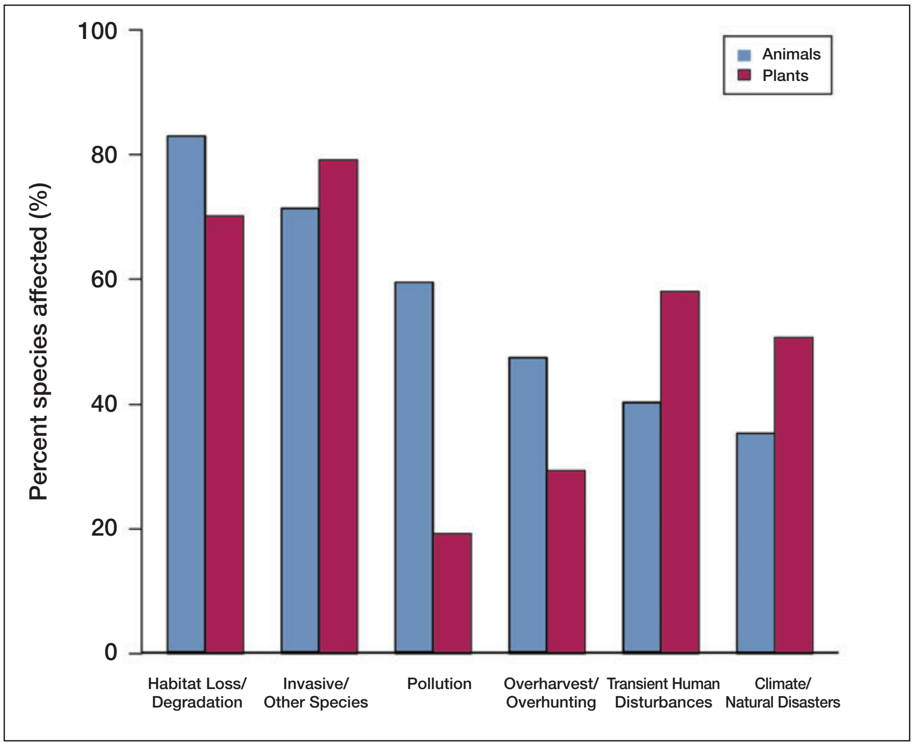


Figure 4. *Primary threats to 1,421 species, subspecies, and distinct population segments listed under the ESA (621 animal and 800 plant listing units). Data reflect threats identified in recovery plans for all species that had recovery plans approved as of January 2010 (for 528 animals and 645 plants) and threats identified by NatureServe (for the remainder).*

Emerging Hotspots?

Following a legal settlement agreement, FWS is committed to processing a large backlog of species for listing determinations by 2018. Species that are likely to be added to the list are concentrated in existing hotspots (such as the Southern Appalachians) and some new areas (such as the southern Great Basin and the Ouachita and Boston Mountains of western Arkansas and eastern Oklahoma) (Figure 3b).

Figure 3c reflects likely proposed new listings in the longer term, including species that NatureServe currently considers imperiled but are not listed under ESA or proposed for listing. Accordingly, the southwestern Basin and Range (southern Arizona and New Mexico and West Texas) and a portion of the Colorado Plateau (southeastern Utah) are likely to emerge as new hotspots of listed species.

Primary Threats to Listed Species

Based on descriptions in species' recovery plans, the greatest threats to listed species (see Figure 4) are habitat loss and degradation due to factors such as land use conversion for agriculture and development, mining activities, and changes to natural fire regimes. The next most common threats are competition with and predation by other species, especially invasive exotics. Pollution is also a major threat, especially to fishes and freshwater mollusks, and transient human disturbances such as off-road vehicle use and trampling threaten both animals and plants. Other threats include overharvesting, overhunting, and natural disasters. Climate change almost certainly threatens more species than recovery plans indicate. As of January 2010 (the most recent data we used for this analysis), climate change was listed as a threat in only 26 recovery plans for animals and in none for plants. Since 2010, the Services have identified climate change as a threat more often.

Our analysis is consistent with earlier reviews but also shows a higher percentage of listed species threatened by invasive and other problem species and by overharvesting and overhunting. In addition, many recovery plans cite small population sizes and small numbers of populations as demographic threats that can compound the effects of extrinsic threats such as habitat loss, invasive species, and catastrophic events like natural disasters. Further, scientists are increasingly recognizing that many listed species are threatened by the loss of other species—such as pollinators, seed dispersers, decomposers, and keystone predators—that have critical roles in maintaining ecosystem processes.

RECOVERY TRENDS AND MODERN CHALLENGES

Here we describe historical status trends for listed species, discuss several factors that correlate with these trends, and highlight modern challenges to managing species for recovery.

Historical Trends

The only source of regularly generated government data on the progress of listed species toward recovery over time has been biennial reports that the Services have submitted to Congress. These reports have provided a 2-year status update on each species, identifying whether listed species were presumed extinct, declining, stable, or improving—or whether their status was unknown. The reports have not always been rigorously verified, but they are often the best information available. Based on reports from 1990 through 2010 (the most recent year for which the reports are available), we found that 35 percent of all listed species had stable status trends and that 8 percent were improving (Figure 5). However, declining taxa (52 percent) far outnumbered improving ones. Three percent of species were presumed extinct, but at least half of these species were probably already extinct when they were listed.

In 2012, the Services stopped reporting 2-year status trends. Instead, their biennial reports to Congress will now summarize whether species have been recommended for reclassification or delisting as part of a more comprehensive 5-year status review. Furthermore, the Services have begun producing 5-year reports for many more species, providing more detailed information about the status of and threats to species as well as actions to conserve them. More than 850 species have been reviewed since 2009, and FWS has recommended that 37 of these be delisted or reclassified from endangered to threatened.

Large gaps remain in scientific knowledge of the status of listed species, their population trends, and their life histories. Monitoring programs that track species responses to recovery investments exist for only a handful of species. Nonetheless, some factors are correlated: species with recovery plans are more likely to improve, and the longer a species is listed, the more likely its abundance is to increase, although there is considerable variation among taxonomic groups.

Some studies conclude that designating critical habitat also helps promote species recovery, but other studies that address confounding factors show no correlation. Because critical habitat restrictions apply only to the activities of federal agencies (under the ESA's section 7 prohibition of federal actions that "result in the destruction or adverse modification of critical habitat") and because all federal agencies are also restricted from actions that "take" or "jeopardize the continued existence" of listed species, some have argued that designating critical habitat is superfluous. Others maintain that protecting critical habitat effectively addresses the primary threat to listed species. In practice, the Services often exempt habitat degradation from regulation. As a result, designating critical habitat has had limited regulatory effect.

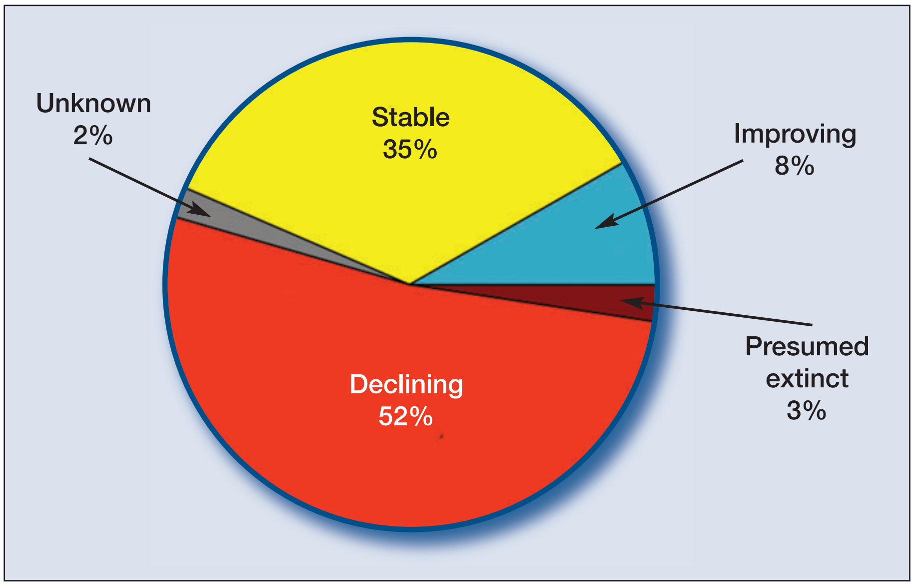


Figure 5. Trends in recovery status for 1,292 listed species, based on a summation of trends reported in 2-year status updates submitted by the Services to Congress from 1990 to 2010.

Government Funding Issues

The amount of government funding available for species protection and recovery is one of the best predictors of recovery success. But government spending has long been insufficient and highly disproportionate among groups of species.

Insufficient Spending

From 1998 to 2012, total state and federal spending on endangered and threatened species (adjusted for inflation to equal 2013 dollars) rose from $547 million to just over $1.364 billion per year. Most spending (79 percent in the average year) came from federal sources other than FWS, including NMFS and the U.S. Department of Defense. Spending by FWS, as provided by Congress, represented just 13.1 percent of total funding, and spending by the states represented another 8 percent. Although state expenditures did not rise appreciably from 1998 to 2012, average FWS expenditures doubled from $77 million to $156 million per year. Other federal spending increased more, from $446 million to $1.164 billion per year.

However, much of this spending does not go directly to on-the-ground species recovery actions but rather to pay staff and fund activities related to law enforcement, listings, and consultations (such as negotiating mitigation and extinction prevention actions). Nonetheless, even if total government spending on listed species over the past 15 years had been strictly applied to recovery actions, it still would have lagged far behind the needs stated in the recov-

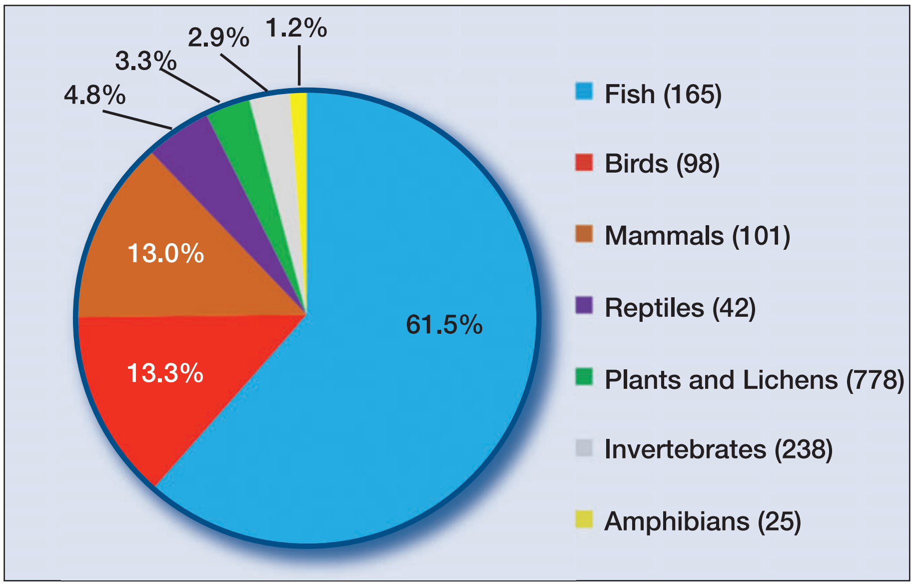


Figure 6. Disproportionate government spending among listed taxa in 2012, as depicted by the percentage of total expenditures (size of wedge) and the number of listed species in each taxonomic group (shown in parentheses in the legend). Total government spending was approximately $1.364 billion.

ery plans. Researchers have estimated that total spending over the past 15 years has covered only about a third of species' recovery needs.

Disproportionate Spending

Funding for endangered and threatened species is not only insufficient but also highly disproportionate among taxonomic groups. From 1998 to 2012, over 80 percent of all government spending went to support 5 percent of all listed species, whereas 80 percent of all listed species shared less than 5 percent of all funds. Most federal spending has gone to just 15 fishes: 7 salmonid and 8 sturgeon species. In fact, the 46 species managed by NMFS alone or by NMFS and FWS together—including salmon, sturgeon, seals, and whales—receive far more funding than other species. From 1998 to 2012, the median annual expenditure (adjusted for inflation) on such species was $1.8 million, including over $197 million per year for Chinook salmon. In contrast, the median annual inflation-adjusted expenditure for the species managed solely by FWS was $2,686, ranging from less than $200 per year for the seven least-funded species to $2 million per year for bull trout. These spending patterns are well illustrated by 2012 expenditures, with 165 listed fishes receiving 61.5% of total funds and 778 listed plants and lichens receiving just 3.3% (Figure 6).

In part, disproportionate spending on listed species has been a result of congressional earmarks that limit the Services' abilities to distribute funds more equitably, and it also reflects different species' needs. However, the degree to which funding is skewed appears to far exceed reasonable expectations for what is required. For example, 7 out of 167 taxa with species-specific reported recovery cost estimates received more than 10 times the funding called for in their recovery plans, whereas 18 taxa received less than 10 percent of their estimated funding needs. Underfunded species include both well-funded species that require additional investments (such as Guam kingfisher, found only in captivity) and species that receive scant funding (such as Hinckley oak).

Without more funding for species recovery, protection for most underfunded species will likely continue to be limited to consultations and prohibitions under ESA sections 7 and 9 (See "Extinction Prevention" requirements in the ESA Overview section). Plants in particular are a challenge (see Box 3), partly because plants on private land are not usually covered by section 9 prohibitions. The Services have made great strides over the past decade in disseminating documents that describe recovery plans, recovery actions, expenditures, critical habitat designations, cooperative agreements, and other measures for evaluating ESA outcomes. However, unless the Services do more to document the outcomes of actions taken under ESA sections 7 and 9, it will remain difficult to tell whether they are effective in stabilizing and improving the status of underfunded species.

Spending Priorities

Due to insufficient funding, tradeoffs are necessary, and the Services must decide what

Box 3. Listed Plants: Bottom of the Funding Food Chain

First added to the endangered species list in 1977, plants now comprise 55 percent of all listed taxa, far more than any other taxonomic group (Figure 1). From 1998 to 2012, however, plants accounted for less than 12 percent of FWS funding for all listed species—and for less than 4 percent of total government expenditures on listed species in 2012 alone (Figure 6). From 1998 to 2012, the inflation-adjusted median annual government spending per listed plant species was $20,000, well below estimated recovery costs for most listed plants. Moreover, much of the money spent on plants goes to pay for ESA section 7 consultations, with relatively little going into recovery actions or monitoring studies of population status and trends.

recovery actions take priority. For example, investing in habitat restoration for a threatened mammal might delay reintroduction plans for an endangered fish, and surveying populations of an endangered bird might mean postponing a seed germination project for imperiled orchids. Accordingly, FWS and NMFS each developed a prioritization system for analyzing tradeoffs. The FWS system includes 36 ranked categories grouped according to 4 factors: degree of threat, potential for recovery, taxonomic uniqueness, and conflict with human activities. The NMFS system is similar but has only 12 categories and omits taxonomic uniqueness. To our knowledge, no researchers have evaluated how frequently or successfully NMFS uses its prioritization system to allocate recovery funding, perhaps because NMFS manages fewer than 5 percent of all listed species. However, it is well established that FWS does not frequently use its system. Instead, FWS's allocations are more often driven by political and social factors, including congressional representation, the number of employees in field offices, staff workload, and opportunities to form partnerships and secure matching funds. In addition, different regions and field offices often use different allocation formulas.

Without following a uniform and explicit system for prioritizing recovery actions, FWS cannot efficiently allocate its funding to meet recovery needs. That is partly why most recovery funding has benefited only a small fraction of listed species. Moreover, FWS cannot clearly articulate to Congress and other stakeholders what recovery actions it will implement with available funding and what additional achievements are possible with more funding. As a result, the agency is poorly positioned to request additional funding.

Modern Ecological Challenges to Managing for Species Recovery

The United States and its ecosystems have changed dramatically since the ESA was enacted in 1973. Human population growth, economic activity, and intensive land uses have rapidly increased. Threats to listed species such as habitat loss and degradation and invasive exotic species have increased in severity. Climates have undergone fundamental change. These trends will likely continue.

Conservation-Reliant Species

Researchers are increasingly recognizing that many listed species face pervasive and persistent threats that can be managed but are not likely to be eliminated. These species are known as "conservation reliant." Conservation managers might be able to increase their populations and sufficiently mitigate threats to achieve recovery targets, but the species remain at risk because the threats they face require ongoing monitoring and management.

There are two forms of conservation reliance, depending on what kind of management is needed—whether management is directed toward populations or toward extrinsic threats. For example, the northern Idaho ground squirrel lives in habitat patches that have become increasingly fragmented, making it susceptible to loss of genetic diversity; its populations therefore need to be managed through translocation or captive breeding to meet recovery targets. By contrast, the Kirtland's warbler requires that its breeding grounds, which are almost exclusively in Michigan, remain in an early-successional habitat stage that historically was maintained by fire. Human intervention will likely be needed for the foreseeable future to maintain the habitat in an early-successional stage.

The most common management strategies needed to mitigate threats to conservation-reliant species are: creating or restoring habitat; controlling invasive exotic species; reducing pollution and other human impacts, such as overexploitation; and increasing the size and/or genetic variability of populations through artificial recruitment.

Climate Change

Climate change is expected to increase the number of species at risk of extinction, and it will exacerbate the problem of conservation reliance. Since 1900, global mean temperatures have increased by 0.7 degrees Celsius, affecting every major group of plants and animals. Approximately half of all species studied have shifted their ranges to higher latitudes (50 to 1,600 kilometers poleward) or elevations (up to 400 meters upslope). About two-thirds of all species studied have shifted toward earlier spring breeding, migration, or blooming. Because responses among species vary widely in both strength and direction, it

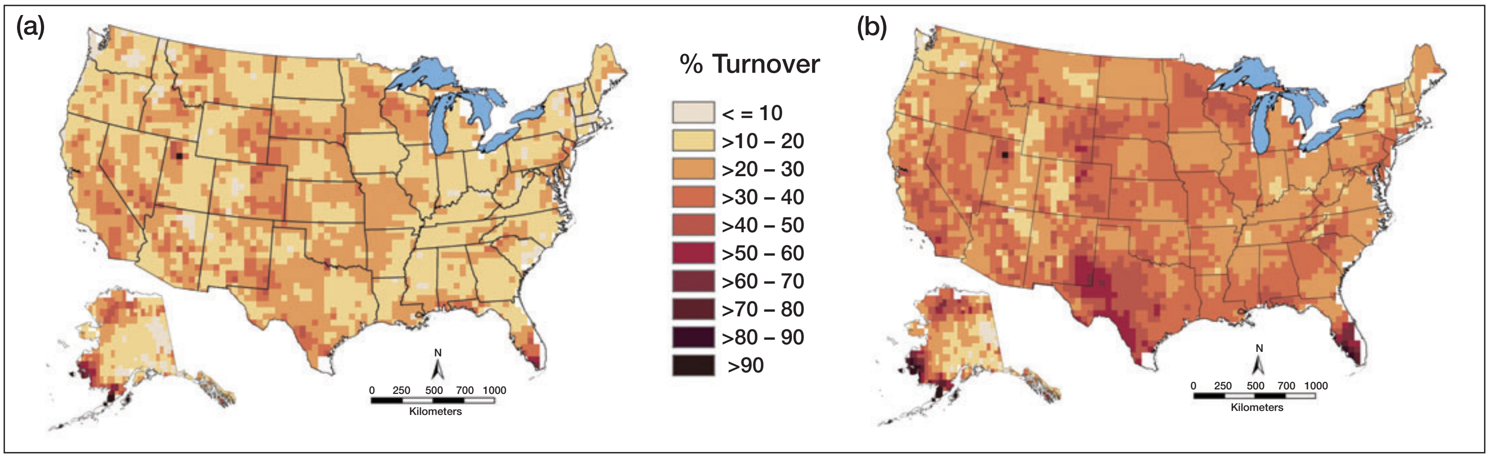


Figure 7. Percent turnover in amphibians, birds, and mammals attributable to climate-induced range shifts under two greenhouse gas emissions scenarios devised by the Intergovernmental Panel on Climate Change for the 21st century: (a) the B1 scenario projects relatively modest increases in future emissions; and (b) the A2 scenario is in the "mid-high" range of future emissions. (Turnover is the number of species predicted to be gained and lost in each 50-by-50-kilometer area from 2071 to 2100, compared to the number of species in each area from 1961 to 1990.) Hawaii is not shown because there were insufficient data to estimate species turnover.

can be difficult to predict how particular species will respond to climate change. This increases uncertainty for conservation researchers and managers.

Nonetheless, climate change is clearly causing biological communities to disassemble and reassemble in new configurations, and scientists can estimate how species will be affected. In 2009, a large-scale study of amphibians, birds, and mammals showed how species are expected to undergo climate-induced range shifts, producing "turnover" in ecological communities as species are gained and lost (Figure 7). For these groups of species, turnover is likely to be high over the next century, especially on the west coast and northern mountains of Alaska and in peninsular Florida, southwestern Texas, and the southern Great Plains.

Climate change also might cause broad shifts in environmental conditions, such as large-scale changes in temperature and precipitation. These changes could expose multiple populations of endangered and threatened species located in different areas to similar environmental threats, thereby reducing the chances that declining populations can be rescued by immigration from more abundant neighbors. In addition, climate change is already causing sea levels to rise, affecting coastal areas and their attendant set of imperiled and listed species.

Box 4. New Zealand's Prioritization System for Species Recovery

New Zealand's Department of Conservation lacks sufficient funding to conserve all of New Zealand's approximately 2,800 threatened species. Until recently, the Department also lacked an explicit system to prioritize conservation actions, and its annual budget covered only 188 species, many of which were inadequately managed. In response, the Department worked with scientists to estimate management needs and costs for all of New Zealand's threatened species, and they developed a ranking system that established funding priorities according to the agency's goal of "securing (over a period of 50 years) the greatest number of threatened species." Because the Department now has management plans and cost estimates for all threatened species, managers are able to efficiently prioritize many more species for conservation with no additional funding. Through its new prioritization system, the Department expects to effectively manage 273 species with the same level of funding, a 45-percent increase in species covered.

INCREASING THE EFFECTIVENESS OF ESA IMPLEMENTATION

The ESA provides a flexible framework for meeting the national commitment to listed-species recovery. Given the daunting challenges facing conservation managers, and in view of modern insights from ecology and conservation science, changes are needed in at least six key areas, including: setting priorities, strengthening partnerships, promoting monitoring and adaptive management, refining methods to develop recovery criteria, using climate-smart conservation strategies, and evaluating and developing ecosystem-based approaches.

SETTING NEW PRIORITIES FOR SPECIES RECOVERY

The ESA requires the Services to set priorities for drafting and implementing recovery plans, but it offers limited guidance for how to prioritize species for recovery measures in the face of chronic funding shortfalls. When FWS created its current ranking system for listed species in 1983, it did so in good faith and in accordance with the requirements given in the ESA (sec. 4(f)(1)). FWS weighted each of the four factors it considers for prioritization (degree of threat, potential for recovery, taxonomic uniqueness, and conflict with human activities), but the system is rudimentary and insufficiently transparent, and it has failed to meet FWS needs.

Conservation managers around the world face the same problem of insufficient funding to conserve endangered and threatened species. Agencies can best manage the problem by adopting and implementing more systematic and transparent criteria for allocating limited funds (see Box 4). As an initial step, the Services need a renewed commitment to using a priority-setting system that allocates recovery funds in order to maximize strategic outcomes for listed species. The Services could more consistently apply the ranking system they currently have or use new or additional criteria that remain consistent with the recovery prioritization factors given in the ESA.

Choosing recovery-funding priorities requires policy judgments about the types of species that the Services seek to prioritize. Science alone cannot identify which or how many goals to build into a ranking system. To determine which criteria to use and how much weight to assign to each, the Services should consider using a process that engages expert scientists and practitioners to analyze the goals for recovery funding, achieve a consensus based on the objectives of the ESA, and then submit the results for public comment.

The outcome of such a process would be constrained by the Services' current budgeting practices and appropriations from Congress. For example, FWS currently uses most recovery funds to pay salaries, so staff size determines which regions receive the most funding. A system for allocating recovery funds in a way that maximizes strategic outcomes for listed species might require new budgeting allocations for the Services to pay their staffs.

Strengthening Partnerships for Species Recovery

State, private, tribal, and federal entities have long played mutually supporting roles in protecting fish and wildlife species and the habitat they need. Conservation managers can build on a variety of partnership traditions for species recovery.

The Role of the States

States can provide funding and pass laws to help species recover in ways that are both specific and flexible (see Boxes 5 and 6). For example, Florida created dedicated funding sources for the endangered Florida manatee and Florida panther, and Florida's legislature passed laws authorizing boat speed zones to protect manatees and car speed zones to protect panthers. Florida has spent about twice as much as FWS on manatees and over three times as much on panthers. FWS is now considering reclassifying the manatee from endangered to threatened, and the estimated panther population has more than tripled since conservation began in the 1970s.

State wildlife agencies can also provide "boots on the ground" for research and management activities that foster species recovery. Although many states have limited capacity to manage endangered and threatened species,

Box 5. Florida's Imperiled Species Management System

The Florida Fish and Wildlife Conservation Commission (FWC) conserves species on a wide continuum, from extremely rare to abundant. Along this continuum, FWC has programs to address federally listed as well as unlisted species.

FWC created Florida's Wildlife Legacy Initiative to implement and manage the state's wildlife action plan (SWAP). The Initiative, which is nonregulatory and incentive-based, has identified more than 1,000 species that are high priority for conservation, and it has explicit 5-year goals for maintaining, restoring, and connecting high-priority habitats across the state. In the first 5 years of implementing the SWAP, FWC worked with more than 100 partners to secure $33 million in funding and matching contributions and launched about 150 projects on both public and private lands. By managing habitat, stabilizing populations, and reducing and removing threats, these projects have helped prevent the need for federal listings. For example, FWS did not list the Florida black bear because state-level conservation efforts are working.

In 2010, Florida revised its rules regarding state-listed imperiled species to improve conservation and make the listing process more transparent, thereby reducing public controversy. Florida's list includes federally listed species and "state threatened" species that are not federally listed. FWC decides whether to list a species based on criteria similar to those developed by the International Union for Conservation of Nature. All listed species are covered by a management plan developed with public input. FWC is currently working on a single unified management plan for 60 species to avoid the need for federal listing.

Florida also works with FWS to conserve federally listed species. Close cooperative relationships are maintained through annual coordination meetings involving state and federal staff, regular coordination calls involving interagency leadership, collaborative fieldwork, and joint press releases. A cooperative agreement signed in May 2012 has created a framework that could allow the state to authorize incidental take for federally listed species, the first such program in the nation.

all states have agencies dedicated to managing wildlife, and most have longstanding relationships with key stakeholder groups—including hunters, anglers, outdoor recreationists, landowners, and farmers—enjoying a level of trust that the federal government often does not. Trust is essential for developing public consent to and acceptance for the actions needed to recover listed species.

Moreover, state wildlife agencies can conduct broad proactive conservation planning through their state wildlife action plans (SWAPs). In 2005, all 50 states, the District of Columbia, and 5 U.S. territories developed SWAPs in order to receive federal funds through the Wildlife Conservation and Restoration Program and the State Wildlife Grants Program. Congress funded these programs to help conserve species of greatest conservation need—before they need to be listed under the ESA. However, many states direct SWAP funding primarily to sport fish and game, instead of broadly addressing all species at risk. For example, most SWAPs fail to adequately conserve plant species because states are not required to consider plants in order to receive SWAP funding; only 8 SWAPs include plants among the species of greatest conservation need. In addition, many states spend SWAP funding disproportionately on the most iconic or charismatic at-risk species. Statewide systems are needed for assessing all at-risk species as part of a comprehensive program to conserve species diversity and ecosystem health.

Partnering with Private Landowners

More than two-thirds of all listed species occur on private lands, and about one-third occur only on private lands. By restricting the use of lands that support listed species, the ESA can create disincentives for species recovery. Landowners might be motivated to preemptively destroy habitat for listed species or otherwise hinder their conservation.

Over the past 20 years, the Services have developed tools to reduce disincentives for conserving listed species and provide incentives for protecting them (see Box 7), including safe harbor agreements, habitat conservation plans, candidate conservation agreements, candidate conservation agreements with assurances, and conservation banks. Most of these tools include "no surprises" assurances that increase regulatory certainty by ensuring that unforeseen circumstances do not trigger unexpected restrictions on private landowners or require them to commit new resources.

The Services' incentives for landowners do increase landowner flexibility, but it is difficult to evaluate their effectiveness. Information about landowner compliance is limited, as is biological monitoring to establish the outcomes for listed species. To date, habitat conservation plans (HCPs) are the best evaluated program, although conclusions are mixed and most studies are based on small sample sizes and do not include rigorous statistical evaluation. One evaluation concluded that HCPs have aided

Box 6. Multispecies Cross-Jurisdictional Conservation in California

California leads all states in the number of listed animal species and is second only to Hawaii in the number of listed plant species. Although half of the state is public land, many listed species depend on private lands or on water sources with heavy human use. For example, the state's $45 billion agricultural sector encompasses 43 million acres of cropland and rangeland (43 percent of the state land area) and uses up to 80 percent of the available water supply. Protection and recovery of listed species has engendered costly and politically charged conflicts.

The magnitude of the challenge has led the state to pursue cross-jurisdictional ecosystem-based planning over large areas. The California Natural Community Conservation Planning Act, passed in 1991 and revised in 2003, provides a mechanism for permitting development and incidental take. The program creates large habitat preserves for multiple species through cooperative agreements, relying on voluntary enrollment by private landowners in conservation banks (see Box 8) that are purchased over time and funded largely by land developers. Eight natural community conservation plans already cover 3.4 million acres and 18 more are planned. Together, they will cover about a third of the state.

It is too early to tell whether the regional plans will reverse the decline of listed species. Many habitats are already degraded and fragmented by development, and the natural community conservation plans are generally designed for mitigation rather than recovery. Information about the ecology and habitat requirements of species covered by the plans is often minimal, and funding is limited. Climate change also poses a challenge to this kind of blueprint planning based on fixed development areas and reserve boundaries.

However, there is some evidence that large habitat conservation plans of the type being implemented in California benefit listed species compared to species without such plans or in smaller plan areas. In addition, the planning framework brings multiple organizations and stakeholders to the table, and it provides an opportunity for scientifically guided systematic conservation planning to avoid unnecessary impacts on listed species while encouraging species protection and mitigation for unavoidable impacts.

species recovery and that benefits increase with the size of the area covered. However, the researchers did not find that plans covering multiple species provided additional benefits.

The Services encourage landowners to use multispecies HCPs to gain flexibility, reduce logistical burdens, and increase the biological value of individual plans. Lack of supporting evidence for such benefits might be an artifact of their limited use. There are no multispecies HCPs (covering five or more species) in the areas where listed species are concentrated in the eastern United States (Figure 8). Their true usefulness therefore remains to be seen.

Moreover, most HCPs are designed to meet regulatory requirements, allowing landowners to mitigate the impacts of development without requiring actions that provide a net benefit to listed species. More plans that directly link management actions to species benefits are needed.

Processes for implementing landowner agreements are often time consuming and lack timelines for completion. By reducing the complexity of agreements and the time required to complete them, the Services might increase landowner interest in participating while freeing up more agency staff time. Better integration of landowner programs into other aspects of ESA implementation, including recovery planning, would allow programs to have a greater impact.

FWS continues to develop new landowner incentives and funding mechanisms to promote listed-species recovery. (See Table 1 for a summary of landowner incentives and

Table 1. Landowner Incentives and Intended Benefits

Benefits	Incentives
Reduces disincentives for conservation	SHA
Provides regulatory certainty for landowners	SHA, HCP, CCAA, habitat credit programs
Reduces constraints on land use by providing a legal pathway for incidental take	HCP, CCAA
Helps avoid the need for species listings	CCA, CCAA, habitat credit programs
Provides revenue or financial assistance for conservation	Conservation banks; habitat credit programs; Working Lands for Wildlife initiative; ecosystem service markets

Note: CCA = candidate conservation agreement; CCAA = candidate conservation agreement with assurances; HCP = habitat conservation plan; SHA = safe harbor agreement.

Box 7. Incentives for Landowners

Safe harbor agreements (SHAs) are appropriate for landowners who have a listed species on their property and are generally comfortable having the species there but don't want the species to generate new regulatory restrictions if its population increases. SHAs are voluntary agreements between the Services and private or nonfederal public landowners who agree to take action to help recover listed species. In exchange, landowners receive permits for the incidental take of listed species and formal assurances that the Services will not require anything more, as long as landowners abide by the terms of the agreement. At the end of the agreement period, landowners may return the enrolled property to an agreed-upon "baseline" condition. By the end of 2012, FWS had approved more than 70 SHAs covering 4.4 million acres and 213 miles of aquatic habitat.

A ***habitat conservation plan*** (HCP) is appropriate when landowners know their actions might cause incidental take of a listed species. The ESA requires landowners who intend to undertake otherwise lawful actions that might result in take of a listed species to apply for incidental take permits. To receive permits, landowners must submit a ***conservation plan*** (CP) (ESA sec. 10(a)(1)(B)), usually a HCP. The plan describes the anticipated effects of the proposed take, identifies management actions that minimize and mitigate adverse impacts to species, and describes how actions will be funded. Most HCPs currently cover a single listed species, with fewer than five percent covering five or more species. By the end of 2012, FWS had approved more than 650 HCPs covering 85.5 million acres and several hundred species. NMFS had completed about 34 CPs, mostly HCPs, but some addressing incidental take of listed fishes because of fishing gear.

Candidate conservation agreements (CCAs) are appropriate for landowners who want to help protect "candidate species," which warrant listing but have not been proposed for listing because of resource constraints or other species receiving higher priority. CCAs with assurances (CCAAs) provide landowners with regulatory certainty if the species is eventually listed. Under both types of agreement, landowners agree to proactive conservation measures designed to reduce threats to the candidate species. Under CCAAs, the Services provide assurances that landowners who implement conservation measures will not be subject to additional restrictions if the species covered by an agreement is ultimately listed. By the end of 2012, FWS had approved more than 100 CCAs and 26 CCAAs. NMFS had not issued any CCAs or CCAAs.

Conservation banking enables private landowners to receive payments for permanently conserving and managing land parcels (conservation banks) for listed or candidate species. The Services allocate conservation credits to landowners according to a bank's value for supporting species. Landowners can then sell the credits to buyers who need to purchase them in order to compensate for some permitted incidental take of species in a different location. By the end of 2012, the FWS had approved about 80 conservation banks covering about 48,000 acres.

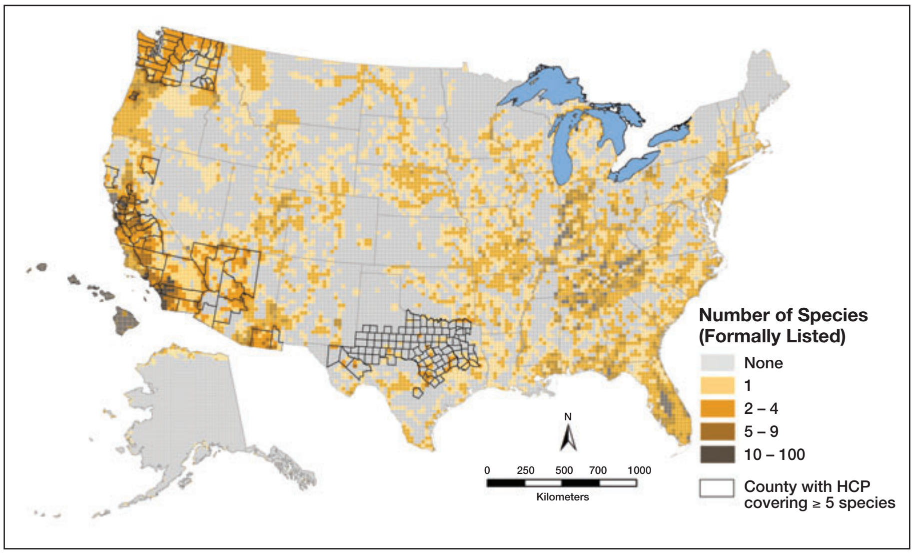


Figure 8. *The geographic overlap of listed-species hotspots with counties that have HCPs covering at least five species.*

intended benefits.) Under one proposed program, landowners who take action to help a species before it is listed would earn credits they can use to mitigate development activities after it is listed. In another program, called Working Lands for Wildlife, FWS partners with the USDA Natural Resources Conservation Service in furnishing technical and financial assistance to farmers, ranchers, and forest landowners who voluntarily implement proven conservation practices on their land. Working Lands for Wildlife allows landowners to keep lands in production while complying with the ESA and restoring species' habitats.

Habitat credit exchanges provide another example. Landowners can offset development impacts on listed or candidate species by purchasing credits from landowners who create, maintain, or improve habitat through conservation actions. A habitat exchange administrator oversees monitoring and verification of credit transactions and measures progress toward conservation goals. The Services should use such market-based funding mechanisms more widely to promote species recovery, and they should consider other ecosystem-market-based tools similar to those developed by nongovernmental organizations in California (see Box 8).

All of the Services' incentives for landowners need further evaluation of conservation outcomes, landowner satisfaction, and strategies to increase effectiveness. Research would benefit from greater public access to basic information about voluntary landowner agreements, including their terms and locations, landowner compliance, and outcomes for listed species. In addition, a better understanding of landowner motivations is needed in order to design better incentive mechanisms, so the Services could benefit by increasing the social science capacity of their staffs.

Robbins' cinquefoil.
Photo credit: U.S. Fish and Wildlife Service.

Recovery Management Agreements for Conservation-Reliant Species

Conservation-reliant species require ongoing management following recovery. Recovery management agreements are designed to ensure that conservation-reliant species will be adequately protected and managed after delisting. A good example is the Robbins' cinquefoil, a small perennial plant that was listed due to habitat loss and trampling near the Appalachian Trail. After successfully increasing the cinquefoil's population numbers and working to have the trail rerouted, FWS entered into recovery management agreements with the USDA Forest Service to protect the cinquefoil's habitat and with a nonprofit organization to monitor trail use and prevent trampling in the future. These agreements provided the regulatory assurances needed to delist the cinquefoil in 2002.

The regulatory status of conservation-reliant species that have met recovery criteria would be more certain if the Services developed an explicit policy for evaluating proposals to delist these species, similar to their Policy for Evaluation of Conservation Efforts (PECE), which applies only when the Services make listing decisions. PECE establishes criteria for deciding when it is unnecessary to list a species because federal agencies, state and local governments, and private entities have already agreed to conservation efforts that are likely to be effective. Similarly, when deciding whether to delist conservation-reliant species based on recovery management agreements, it is crucial to ensure that conservation actions continue to be implemented. Accordingly, recovery management agreements require: willing landowners within the species' range who have authority to implement them, technical guidance and assistance for landowners, agreements with landowners and local regulators to continue successful management actions, a monitoring program, mechanisms for ensuring long-term funding, and triggers for the Services to reevaluate listing decisions if species recovery is reversed.

Are nonfederal parties, particularly private landowners, willing to take responsibility for managing conservation-reliant species? Studies suggest that landowners are not motivated solely by economic considerations and that some are willing to protect or restore habitat in exchange for technical assistance and other incentives. Recovery management agreements that permit delisting conservation-reliant species can provide private landowners and other nonfederal conservation managers with greater certainty in managing their lands. Such agreements are predicated upon species having increased in population abundance and distribution as a result of specific management actions that have proven successful. By demonstrating the ESA's effectiveness, delisting conservation-reliant species can also increase public support for the law and permit conservation managers to celebrate successes.

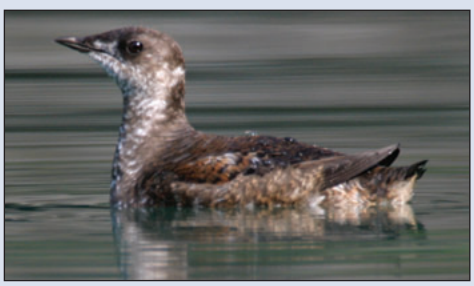
Partnerships for Data Storage, Management, and Sharing

In 2009, the Obama administration instructed federal agencies to publish data online in an open and searchable format to increase transparency and foster public participation in government decisionmaking. Because many stakeholders are involved in managing listed species for recovery, relevant information should be readily available and widely shared (to the extent permitted by law and subject to valid concerns about protecting species).

The most comprehensive system that the Services have developed for managing and sharing information about listed species is the FWS Environmental Conservation Online System (ECOS), which gives species descriptions and information about species distributions, listing status, federal register publications, special rule publications, recovery plans, downloadable maps of critical habitat, and links to other resources. ECOS also includes an online planning tool, the Information, Planning, and Conservation decision support system, which helps users avoid adverse impacts on listed species and take steps to support their recovery (http://ecos.fws.gov/ipac/). The Services could further increase transparency and facilitate

Box 8. Ecosystem Markets for Species Recovery in California

Not only is California the leader in conservation banking and habitat credit exchanges, but conservation interests in the state are also increasingly looking beyond regulatory solutions to more direct engagement with private landowners and companies in ecosystem markets. For example, The Nature Conservancy (TNC) recently launched a program that pays Sacramento Valley rice growers to keep their fields flooded during bird migration periods on the Pacific Flyway. The program uses a reverse auction approach: farmers put up secret bids, setting a price for flooding their fields, and TNC selects which properties to enroll. The approach is far less costly than traditional conservation approaches and could promote sustainable agricultural practices while improving habitat for species of concern. In the Garcia River Forest project, The Conservation Fund and TNC are working with state agencies and private timber interests in a nonprofit land management scheme that uses revenues from timber harvest and carbon credits to restore habitat for a variety of listed species, including the red-legged frog, marbled murrelet, and Chinook salmon. Both programs involve scientists in project design, implementation, monitoring, and adaptive management.



Marbled murrelet.
Photo credit: Larry Master.

Red-legged frog.
Photo credit: L. Lee Grisner, U.S. Fish and Wildlife Service.

Chinook salmon
Photo credit: John R. McMillan, Trout Unlimited.

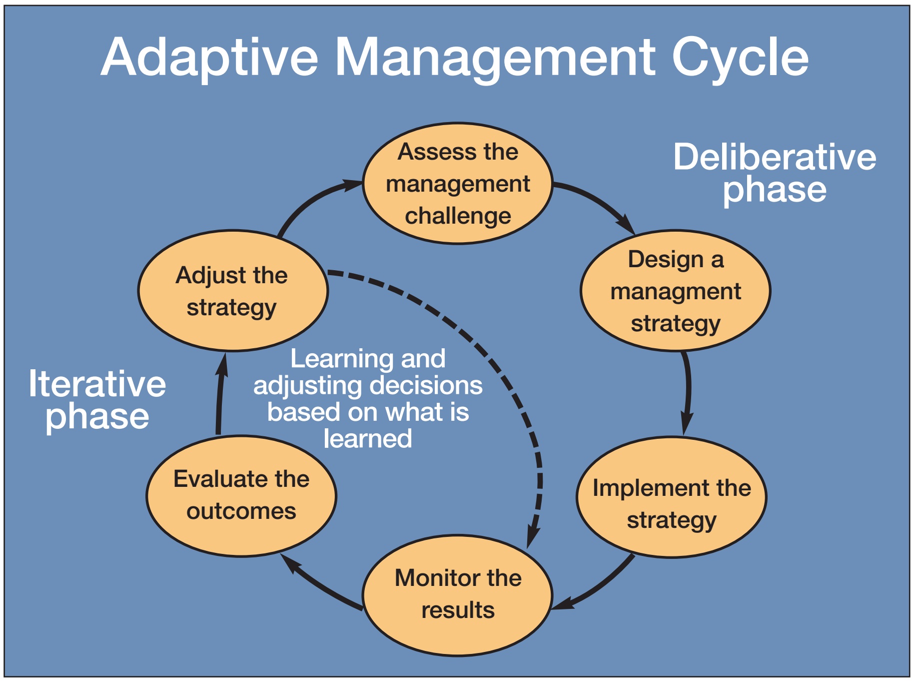


Figure 9. The adaptive management cycle in terms of designing, implementing, and evaluating management strategies, learning from the outcomes, and increasing management effectiveness.

research by making public searchable electronic documents related to listing decisions, consultations, and recovery actions. Of particular value for assessing the effectiveness of the consultation process would be biological opinions and HCPs, along with the associated incidental take permits and monitoring reports. The documents could be posted on ECOS or the federal government's www.data.gov website.

NatureServe's databases also include substantial information about the status, trends, threats, and distribution of listed species and thousands of other at-risk species. Though used by every federal agency involved in natural resources management, NatureServe's databases could be better integrated into decisionmaking related to species listing and recovery as well as other management actions. Unfortunately, licensing arrangements are fragmented and inefficient. A single federal license permitting multiple agencies to access NatureServe data would foster greater sharing of data both among federal agencies and with state agencies and private stakeholders that collaborate in managing listed species.

Promoting More Monitoring and Adaptive Management

Managing species recovery requires monitoring the implementation of recovery plans and compliance with permits and other agreements; the occurrence, persistence, distribution, and status trends of the species themselves; and the consequences of management actions in order to support adaptive management.

Implementation and Compliance Monitoring

The Services regularly monitor recovery plan implementation to determine whether adjustments are needed to recovery plans and whether additional partners are needed. However, it can be difficult to get the necessary data because their partners do not always submit complete data on time. The Services also monitor compliance with permits and other agreements, such as HCPs, but their capacity to do so is often limited by insufficient staff and funding.

Monitoring Species

The simplest approach to monitoring listed species is to find out where they occur and how abundant they are in particular areas. Presence/absence surveys can help the Services better target recovery actions, assess human impacts, and determine whether consultations are needed. Repeated, systematic presence/absence monitoring can help conservation managers assess species' status, trends, and distribution over time.

However, with few exceptions (such as the California condor and Florida manatee), listed-species monitoring is rarely rigorous, because a robust monitoring program requires more staff time and is usually more expensive. This is a major gap in listed-species management. Rigorous monitoring programs with clear and consistent protocols are necessary to accurately assess trends in species' abundance and distribution, the threats they face, and their responses to management actions.

Adaptive Management

Conservation managers typically have only limited information about listed species, and they often cannot predict species' responses to management actions, especially in rapidly changing environments. Through adaptive management, managers can take actions to promote recovery, monitor and learn from the results, and improve their techniques in light of new understanding about the ecological and social contexts in which they are working. Unfortunately, managers have not used adaptive management as frequently as they should to recover listed species, largely because of limited staff time, research capacity, and funding.

Adaptive management requires structured decisionmaking in two phases (Figure 9). In the deliberative phase, managers assess the challenge, clarify objectives and alternatives, and design and implement a management strategy. In the iterative phase, managers monitor the results, evaluate the outcomes, and adjust their strategies accordingly. Throughout the process, managers integrate the elements of the iterative phase into the deliberative phase in an ongoing cycle of learning and adaptation.

Adaptive management typically takes two forms—passive and active. Passive adaptive management is like systematic trial and error. It involves setting trigger points for review and reconsideration of the current management strategy but rarely limits the number of variables tested or establishes controls for comparison. Consequently, it can sometimes be inadequate to resolve uncertainty about key requirements for species recovery. Active adaptive management is more rigorously experimental. It usually involves testing management strategies one variable at a time, with controls, and evaluating the strategies with more intensive monitoring. It is generally more expensive than passive adaptive management, but it has greater potential to identify the necessary elements for an effective recovery program.

However, active adaptive management might not be appropriate for listed species in some cases, for example, if experiments might harm or even kill species. This is the case for the Florida manatee, which is threatened by collisions with boats. To promote manatee recovery, managers and policymakers closed areas to boating and imposed boat speed limits where manatees are known to gather. It would create unacceptable risks to manatees to allow unregulated boating in some of these areas for experimental comparison, so no one has conducted a controlled experiment to evaluate the efficacy of boat closures and speed limits. But managers have monitored manatee populations before and after the boating regulations were imposed, and this monitoring confirms that fewer manatees are killed in the protected areas.

Before using experimental management strategies, managers and regulatory authorities need to develop a clear understanding of the knowledge gaps related to the strategies they are considering, how adaptive management experimentation can fill those gaps, and what conditions would trigger new strategies in light of new information. However, conservation managers should regularly use at least a passive form of adaptive management, in which they establish baseline conditions for listed species, monitor species' responses to management actions, and adjust management strategies accordingly.

Overcoming Obstacles to Monitoring and Adaptive Management

The biggest obstacles to monitoring are the need for long-term commitments, relatively heavy staff involvement, and equipment that can be costly. Given the choice, most managers will opt to commit their limited staff and resources to additional recovery actions rather than monitoring.

Leaders and funders of conservation agencies and organizations need to make stronger commitments to increase monitoring. Scientific researchers can also help by collaborating with managers to make monitoring more efficient—by identifying the minimum information necessary to evaluate species status and trends and by designing protocols for particular types of species (such as potential indicator species) or species assemblages. Other practical measures include determining what type of monitoring is most critical where and designing protocols that can be appended to existing monitoring efforts, especially by state and federal agencies (such as the National Park Service Inventory and Monitoring Program).

In addition, conservation managers can take advantage of low-cost citizen science pro-

Loggerhead sea turtle.
Photo credit: Larry Master.

grams, such as the North American Breeding Bird Survey and state-based natural heritage program efforts to enlist members of the public to monitor species. Citizen science—participation by the public in part of a scientific project—is growing exponentially and can be useful for many types of monitoring. For example, each summer in South Carolina citizen scientists volunteer to monitor threatened Loggerhead sea turtles on beaches. Volunteers keep track of when the turtles arrive to lay eggs, the number and distribution of turtle nests, how many eggs hatch, and other parameters important for turtle conservation. Researchers evaluating this citizen science program found that in 2012 volunteers contributed $390,000 worth of monitoring effort, which led to more than a million dollars in matching funds. Although nonprofessional citizen monitoring of listed species might require special permitting in some cases, citizen scientists can gather essential data for conservation managers and free up funding for additional monitoring and management.

The biggest obstacles to adaptive management have to do with its requirement for extensive monitoring and situations that require active experimentation with listed species. Conservation managers are understandably cautious about experimenting with listed species for fear of losing critical habitat or jeopardizing species' continued existence. Leaders of conservation agencies and organizations can help by rethinking the notions of risk and risk aversion, by developing protocols to evaluate when active experimentation with listed species can be most useful and to estimate the risks to the species involved, and by encouraging and rewarding ongoing learning by individual managers and practitioners. Similarly, private landowners who receive incidental take permits are often more interested in complying with regulatory requirements than in ongoing experimental management and monitoring. All management agreements (such as HCPs) and recovery plans should specify clear thresholds and triggers that signal the need to reassess and potentially change management. Scientists should work with conservation managers to establish appropriate thresholds that can be used to evaluate management outcomes and trigger the need to modify a strategy before irreversible harm occurs. Triggers should be enforceable and transparent to all stakeholders, and the responsibilities for designing, conducting, and funding monitoring programs should be made explicit up front.

Many agencies do not have enough scientists to design, implement, and evaluate the monitoring necessary for adaptive management, especially the experimental treatments needed for active adaptive management. Moreover, monitoring is not generally conducive to research leading to peer-reviewed publications, which discourages scientists from contributing to management-oriented monitoring. More scientists need to partner with conservation management agencies and organizations to design, conduct, and interpret experimental treatments in an adaptive management framework. Researchers can also help train skilled practitioners and support them in the field.

Refining Methods to Develop Recovery Criteria

Recovery plans are supposed to include "objective, measurable criteria" for determining when species can be delisted (ESA sec. 4(f)(1)). The Services have generally used three types of criteria: (1) thresholds for species abundance and geographic distribution, (2) qualitative criteria related to population trends (for example, recovery plans might state that populations should be "healthy" or "stable or increasing"), and (3) requirements that threats are sufficiently abated. However, scientists have often criticized the criteria in recovery plans as not sufficiently based on the best available science.

Problems with Recovery Criteria

Reviews of recovery plans have found that criteria specifying a given number of individuals or populations usually give a number that is too low to provide for a high likelihood of species persistence. Conversely, qualitative criteria related to population trends lack specificity, so it is difficult to determine when they are met. Further, few species have quantitative criteria specifying how much habitat is needed and how it should be distributed – even though habitat loss and degradation are the most common threats to listed species – and recovery criteria have varied widely for different species.

These problems have several sources. The ESA does not precisely define the phrases "in danger of extinction throughout all or a significant portion of its range" and "within the foreseeable future" (ESA secs. 3(6), 3(20)).

Interpretations have ranged from accepting minimum viable populations to requiring self-sustaining and ecologically functional populations. The Services lack transparent and consistent approaches for determining quantitative recovery criteria, and recovery criteria unavoidably reflect a wide range of societal values, economic conditions, and competing uses for habitat.

Furthermore, the likelihood that a particular species will go extinct depends on the type and severity of the threats it faces as well as various biological factors (such as body size, life history, and genetic diversity) and ecological characteristics (such as habitat specialization, successional status, and the size and distribution of populations). Extinction risk is therefore highly contextual, and methods are still lacking for using general principles of conservation science and the often-minimal data available to estimate probabilities of persistence for most listed species.

Box 9. Biological Scales for Conserving Habitat

When estimating the area of habitat needed for species recovery, conservation managers should consider habitat needs at three scales:

Individual organism scale: The area needed to provide the resources and physical conditions required for an individual organism to survive and reproduce.

Local population scale: The area needed to support a population large enough to persist despite short-term inbreeding effects and periodic threats such as drought, wildfire, and disease.

Geographic range scale: The areas required by multiple local populations so that different populations are dispersed and will not all be affected by and respond in the same way to periodic threats such as drought, wildfire, and disease.

Strengthening the Scientific Foundation for Recovery Criteria

For recovery criteria that address the abundance and distribution of listed species to be objective and measurable, they should be based on numerical measurements, at specific times and places, with clearly stated levels of statistical confidence. Such recovery criteria should meet the requirements of individual organisms for survival and reproduction, reflect the species abundance and densities needed to sustain secure local populations, specify the number of local populations and the geographic distribution necessary for persistent populations across the species' range, and state the rangewide minimum habitat area required for species to survive random disturbance events (see Box 9). Recovery criteria that address the mitigation of threats and the adequacy of other regulatory mechanisms to prevent species from declining after they are delisted might not lend themselves to numeric values, but they nevertheless should be objective and measurable, e.g., they should identify specific regulations and management plans that will remain in force to reduce threats.

Population viability analysis (PVA)—a quantitative assessment of the probability of extinction based on several often-interacting factors—is one useful scientific method for recovery planning. However, for most species, it is not possible to collect the extensive data needed for a robust PVA, given limited time and funding. Scientists often conduct PVAs using only population-level data, but this method also typically requires extensive data collection, and it is insufficient for addressing threats to habitat and range. Nevertheless, scientists and recovery planners can constructively use PVA to develop recovery criteria, even in the absence of extensive quantitative data, so long as the criteria are based on probabilities of persistence over a specified time and area. As with any recovery criteria, the timeframe chosen for evaluating population viability will require value judgments, but decisions based on estimates of extinction risk have the advantages of being transparent and allowing comparisons across species.

In addition, the 3R framework—resiliency, redundancy, and representation (see Box 2)—provides a science-based approach to specifying recovery criteria for a species rangewide and considers multiple aspects of recovery. It allows for genetic and ecological diversity in populations large enough for resilience under changing environmental conditions, providing the redundancy needed to safeguard a species when catastrophic events occur. Using the 3R framework can lower extinction risk by protecting populations of appropriate size, genetic diversity, demographic mix, and geographic distribution. The 3Rs are often incorporated into conservation plans developed at the species and rangewide level (see Box 10), and they can be specified in terms that managers can use on the ground, such as acres, individuals, or populations in particular locations and spatial configurations.

Nevertheless, the 3R framework alone does not provide sufficient guidance for species recovery. For example, representation can mean different things. In the Services' view, representation is important in the sense that a species' genetic diversity should be conserved; other groups argue that species should be conserved across geographic areas representative of their historical ranges. Similarly, resiliency might require population sizes that are only minimally viable, or it might require larger, ecologically effective populations (see Box 11). Moreover, two populations technically amount to redundancy, but are the two populations far enough apart that they are not equally vulnerable to localized threats, such as a wildfire or disease outbreak? In practice, it is difficult to justify appropriate thresholds for the 3Rs, and it is not yet clear how to translate them into a spatially explicit conservation strategy.

Strengthening the scientific foundation of the 3R principles would considerably improve recovery criteria. We strongly encourage scientists to work with the Services and other agencies responsible for implementing the ESA to more clearly articulate the 3R principles, paying special attention to recent advances in population ecology, conservation genetics, and the role of biodiversity in sustaining species' habitats at the ecosystem level. Conservation managers need more user-friendly scientific methods and tools that take both species biology and extrinsic threats into account to develop integrated measures of extinction risk. Such methods should allow for assessing the consequences of environmental changes or management actions that alter landscape patterns (resulting, for example, in habitat loss or restoration), thereby helping managers integrate implementation of ESA sections 7, 9, and 10 into recovery actions. The methods also should allow for evaluating all types of decline (including population decline and loss, habitat loss, and range decline) due to threats that conservation managers consider when deciding whether to delist a species.

Using Climate-Smart Conservation Strategies

President Obama's Climate Action Plan (released by the White House in June 2013) directed federal agencies to increase the resilience of ecosystems in an era of climate change, creating opportunities for improving ESA implementation. For most species in the United States, the growing threats associated with climate change are more diffuse, less well documented, and farther in the future than other major threats (see Figure 4), and conservation managers will need more proactive conservation strategies to help species adapt. Ironically, smart management might require taking greater risks with some of the rarest species because they can be the most vulnerable to extreme climate-related events or to total loss of suitable habitat. Managers will need to determine the best climate

Box 10. The 3Rs and Northern Spotted Owl Recovery

The northern spotted owl was listed as threatened in 1990, primarily because of the loss and fragmentation of old-growth forest habitat in the Pacific Northwest. In developing the conservation strategy for the owl, scientists drew on the fields of population viability analysis, island biogeography, and other fundamental aspects of conservation biology. They used the following guidelines:

- Species widely distributed across their potential range are less at risk than species with more restricted ranges because they have multiple local populations whose growth rates and responses to threats can vary (**redundancy** and **representation**).
- Large patches of habitat supporting many individuals are more likely to sustain populations than small patches because large populations are less subject to the adverse effects of inbreeding and catastrophic events (**resiliency**).
- Populations in habitat patches that are in close proximity—or where the areas between habitat patches resemble suitable habitat—are less at risk because it is easier for individuals to disperse and recolonize (**resiliency**).
- Long-term sustainability for a species requires evaluating its demographic processes at three spatial scales: the individual territory, the local population, and the collection of interacting populations (**redundancy** and **representation**).

Northern spotted owl in Pacific Northwest old-growth forest.

Photo credit: Courtesy of Resources for the Future.

change adaptation strategies for listed species on a case-by-case basis. Here we discuss and recommend several options that can be applied within the framework of the ESA.

Increasing Habitat Connectivity

Conservation managers, policymakers, and other stakeholders need to conserve natural habitats and increase habitat connectivity across large areas. When people modify natural habitats, for example by clearing land for farms and urban development, the remaining habitat patches are typically much more fragmented and disconnected than they would be under natural conditions. Habitat fragmentation impedes species' natural movements across large areas by isolating individuals and populations. Increasing connectivity among fragmented habitats benefits a wide variety of species because it facilitates their natural movements. Habitat fragmentation is a leading cause of species decline and extinction around the world, and it is a major component of the habitat degradation that commonly threatens listed species in the United States (see Figure 4). As habitats have become more fragmented and scientific evidence has accrued, a broad consensus has emerged that natural resource managers need to substantially increase connectivity among terrestrial, freshwater, coastal, and marine habitats, for example by maintaining and restoring habitat corridors and removing dams from rivers. Climate change adds urgency to the need to facilitate the natural movement of species as they attempt to keep pace with rapidly shifting climate conditions.

Reducing Other Nonclimate Stressors

Reducing impacts from other nonclimate stressors—such as exotic invasive species, pollution, atypical fire regimes, and overexploitation—will help many native species be more resistant and resilient to climate change. There is increasing evidence that managing these nonclimate stressors is essential to help species adapt to climate change. Managers who adopt these strategies are seeing positive results for ESA-listed species and other imperiled species in a variety of ecosystems.

Integrating Climate Change into Vulnerability Assessments for Listed Species

Conservation managers should more thoroughly integrate climate change into vulnerability assessments for listed species. Many tools are available. Both the International Union for Conservation of Nature and the U.S. National Wildlife Federation, in collaboration with FWS, have recommended a three-factor framework for assessing species' vulnerability to climate change: (1) the species' exposure to climate change (based on the extent of past and projected future climate change); (2) the species' biological sensitivity (using physiological or ecological studies or long time series documenting species' responses to climate variability); and (3) the potential adaptive capacity of the species and their habitats. One study of 16,857 birds, amphibians, and corals found that only when a species was vulnerable

Box 11. Ecologically Effective Populations as a Recovery Criterion

Conservation researchers and practitioners often distinguish between recovery criteria defined strictly by demographic considerations, such as minimum viable population sizes, and criteria defined by ecologically functional roles, such as ecologically effective population sizes. An ecologically effective population size for a species is the population size below which the species is so rare that it cannot perform one or more ecosystem functions, such as predation or seed dispersal. Without ecologically effective populations in ecosystems, critical interactions among species are lost, and overall biodiversity can decline. This is especially true for highly interactive species, such as top predators like wolves.

Setting recovery criteria to achieve ecologically effective population sizes departs from how the Services have historically administered the ESA, and it could be politically controversial. Moreover, quantifying such criteria might be difficult because it would require extensive ecological analysis. Nonetheless, scientists generally agree that conserving ecosystems that support endangered and threatened species requires conserving ecologically effective populations of species that have key functional roles in those ecosystems. To conserve ecologically effective populations of listed species, recovery plans would need to address the species' functional roles in ecosystems as well as the genetic diversity, resilient population sizes, and geographic distributions needed to sustain those functional roles.

Gray wolf.
Photo credit: Gary Kramer, U.S. Fish and Wildlife Service.

in all three regards—with high exposure to climate change, high biological sensitivity, and low adaptive capacity—was it at high risk due to climate change. Species that are relatively insensitive to climate shifts or have a natural suite of adaptation options will likely be climate resistant or resilient even if climate rapidly changes. In light of uncertainties about climate futures for particular species, ongoing learning about management options in a rapidly changing environment is especially important. The Services' 5-year reviews of listed species should consistently include judgments as to whether recovery plans adequately take climate change into account and recommend adaptive management actions to better address climate change.

Conservation managers can sometimes assess species' vulnerability to climate change even without species-specific information by characterizing the projected climate change according to more generic metrics such as changes in temperature and precipitation, climate variability, and extreme weather events. Managers can use such approaches to identify continental-scale gaps in protected areas and in connectivity among habitat areas.

Protecting Future Suitable Habitats

Conservation managers, policymakers, and other stakeholders will also need to protect areas that are projected to become suitable habitat for listed species as climates change. Unfortunately, modeling tools do not currently provide high consistency among projections: different biological models produce large differences in results. For any given species, carefully designed regular surveys outside its range might indicate the areas that it is likely to move into. Managers could integrate the surveys into adaptive management plans. Although conducting such surveys might seem daunting, managers can use species distribution models as a first step to search for potential new areas that are outside of species' current ranges but might become climatically suitable.

Using Assisted Colonization

Actively helping species move beyond their historical ranges to areas that are projected to be more climatically suitable has been variously called assisted colonization, translocation, relocation, or migration. Conservation managers will need to consider using this approach more frequently. The ESA permits it (ESA secs. 3(3), 10(a)(1)), and FWS programs have already helped establish new populations of a number of species, including the California condor in Arizona and the gray wolf in Idaho and Wyoming (both within the species' historical ranges) and new populations of the Pahrump poolfish outside of its historical range in Nevada. FWS has also introduced Guam rails to two Pacific islands where they never occurred before, Rota and Cocos.

Assisted colonization can be expensive, and it can fail. Theoretical models for predicting climate suitability typically harbor too much uncertainty to be used alone, but they can serve as a useful first step. The differences among model outputs can be used to define the likely range of possible futures and point to areas for further study as potential assisted colonization sites.

Conservation managers should consider not only the likely effectiveness of assisted colonization for the species that could be relocated but also the potential impacts on the ecological community at the colonization site. Assisted colonization might be most appropriate for species that are highly sensitive to climate change, have low dispersal ability (so they are at high risk of extinction), are weak competitors and poor predators (and therefore unlikely to be invasive species or to otherwise harm the ecological community), and can be easily and inexpensively established as new populations.

Engineering Habitat

Conservation managers can sometimes design and create entirely new, functional ecosystems in previously degraded areas. For listed species with very small ranges and narrow habitat requirements, conservation managers might choose to create new habitats and perhaps even new ecological communities that are better adapted to future climate conditions. Like assisted colonization, habitat engineering is relatively expensive, and proposed projects would need to withstand scientific and public scrutiny. Geographic regions like California that already have multispecies HCPs associated with large tracts of land might have sufficient flexibility to change land use designations and implement habitat engineering projects to improve recovery prospects for some species.

Evaluating and Developing Ecosystem-Based Approaches

The large numbers of endangered and threatened species and limited resources for recovery have prompted renewed interest in moving beyond single-species management and finding more efficient, ecosystem-based approaches to conservation planning. One such approach is to focus management efforts on surrogate species that simultaneously benefit multiple listed species; another is to use "coarse ecological filters" to identify and manage ecosystems rich in listed species.

Using Surrogate Species

One species can serve as a conservation surrogate for another if the species are closely related or have similar ecological requirements, biological traits, or responses to environmental change; if the species are interdependent, such as predator and prey; or if the surrogate species is an umbrella species, with broad ecological requirements or geographic ranges that include those of multiple species of concern. The FWS Strategic Habitat Conservation approach and Landscape Conservation Cooperatives use surrogate species in their conservation planning process, based on the premise that surrogate species represent the habitat and/or management needs of larger groups of species.

However, surrogate approaches to managing listed species are not well supported by research. Studies have generally found poor correspondence between surrogates and target species in terms of biological traits, presence and abundance, and patterns of decline. Selection of conservation sites based on one taxonomic group rarely represents other groups well, and the degree of spatial overlap between groups is idiosyncratic. FWS will test its surrogate species approaches by evaluating the underlying assumptions and monitoring both the surrogate species and the target species. In practice, this might require a return to more intensive species-specific management. Moreover, setting recovery criteria and evaluating progress toward recovery will still be required for all listed species.

Nonetheless, if appropriate surrogates can be found, using surrogate species to manage for listed species could allow conservation planning without full knowledge of every species or ecosystem element, and it could facilitate decisionmaking within policy- and management-relevant timeframes. Conservation managers have already used surrogates in a wide range of situations, including systematic reserve selection, forest management, and ecosystem management and monitoring, and researchers continue to explore new methods to identify surrogate species. But surrogate approaches to managing listed species need more evaluation, and managers should be careful only to implement approaches that are scientifically credible.

Using Coarse Filters

Conservation managers might be able to move beyond traditional species-by-species recovery strategies by using ecosystem-based coarse filters to target geographic concentrations—or hotspots—of listed species (Figure 3). Coarse filters are broad characteristics of a natural environment, much like the cues used by naturalists to generate lists of expected species in a particular habitat. They are easily measured and often based on existing information such as satellite images, digital elevation models, and weather station data. As such, coarse filters are simply another kind of surrogate. They are environmental cues—such as dominant vegetation and plant community types identified by satellites—that researchers can use to predict the occurrence of species in a particular habitat or ecosystem. Importantly, coarse filters are defined independently of any particular species' habitat needs: they are meant to capture the needs of entire groups of species.

The coarse-filter approach has rarely been tested and only with mixed results. Coarse filters have often led to overestimating the presence of species in a region of interest. Furthermore, they have worked better for species that are small and abundant than for ones that are large or rare—the ones more likely to be of conservation concern.

Nonetheless, researchers can develop coarse filters that identify overall patterns of biological diversity or concentrations of rare species, and this might increase the efficiency of management efforts to recover listed species. By combining information about the geographic distribution of listed species (Figure 3), their taxonomies and life histories, the portfolio of threats that triggered their listing, and the biological and physical features of the regions where they occur, researchers might develop coarse filters that reliably identify key ecosystem units. Conservation managers could then focus recovery efforts on those units.

Box 12. Strategies to Increase the Effectiveness of ESA Implementation

- Establish and consistently apply a system for prioritizing recovery funding to maximize strategic outcomes for listed species
- Strengthen partnerships for species recovery
- Promote more monitoring and consistently implement and refine approaches for adaptive management
- Refine methods to develop recovery criteria based on the best available science
- Use climate-smart conservation strategies
- Evaluate and develop ecosystem-based approaches that can increase the efficiency of managing for recovery

There is evidence in the scientific literature that such a strategy has merit, and managers are already taking similar approaches. On the island of Kauai in Hawaii, FWS has grouped 48 listed species based on common factors such as shared threats and types of habitat, focusing restoration broadly on habitats and ecosystems rather than solely on individual species in their last few known locations. Such thinking is also behind a push for species conservation across large landscapes under collaborative adaptive management. For example, the Forest Service has adopted a new planning rule governing biodiversity conservation on lands that it administers based largely on a coarse-filter strategy.

Coarse filter approaches appear to hold promise for designing management actions directed at recovering listed species, although these approaches are still hypothetical. Testing the hypotheses will require species-level monitoring to gauge species recovery.

Protecting America's Heritage

"The public is (and the sportsman ought to be) just as much interested in conserving non-game species, forests, fish, and other wild life as in conserving game." These prescient words are as true today as when Aldo Leopold wrote them 43 years before Congress enacted the ESA.

As Leopold knew, America's heritage and identity are bound up with wild, untamed landscapes—with the American frontier, from the first settlement at Jamestown to the last of the great migratory bison herds on the Great Plains—America's Serengeti, now lost to posterity. To prevent further loss, conservationists formed great systems of public lands and passed laws designed to protect America's remaining native species—and with them a piece of what it means to be American. Chief among those laws was the ESA.

The ESA has worked remarkably well to shield hundreds of species in the United States from extinction, and it remains one of the country's strongest environmental laws. It is also a flexible statute that permits considerable innovation in its implementation. Innovation will be key to the ESA's future success because the threats to at-risk species are pervasive and persistent, many listed species are now conservation reliant, and climate change will continue to shuffle the mix of species in ecological communities, increasing both extinction risk and management uncertainty. At the same time, without a dramatic shift in public priorities, government funding for species recovery will likely remain insufficient.

Accordingly, we have identified six broad strategies to increase the effectiveness of ESA implementation (Box 12). By adopting these strategies, conservation managers, policymakers, scientists, and the public can use the ESA more effectively and efficiently to save species at risk.

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