Federal Lands and Endangered Species: The Role of Military and Other Federal Lands in Sustaining Biodiversity

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The US government has multiple responsibilities for the protection of endangered species, many of them stemming from its role as the nation's largest landowner. To explore how endangered and imperiled species are distributed across the federal estate, we carried out a geographic information system (GIS)-based analysis using natural heritage species occurrence data. In this 10-year update of a previous analysis, we found that the Department of Defense and the USDA Forest Service harbor more species with formal status under the Endangered Species Act (ESA) than other US agencies. The densities of ESA status species and imperiled species are at least three times higher on military lands—2.92 and 3.77, respectively, per 100,000 hectares—than on any other agency's lands. Defense installations in Hawaii are especially significant; more than one-third of all ESA status species on military lands are Hawaiian. These findings highlight the continued importance of public lands for the survival of America's plant and animal species.

Keywords: endangered species, biodiversity, federal lands, Department of Defense, natural heritage

The federal government owns more than 264 million hectares (ha) across the United States, representing nearly one-third (29%) of the nation's land area, and one-fifth (21%) just in the lower 48 states. These lands span a wide array of ecosystems, from frozen tundra in the north to subtropical hardwood hammocks in southern Florida. In turn, these habitats support diverse assemblages of native wildlife, including many that are rare or have suffered serious declines. Such rare or declining species are of particular scientific and conservation interest because of their heightened risk of extinction.

The Endangered Species Act (ESA) of 1973 represents a formal expression of the American people's concern about the loss of plant and animal species to extinction. The federal government has dual responsibilities under this act. Administration and enforcement of the act's provisions are federal obligations of the US Fish and Wildlife Service (USFWS) within the Department of the Interior, and the National Marine Fisheries Service (NMFS) within the Department of Commerce. A second area of responsibility relates to the federal government's role as the nation's largest landowner and manager, with broad responsibilities for managing the resources under its control. The mandates of federal agencies vary widely; consequently, land-management objectives range from a focus on protection and preservation, as is the case with the National Park Service (NPS), to multiple uses of the land, including resource extraction, as with the USDA Forest Service and the Bureau of Land Management (BLM).

Despite these differences in objectives, all federal land-management agencies are obligated to comply with federal environmental laws and regulations such as the ESA. Thus, while considerable attention in recent years has rightfully focused on how to better protect endangered and threatened species on private lands, federal lands must play a key role in any national strategy for preserving the nation's rich array of wildlife species. Protection of threatened or endangered plant species under the ESA, for example, differs depending on whether the plant is found on federal property or on private property. The no-take provisions under the act, which prohibit landowners from causing harm to listed species, apply only to animals. Plant species on private lands are, in general, protected only where a federal action (e.g., regulatory permit) is involved. In contrast, listed plants occurring on federal lands receive full protection under the act.

What then is the scope of federal land management responsibilities for endangered species? Several previous

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studies have examined the degree to which federal lands support rare and endangered species. Our initial review of this question, based on species locality data from the network of state natural heritage programs, found that only about half of the 728 species that were federally listed at that time were known to occur on federal lands (Natural Heritage Data Center Network 1993, Stein et al. 1995). Similarly, a US Government Accountability Office study based on estimates of habitat availability determined that between one-third and one-half of federally listed species did not occur on federal lands (USGAO 1995). In a subsequent review using 1996 data, we documented the presence of nearly three-fifths (59%) of federally listed species on federal lands (Groves et al. 2000). That analysis considered 1184 species that were listed as threatened or endangered, or were proposed or candidates for listing, under the act.

Groves and colleagues (2000) also considered how the presence of listed species varied across lands of the major federal land management agencies. Surprisingly, the Department of Defense (DOD), which manages just 3% of the federal estate, emerged as harboring the greatest number of federally listed species. This result echoes what Flather and colleagues (1994) found using different methods. The seemingly disproportionate significance of military lands for endangered species documented in our previous study has played a key role in motivating the DOD to be proactive in its efforts to manage military lands in ways that both sustain biodiversity and maintain military readiness (Boice 2006).

Beyond legally protected species

Although plants and animals listed under the ESA represent one set of species at increased risk of extinction, they are by no means the nation's only species of conservation concern. Listings under the act not only reflect biological need and conservation conditions but also are sensitive to such factors as shifts in policy and availability of funding (Goble et al. 2005). Indeed, the pace of listings under the act has fallen sharply since the late 1990s, reaching a nadir in 2003 when just a single species (the plant *Polygonum hickmanii*) was added to the list (figure 1).

NatureServe conservation status assessments represent an independent and complementary view of the extinction risk facing US species (Stein et al. 2000, Wilcove and Master 2005). Plant and animal species are evaluated on the basis of a dozen criteria that are correlated with extinction risk, such as population numbers and trends, range size, and habitat specificity. This multifactorial analysis is summarized and expressed as ranks on a scale of 1 through 5, where 1 represents species considered to be critically imperiled and 5 those that are considered abundant and secure. These conservation status ranks can be applied to a species across its entire range (i.e., at the "global" scale), as well as at national and state scales. As a result, the NatureServe global conservation status ranks (or G-ranks) represent an assessment of the overall extinction risk facing the species. Such assessments have been carried out for more than 35,000 US species, including all vertebrate animals and vascular plants, and many of the better known invertebrate groups; these assessments are available online through the NatureServe Explorer Web site (*www.natureserve.org/explorer*).

The NatureServe status assessments provide a means to identify species of conservation concern that may not be legally protected under the ESA, and thus they are used widely by federal agencies, conservation organizations, and industry to target conservation and land-management efforts. These assessments also provide a means to identify opportunities for stabilizing and protecting species, which may help avert the need for listing and regulation under the ESA.

A 10-year reassessment

Our last comprehensive analysis of the role that federal lands play in sustaining the nation's endangered species was based on locational data that were current as of 1996 (Stein et al. 2000). Over the past 10 years, several changes have occurred that make it timely to reassess the relative stewardship

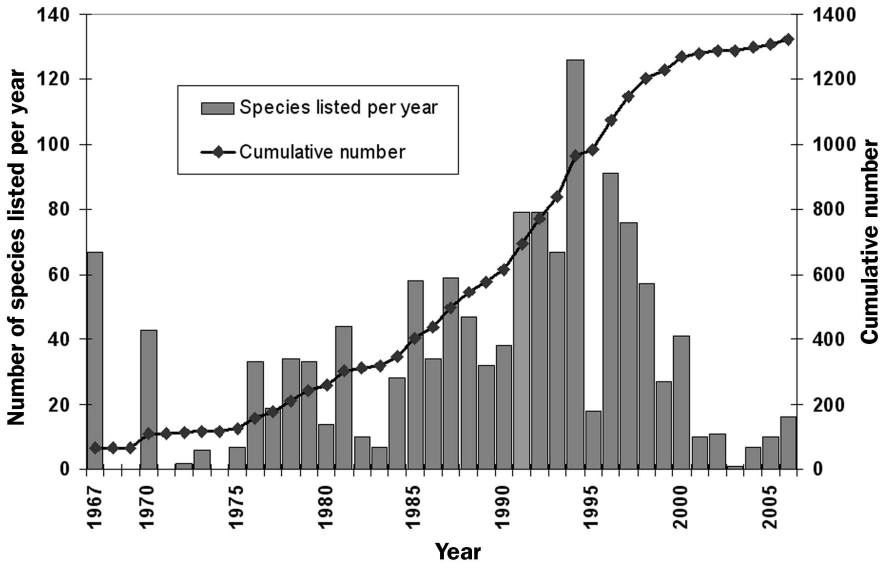

Figure 1. Listings under the US Endangered Species Act. The pace of listings under the ESA has varied considerably over time, primarily reflecting availability of funding for listing activities and shifts in policy. As of October 2007 a total of 1333 US species and populations were listed as threatened or endangered under the act. Under the ESA, listings can apply to species, infraspecific taxa, or, for vertebrate animals, "distinct population segments." Source: US Fish and Wildlife Service, Threatened and Endangered Species System, October 2007.

responsibilities of different federal land-management agencies with respect to listed species and other species at risk.

First, considerable attention has focused in recent years on the ESA itself, with a number of proposals being put forward for changes as part of a long overdue reauthorization of the act. Many of these changes relate to how ESA protections and implementation should relate to private lands, but a number of important issues also under consideration are related to implementation of—and exemptions from—provisions of the act by various federal agencies, including the DOD. Second, the number of species listed under the act has continued to increase, albeit at a diminished pace. As of December 1996, 1078 US species were listed under the act; in October 2007, 1333 US species were listed, an increase of 24%. Third, in the past decade a considerable amount of new inventory work on federal lands has been incorporated into state natural heritage program databases. Finally, many changes have taken place on the landscape itself, both on and off public lands.

Methods

NatureServe coordinates a nationwide network of state natural heritage programs, each of which maintains a database of documented populations of species of conservation concern. These state-based inventories manage their data according to common standards and protocols, enabling NatureServe to assemble a nationally consistent dataset of precise localities ("element occurrences") for endangered and imperiled species. We used this nationally aggregated occurrence data set as the basis for our analysis of species distributions across federal lands. Although our previous analyses of endangered species on federal lands used earlier versions of this same data set, they relied on landowner attribute data included in each occurrence record. This was necessary at the time because the occurrences were managed as point localities rather than as polygon footprints. The current generation of natural heritage software (Biotics 4) provides geographic information system (GIS) functionalities that allow occurrence records to be managed as spatially explicit polygons. These polygons take into account both the footprint of the biological feature (where it is known) as well as estimates of spatial uncertainty.

Our analysis was conducted in two stages. We first carried out a GIS-based analysis comparing natural heritage locational data for imperiled and endangered species with a coverage of federal land holdings. These preliminary findings were then reviewed by state natural heritage or federal agency biologists, and in the case of species with ESA status, vetted against agency-generated endangered species lists.

We used the US Geological Survey (USGS) federal lands data layer (*www.nationalatlas.com*) as the federal lands coverage for the continental United States (the lower 48 states and Alaska). Although more detailed data layers are available for specific states, the USGS data layer is considered to be the most comprehensive and consistent nationwide coverage for federal lands. The only exception to our use of the USGS data layers was for Hawaii, where issues of scale and registration, coupled with the extremely localized distribution of many species, led us to rely instead on higher resolution data from the Hawaii Gap Analysis Program (*www.higap.org*). For our use of the USGS federal lands data layer, we downloaded and merged the line and polygon layers. Because our interest was in the five major land management agencies (USDA Forest Service, BLM, NPS, USFWS, and DOD), we excluded several other minor federal land classes from our analysis (table 1). With the exception of the DOD, for which we wished to carry out more detailed analyses, spatial units for each of the major land-management agencies were dissolved into distinct polygon classes.

Species selection criteria. Consistent with our previous analyses, our selection of species with federal status included all taxa listed as endangered or threatened under the ESA or that are proposed or candidates for listing under the act. (We refer to these collectively as "ESA status species.") This includes full species as well as infraspecific taxa (e.g., subspecies) and distinct population segments as recognized by the act. In total, 1520 taxa met our criteria for species with ESA status. Our selection criteria for imperiled species included species and infraspecific taxa assessed by NatureServe as critically imperiled or imperiled across their range (G-rank = G1, G2, T1, or T2). To avoid biases resulting from inclusion of species groups that are not consistently available in the state databases, our analysis of imperiled species included only vertebrate animals and vascular plants. A total of 3069 taxa met our criteria for imperiled species (table 2). The two sets of species—listed and imperiled—are not mutually exclusive.

Because our interest here is in understanding the current stewardship responsibilities of the different federal agencies, only species occurrences that have a reasonable likelihood of being extant were included in this analysis. As a result, populations for species known or suspected to be extirpated in a given state (S-rank = SX or SH) were excluded, as were specific populations known or suspected to be extirpated (EO rank = X or H). Consistent with our previous analyses, we also excluded older population occurrences, defined as those not reverified since 1970. In total, more than 60,000

Table 1. Area of land managed by federal agencies.

Agency	Hectares (millions)
Bureau of Land Management	104.4
USDA Forest Service	78.1
US Fish and Wildlife Service	38.8
National Park Service	33.8
Department of Defense	12.1

Note: Because of their smaller land bases, two federal agencies, the Bureau of Reclamation (3.5 million hectares) and Tennessee Valley Authority (0.1 million hectares), were not included in this analysis.

Table 2. Number of species included in the analysis of ESA status species and imperiled species on federal lands.

Classification	Number
ESA status species	
Lichens	2
Invertebrates	313
Vertebrates	374
Vascular plants	831
Total ESA status	1520
Imperiled species	
Vertebrates	383
Vascular plants	2686
Total imperiled	3069

Note: ESA status species include taxa that are listed under the Endangered Species Act as endangered or threatened, or that are formally proposed or candidates for listing under the act. Imperiled species include taxa assessed by NatureServe as critically imperiled (G1 or T1) or imperiled (G2 or T2).

occurrences of ESA status species and 55,000 occurrences of imperiled species met our selection criteria.

Spatial analysis criteria. Because not all occurrence polygons nest completely within individual land-management units, we developed explicit decision rules for assigning species occurrences to agency landholdings. These criteria were designed to minimize type I errors, where a species might be erroneously reported for a land unit on which it does not actually occur.

Subsumed polygons. A species was assigned to a landholding if an occurrence polygon of the species fell completely within the unbuffered boundaries of the land management unit.

Overlapping polygons. If an occurrence polygon overlapped but was not entirely within the unbuffered boundaries of a land-management unit, we considered the precision of the record in evaluating whether to include or exclude the species from our counts for that agency's lands. For locations known to have been mapped with a high degree of precision (representational accuracy = high or very high), any amount of overlap was considered sufficient for inclusion. For less precise occurrence polygons, we required an overlap of at least 50% before including the occurrence in our species counts. To further reduce type I errors in our counts of federally listed species, before including species known on an agency's land only from such partially overlapping polygons, we required an independent validation during the review process.

Data review procedures. On the basis of our spatial analysis decision rules, we identified a number of "questionable" species with respect to their assignment to lands of a given agency. Our data review procedures focused on determining which of these questionable species could reasonably be attributed to federal agency lands on the basis of other forms of documentation. Lists of such questionable species were generated for each state and provided to natural heritage program biologists for review. Species were included in agency counts where these biologists could positively confirm their presence on agency lands. In some cases, species with well-known distributions could also be confidently excluded as not occurring on an agency's land. A second step in the review process involved federal agency input or review. Each federal agency included in the analysis was invited to provide a list of species thought to exist on their lands or to review our preliminary list in order to validate (or refute) the presence of such questionable species. Agency-provided lists served as a valuable cross-check, but these lists do not necessarily coincide with the criteria used in this analysis. For example, many lists include species that historically occurred but no longer are present on those lands. Discrepancies were investigated and considered on a case-by-case basis.

Caveats. This analysis is sensitive to several factors. First, although the data gathered and managed by state natural heritage programs are widely considered to be the most comprehensive available for rare and endangered species locations, these data generally are not the result of systematic inventories. The state databases incorporate data from a variety of sources, including targeted inventories carried out by natural heritage biologists, and collection and observation data from the broader biological community. Natural heritage databases generally reflect the state of biological knowledge for the species reported, including gaps in such knowledge. Inventory data, however, appear to be more complete for public lands than for private lands (Cutko et al. 2008), although some agencies may be underrepresented because of restrictive collecting policies (e.g., the NPS).

The distributions for many of these rare species are highly localized, so even minor errors in land boundaries can influence the analysis. These issues are well illustrated by Eglin Air Force Base, an installation in northwestern Florida with fairly well-documented flora and fauna. An anomaly detected during our data review revealed that the USGS land coverage erroneously attributed the base's coastal barrier islands to the NPS. This boundary error had the effect of excluding three federally listed species from our tally for Eglin: perforate reindeer lichen (*Cladonia perforata*), the green turtle (*Chelonia mydas*), and the loggerhead turtle (*Caretta caretta*). Those boundary issues that came to light were corrected, but clearly in a national-scale analysis we would expect others to go undetected.

Species across the federal landscape

Federal lands provide habitat for a considerable number of rare and endangered species, and are likely to play an increasingly important role in sustaining the nation's complement of plants and animals. How federal agencies discharge those stewardship responsibilities depends on their mandates and statutory obligations, as well as on the nature of the resources they are called upon to manage.

This updated analysis indicates that lands of the USDA Forest Service and the DOD share the distinction of supporting the greatest number of species with formal status under the ESA. Lands of both agencies harbor about 23% of the ESA status species included in our analysis, with each agency hosting at least 355 such species (figure 2). These two agencies are followed by the NPS (19%), the USFWS (18%), and the BLM (16%), respectively. We should emphasize that because of the restrictive criteria used in our spatial analysis, these figures represent a minimum number of listed species that currently exist on these land holdings.

In contrast to the pattern for ESA status species, Forest Service lands by a wide margin harbor the most NatureServe-defined imperiled species, with 27% of the total number analyzed, accounting for at least 821 species (figure 2). The BLM ranks second with 20% of the total, followed by military lands with just 15% of imperiled species.

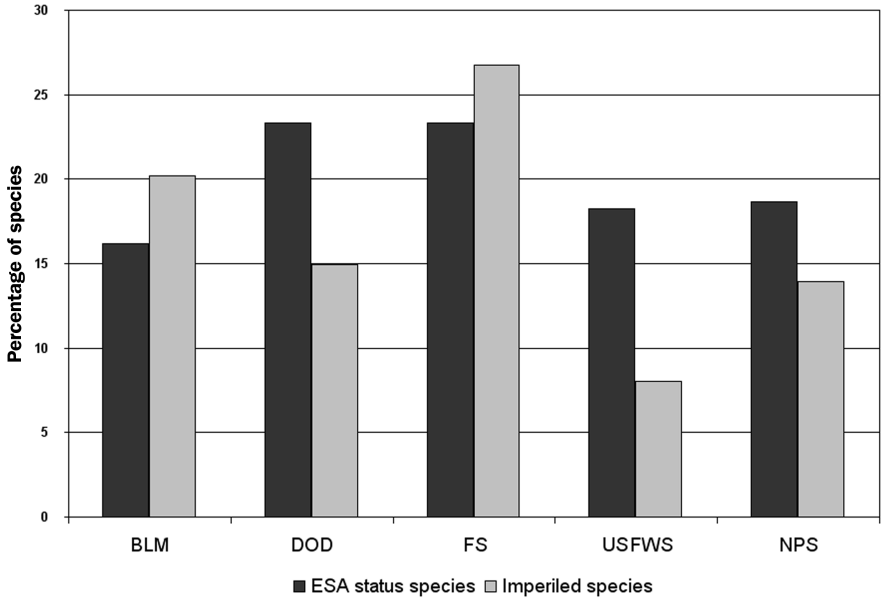

Figure 2. Distribution of endangered and imperiled species on federal agency lands. Lands of the DOD and USDA Forest Service harbor the greatest number of species with status under the Endangered Species Act (23%), while Forest Service lands support the largest number of NatureServe-assessed imperiled species (27%). Source: NatureServe Central Databases (based on data from US natural heritage programs), February 2007. Abbreviations: BLM, Bureau of Land Management; DOD, Department of Defense; FS, Forest Service; NPS, National Park Service; USFWS, US Fish and Wildlife Service.

These updated figures for both ESA status and imperiled species generally are consistent with the results of our previous analysis, based on 1996 data (Groves et al. 2000). For ESA status species, most agencies displayed only modest increases—between 1 and 2 percentage points—although both the Forest Service and the USFWS showed increases exceeding 5% (table 3). Increases in representation of imperiled species were in general less than that for ESA status species, ranging from a low of 0.2% for the DOD to a high of 1.5% for the USFWS.

Although the overall number of species occurring on an agency's lands offers an important perspective on relative stewardship responsibilities, this measure masks the vast differences in area under management of the different agencies. BLM lands, for example, cover 104 million ha, an area nearly nine times the size of the DOD's 12 million ha. Analyzing the concentration or density of species per unit area provides an alternative perspective on stewardship responsibilities that normalizes for size differences. Based on a calculation of number of species per unit of area, DOD lands stand out with 2.92 ESA status species and 3.77 imperiled species per 100,000 ha (figure 3). By this density measure, the significance of military lands exceeds that of any other agency by a factor of three. Lands of the NPS, which cover about 34 million ha, have the second highest concentrations of both ESA status and imperiled species (0.84 and 1.26, respectively).

Table 3. Comparison of the percentages of ESA status species and imperiled species on federal lands, 1996 and 2007.

	ESA status species (percentage)			Imperiled species (percentage)		
Agency	1996	2007	Change	1996	2007	Change
Bureau of Land Management	14.7	16.2	1.5	19.5	20.2	0.7
Department of Defense	21.0	23.4	2.4	14.7	14.9	0.2
Forest Service	18.1	23.4	5.3	26.3	26.8	0.5
US Fish and Wildlife Service	12.8	18.2	5.4	6.5	8.0	1.5
National Park Service	16.8	18.7	1.9	13.3	13.9	0.6

Note: These figures represent the percentage of total ESA status species and imperiled species documented on federal agency lands in our previous analysis (Groves et al. 2000) using 1996 data, and by the current study using 2007 data.

A focus on the military

Given the disproportionate significance of DOD lands for endangered species, we explored their distribution across military lands in greater detail. At the service level, army lands harbor more than twice the number of species of concern (15% of ESA and 9% of imperiled) as those of the navy (7% ESA and 4% imperiled), which had the second highest number (figure 4). Installations from each of the services are represented among the top 10 for number of both ESA status

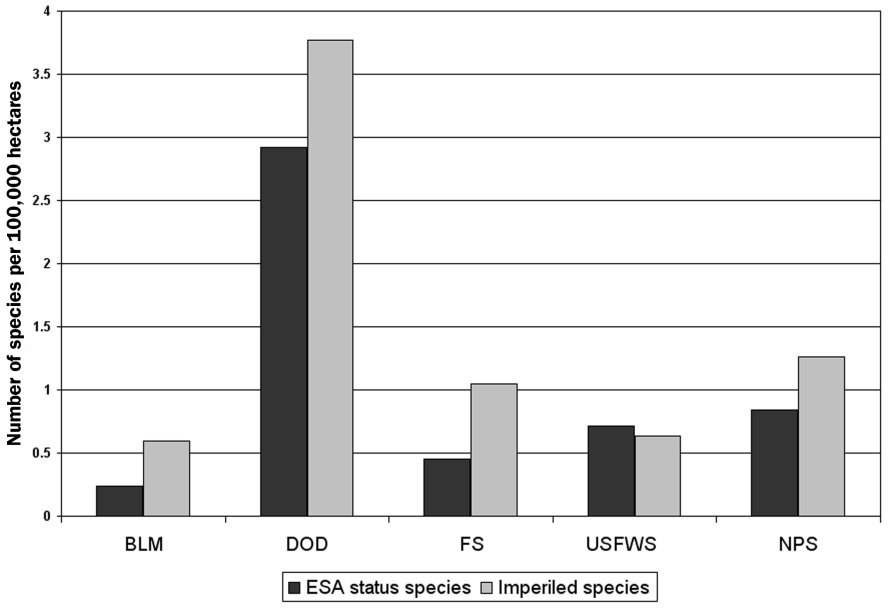

Figure 3. Density of endangered and imperiled species on federal agency lands. Calculating the density of species per 100,000 hectares highlights the disproportionate role that DOD lands play in sustaining the nation's biodiversity. Military lands have three times higher densities of ESA status and imperiled species than do lands of the NPS, the second-ranked agency for densities of both ESA and imperiled species. Source: NatureServe Central Databases (based on data from US natural heritage programs), February 2007. Abbreviations: BLM, Bureau of Land Management; DOD, Department of Defense; FS, Forest Service; NPS, National Park Service; USFWS, US Fish and Wildlife Service.

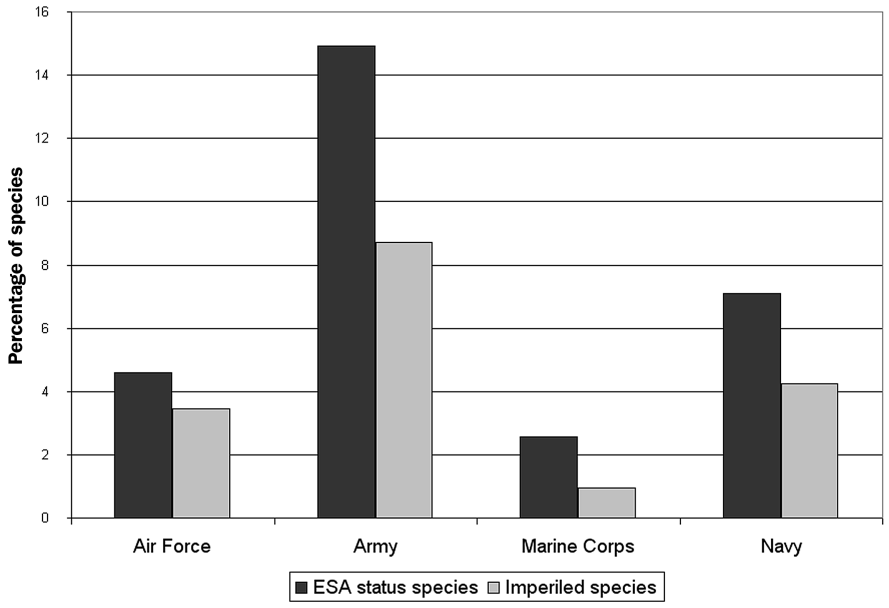

Figure 4. Distribution of endangered and imperiled species by military service. Army lands harbor more than twice the number of ESA status and imperiled species as those of the navy, which supports the next highest number. Source: NatureServe Central Databases (based on data from US natural heritage programs), February 2007.

species (table 4) and imperiled species (table 5). Army bases, however, constitute 4 of the top 10 installations for ESA status species and 5 of the top 10 for imperiled species.

A key question regarding the overall ranking of military lands is whether these patterns are based on biological factors, or whether these lands are simply better inventoried than the lands of other agencies. The relatively modest size of the landholdings of the DOD, at least compared with the Forest Service and the BLM, does make comprehensive inventories more tractable, and the military has sponsored a considerable amount of inventory work on its installations over the past two decades. A comparison of the location of military installations with known hotspots of rare species (e.g., Dobson et al. 1997, Flather et al. 1998, Chaplin et al. 2000), however, lends credence to the underlying biological significance of the military's land holdings.

The Hawaiian islands, in particular, play an important role in the DOD's overall ranking. This chain of oceanic islands is well known for its high levels of endemism, many extremely rare species, and large number of species extinctions (Wagner and Funk 1995). Just three federal agencies manage significant amounts of land in Hawaii: the NPS, USFWS, and DOD. Although the NPS administers the largest areas—including Hawai'i Volcanoes National Park and Haleakala National Park—the DOD manages more discrete land units. Because of the highly localized ranges of many Hawaiian plant and animal species, the presence of multiple, dispersed military installations has the effect of increasing the number of different species found on DOD lands. It is noteworthy that four of the top five military installations for both ESA status species and imperiled species are located in Hawaii (tables 3, 4), lead by Oahu's Schofield Barracks Military Reservation, which supports at least 47 species with federal status and 53 imperiled species. Overall, more than one-third (34%) of species with ESA status found on military lands nationwide are Hawaiian.

Table 4. Top 10 military installations for ESA status species.

Rank	Service	Installation	State	Number of ESA species
1	Army	Schofield Barracks Military Reservation	HI	47
2	Army	Makua Military Reservation	HI	39
3	Navy	Lualualei Naval Reservation	HI	38
4	Army	Pohakuloa Training Area	HI	17
5	Marine Corps	Marine Corps Base Camp Pendleton	CA	17
6	Navy	San Clemente Island Range Complex	CA	10
7	Air Force	Eglin Air Force Base	FL	10
8	Air Force	Vandenberg Air Force Base	CA	10
9	Army	Fort Lewis Military Reservation	WA	10
10	Air Force	Avon Park Air Force Range	FL	10

Note: These figures, based on documented occurrences in natural heritage databases, represent the minimum number of species on these installations.

Patterns of listed versus imperiled species

What do the differences in patterns exhibited by listed species relative to imperiled species tell us about how well we are protecting species at risk? To address this question, one first must consider the relationship between these two status designations. Master and colleagues (2000) found that 90% of species listed at the time under the ESA also were categorized by NatureServe as imperiled species (G1, G2) or subspecies (T1, T2). Conversely, only a small fraction of the more than 4500 species that have been assessed as imperiled by NatureServe are listed under the ESA (Wilcove and Master 2005). We found the variance among agencies for imperiled species to be much greater than for listed species (table 3). Specifically, there is a spread of 19% between the agency with the greatest number of imperiled species (Forest Service) and the least (USFWS). In contrast, there is only a 7% interagency variance for ESA status species.

The BLM exhibits the greatest disparity in its rankings for ESA and imperiled species. The BLM lands have the fewest ESA status species, yet the agency ranks second for number of imperiled species. The BLM manages vast areas of land in the western United States and Alaska. Although Alaska is not known for supporting large numbers of rare species, BLM lands in the western United States contain many specialized habitat types that support locally endemic species, which no doubt contributes to the large number of imperiled species documented from the agency's lands. It is therefore puzzling that ESA species are not as well represented on the agency's lands, particularly given the enormous size of that land. Perhaps because many of these lands are remote and receive relatively little public attention, declining species on BLM lands are less likely to enter (or emerge from) the pipeline for ESA listing consideration. This disparity is particularly noteworthy in view of the intense current pressures on BLM lands concerning oil and gas exploration and extraction.

The federal role in managing at-risk species

The federal government has both regulatory and land-management responsibilities in connection with the protection of wildlife species. The USFWS and the National Marine Fisheries Service have statutory responsibilities for managing and protecting federal trust species, including those protected under laws such as the ESA, the Marine Mammal Protection Act, and the Migratory Bird Treaty Act. Because wildlife resources are considered public trust resources, regulations under these acts generally apply to both public and private lands. Definitions of "wildlife" variously include or exclude plants, and as noted previously, plant species do not receive full protection under the ESA on private lands. Similarly, plants were excluded from consideration as "species of greatest conservation need" in the federally funded state wildlife action plans, although some states voluntarily included them with nonfederal funding (Stein and Gravuer 2008). The nation's flora is an important aspect of our biological heritage, and plants represent more than half (57%) of all US species currently listed under the ESA. Given the diminished protections afforded these species off the federal estate, the long-term survival of endangered and threatened plant species are particularly dependent on the management of federal lands.

Our results confirm the importance of Forest Service lands for maintaining the nation's complement of flora and fauna. Forest Service lands harbor as many or more ESA and imperiled species than any other agency. Given the large number of at-risk species found on Forest Service lands that are not legally protected under the ESA, we are encouraged by the inclusion in new forest planning rules of a requirement that new forest plans explicitly take into account not just listed species but also those with NatureServe statuses of critically imperiled, imperiled, or vulnerable (USDA FS 2005).

Table 5. Top 10 military installations for imperiled species.

Rank	Service	Installation	State	Number of imperiled species
1	Army	Schofield Barracks Military Reservation	HI	53
2	Army	Makua Military Reservation	HI	46
3	Navy	Lualualei Naval Reservation	HI	44
4	Army	White Sands Missile Range	NM	33
5	Army	Pohakuloa Training Area	HI	24
6	Navy	San Clemente Island Range Complex	CA	24
7	Army	Fort Hunter-Liggett	CA	18
8	Air Force	Eglin Air Force Base	FL	15
9	Air Force	Vandenberg Air Force Base	CA	13
10	Marine Corps	Marine Corps Base Camp Pendleton	CA	13

Note: These figures, based on documented occurrences in natural heritage databases, represent the minimum number of species on these installations.

Although the DOD now shares with the Forest Service the distinction of having the greatest number of federally listed species, it remains clear that military lands have a disproportionate importance to the nation's rare and endangered species. This is seen most dramatically in the high concentrations of imperiled and listed species on military lands (figure 3). Although conflicts sometimes exist between the military's use of these lands and protection of endangered species, the two have found a balanced coexistence at a growing number of installations. Indeed, the maintenance of natural habitats and native biodiversity is increasingly viewed as important for providing realistic military training experiences (Leslie et al. 1996, Benton et al. 2008). At Fort Bragg in North Carolina, for example, the type of open understory longleaf pine forest preferred by the threatened red-cockaded woodpecker also turns out to be ideal for conducting army training exercises and maneuvers. By actively restoring these forests with prescribed burns, and carrying out other on-base and off-site conservation measures, natural resource managers have been able to accommodate both endangered species protection and intensive military training (Beaty et al. 2003).

About 890,000 ha of open space a year are being lost to development nationwide (NRCS 2003), putting increased pressure on remaining wildlife habitat. In many parts of the country, development is expanding rapidly into the so-called wildland-urban interface, fueled in part by the desirability of living adjacent to public lands with perceived high amenity values (Brown et al. 2005, Radeloff et al. 2005). This trend not only has the effect of diminishing wildlife habitat adjacent to these public lands but also limits management options on the public lands themselves. Fire management, in particular, becomes vastly more complicated when housing is interspersed with formerly unpopulated natural areas. Encroachment of private development along the edge of military installations is now recognized as a threat not just to wildlife habitat but to military operations as well. Perhaps no place illustrates this more vividly than along the coast of southern California, where Marine Corps Base Camp Pendleton stands as the only significant natural buffer between the sprawling metropolises of Los Angeles and San Diego.

Given the current and projected pace of private land development, we can expect that federal lands will assume greater importance for the protection of our native species. At the same time, public lands are under increasing pressure to produce energy, fiber, and other resources, a push that has led to the relaxation of some environmental safeguards. This reassessment of the role of federal lands for endangered and imperiled species provides clear evidence of the importance of public lands as reservoirs of biodiversity. While the nation's biological heritage cannot be maintained on federal lands alone, how these public trust lands are managed will be a major determinant of our success at sustaining America's rich diversity of wildlife.

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