Lost in Space: Making geographic sense out of species imperilment, habitat, and the Endangered Species Act

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Executive summary: We scrutinized peer-reviewed literature, technical books, and key reports in order to detect any evidence for a differential ability between public and public lands to protect imperiled species in the United States. Limitations in data availability and/or in study scale limited our comparison mostly to certain contrasts of federal public versus mostly private lands. At a national scale, we found no unequivocal evidence that rates of imperilment were inherently higher or lower on federal public versus private lands. Nor could we identify conclusively that either federal public or private lands have demonstrably better rates of recovery at the national scale. Despite private lands covering 70% of the country, only 40% of ESA-listed species occur only on this land base. We found that the top 10 states with the greatest proportion of species at risk (10−63%) tend also to have the highest initial species richness. Contrary to our expectations, we found that all federal land categories contained substantially higher concentrations of imperiled species (1 to 11 species/million acres) than did private and non-federal public lands combined (<0.5 species/million acres). Across federal land management agencies, the density of species listed under the Endangered Species Act was highest on Department of Defense and lowest on Bureau of Land Management lands. We attribute our findings to certain novel 'location effects' for a greater representation of imperiled species on federal public lands. These include potential for federal public lands to act as the last refugia for remnant populations of scarce species, and a fortuitous placement of the combined federal land base over regions that were historically species-rich (e.g., the arc from southern Oregon to the southeastern U.S.). Department of Defense lands, which a) contain some large, relatively pristine training lands juxtaposed near large urban centers, and b) have superior national representation of bioregions, ecosystem, and community types, contribute uniquely to the locational 'capture' of more imperiled species compared to the other federal land management agencies.

Rationale: Endangered species in the United States occur over a wide range of ecological and geographic conditions, making design for a comprehensive strategy to protect them a complicated goal. Despite various habitat provisions, the primary original aim of the Endangered Species Act (ESA) was to protect and recover *populations* of species from extinction. Given this taxonomically-based goal, the well-known importance of habitat to species' survival, and attempts to revise, reauthorize, and improve the Act, several unresolved issues related to habitat geography and land stewardship arise when considering how to evaluate or improve species and habitat conservation.

We used an extensive review and conducted limited analyses to answer the following questions: 1) Where are the hotspots of species imperilment in the U.S.? 2) Which public land managers steward the most imperiled species? 3) Do either private or public lands play a disproportionate role in reducing imperilment and/or in aiding recovery of imperiled species? and 4) Would greater conservation investment give more 'bang-for-the-buck' on private or on public lands? Our results are presented in this background white paper in four parts: I. key facts; II. key conclusions

that arise from those facts; III. unresolved issues that require more analysis; and IV. important references, sources, and citations.

Objectives: 1) to provide and synthesize key facts related to habitat, stewardship, and geography of the ESA and species imperilment for use by Defenders' staff involved with messaging, communication, legislation, and conservation policy.

2) to identify gaps that present longer-term opportunities to strengthen the ESA, its mission, and the general conservation of species and their habitat; to prompt dialogue and action 'outside the box' of current, conventional wisdom.

I. Key facts

A. Role of habitat in species imperilment

1. The two single greatest threats facing imperiled species in the United States are habitat loss and non-native/invasive species, the latter essentially a form of habitat degradation.[1]

2. Yet, less than 6% of the coterminous U.S. (all states except Hawaii, Alaska) is in nature reserves that have as their primary function protecting these species and/or biodiversity in general.[14]

3. And 126 ecosystems or habitat types in the U.S. have themselves been identified as threatened or endangered.

4. Larger blocks of protected areas tend to have fewer imperiled species than smaller-sized reserves (log-log relationship; $R^2 = 0.76$, for Canada).[28]

B. Geography of species imperilment and the ESA

1. As a general rule most species' ranges are very small; very few species have ranges that are very large.[25] Thus, endangered and threatened species tend to be concentrated in a few 'hotspots' that cover relatively small portions of the nation's land base (Figs.2 a-c):

a. The greatest numbers (concentration) of endangered species occur in Hawaii, southern California, southeastern coastal states, southern Appalachia, and northern Pacific and Atlantic coast forests.[2-5]
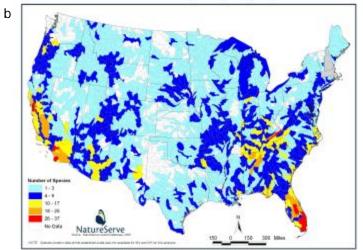
b. Overall biogeography patterns of species follows these hotspot trends with states such as California, Arizona and Florida leading the country in categories of species diversity and risk levels. [37]

a

SPECIES DIVERSITY BY STATE		
Rank	State	# of species
1	California	6717
2	Texas	6273
3	Arizona	4759
4	New Mexico	4583
5	Alabama	4533
6	Georgia	4436
7	Florida	4368
8	Oregon	4136
9	North Carolina	4131
10	Utah	3892

b

RISK LEVELS BY STATE		
Rank	State	% species at risk
1	Hawaii	62.7
2	California	28.5
3	Nevada	15.8
4	Alabama	14.8
5	Utah	14.7
6	Florida	14.3
7	Arizona	13.6
8	Georgia	12.9
9	Oregon	10.9
10	Tennessee	10.3

Fig. 1 a-b. Top ten states in categories of Species Diversity and Species at Risk percentage. Note- At-risk percentage was calculated by dividing the total species at risk in a state by the total number of species in that state. [37]

Number of U.S. ESA Candidate Species by 8-Digit Watershed

a

Number of U.S. ESA Listed and Proposed Species by 8-Digit Watershed

b

Number of G1-G2 and U.S. ESA Listed, Proposed, and Candidate Species by 8-Digit Watershed
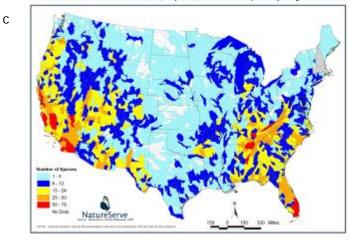
c

Fig.2 a-c. Illustrations of various levels of ESA status and imperilment. Notice the concentration of biodiversity 'hotspots' in areas such as southern California and Appalachia.

4

c. Depending on the taxonomic group (for example: insects, fish, or birds), more than 50% of endangered species can be represented on as little as 0.14% to 2.04% of the nation's land base [2]

Fig. 3. Complementary set of counties that contain 50% of the listed species for each taxonomic group. [2]

d. About 48% of imperiled plants and 40% of imperiled arthropods are restricted to single counties. [2]

2. For some taxonomic groups at least, species with their entire ranges peripheral to the United States *per se* tend to be overrepresented in listings under the Endangered Species Act. [19]

3. Regionally (but not necessarily nationally), greater <u>proportions</u> of endangered species are typically found where human population levels and land values are the highest. [6]

a. Regionally (but again- not necessarily nationally), species imperilment thus tends to occur locally with higher frequency wherever human impacts on their habitat are the greatest. [6]

b. Patterns of species imperilment, however, vary by taxonomic group (Fig. 4 a-b). It can be quite problematic to extrapolate habitat needs or patterns of imperilment from one taxonomic group to another. [6] For example, highest densities of endangered birds are in Florida, the Gulf Coast, in western and coastal California, and along the U.S./Mexico border, overlapping somewhat but also diverging from endangered species a whole. [19]
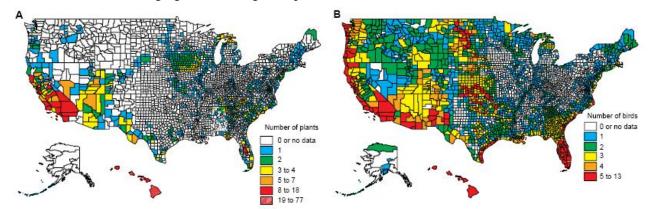

Fig. 4 a-b. Example depiction of ESA species of plants (a) and birds (b) sorted by counties within the United States. [2]

4. Sites containing wide ranging predators can be consistently associated with areas of high biodiversity in general.[21]

C. Distribution of ESA-listed species on private and public lands

    1. National Park lands
    Ecosystem Representation

        a. National Park lands contain the second-best coverage and highest representation of ecosystems for any single federal agency (67% of ecosystem types). [17]

    ESA Species Representation

        b. 1,311 populations of endangered, threatened, proposed and candidate species currently reside or historically resided on National Park Service (NPS) units.[7]

        c. 40% of the threatened and endangered species in National Parks are making some progress toward recovery – that is, they are either stable, increasing, or not-at-risk.[7]

        d. 288 ESA-endangered and 108 ESA-threatened species occur on NPS units, for a total of 396 species.[7]

        e. This total includes: 189 plants, 57 invertebrates, 52 fish, 9 amphibians, 19 reptiles, 66 birds, and 59 mammals (totals do not add up to 396 because some species are listed as both endangered and threatened in different portions of their range).[7]

    2. USDA Forest Service lands
    Ecosystem Representation

        a. The best coverage and highest representation of ecosystem types among any single federal agency is from the USDA Forest Service (73% of ecosystem types).[17]

    ESA Species Representation

        b. There are 425 threatened and endangered species which occur on Forest Service lands and/or are potentially impacted by Forest Service decisions. [30]

        c. This total includes: 170 plants, 77 invertebrates, 89 fish, 9 amphibians, 11 reptiles, 30 birds, 39 mammals. [30]

    3. National Wildlife Refuges
    Ecosystem Representation

        a. Over half (53%) of major ecosystem types appear to be missing from the National Wildlife Refuge System, apparently the result of the agency's highly specialized mandates (e.g., wetland protection) and concentration of its land holdings in coastal areas and in the northern Great Plains. [17]

    ESA Species Representation

        b. 61 (11%) of all 544 refuges (totaling 240,000 acres) in the National Wildlife Refuge System were established for the express purpose of conserving federally listed threatened and endangered species (http://refuges.fws.gov/habitats/endSpRefuges.html).

c. 281 (22%) of the 1258 federally listed species found in the United States and its possessions occur on the Refuge System; this total includes 514 animal and 744 plant species (http://refuges.fws.gov/databases/tes.html).

d. 186 of 514 federally ESA-listed animal species are protected in whole or in part on the 38-million acre National Wildlife Refuge System.[8]

e. The Refuge System carrying capacity is in the tens of individuals for 2 animal species, hundreds for 3 species, thousands for 4 species, and tens of thousands for 8 species, and hundreds of thousands for 4 species.[8]

f. Of these 186 animal species, approximately 81 (16%), 101 (19%), and 107 (21%) are believed to have long-term viability on the System at evolutionary, demographic (population), and outbreeding (genetic) levels, respectively.[8]

g. In addition to a significant reprieve for declining species, the Refuge System provides long-term security for some [as yet undocumented] number of species that are not declining.[8]

h. Certain individual refuges, such as the Alaska Maritime National Wildlife Refuge, support the entire breeding population of some imperiled species, e.g., Aleutian Canada Goose.

i. The Refuge System also supports endangered species rearing facilities (Sevilleta National Wildlife Refuge for Mexican gray wolf) and associated research programs (Florida Panther National Wildlife Refuge).

4. Bureau of Land Management lands
   Ecosystem Representation
   a. About (53%) of all major ecosystem types are represented on the Bureau of Land Management lands. [17]

   ESA Species Representation
   b. Bureau of Land Management lands support 171 federally endangered, 114 threatened, 13 proposed endangered, and 8 proposed threatened species. (31)

5. Tribal lands
   Ecosystem Representation
   a. For tribal lands, representation of all U.S. ecosystem types is on the order of 47%. [17]

   ESA Species Representation
   b. Tribal lands contain habitat for 61 listed species [40]. Note that this figure is most likely out of date (1993) and requires updating. It is only included here as a base estimation.

6. Department of Defense lands
   Ecosystem Representation
   a. About 40% of major ecosystem types are represented on Department of Defense (DoD) lands. [17]

b. Among all the federal land-managing agencies, lands owned and operated by DoD have been asserted to contain the largest number of federally listed species.[9]

c. The DoD has 320 threatened and endangered species occurring on 252 of its installations. [29]

d. This total can be broken down into the services by the following:
76 species on Air Force bases, 173 on Army, 56 on Marine Corps, and 138 on Naval. [29]

e. Roughly 55% of DoD expenditures towards threatened and endangered species from 1991-2004 went towards listed birds occurring on defense lands. [29]

f. DoD lands contain the highest number of federally listed species per million acres of land owned (Fig. 5).
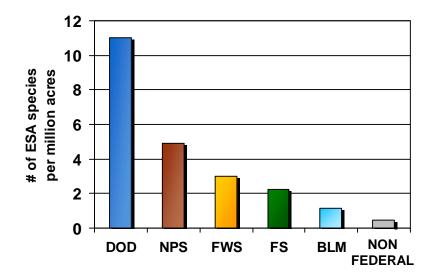

Fig. 5. Representation of ESA species per amount of land owned per major federal agency or department.

7. State lands
  a. Excluding Alaska, state lands make up over 90 million acres, or just fewer than 4% of the nations landbase. [11]

  b. In California, state managed lands consist of about 2.4% (about 2.3 million acres) of the state's total landbase. [33]

  c. In Florida, 14.6% (over 5 million acres) of the state is state-managed conservation land. [34]

ESA Species Representation
  d. 58% of all ESA listed species have at least one population on state managed lands. [11]

Ecosystem Representation
  NO PRESENT DATA

8. ESA, biodiversity conservation, and **public** lands -- GENERAL

Ecosystem Representation

a. The majority of U.S. ecosystem types have only a small percentage of their total area represented on lands that are managed primarily to support biodiversity conservation (in other words, GAP status 1 and 2 lands).[10]

b. Of 83 ecoregions in the U.S., 28 have more than 12% of their total area in mostly public conservation reserves. [15]

c. Of 135 major terrestrial and wetland ecosystem types, nine (~7%) are not represented at all on any federal or tribal lands. Remaining major ecosystem types on the federal land base range in size from as little as 4003 to over 28 million hectares. All federal agency and tribal lands have large gaps in their coverage of ecosystem diversity. [17]

d. Thirty-four (27%) of the 126 major terrestrial and wetland ecosystems that do occur on federal and tribal lands are located 90% or more within lands managed by a single agency. [17]

e. When inventoried roadless areas (IRAs) are considered along with these conservation reserves, the number of ecoregions exceeding a 12% threshold rises from 28 to 32. [15]

f. In some regions of the country, IRAs actually protect some of the rarest and most steeply declining land-cover types. [16]

ESA Species Representation

g. Threatened and endangered species found exclusively on *federal* public lands are more likely to be stable or improving in status. [27]

h. Existing networks of formally protected areas do not necessarily perform better in representing imperiled species than do randomly selected areas, and may even include fewer endangered species than expected by chance (e.g., as documented for Canada). [27]

i. Public lands have been shown to have a greater amount of rare-species richness and diversity when compared with private lands of similar land types. [39]
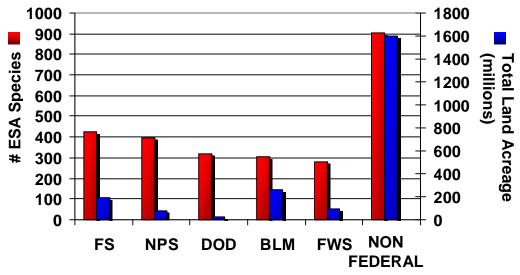
Fig. 6. Graph illustrating the large ratio Federal Lands ESA species in proportion to their relatively small land area. Note that Non-Federal lands include all state and various local public lands as well as private lands.

9. ESA, biodiversity conservation, and **private** lands -- GENERAL

    a. Private lands make up about 70% of the United States, roughly 6.92 million square kilometers.[12]

    b. Over 60% of threatened and endangered species are found on private lands or in aquatic habitats typically bordered by private lands.[11]

    c. Nearly 40% of plant and animal species listed as threatened or endangered are found only on private or state lands.[11]

    d. Farms in the United States (croplands, woodlands, rangelands, etc.) comprise roughly over about 40% of the nation's landbase.

    e. Over 50% of plants and animals that were listed as endangered or threatened were listed in part due to detrimental agricultural activities.[13]

    f. Private lands intensively developed for agriculture, timber production, and residential development tend to occur at low elevations and are thus underrepresented in nature reserves.[14]

    g. Certain private land incentives for imperiled species, such as Safe Harbor agreements, may be best accomplished by emphasizing the largest parcels of privately held land that meet the species' biological requirements.[26]

    h. Lack of access to private lands is a significant impediment to comprehensive inventory and protection of listed species.[27]

    i. Private lands have been shown to contain greater amounts of habitat fragmentation when compared to public lands of similar types.[32]

II. Key conclusions that arise from the facts

A. Research has been unable so far to attribute certain habitat-related provisions of the ESA as the primary reason for greater recovery rates in endangered or threatened species. In two separate studies critical habitat designation could not be identified as a significant factor in whether or not the status of listed species either stabilized or improved.[22, 24]

B. For some species groups, and by overemphasizing species that occur at the periphery of their range in the United States, ESA listings suffer from a certain amount of geographic subjectivity.[20] This 'scale' problem arises not only at the national level of conservation priorities, but state-by-state strategies as well. It can be too easy to expend great energy on species that are rare within single jurisdictions yet still common (or at least not imperiled) globally.

C. Conservation priorities that focus on top predators are justifiable on ecological grounds because this strategy has been documented as delivering broader biodiversity benefits, including benefits to imperiled species.[21]

D. Despite an extensive system of nature reserves (national parks, wildlife refuges, and designated wilderness areas), the United States continues to face serious, ongoing challenges of species imperilment resulting from an incomplete portfolio for wildlife conservation. One approach based on biodiversity significance estimates this shortfall to be as much as 29% of the lower 48 U.S. (Nature Conservancy 2004).

E. Species at risk occur on multiple-use public, narrow-use/highly-protected public, and on privately owned lands with a wide mixture of land uses. A conservation focus only or mostly on one type of ownership carries great risk that our protection efforts are inefficient.

F. Existing reserves in the strictest category of protection in the coterminous U.S. tend to be concentrated in regions of marginal economic value at higher-than-average elevations. The result is that significant elements of biodiversity remain underrepresented.

G. One way in which the Endangered Species Act prevents extinctions is by establishing authority for the U.S. Fish & Wildlife Service to acquire land for purposes of recovery; on refuges, recovery can be one of the primary, proactive functions.[8]

H. By refocusing (improving) management of GAP status 3 lands, the conservation portfolio of the U.S. could grow without acquisition of any new, additional lands (public or private). At least some of this improvement might focus on more conservation-friendly management of federal and other public lands.[10]
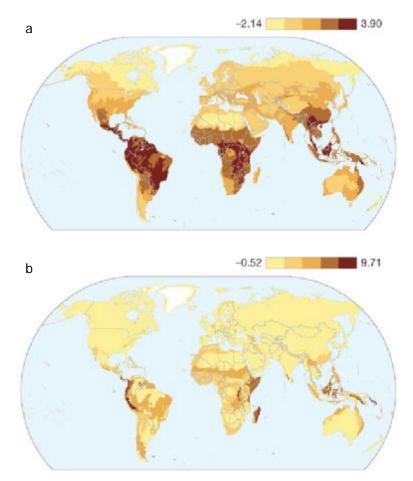
I. Adding inventoried roadless areas (IRAs) to the conservation reserve network is one means to accomplish this goal (H, above). IRAs would expand ecoregional representation, increase the extent of reserves at lower, more biologically productive sites[16], and increase size of refugia necessary for those species that require large, contiguous tracts undisturbed by humans.[15]

J. Extending the protection of IRAs to federal public lands beyond those administered just by the USDA Forest Service also provides a significant but as yet untapped opportunity to expand the nation's portfolio for wildlife conservation.[15]

K. For one-fourth of all major ecosystem types, 90% of each type occurs on the holdings of a single public agency, suggesting that biodiversity protection for those types could be consolidated within jurisdiction of just one land management agency.

L. Federal land locations, DoD lands especially, fortuitously coincide with biodiversity hotspots containing many imperiled species. Furthermore, private lands, especially those with agricultural purposes, coincide with areas in the country that contain relatively few endemic species.

M.   As a general biogeographic principle, high species endemism is associated with high biodiversity patterns at a global scale for vertebrate species. Although globally, endemism is an indicator of high species richness, the reverse is not always true. [36]

Fig. 7 a-b. Global correlation of terrestrial vertebrate species richness (a) with endemism (b). These proportional indices combine the four terrestrial vertebrate classes and adjust for ecoregion area. Each scale bar of five colours represents relative levels of diversity from low (light) to high (dark). [36]

Studies in the United States find a correlation between number of species (8a), number of endemics (8b), and at risk species (8c). These figures demonstrate how areas of high endemism, high biodiversity and high imperilment are all linked on a broad national scale. Again, these trends have _not_ yet been found on all regional scales and when considering all individual taxonomic groups.

Number of Species

- ☐ < 500
- ☐ 500–599
- ☐ 600–699
- ☐ 700–799
- ☐ ≥ 800

Number of Endemic Species

- ☐ 1–3
- ☐ 4–10
- ☐ 11–20
- ☐ >20

Species at Risk

- ☐ < 3.5%
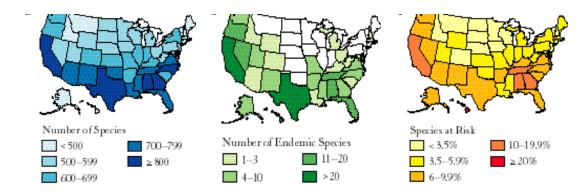- ☐ 3.5–5.9%
- ☐ 6–9.9%
- ☐ 10–19.9%
- ☐ ≥ 20%

Fig. 8 a-c. Vertebrate species diversity, endemism and rarity. [38]

N. It's all about *location, location, location*. As illustrated in Fig. 9, the drivers for determining the biodiversity level and imperilment at the national scale are largely dictated by rate of natural endemism (as this analysis has preliminarily shown). This endemism in turn was (and to a great extent still is) determined by the evolutionary histories from geology, topography, isolation, and climate.

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┌─────────────────────────────────────────────────┐
│         Natural History of an Area                │
│ i.e.- the geology, topography, evolution, climate, etc. │
└─────────────────────────────────────────────────┘
                        │
                        ▼
              ┌──────────────────────┐
              │ High levels of endemism │
              └──────────────────────┘
               ↙                      ↘
┌───────────────────────┐   ┌───────────────────────┐
│ High numbers of species │   │       Increased        │
│  i.e- High biodiversity  │   │   risk of imperilment   │
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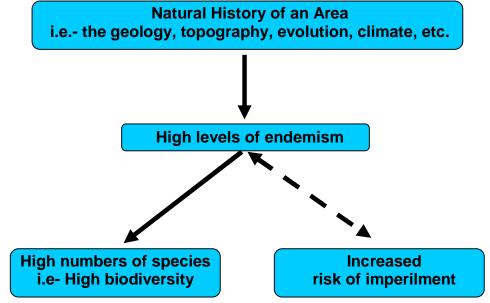
Fig. 9.   Flowchart of the basic drivers behind broad scale levels of biodiversity and (as suggested in this paper) risk levels of species imperilment. Note that the dashed line is the speculative connection between endemism and imperilment and that it can be used in both directions (i.e. endemism may predict imperilment and vice versa).

III. Issues meriting more attention and study

A. Imperilment (including the more serious statuses of endangered and threatened under the ESA) is more concentrated on public than on private land. In other words, relative to the area of land owned, federal stewards manage more imperiled species than other non-federal stewards and land owners. This finding was highly unexpected.

This concentration is not necessarily equally true for every species group (e.g., birds, insects, fish), or for every life history trait (e.g., long-ranging carnivores, small mammals). Some species that are imperiled on private lands seem to have relatively modest spatial requirements (and possibly may be easy to recover, at least in a biological sense).

Ultimately, both public and private lands are essential to develop and implement a comprehensive strategy for conservation. It is appropriate to ask whether for any defined conservation objective, available resources would be more efficiently deployed to a primarily

public- or to a primarily private-land approach, that is, which one would give conservation practitioners the greatest "bang-for-the-buck".

Based on our comprehensive review and analysis, we cannot conclude that at a national scale the risk of imperilment and/or the rate of recovery vary solely as a function of private versus public ownership.

B. Despite the fact that representation and other forms of biodiversity protection for some ecosystems falls almost entirely within the jurisdiction of a single federal agency, it is not clear that those agencies actually realize the responsibility and/or opportunity that such an allocation entails.

C. Ecosystem diversity and the conservation portfolio for the nation must be described, inventoried, and analyzed far more accurately and at greater spatial resolution at the state level for all states. At a national scale, it is not even clear that state-protected lands are routinely included in some protected area inventories. As a consequence, some depictions of the extent of our national protected area system may be biased low.

D. Furthermore, there are significant gaps in stewardship and land use data between states and even between agencies within a state. There is also very little accessible data of ESA species occurrence on strictly state-managed lands. This lack of information results in serious difficulties when assessing the conservation effectiveness on any state managed lands.

E. A major need for rigorous study is whether specific kinds of conservation investment on public or private lands provide a better 'return' per unit of investment. For example, conservation of large carnivores may be less practical, or more expensive, on private lands.[18] Private land incentives may be effective, say, for cave-dwelling isopods or salamanders but wholly inappropriate for grizzlies and marbled murrelets.

F. Beyond imperilment, we might also ask: Is there any evidence that recovery of listed species has occurred disproportionately more (or with greater success) on public or on private lands? At present we seem to have inadequate evidence for stating that recovery *per se* has been more effective on either public or private lands (studies documenting a significant effect on recovery from *federal* lands were unable to also include state and regional public lands [27]). But there are some regional examples indicating that recovery of a species has occurred disproportionally more on public lands rather than private (see example- Fig 9). This complements other measures of ESA effectiveness in which such factors as funding level and time-since-listing have been found to improve recovery prospects. [22-23]
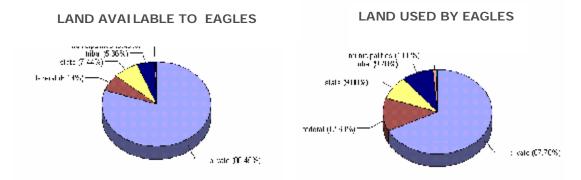

Fig. 10. Example of Washington State Bald Eagle populations which apparently shows, that recovering Bald Eagles occur disproportionately more on various public land rather than private. [35]

G. Is the relative success of species recovery greater on versus off the National Wildlife Refuge System? In other words, is the System having any disproportionately beneficial impacts on species recovery, i.e., more than would be expected on its size alone?

H. From a regional point of view, where would additions to conservation lands be most likely to improve habitat representation? Ecoregional representation is notably poor in the eastern U.S.[15] Thus, in this region adding IRAs from existing public lands would pay handsome dividends to the nation's conservation portfolio. In contrast, on western public lands where representation of biodiversity *per se* is already quite good, improving management practices might be the best approach.
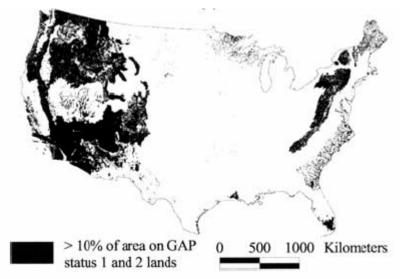

Fig. 11. Depiction of conservation lands in United States in which 10% representation of ecosystem analysis units is either GAP status 1 or 2 lands.[10]

Conservation strategies in the middle portions of the U.S., particularly the prairie and grassland states, pose special challenges. Wildlife conservation here would need to include significant attention to easements, economic incentives, and other conservation tools appropriate for protecting imperiled species on private lands. Public land holdings, especially on national wildlife refuges, may be biased towards wetland and against other ecosystem types. Although large public land holdings are generally absent from this region, a good blueprint for ecoregional representation has been prepared and mapped by other organizations, e.g., the Nature Conservancy.

I. If more conservation attention is in order for public lands, is the ESA the best, only, or adequate statutory vehicle to accomplish this objective? Are other existing statutory instruments up to the task? Would new, statutory instruments be necessary for an effective conservation strategy?

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