

GETTING TO 30X30: Guidelines for Decision-makers

Conservation strategies for protecting 30%
of our terrestrial and marine systems by 2030



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Acknowledgments

Defenders of Wildlife's Center for Conservation Innovation (CCI) identifies pressing conservation challenges and harnesses the power of science, technology and policy to address them. The research discussed in this report required a unique combination of geospatial science and policy knowledge to advance the understanding of the needs for strategically conserving lands and waters to achieve "30x30."

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Addressing the current biodiversity crisis

will require transformative changes to social, political and economic structures. One science-based recommendation is protecting at least 30% of Earth's terrestrial and marine systems by 2030, a goal embraced by a global movement and popularized as "30x30." Here we report the current spatial patterns of biodiversity and carbon stores in the U.S. relative to protected areas to help conservationists and decision-makers understand the starting point on the path to achieving 30x30. Multi-scale analyses demonstrate that 30x30 is numerically achievable nationally, but high spatial heterogeneity highlights the need for tailored approaches from a mix of authorities at federal, regional and state scales. Critically, current protections regularly don't overlap with areas essential for conserving imperiled species biodiversity and mitigating climate change impacts through carbon sequestration. We discuss this baseline relative to key policy considerations for making substantial progress toward the goal.

Introduction

The international conservation community has made it clear that goals for conserving biodiversity cannot be met given current trajectories of environmental degradation and without transformative changes across economic, social, political and technological factors (IPBES Secretariat 2019, Diaz et al. 2019). Among the strategies considered essential for biodiversity conservation is the restoration and maintenance of quality habitat through a more extensive global protected areas (PAs) network (see Aichi Target 11, <https://www.cbd.int/sp/targets/>). Yet targets set for global PA coverage by 2020 have not been met even as threats to biodiversity—foremost, habitat conversion—are at an all-time high (Conservation Science Partners 2019, Powers and Jetz 2019).

Recognizing the critical role that protected areas have in conserving biodiversity and mitigating climate change impacts has led to increased interest in adopting new targets for conservation at national and international levels. The Global Deal for Nature, a science-driven plan to sustain biodiversity and address climate change, calls for at least 30% of Earth to be formally protected by 2030 (“30x30”; Dinerstein et al. 2019). In addition, the Convention on Biological Diversity (CBD) has drafted a post-2020 global biodiversity

framework that includes protection of 30% of land and sea (with at least 10% under strict protection) to set nations on the path toward a 2050 Vision for Biodiversity (CBD 2020). These efforts provide an opportunity to integrate biodiversity and climate agendas and promote protection of areas that can maximize biodiversity conservation and minimize carbon loss at multiple scales.

In the U.S., the number of proposed policy measures aligning with a 30x30 framework is on the rise. As of 2020, this includes federal resolutions and state bills echoing this goal for protecting terrestrial and marine environments at matching scales (Senate Resolution 372 2019, House Resolution 835 2019, California Assembly 2020, South Carolina General Assembly 2019). The past century has seen a marked increase in lands and seas protected for conservation in the U.S., but the rate of new additions has slowed in recent years (Lewis et al. 2019, Center for American Progress 2018) and a new generation of protections are needed.

Past research on setting PA priorities for biodiversity (Kulberg et al. 2019, Belote et al. 2017a, Jenkins and Van Houtan 2016, Jenkins et al. 2015, Venter et al. 2014, Withey et al. 2012) and natural climate strategies (Soto-Navarro et al. 2020, Stralberg et al. 2020, Carroll et al. 2018, Belote et al.



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2017b, Belote et al. 2016, McGuire et al. 2016) provide a useful foundation for addressing this need, but do not align with the policy tools and units at which federal and state decision-makers govern. Achieving the goal of 30x30 for biodiversity and climate protection will require guidance on how to operationalize these targets given current and potential policy opportunities and constraints.

Here we synthesize biodiversity and ecosystem carbon data with policy-relevant land protections at multiple scales to provide a baseline assessment for charting a path to 30x30 in the U.S. We use the Protected Areas Database of the U.S. (PADUS; U.S. Geological Survey 2018) to spatially define areas that are currently protected or in need of protections,

where the Gap Analysis Project (GAP) status code aligns consistently with legal and regulatory tools for landscape protections (Box 1). We compared classified lands with imperiled species richness data from the Map of Biodiversity Importance (NatureServe 2020), which represent species in greatest need of conservation and exhibit spatial patterns consistent with other measures of biodiversity (e.g., Jenkins et al. 2015). Additionally, we assess the degree to which lands with high carbon sequestration potential (i.e., total ecosystem carbon stock and flux; Zhu 2010) are protected. These results will help conservationists and decision-makers plan and take critical next steps to operationalize 30x30 and address some of the greatest conservation challenges facing the U.S. and the world.

Box 1. PADUS and GAP

We use the USGS Gap Analysis Project’s GAP protection status from the Protected Areas Database of the U.S. (PADUS; Box Figure 1) to characterize current protections and future possibilities. GAP codes are specific to the management intent to conserve biodiversity and largely coincide with legal requirements for protections: GAP 1 and 2 areas are managed in ways typically consistent with conservation (e.g., national wilderness and national wildlife refuges); GAP 3 areas are governed under multiple-use mandates (e.g., wildlife, forestry and mining); and GAP 4 areas lack any conservation mandates (Appendix 1, Table 3).

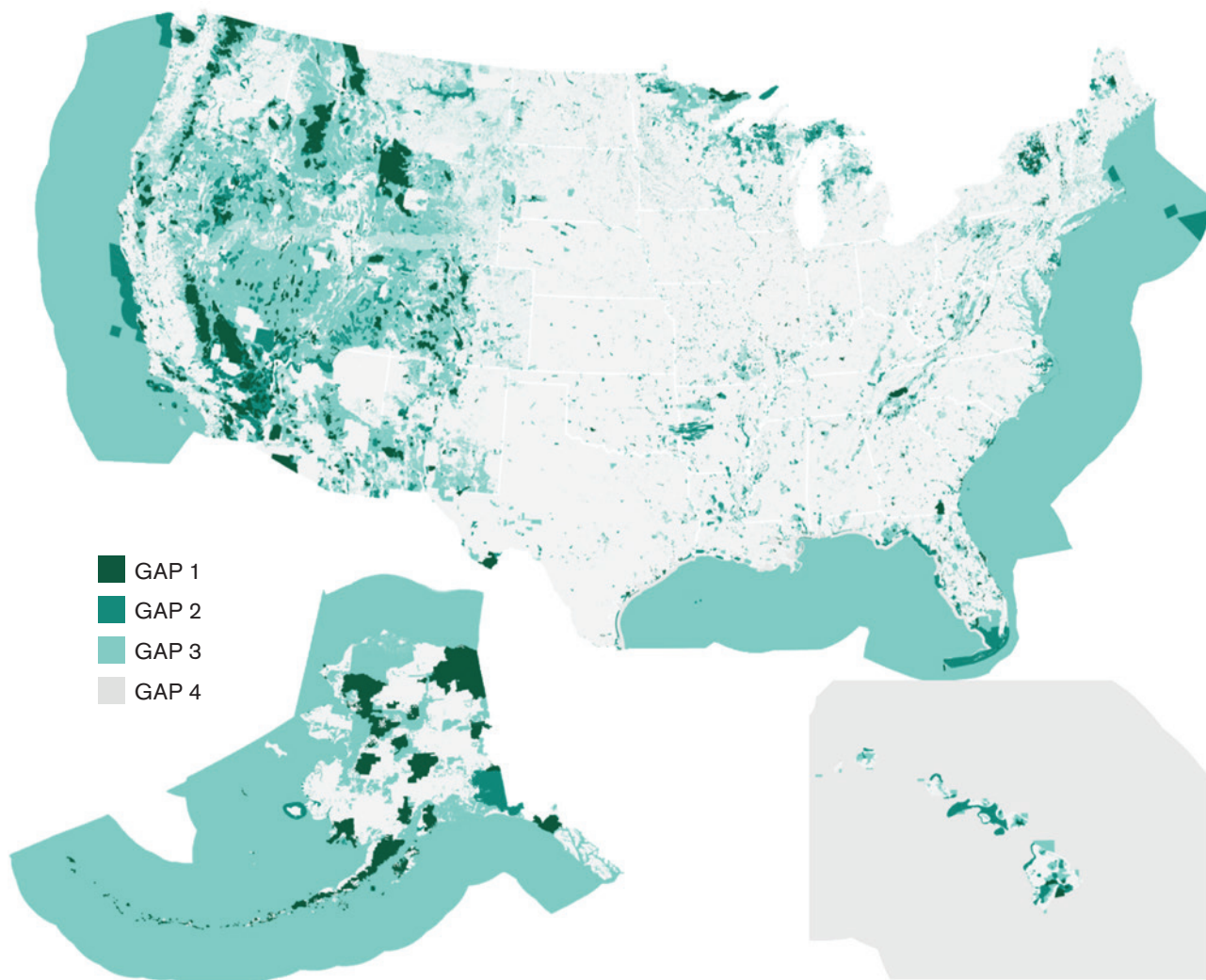
- GAP 1** An area having permanent protection from conversion of natural land cover and a mandated management plan to maintain a natural state.
- GAP 2** Permanent protections and a mandated plan maintain a primarily natural state, but management practices may degrade quality.
- GAP 3** Permanent protections in majority, but some areas subject to extractive uses. Protections for federally listed species exist throughout.
- GAP 4** The area generally allows conversion to unnatural land cover throughout or management intent is unknown.

Approximately 39% of terrestrial and over 73% of marine territories are included in PADUS, but only GAP 1 and 2 are typically considered protected (e.g., Richards 2018). However, GAP 3 may have particular potential to advance biodiversity and climate protections more quickly through administrative mechanisms (Figure 1).

Management Level	Example Protections
Federal	National parks, national forests, national conservation lands, national marine sanctuaries, national recreation areas, national estuarine research reserves, national trails, national wild and scenic rivers, national wilderness areas and national wildlife refuges
State	Parks, wilderness, wildlife management areas
Local	Tribal, regional, county or city parks and public lands
Private	Easements: agricultural, conservation, forest stewardship, cultural area, ranch, recreation or education

Box Figure 1

The GAP status map highlights the high spatial variation in areas currently protected (GAP 1 and 2) in the U.S. and the reality that unprotected areas (GAP 3 and 4) dominate most of the country.



Results and Discussion

The GAP data indicate that 12% of lands within the U.S. and its territories and 26% of seas are protected at levels consistent with the biodiversity and climate goals of 30x30 proposals (i.e., GAP 1 and 2). While there remains significant potential for achieving a national 30x30 numerically, high spatial variability in current PA designations will mean considerable heterogeneity in how numerical goals can be met at state levels (Figure 1, Appendix 1).

An option for more rapidly reaching or surpassing 30% in some regions includes establishing additional protections on GAP 3 lands and oceans. For example, up to 29.8% of terrestrial and 73.7% of marine habitats in the U.S. would be protected if regulatory changes to GAP 3 PAs emphasized biodiversity protection over other uses. Terrestrial areas classified as GAP 4 are, by far, the most extensive in the U.S., but would require more effort and investment from decision-makers to establish biodiversity protections as priorities. For example, Department of Defense (DOD) installations cover some 20 million acres (with high imperiled species diversity; Stein et al. 2008) that are classified as GAP 4, and while each has an integrated natural resource management plan (INRMP) that includes biodiversity concerns, military readiness is the legal mandate and priority. Further, the GAP classification definitions may not account for substantive protections observed on the ground, such as those afforded by Tribal nations over some 56 million acres held in trust by the Bureau of Indian Affairs (Lee-Ashley et al. 2019). These and similar situations highlight the nuances of inferring protection status considering the substantive goals of 30x30.

While the basic numerical accomplishment of protecting 30x30 is feasible nationally given the current extent of public lands and waters, the fundamental purposes of protecting biodiversity and addressing climate change show patterns of challenge and opportunity. For imperiled species, biodiversity hotspots and existing PAs are largely spatially incongruous with only 7% of hotspots (90th percentile of the diversity distribution) covered by GAP 1 and 2 (Figures 2 and 3; Appendix 2). This result is consistent with other research showing that current PA siting is often not concordant with

diversity-rich areas of the country (e.g., Jenkins et al. 2015). Similarly, less than one quarter of carbon stocks and less than 3% of high potential areas (90th percentile of the carbon stock distribution (Figures 2 and 3) fall in GAP 1 and 2, meaning there is significant under-protection of remaining natural habitats that could contribute to both climate mitigation and biodiversity conservation. This result highlights the alarming reality that focusing strictly on the numerical goal of 30x30—the number of acres covered by PAs—could lead to outcomes contrary to intent, with new PAs being established in areas with low biodiversity or carbon mitigation potential (Barnes et al. 2018). In particular, regions with few public lands will face trade-offs between siting new areas based on biodiversity need or opportunity (e.g., isolated and sparsely populated; Baldi et al. 2017).

A 30X30 TYPOLOGY

To guide operationalization of the 30x30 framework for decision-making, we identify a potential typology using GAP categories as a proxy for policy options and biodiversity and ecosystem carbon as representative of the driving goals of 30x30 (Figure 2 legend):

Well-sited: Areas with high protection (GAP 1-2 coverage) and high imperiled species richness and/or ecosystem carbon potential, where PAs are effectively placed to achieve higher biodiversity conservation and climate mitigation.

Examples of areas protecting biodiversity hotspots include Golden Gate National Recreation Area, parts of Ouachita National Forest and Florida Keys and Hawaiian Islands national marine sanctuaries. For carbon mitigation, High Peaks Wilderness, Okefenokee National Wildlife Refuge and parts of Huron-Manistee National Forests provide key protections. Priority actions for these well-sited areas include maintaining existing protections, expanding protections outward across the landscape, and ensuring connectivity among these and other important areas.

Figure 1. Proportion of U.S. territorial lands (A) and seas (B) in PADUS by GAP status code, showing most areas have few protections for biodiversity. Most states (C) fall well short of achieving 30x30 given existing and potential (GAP 1-3) protections.

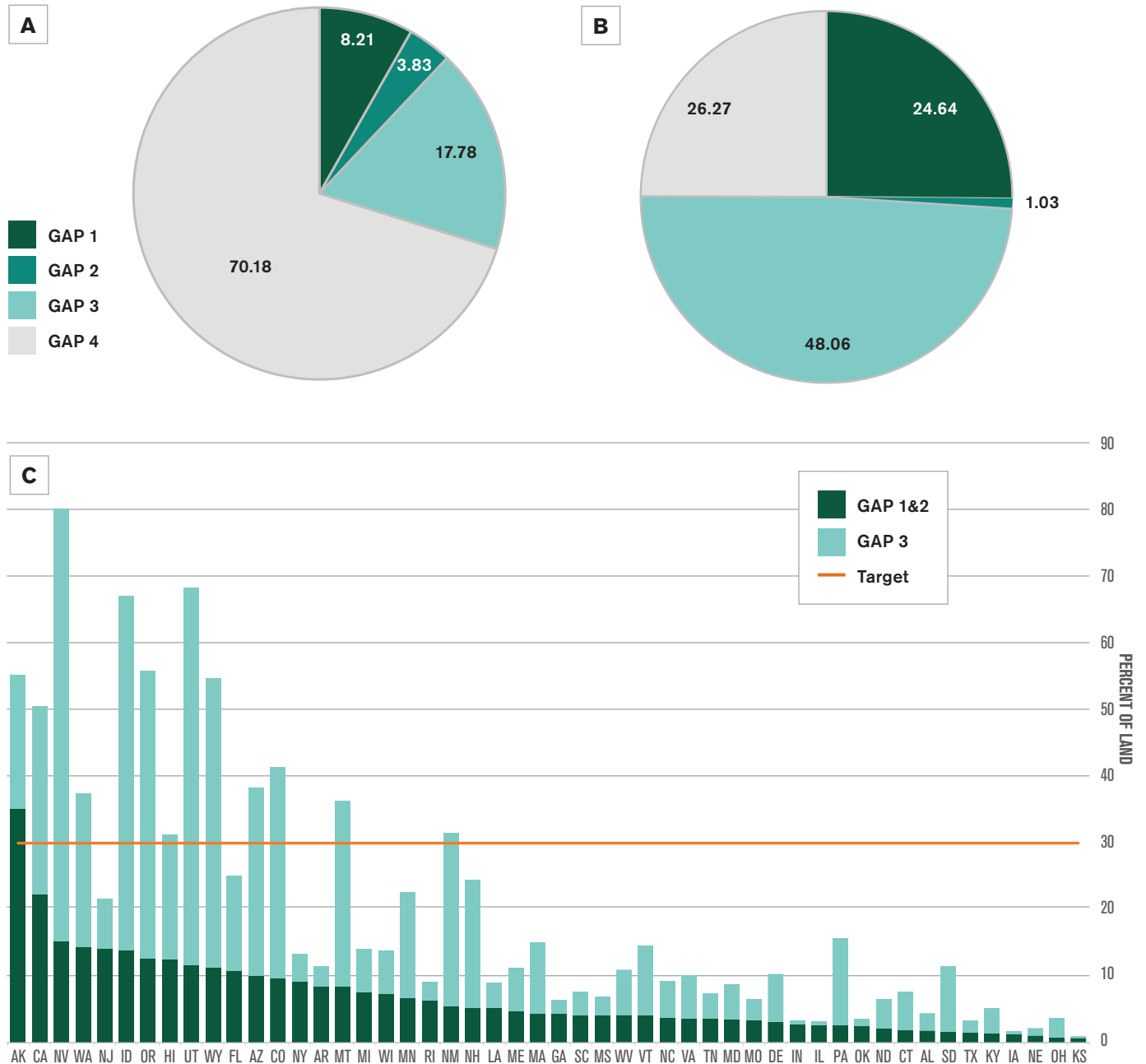
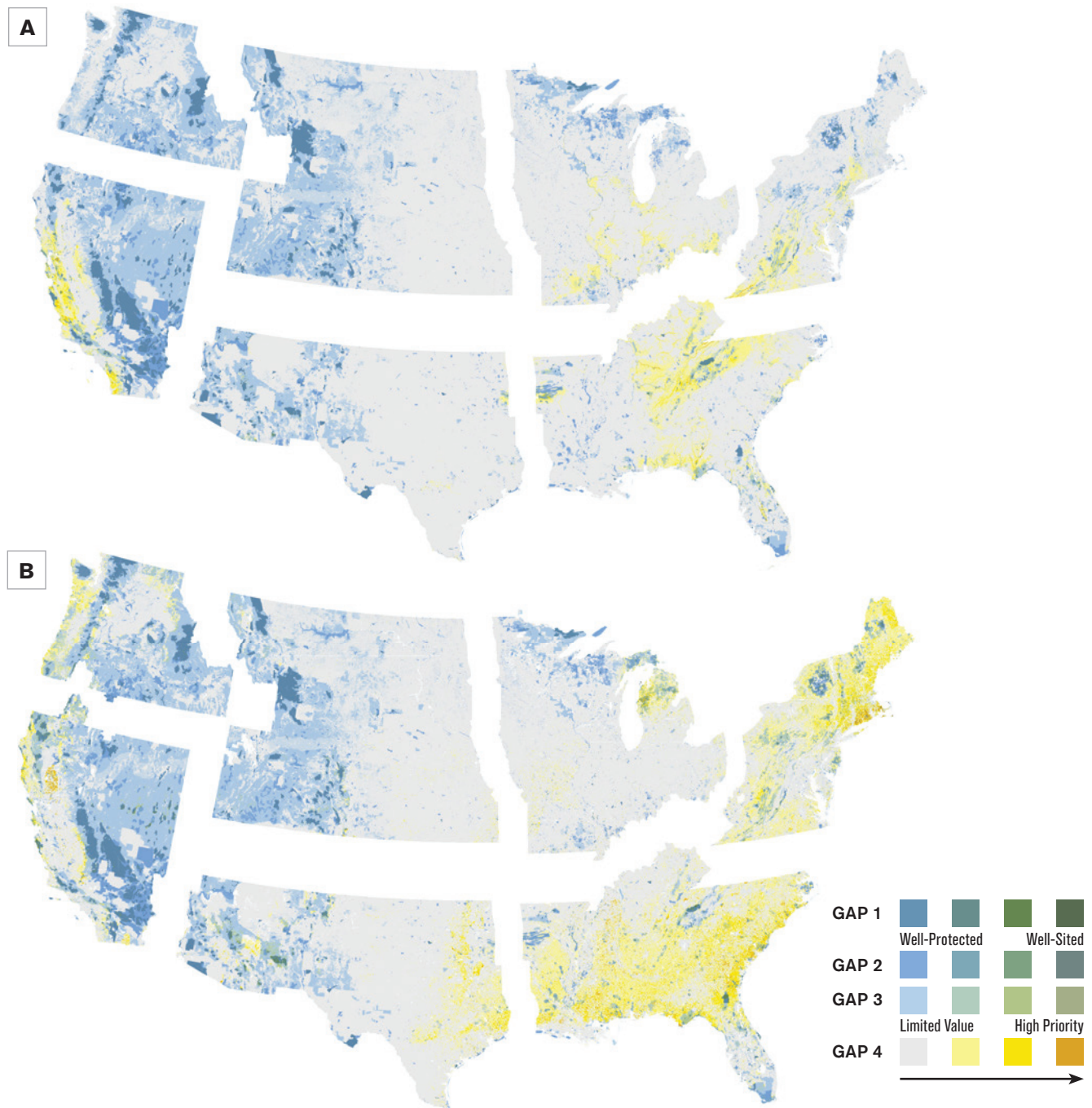


Figure 2. Combining terrestrial protected area coverage to locations of A) imperiled species richness and B) ecosystem carbon show significant areas of mismatch that need to be addressed. The blue (y-axis) component of the bivariate color ramp signifies protections under GAP categories 1-4 while the yellow (x-axis) component signifies the corresponding 30x30 variable based on regular intervals. Imperiled species richness from the Map of Biodiversity Importance program (NatureServe 2020) and ecosystem carbon from the LandCarbon Program USGS 2010). Resolution is 1km².



High Priority: Areas of overlap between lower protection (GAP 3-4) and higher imperiled species diversity and/or ecosystem carbon potential, where new PAs or more protective policies would do the most to protect biodiversity and mitigate climate.

Parts of the West are in this category because of extensive GAP 3 lands (e.g., national forests); areas east of the Ozark Mountains, such as the Florida Panhandle and the Southern Appalachians, have high imperiled species diversity and high carbon stock, but tend to be GAP 4. Many of these areas also have higher human disturbance, which elevates the importance of restoration efforts in addition to defending existing protections and extending new ones (Appendix 3). Lands classified as GAP 3 are particularly attractive for quickly expanding protections, such as through administrative changes to federal lands (Haber et al. 2015). These are the areas of greatest opportunity, where efforts to expand PAs—to move from the *high priority* to the *well-sited* quadrant—would have especially high returns on investment.

Well-protected: Areas with higher protections but relatively low local imperiled species diversity and/or ecosystem carbon potential, indicating lower return on biodiversity protection goals than other areas might provide.

These are mostly in the western U.S., including many high-elevation wilderness areas and some wildlife refuges. While these areas may have lower local biodiversity or carbon, they may be indirectly critical for more distant areas, such as protecting upper reaches of watersheds that harbor higher biodiversity or carbon stocks. Defending the protections of well-protected areas, which may serve as anchors for expanding protections to adjacent areas, is a critical aspect of achieving 30x30.

Limited Value: Areas of low protection coverage and low levels of biodiversity and/or ecosystem carbon potential, indicating a low return on protections and a need to site PAs elsewhere.

These are the lowest priority areas for 30x30. However, it is important to note that basing decisions solely on current

habitat and species ranges may discount the necessity for future habitat recovery and restoration given climate-driven shifts in species distributions (Lawler et al. 2013, Rehfeldt et al. 2012). Thankfully, a growing body of literature focusing on climate corridors (Stralberg et al. 2020, Carroll et al. 2018, McGuire et al. 2016) can be applied to forward-looking 30x30 prioritization decisions. Defending any existing protections (e.g., associated with GAP 3 status or implementation of DOD INRMPs) may be locally important and, in the case of carbon stocks, may mean protecting a greater diversity of habitats (e.g., grasslands and shrublands).

BROAD PRIORITIES FOR ACHIEVING 30X30

Our typology highlights the five highest priority considerations for charting a path to achieving 30x30 for biodiversity and climate.

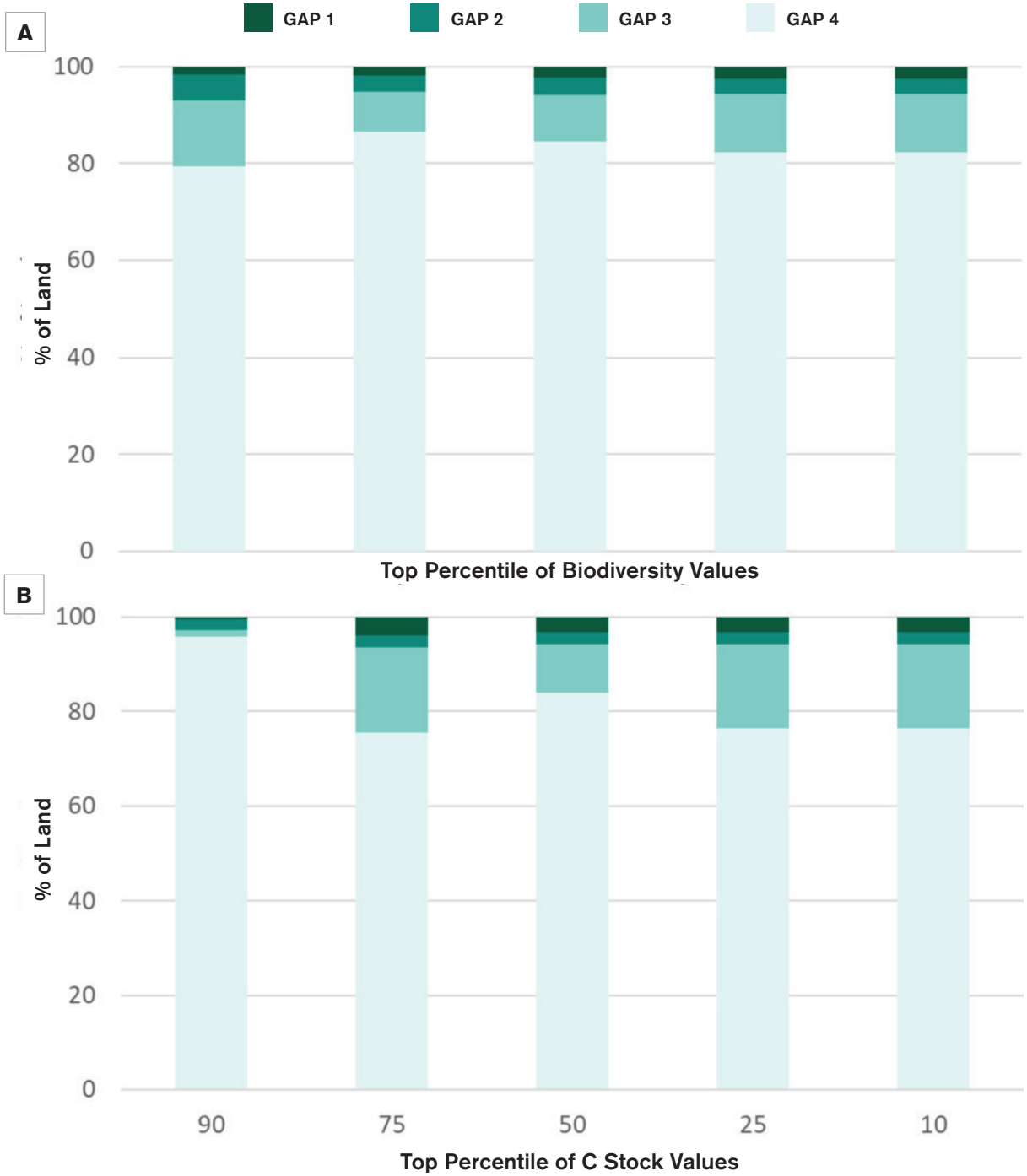
1. Action at the federal level is essential.

Areas protected for biodiversity in the United States are largely reliant on federal policy: over 87% of GAP 1 and 2 PAs and 85% of GAP 3 areas are federally managed. A cursory calculation shows that protecting 30% of the U.S. could nearly be achieved at the national scale if new conservation-based mandates were applied to all federally managed GAP 1-3 areas (27% of lands and 73% of seas). Marine areas with federal jurisdiction off the coasts of the lower 48 states are particularly well situated to make substantial gains by prioritizing biodiversity and climate protection purposes in management decisions.

Critically, however, while such expansion would significantly increase the coverage for U.S. biodiversity hotspots (from 7% to 20% of lands falling into the 90th percentile of diversity; Figure 3), many of the most diverse areas would remain unprotected. Conversely, 80% of biodiversity hotspots would still lack significant place-based protections because they reside on GAP 4 or otherwise unprotected private lands (see number 2, page 10).

In addition to land management laws like the National Forest Management Act and the Federal Lands Planning and Management Act, other federal laws afford species and

Figure 3. Protecting different subsets of coverage to the distribution of A) imperiled species and B) ecosystem carbon values. Biodiversity and carbon hotspots discussed in the text were considered as locations with values in the top 90th percentile of the distribution. The green color ramp signifies protections under GAP categories 1-4.



habitats protections, but the effectiveness of protections may vary by ownership (Eichenwald et al. 2020). For example, the Endangered Species Act (ESA) requires agencies to use their authorities to conserve threatened and endangered species, including a prohibition on carrying out, funding or permitting activities that destroy or adversely modify critical habitat (ESA; 16 U.S.C. § 1531 et seq.). About half of species listed under the ESA (n = 742) have designated critical habitat, and of those, two-thirds (n = 494) have GAP 1-3 coverage for ≥50% of the designated critical habitat. This means that many listed species will receive substantial protections across GAP status if the ESA is properly implemented (Malcom and Li 2015, Evans et al. 2019, Evansen et al. 2020).

Moreover, the role of the federal government in advancing protections on a per-ecosystem basis to better ensure representation of natural systems is significant (Dinerstein et al. 2019). Ecosystem boundaries rarely follow political boundaries, and federal agencies can provide necessary leadership and coordination across jurisdictions.

2. GAP 4 and private lands lacking formal conservation designations are critically important to addressing biodiversity and climate goals.

Most of the areas of greatest biodiversity and carbon potential in the U.S. are in GAP 4 areas. Current federal conservation incentive programs, such as Farm Bill programs and those administered by the U.S. Fish and Wildlife Service are inadequate to address the need. As such, there is a need for significant efforts to advance conservation on private lands in key parts of the country (Kremen and Merenlender 2018). In particular, states across the Southeast harbor particularly high levels of biodiversity and very few protected areas. Similarly, key areas for biodiversity in California, the Ozarks and the Edwards Plateau are dominated by private lands. Recent calls for deep investment in private lands conservation to help advance conservation and support farmers and ranchers (Richards and Lee-Ashley 2020) need greater attention and quick action.

3. Understanding state and Tribal variation in biodiversity and protections is vital.

Important legal and policy mechanisms operate at the levels of states and Tribes, and common social patterns correlate with these levels. Twelve western states—California, Nevada, Washington, Idaho, Oregon, Hawaii, Utah, Wyoming, Arizona, Colorado, Montana and New Mexico—would achieve the 30% numerical target of 30x30 if GAP 3 PAs were managed for wildlife. (Alaska has already reached 30%). However, except for California, many areas of these states fall into the *protected, low value* category, harboring few biodiversity hotspots and lower carbon stocks.

In contrast, the 11 states where the state manages the majority of GAP 3 lands are in the Northwest and Midwest (Appendix 1, Tables 1 and 2). Many of these states have higher biodiversity on average than the previously listed western states, but GAP 3 areas may not overlap with hotspots or be enough to significantly lessen the disparities in current PA coverage and the 30% target.

Currently, state wildlife conservation programs employ state wildlife action plans that have the potential to advance conservation (e.g., Michalak and Lerner 2008). However, state wildlife programs are woefully underfunded (House Resolution. 3742 2019), and most lack authorities needed to sufficiently protect many species (e.g., Camacho et al. 2017), including imperiled species that are threatened at range-wide scales. However, new state-level programs for public and private lands conservation can complement federal programs and create a more complete, multi-level solution.

Tribal areas have some of the lowest rates of habitat modification, yet most are not considered “protected” under PADUS (Lee-Ashley et al. 2019). More extensive engagement and consultation, including learning how to better support and collaborate with tribes, is essential for advancing conservation on and off of tribal lands.

4. Marine protections present new opportunities for interagency cooperation.

Significant spatial gaps in federally managed coastal protections mean that states could play an essential role in marine biodiversity conservation. The state-managed marine PA network is most extensive in states with the highest coastal biodiversity (Hawaii, California, Florida, Washington territorial waters are over 30%). However, if only considering state-managed PAs, all states except Florida (26%) fall drastically short of the 30% target (Appendix 1). Because 97% of GAP 3 seas are federally managed, significant growth of the PA network cannot be achieved by strengthening protections on state-managed GAP 3 seas, with the exception of Alaska, Massachusetts and North Carolina.

5. Additional considerations need to be weighed.

In addition to the primary focus on biodiversity and climate mitigation, pursuing 30x30 will mean considering issues related to the human dimension of natural resources planning, including economic, political and social constraints (Senate Resolution 372 2019, House Resolution 835 2019, California Assembly 2020). For example, protecting significantly degraded (e.g., intensively grazed or mined) environments to achieve targets numerically will have negligible conservation benefits and relative habitat condition could be integrated into analyses. GAP 3 areas tend to have slightly lower biodiversity and slightly higher human footprint estimates (Sanderson et al. 2002), but there is substantial variation (Appendix 3).

Another opportunity that implementing 30x30 presents is improving the health and well-being of people and wildlife. Achieving more equitable access to public land, nature and a healthy environment for all communities has long been ignored or discounted in protected areas designations (Wood et al. 2018), in part because it is not well studied (Ussery et al. 2016, Wen et al. 2013). Further research and planning are essential to ensuring access to quality nature for all.

Conclusions

Achieving 30x30 to help protect biodiversity and address the climate crisis in the U.S. is feasible but will require coordinated efforts across levels of government and in coordination with nongovernmental landowners. Our analysis recognizes that the approaches and policy tools for doing so will vary considerably across the country.

Under existing laws and policies, relatively direct federal regulatory changes can lead to rapid advancement toward 30% targets because the vast majority of the existing public lands network is managed by federal agencies. Under conditions favorable to pursuing 30x30, federal agencies could revise their interpretations of multiple-use mandates to focus more on management for biodiversity conservation goals. However, current legal limitations will likely require developing new statutory designations to operationalize the 30x30 framework.

Critically, relying on current GAP 3 lands to numerically achieve 30x30 will not maximize benefits to biodiversity conservation or carbon mitigation because many hotspots lie in areas with no protections; improving private and working lands conservation programs is essential. Protections for marine environments could be more than doubled with GAP 3 marine areas, and the states with greatest imperiled marine species biodiversity are the furthest along in PA coverage (see also Knowlton 2021). As such, GAP 3 PAs, private lands and the current set of policy tools will play an integral role in helping states grow their terrestrial and marine protected areas networks.

The key to operationalizing 30x30 will be planning beyond the numerical target for a protected areas network that can be established in a way that ensures a long-term commitment to biodiversity and climate. By doing so, the U.S. can continue to lead the way globally in protecting nature for its own sake and for our health and well-being.

Methods

We used spatial overlay analysis to describe the extent to which the PA network covers U.S. lands and seas as well as areas of high imperiled species biodiversity and ecosystem carbon. U.S. terrestrial boundaries reflect all states and territories from U.S. Geological Survey and marine boundaries reflect territorial waters and the exclusive economic zone (National Oceanic and Atmospheric Administration) for states and national analyses, respectively. Data on protected areas are from the PADUS 2.0 database.

We use U.S. Geological Survey's Gap Analysis Program (GAP) codes, which are specific to the management intent to conserve biodiversity. GAP 1 and 2 areas are managed in ways typically consistent with conservation and are considered 'protected' in this context. Unprotected areas include GAP 3 areas governed under multiple-use mandates (e.g., forestry, mining) and GAP 4 areas lack any conservation mandates. As such, GAP codes are a natural system for identifying possible policy paths to achieving 30x30 and advancing wildlife conservation in the United States. Other PA classifications we assess include manager type (i.e., state, federal, private, etc.) and managing authority.

Terrestrial imperiled species richness is from the Map of Biodiversity Importance dataset (MoBI; NatureServe 2020) and is based on habitat suitability models for 2,216 species and 11 taxa, showing patterns similar to other analyses (e.g., Jenkins et al. 2015). Marine imperiled species richness data are from the International Union for the Conservation of Nature and represent 254 species ranges and 9 taxa (Jenkins and Van Houtan 2016). Modeled total ecosystem carbon (g Carbon/m²) and carbon flux (g Carbon/m²/yr) are from the USGS LandCarbon Program (<https://www.usgs.gov/apps/landcarbon/>, Zhu 2010) and represent current stocks and sequestration potential, respectively. We used ArcGIS v. 10.7 (ESRI, USA) to produce maps and run analyses. Maps use the Albers Equal Area Conic, Alaska Albers, and Old Hawaiian UTM Zone 4 projections.

We also note several limitations of this research. First, these analyses are national in scope and intended to identify broad patterns to frame the national discussion of achieving 30x30; as such, local and domain-specific details are likely to vary. Further research that pairs conservation scientists and decision makers will be needed to flesh out these details.

Second, we are using models of current imperiled species distributions to infer the general patterns of protections, some of which may shift with global climate change (see Elser et al. 2020). Future local, regional and continental scale analyses will be needed to help inform which areas need protections and in what order given variation in threats, whether immediate modification or destruction from development or longer-term with climate shifts.

Third, we are unable to evaluate certain biodiversity characteristics that may be important in prioritization with MoBI data, such as complementarity of different areas for protecting biodiversity. Open data will be essential to having the best *available* science inform operationalizing 30x30 and advancing equity and inclusion.

Lastly, multi-objective decision theoretic analyses will ultimately be needed to balance competing priorities for siting PAs and accomplishing 30x30, and that is an issue that must be addressed by a large, inclusive community rather than a single research group.

DATA AVAILABILITY

Data used in this research are available or linked through the Open Science Framework repository at <https://osf.io/2prdy/> (DOI 10.17605/OSF.IO/2PRDY).

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Appendices

Appendix 1. Protected Areas Coverage Summary

GAP data show that 12% of lands within the U.S. and its territories and 26% of seas are protected at levels consistent with the biodiversity and climate goals of 30x30 proposals (i.e., GAP 1 and 2). Protections vary widely yet systematically across federal agencies (Table 1), which has significant implications for how federal agencies will contribute to achieving 30x30. For example, the Forest Service and Bureau of Land Management have particular potential if biodiversity and climate are given priority among multiple uses, an approach that cuts across many states. While there remains significant potential for achieving a national 30x30 numerically, high spatial variability in current protected area (PA) designations will mean considerable heterogeneity in how numerical goals can be met at state levels.

There is high variability among states and regions in GAP 1 and 2 PA coverage (Table 2). Alaska is the only state that currently achieves the 30% goal given this baseline. Coverage disparities become greater when GAP 3 PAs are included. Twelve Western states numerically achieve 30x30 if GAP 3 PAs are included in conservation-based protections: Alaska, California, Nevada, Washington, Idaho, Oregon, Hawaii, Utah, Wyoming, Arizona, Colorado, Montana and New Mexico, in descending order of GAP 1-2 coverage. All except one of these states (Hawaii, which lacks sufficient federal lands alone to meet the goal) can get to 30x30 by focusing on strengthening protections solely on federal lands. In fact, for 31 out of 50 states, a large majority of GAP 3 PAs are owned

by the Bureau of Land Management (BLM), U.S. Forest Service (USFS), or U.S. Fish and Wildlife (USFWS).

Relative to international efforts, the U.S. ranks highly in marine PA coverage (UNEP-WCMC 2018). However, within regions, spatial patterns of federally managed PAs indicate significant gaps in coastal protections including the northeast and the Gulf of Mexico where industrial fisheries are particularly active. Just under half of all U.S. states have marine PAs, which are located on coastlines and in the Great Lakes. If taking into account all PAs, four states have already achieved 30% protections within state territorial waters (Table 3). However, once constraining the PA network to state-managed seas, all states fall short of the 30% target, with only a few (Hawaii, Florida) over half way. Including GAP 3 seas does not change this outlook. Overall, 97% of seas that fall into GAP 3 classifications are federally managed leaving little room for improvement on the state level. Alaska, Massachusetts and North Carolina are interesting exceptions to this rule: if protections were to be strengthened on state-managed GAP 3 PAs, 51%, 93%, and 41% of the marine zone would serve biodiversity conservation efforts in these states, respectively.

For convenience, we include a crosswalk of types of protected area designations in PADUS with the GAP status codes (Table 4). See also the USGS website for PADUS, <https://www.usgs.gov/core-science-systems/science-analytics-and-synthesis/gap/pad-us-data-manual>.

Table 1. Land in the U.S. protected areas database managed by federal and state agencies summarized percentages in parentheses indicate how much of the U.S. territories this represents (only percentages >1 are given).

Manager Name	GAP 1 acres (%)	GAP 2 acres (%)	GAP 3 acres (%)	GAP 4 acres (%)	Total GAP 1-2 acres (%)	Total GAP 1-3 acres (%)
Agricultural Research Service		55,491	188,582	86,852	55,491	244,073
Army Corps of Engineers	35,414	92,578	83,938	5,032,198	127,992	211,930
Bureau of Indian Affairs		2,152		68,275,595	2,152	2,152
Bureau of Land Management	9,268,471	30,153,512 (1.2)	210,557,393 (8.6)	953	39,421,983 (1.6)	249,979,376 (10.3)
Bureau of Reclamation		36,821	1,513,981	108,852	36,821	1,550,802
Department of Defense	339	884	90,734	20,600,466	1,222	91,957
Department of Energy				1,706,501	0	0
Forest Service	37,060,562 (1.5)	13,487,747	143,276,104 (5.8)	166,667	50,548,309 (2.1)	193,824,412 (7.9)
Joint*	30,321	838,959	1,317,203	3,788,913	869,281	2,186,484
National Park Service	63,682,921 (2.6)	8,460,377	2,817,299	5,667,421	72,143,298 (2.9)	74,960,597 (3.1)
Natural Resources Conservation Service		2,758,893	15,279	38,755	2,758,893	2,774,172
Other or Unknown Federal Land			16,878	3,482	0	16,878
U.S. Fish & Wildlife Service	85,900,058 (3.5)	10,020,613	1,228,363	882,016	95,920,671 (3.9)	97,149,034 (4.0)
Federal sub-total	195,978,087 (8.0)	65,908,026 (2.7)	361,105,753 (14.8)	106,359,840 (4.4)	261,886,113 (10.7)	622,991,866 (25.6)
State Agencies (pooled)	3,972,098	23,068,975	56,418,973 (2.3)	103,922,278 (4.2)	27,041,073 (1.1)	83,460,046 (3.4)
TOTAL	199,950,185	88,977,001	417,524,726	210,282,118	288,928,186	706,451,912

*Joint management occurs between more than one entity, of which one, both, or neither may be a federal agency.

Table 2. The majority of terrestrial protected areas that fall under GAP 3 classifications are managed by federal agencies. This will impact the options for states in achieving 30% protections as well as the role state and local agencies will play in proposing/siting areas for stricter protection.

	% GAP 3 managed by					% GAP 3 managed by			
	Federal	State	Local	Other		Federal	State	Local	Other
Alabama	72.67	17.74	9.11	0.48	Montana	79.02	20.65	0.05	0.28
Alaska	91.04	8.96	0.00	0.00	Nebraska	89.67	0.46	0.04	9.82
Arizona	96.49	2.98	0.34	0.19	Nevada	99.82	0.18	0.00	0.00
Arkansas	98.11	1.89	0.00	0.00	New Hampshire	57.19	15.42	7.41	19.98
California	93.87	2.01	3.77	0.35	New Jersey	7.25	0.58	20.98	71.18
Colorado	86.64	12.47	0.10	0.80	New Mexico	99.38	0.40	0.03	0.19
Connecticut	3.22	88.12	2.70	5.96	New York	2.47	94.87	1.88	0.78
Delaware	0.13	63.03	20.74	16.10	North Carolina	57.13	37.22	4.47	1.19
Florida	30.99	24.07	25.69	19.25	North Dakota	64.11	35.89	0.00	0.00
Georgia	94.63	5.30	0.06	0.00	Ohio	28.90	54.98	9.79	6.33
Hawaii	38.00	49.67	0.36	11.96	Oklahoma	70.10	22.72	3.38	3.80
Idaho	91.41	8.58	0.00	0.01	Oregon	94.30	5.25	0.44	0.01
Illinois	8.43	87.36	4.21	0.00	Pennsylvania	14.26	85.58	0.01	0.15
Indiana	51.11	48.18	0.40	0.31	Rhode Island	0.00	12.80	74.50	12.70
Iowa	8.32	91.27	0.03	0.38	South Carolina	79.65	17.61	0.33	2.42
Kansas	85.53	13.54	0.93	0.00	South Dakota	75.67	24.33	0.00	0.00
Kentucky	86.04	8.40	1.06	4.50	Tennessee	75.03	4.76	16.50	3.71
Louisiana	4.03	75.18	0.36	20.43	Texas	34.29	17.14	47.84	0.73
Maine	5.03	46.76	1.97	46.24	Utah	88.89	11.11	0.00	0.00
Maryland	18.83	79.94	0.00	1.23	Vermont	47.98	44.14	6.02	1.87
Massachusetts	0.83	61.91	30.15	7.12	Virginia	90.52	6.99	1.65	0.84
Michigan	0.02	99.96	0.00	0.02	Washington	71.11	28.57	0.26	0.06
Minnesota	26.71	73.28	0.00	0.00	West Virginia	91.58	8.17	0.24	0.01
Mississippi	92.54	2.31	0.28	4.87	Wisconsin	0.84	11.34	86.54	1.28
Missouri	99.95	0.00	0.00	0.05	Wyoming	85.91	13.41	0.00	0.68

Table 3. Marine protected area coverage by state, broken down by all vs. state-managed and by GAP status code. While some state marine zones (three nautical mile buffer, plus wider buffers for Texas, Puerto Rico, and parts of Florida) go beyond the 30% target, very few PAs are managed by states.

	All (% Cover)		State Managed (% Cover)	
	GAP 1&2	GAP 1-3	GAP 1&2	GAP 1-3
Alabama	0.75	1.21	0.68	0.68
Alaska	7.05	87.33	0.81	50.87
California	43.00	53.63	13.10	13.10
Connecticut	0.01	99.37	0.00	0.00
Delaware	0.86	99.24	0.85	0.85
Florida	52.92	67.27	26.38	27.45
Great Lakes	8.50	8.51	2.74	2.75
Georgia	1.83	84.69	0.75	0.75
Hawaii	35.85	43.32	16.03	23.50
Louisiana	4.54	7.77	3.99	7.01
Maine	0.40	97.51	0.00	0.09
Maryland	0.76	98.70	0.06	11.54
Massachusetts	1.46	99.39	0.00	93.04
Mississippi	14.23	14.38	0.92	0.92
New Hampshire	0.24	99.13	0.25	1.29
New Jersey	5.16	99.29	4.77	4.82
New York	1.19	98.91	0.03	0.03
North Carolina	1.31	97.10	0.46	41.40
Oregon	10.18	10.19	9.82	9.82
Rhode Island	0.69	99.28	0.69	4.94
South Carolina	8.49	89.13	4.73	4.77
Texas	9.87	9.87	5.59	5.59
Virginia	1.04	98.23	0.02	17.18
Washington	45.56	45.57	0.07	0.07

Table 4. Crosswalk between area designations and GAP status in the PADUS GIS data. Wilderness designations fall solely among the higher protection classes. However, for the most part, there are areas that fall across the full spectrum of designations and protection levels.

Designation	GAP 1	GAP 2	GAP 3	GAP 4
Access Area			X	X
Area of Critical Environmental Concern	X	X	X	
Agricultural Easement	X	X	X	X
Conservation Easement	X	X	X	X
Forest Stewardship Easement	X	X	X	X
Federal Other or Unknown Designation		X	X	X
Historic or Cultural Area	X	X	X	X
Historic or Cultural Area Easement	X	X	X	X
Inventoried Roadless Area			X	
Local Conservation Area	X	X	X	X
Local Historic or Cultural Area		X	X	X
Local Other or Unknown	X	X	X	X
Local Park	X	X	X	X
Local Recreation Area	X	X	X	X
Local Resources Management Area	X	X	X	X
Military Land	X	X	X	X
Mitigation Land or Bank		X	X	X
Marine Protected Area	X	X	X	
Conservation Area	X	X	X	X
Not Designated			X	X

Table 4 continues on next page

Table 4. *Continued from previous page*

Designation	GAP 1	GAP 2	GAP 3	GAP 4
National Forest	X	X	X	X
National Lakeshore or Seashore		X	X	X
National Monument or Landmark	X	X	X	X
National Park	X	X	X	X
National Recreation Area		X	X	X
National Scenic, Botanical or Volcanic Area	X	X	X	
National Scenic or Historic Trail		X	X	
National Wildlife Refuge	X	X	X	X
Other Easement	X	X	X	X
Private Agricultural		X		X
Private Conservation	X	X	X	X
Private Forest Stewardship		X	X	
Private Historic or Cultural Area	X	X	X	X
Private Other	X	X	X	X
Private Park	X	X		X
Private Ranch			X	
Private Recreation or Education Area	X	X	X	X
Approved or Proclamation Boundary	X	X		X
National Public Lands			X	

Designation	GAP 1	GAP 2	GAP 3	GAP 4
Ranch Easement		X	X	X
Research or Educational Area	X	X	X	X
Recreation Area	X	X	X	X
Recreation or Education Easement		X	X	X
Resource Management Area	X	X	X	X
Research Natural Area	X	X	X	
State Conservation Area	X	X	X	X
Special Designation Area	X	X	X	X
State Historic or Cultural Area	X	X	X	X
State Other or Unknown		X	X	X
State Park	X	X	X	X
State Recreation Area	X	X	X	X
State Resource Management Area	X	X	X	X
State Wilderness		X		
Native American Land		X	X	X
Unknown	X	X	X	X
Unknown Easement	X	X	X	X
Wilderness Area	X			
Watershed Protection Area	X	X	X	X
Wilderness Study Area	X	X		
Wild and Scenic River		X	X	X

Appendix 2. Rarity-weighted Richness and Protections

The primary map and analyses of biodiversity variation and land protections (e.g., main text Figures 2 and 3) are based on the raw species richness layer from the Map of Biodiversity Importance (<https://bit.ly/mobi-richness>). Raw richness does not capture all dimensions of biodiversity, however, so we also evaluate patterns of needed protections using the rarity-weighted species richness index (<https://bit.ly/mobi-range-rarity>). Here, each species' contribution to the biodiversity value in a given cell of the map is weighted by the inverse of the summed area of its range, giving range-restricted species

greater weight than wide-ranging species. The rarity-weighted data show the same broad patterns as the raw species richness layer when combined with GAP categories (Figures 1 and 2), with substantial needs for protections in the Southeast and western California. One difference is that a few additional areas in the western U.S., such as southern Arizona, stand out as requiring additional protections given the high, range-restricted biodiversity in those areas. As practitioners drill into regional and local details of priorities for protections, this and other measures of biodiversity will need to be considered.

Figure 1. Combining protected area coverage to locations of rarity-weighted imperiled species richness. The blue (y-axis) component of the bivariate color ramp signifies protections under GAP categories 1-4 while the yellow (x-axis) component signifies biodiversity [NatureServe 2020]. Resolution is 1km².

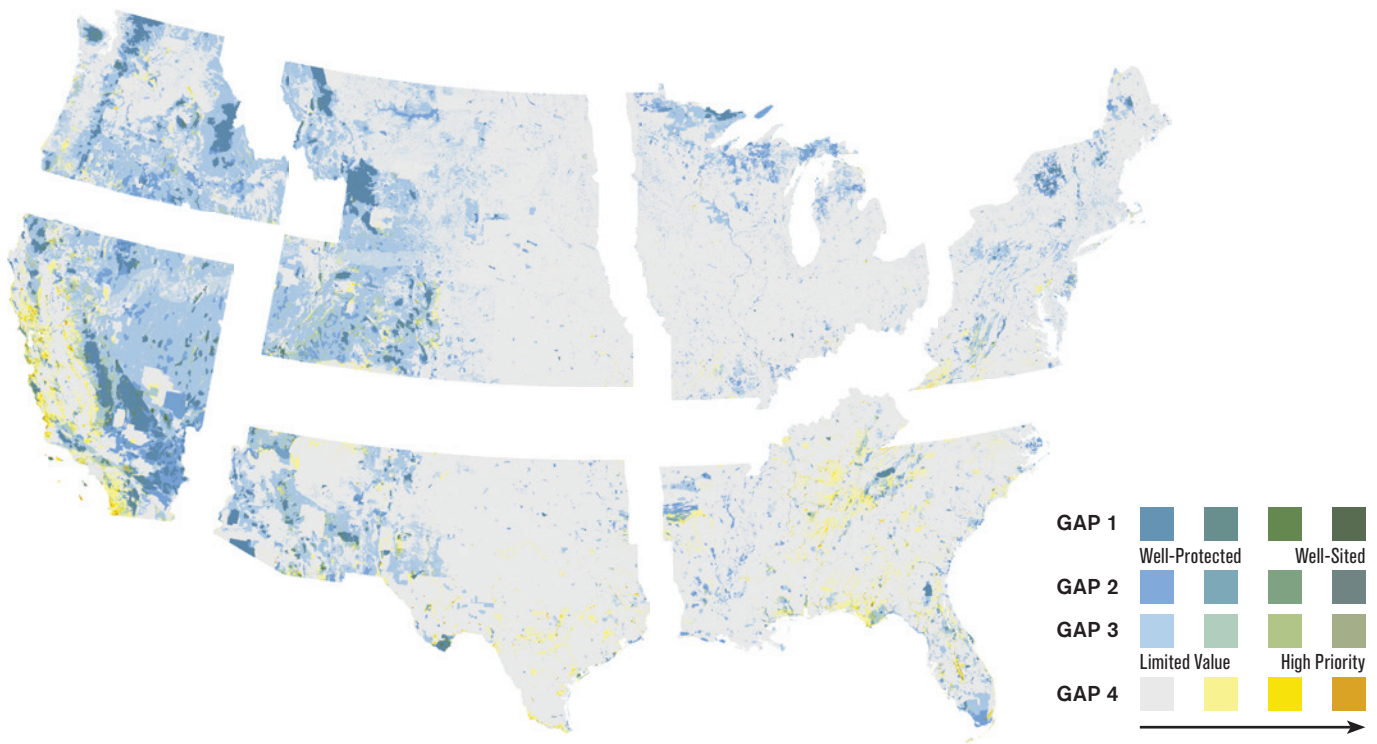
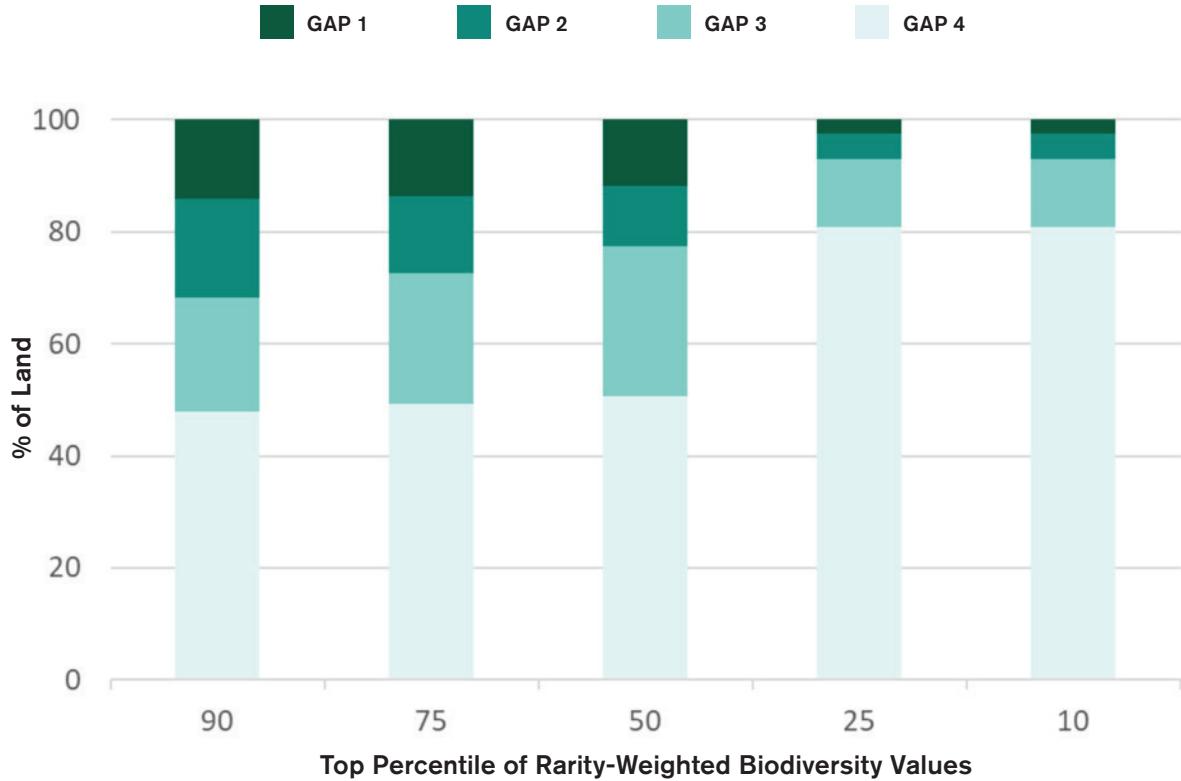


Figure 2. Protecting different subsets of coverage to the distribution of small-range imperiled species. Biodiversity hotspots were considered as locations with values in the top 90th percentile of the distribution. The green color ramp signifies protections under GAP categories 1-4.



Appendix 3. GAP Classification and Human Footprint

Achieving 30x30 for biodiversity and climate purposes will require continued protections of relatively undisturbed areas as well as protecting and restoring areas that have been impacted by human activity. To provide an initial evaluation of patterns of human impacts on protected areas and biodiversity, here we add human footprint data to the analyses. Terrestrial human footprint data are the cumulative results of eight spatial datasets representative of human pressures on the environment (Sanderson et al. 2002). Similarly, cumulative human impacts on marine environments were based on 19 spatial datasets (Halpern et al 2015).

As expected, GAP classifications are strongly correlated with measures of disturbance, as human footprint values (on a scale from 0 to 50) are lower in terrestrial PAs with stricter protections (Figure 1A). There are slight increases in human disturbance on marine PAs with decreasing protections, but because of a lack in variation among human footprint and species richness values, there are no strong relationships between GAP class, human disturbance or biodiversity (Figure 1B). This may be reflective of more general difficulties in studying marine environments (e.g., non-point sources, limited data and techniques for environmental proxies, non-stationary habitats, and environmental boundaries, etc.;

Townsend et al. 2018, Crowder et al. 2000). Regardless, the biological significance of this relationship is real.

Interestingly, higher imperiled species richness coincides with higher human footprint ($r = 0.63$, Figure 2). Greater human reliance on these biodiverse landscapes may make achieving 30x30 more challenging in regions that would be considered high priority, particularly in eastern states. For example, the southeastern U.S. harbors high biodiversity and protections fall severely short of the 30% target, but some of these have lower human disturbance potentially making it easier to site new effective terrestrial PAs. Alabama and West Virginia both have relatively high imperiled species richness and disturbance values under 10 (out of 50). However, these and many other states—including Texas, Georgia, Tennessee, South Carolina, North Carolina and Virginia—will require action beyond securing stricter GAP 3 management to achieve 30x30. While much of the U.S. currently lacks extensive GAP 1-3 protections, we find that the current levels of disturbance tend to be relatively low and may still allow for effective protection and restoration; protections are not too late if we act now. Beyond simply being numerically achievable, 30x30 for biodiversity conservation is also viable.

Figure 1. Average imperiled species richness (blue bars) shows an idiosyncratic relationship with terrestrial GAP designations (A) and declines with GAP designations (B), while human footprint (orange points and error bars) is more correlated with terrestrial GAP (A) but less-so with marine GAP designations (B). Means (\pm SE) were calculated for each 1x1km cell covering the U.S. terrestrial area and marine territorial waters.

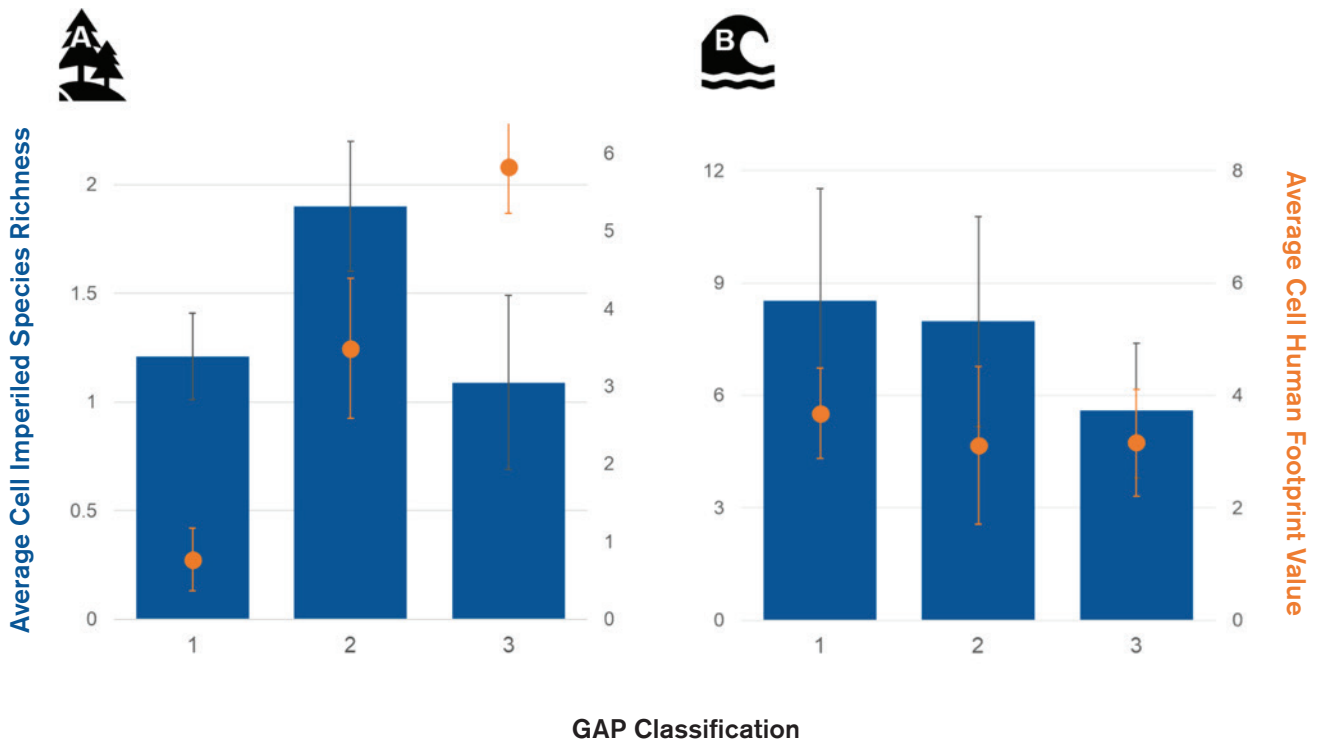
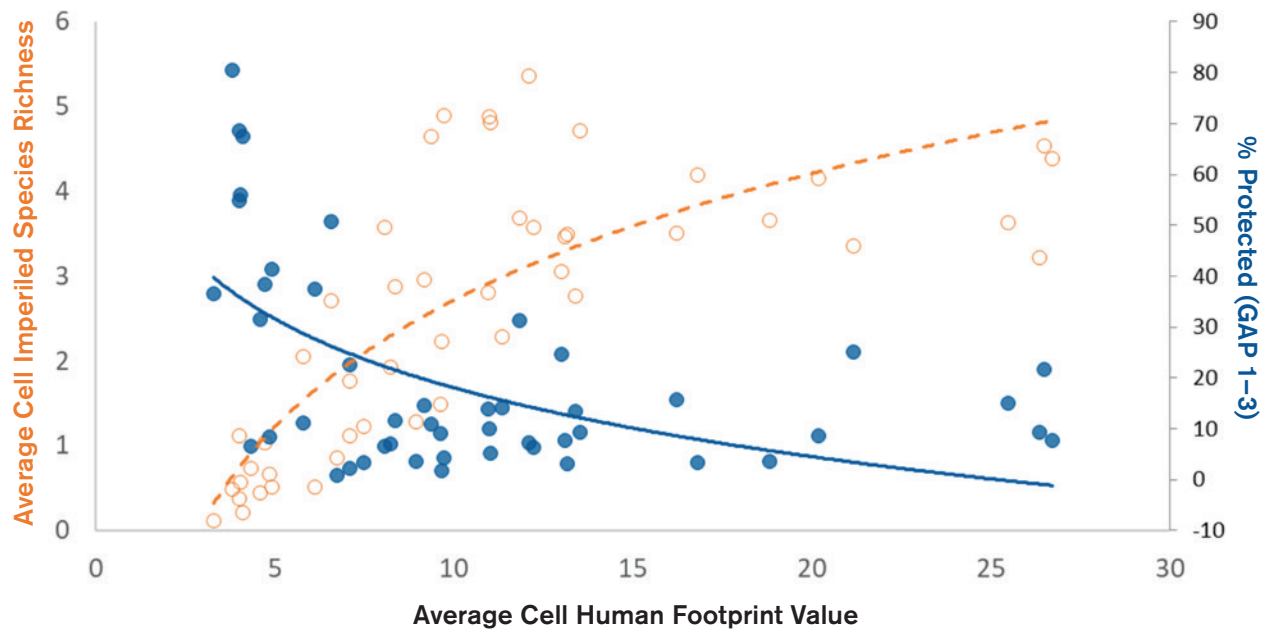


Figure 2. The per-state average imperiled species richness increases with increasing human footprint, while footprint declines with percent area protected under GAP 1-3. This puts some states in a difficult position as areas in greatest conservation need (high diversity, low coverage) are also fairly impacted by human disturbance.



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