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Mapping at the Intersection: Environmental Justice & Conservation

A user guide to integrating equity in spatial conservation planning

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SUMMARY

Today, approximately one million species are at risk of **extinction** globally, **climate change** is widespread, rapid and intensifying, and historically **marginalized communities** are disproportionately impacted by the outcomes of these trends. Maps potentially have important implications for where and how we take action and present an opportunity for ensuring that limited conservation resources are dedicated to places that optimize biodiversity conservation, climate change mitigation/adaptation, and advanced human well-being, particularly for historically marginalized communities. A working group with broad expertise in spatial data (ecological and social), we developed this guide to help map developers/users working at all scales to select and develop maps that support better decision-making at the intersection of biodiversity and equity. We present 1) a set of shared principles that underlie many of the mapping efforts to date focused on identifying priority areas for action, 2) guiding questions to help the user put the principles into practice with a conservation planning project team and 3) a case study example.

Photo credit: Noel_Bauza

INTRODUCTION

Photo credit: Ian D. Keating

Where and how to address biodiversity loss, climate change, and inequitable access to nature and its benefits are critical questions for conservationists and planners working at all scales to turn the tide on these inseparable crises. Maps are an important tool for starting conversations, exploring alternatives, and supporting decisions regarding allocation of limited conservation resources. The result of any map, and therefore the decisions based on that map, is driven by the data and methods underpinning it. The decision to include or exclude particular information can drive resources and investments to certain places over others. Spatial data analysis can play an important role in ensuring that prioritization of future conservation efforts improves biodiversity, addresses climate change, and advances the well-being of people, particularly overburdened and disproportionately impacted communities. For map developers and users, with great power comes great responsibility. There are two key challenges commonly faced by map developers and users tasked with identifying important locations for conservation action.

1. **Implementing an integrated approach: biodiversity & equity.** People and nature are inextricably connected. Nature and the biodiversity it hosts are essential to the health, well-being, and prosperity of every community in America. The health and integrity of our nation's biodiversity are a result

of our land and resource management actions. We also recognize a history of exclusion of marginalized communities in conservation and, with national initiatives like America the Beautiful, there are opportunities to outline a more inclusive and collaborative vision for conservation. While there are growing calls for more work at the intersection of biodiversity conservation and equity, spatial conservation planning and environmental justice analyses are still very siloed. In some cases, map developers may be hesitant to integrate indicators of biodiversity and human health due to confusion about the multitude of available maps (see below) or how to select and combine the "right" ones.

2. **Sorting through an embarrassment of riches: a multitude of maps.** With improved technologies, the availability of geospatial data and spatial prioritization methods has increased, leading to more maps identifying important locations for conservation actions. Different organizations developing different maps representing different values and pointing to different places for conservation leave decision-makers asking "which map(s) do I use?". Critically, growing numbers of maps produced to guide conservation efforts can also create the perception of competing maps, disagreement and uncertainty. This issue resonates at all levels, including federal, where government agencies are tasked with developing decision support tools to measure and track conservation targets, allocate funds for conservation efforts, and more. There is a general consensus that decisions related to where to invest are closely tied to achieving both numerical targets and substantive conservation goals. Science will continue to produce maps, but it should also set the foundation for more cohesive thinking about what maps are being used and why.

In conservation, a shared set of science-based principles often serves as the underlying foundation of spatial conservation plans and biodiversity-focused mapping initiatives. However,

Photo credit: Criadero

there is little clear guidance for what those principles are, how to use them, and whether they are also shared among initiatives to improve equitable human well-being outcomes. A set of shared principles across biodiversity and human equity-focused efforts can offer a framework to address both challenges by guiding purposeful selection and application of maps and advancing equitable conservation planning. A science-guided approach can be critical for achieving, measuring, communicating, and informing biodiversity conservation success, especially as government agencies are tasked with prioritizing places, allocating resources, implementing actions, and tracking conservation progress. As the conservation community recognizes the importance of diversity, equity and inclusion in conservation success, the spatial planning process should adapt to reflect it. Doing so may allow planners to be more explicit in investing limited resources in places that serve to generate positive outcomes at the intersection of biodiversity conservation and equity.

We recognize that integrating concepts of equity into conservation planning requires careful consideration of people and data. The larger process of conservation planning, from scoping to implementing, should also be built around *authentically* engaging the appropriate community partners in a respectful and meaningful way, early and often. There is a growing set of resources on best practices for community engagement and participation we have gathered (see Resources). Rather than reviewing these resources, we will focus on the thought and action processes for data selection and analytics to better integrate equity in spatial conservation planning. However, people and data are not completely separate issues, and users should also be aware of FAIR principles for scientific data and suggestions for operationalizing them with CARE principles for Indigenous Data Governance.

This document is meant to serve as a unified guidance on map usage for supporting biodiversity, climate, and nature equity decisions. It is meant to help you better understand
1) the shared conservation science and equity principles that often serve as the underlying foundation of many mapping initiatives,
2) how to select the appropriate data for conservation assessments and outcomes and recognize their limitations/assumptions,
3) how to think about incorporating equity considerations in spatial conservation planning,
and
4) where to find additional resources highlighting best practices for meaningful involvement of groups in decision-making and procedural equity.

Without a focused and coordinated effort to connect conservation objectives (the what) and conservation maps/data (the where), planning efforts

may continue to be piecemeal, arbitrary, and ineffective at addressing the crisis at hand. A shared, integrated strategy for selecting, developing, and operationalizing maps for conservation action can help you achieve, communicate, and inform U.S. conservation in a more equitable way.

WHAT YOU SHOULD REMEMBER ABOUT MAPS

Western or American conservation, ecological science, and maps all stem from deep histories of colonialism. Factually speaking, they have resulted in the dispossession of power, land, resources, and fundamental rights from non-settler peoples. Today, this leaves us with 1) land systems and spatial patterns in ownership/use that allow disparities in nature access and health to proliferate, 2) data and knowledge that narrow and/or bias our understanding of landscapes, and 3) decision-making tools that oversimplify or misrepresent environmental complexity and/or impacted communities. We will never be able to completely address these challenges, in part because not everything can or should be neatly represented on a map. Nonetheless, it is important to recognize the history of our ideologies, landscapes, and ways of thinking/acting that has shaped where we are today. To the extent possible, mappers and decision-makers should take steps to ensure that the planning process and results do not enforce the persistence of established inequities, whether intentionally or unintentionally, and can help to alleviate harmful disparities.

As such, we recognize some key assumptions that are not mappable, but important to take into consideration:

- "All models are wrong, but some are useful" (G.E.P. Box, 1976). The data and maps oversimplify our world and therefore have inherent errors. We are not trying to correct these, but work within their bounds and make their limitations clear to the user. Importantly, we recognize that these maps are based on our current reality and reflect the systems that we are trying to change (see decolonization). They are often created by historically privileged people and organizations.

- Communities have the right to define, collect, protect, interpret, manage, and apply data in a way that respects their ethics, values, and/or relational

responsibilities. Inclusion of these data should be voluntary and must genuinely make space for the needs of communities. Indigenous communities in particular, have unique governance structures, histories, and practices that should be respected.

- We aim to maximize benefits and minimize harm. Though the principles are shared among us, specific actions that may be beneficial for one - people or wildlife communities - may not benefit the other. It is important to recognize potential harms and unintended consequences (e.g., green gentrification).

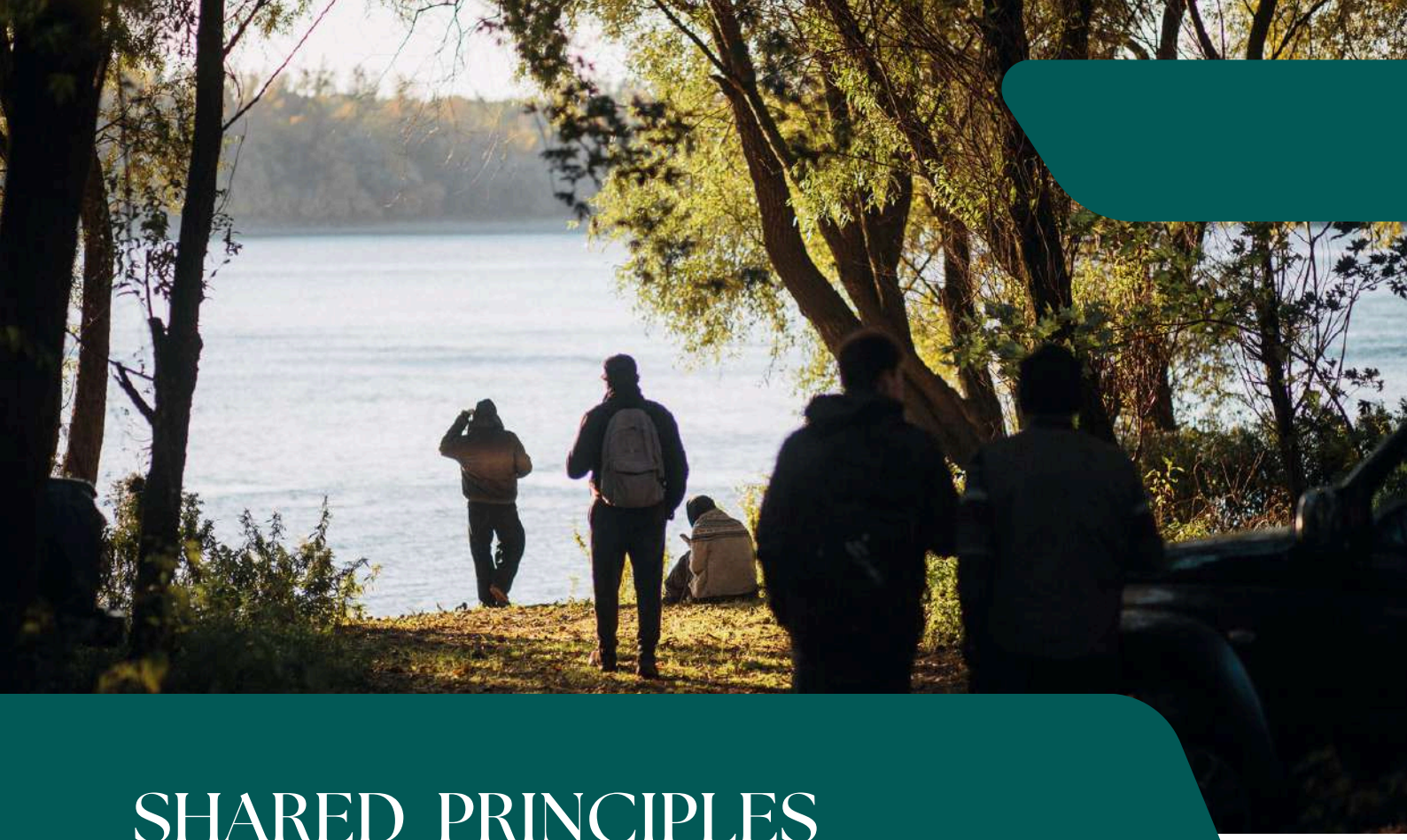
- We may have some data, but we do not have all the information. Local groups hold knowledge critical to prioritizing action and allocating resources in their communities. Understanding values and needs and facilitating meaningful involvement in mapping and decision-making are paramount to achieving better outcomes for people and nature.

- Colonialism has affected marginalized groups in different ways, resulting in different inequities and requiring different approaches and solutions. Forcibly displaced Indigenous peoples have different circumstances and needs than people that endured forced migration from the Global South or minorities that willingly migrated . As a result, inequity can look different for urban communities with largely minority populations than for rural communities, than for Indigenous communities, and so on.

- This work and its context are ever-changing. We cannot assume that because something was right for the past or present, that it will be right for the future. Quantitative and holistic metrics of success will also need to keep pace with the ever-evolving paradigm.

There is not one map to rule them all.

To the contrary, new maps will be created to answer new questions that arise from changing conditions and our understanding of them. These shared principles were developed to guide researchers, practitioners, policymakers, funders, and community members in effectively applying conservation science and community knowledge (which can often overlap) to the map-making and spatial analysis that often informs decision-making. As the number of maps for decision support will continue to grow, intentional map selection and use will be important to addressing biodiversity loss, climate change, and inequitable access to nature and its benefits together.

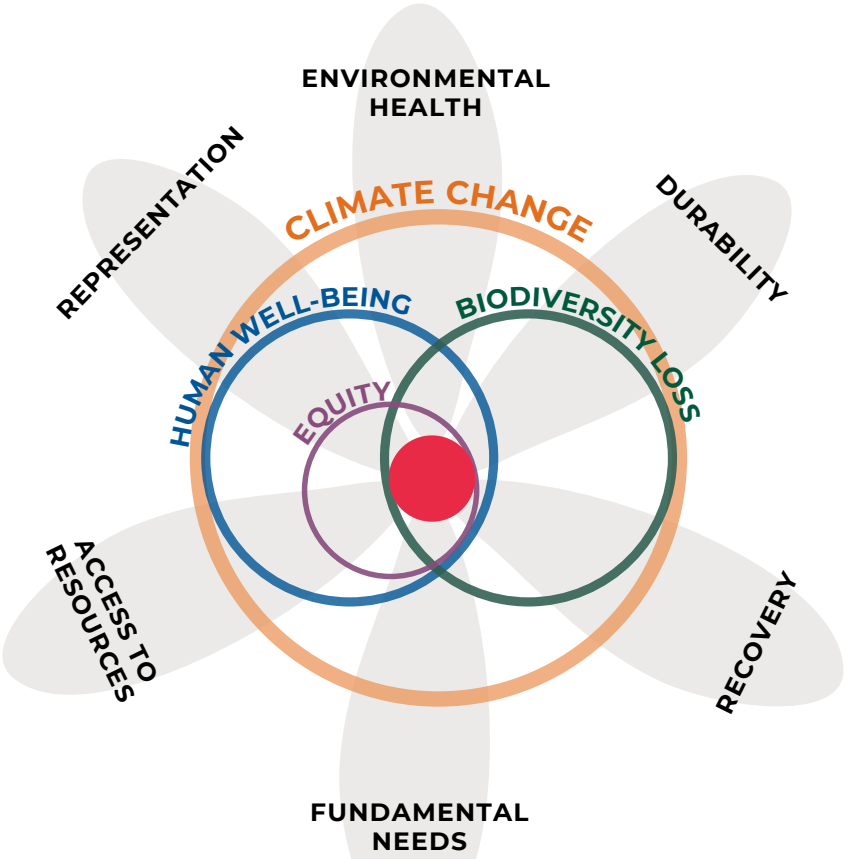


SHARED PRINCIPLES

Photo credit: Bence Szemerey

We gathered scientists with expertise in creating, analyzing and/or using ecological or social data to discuss barriers to the effective use of maps in an integrated approach, cases that exemplify the common challenges faced, and potential solutions. Through a series of workshops we identified a set of shared values and principles that can help guide thinking and mapping at the intersection of biodiversity and equity. Below we define these principles and the implications for their use in developing maps that identify priority areas for action in the environmental conservation and justice domains. Our goal in clarifying a set of common principles is to support map literacy and responsible decision-making. In particular, having a strong understanding of principles and a underlying premises can help with appropriate map selection and usage. We acknowledge that identifying principles is useful for framing priorities and actions but will also need to be put into practice; later, we outline an example of how these principles can be integrated in analysis and mapping efforts.

Throughout this resource, we will discuss biodiversity, equity and work at the intersection. Here we define these terms for the user to clarify the meaning and implications of the sections to come. We also want to recognize that climate change is a third, interconnected crisis that should be explicitly considered and addressed through the spatial planning process. It is not considered separately because



climate impacts change over time and cannot be teased apart from long-term successes in biodiversity conservation and equity. While there may be some or parts of climate mitigation efforts that do not directly connect to biodiversity and/or equity (e.g., technology development for atmospheric emissions reduction), all communities and ecosystems and the work to support their persistence are tied to climate. The following diagram serves as a visual representation of the relationship between work domains and where this resource fits at the intersection.

What do we mean by "**biodiversity**"? Biodiversity is the variety of life and encompasses all scales from genes to ecosystems. In most cases, spatial analyses focus on species and ecosystems for conservation planning and prioritization. We discuss how each principle can be applied to benefit (maximize or optimize) conservation of biodiversity, often with the inclusion of many species or ecosystems in areas undergoing conservation efforts.

What do we mean by "**equity**"? Equity refers to fairness in process and outcomes such that everyone has the opportunity to thrive, regardless of their identity (e.g., racial and economic background, sexual and gender identity, or zip code and birthplace). Here, fairness is about redressing wrongs, not just providing the same opportunities, i.e. equality (adapted from Urban Institute's internal guide on equity definitions). Typically, equity is achieved by prioritizing processes and outcomes that give special attention to the historical reasons underlying policies or programs that privileged some groups and disadvantaged others.

ENVIRONMENTAL HEALTH

the state of well-being that leads to clean air, water, soil, and suitable climate. [The state may change to aid communities in surviving external challenges.]

For Biodiversity

Provides for robust ecosystems, thriving wildlife populations, lower risk of disease, and more. It enables biodiversity to provide abundant and beneficial services to people.

Habitat loss and degradation is one of the leading causes of species imperilment in the United States and the main reason for over 1,200 species listings under the Endangered Species Act. Species will need healthy and connected habitat now and into the future to remain ecologically viable or achieve successful, durable recovery. Degradation can come in the form of habitat fragmentation, impairment from pollution, departure from native community composition (e.g., invasive species introductions), and more. These are some of the leading drivers of global biodiversity loss and the unprecedented rates of extinction we currently experience.

Mapping Approaches & Considerations: Multiple datasets and indices are available for assessing habitat quality (see EnviroAtlas, AdaptWest and others). Many are directly or indirectly related to human modification of environments, and some are similar to those indices used for assessing human health. While the main biodiversity stressors have been identified (e.g., land- and sea-use change, invasive species, pollution, overexploitation, climate change), researchers are still working to refine our understanding of their impacts and tipping points as well as the curve of relationship between stress levels and species or ecosystem health. This information is likely unique for each species and ecosystem. Therefore, it can be difficult to set thresholds of threat exposure or intensity in a meaningful way for a specific species or communities at large. Most commonly, locations are binned into low-high risk categories based on their exposure to the threat relative to the full distribution of values. Importantly, the synergies between drivers of biodiversity health are still understudied, but expected to contribute significantly. Stressors and their impacts are likely not additive, but there are no clear methods yet for how to reflect this.

For Equity

Leads to lower incidence of serious health conditions. Historically marginalized communities are disproportionately burdened by environmental health hazards and deserve greater access to clean air, water, and soil and suitable climate. Exposure to deleterious land uses and infrastructure has been linked to increased cancer and respiratory illness and a decreased overall sense of well-being, as well as exacerbation of comorbid conditions. Robust evidence of disproportionate environmental health risks affecting communities of color, indigenous communities, and low-income people has been documented across a wide variety of contaminants. Furthermore, growing research shows that climate change exacerbates disparities in exposures, both directly through increased exposures to air and water contaminants and indirectly due to limited adaptation and resilience planning. Addressing these variables strategically can potentially combat environmental injustices if these inequities are recognized in the planning process and that process includes community members, policymakers, and EJ organizations to ensure resource development and prevention of neo-segregation and displacement.

Mapping Approaches & Considerations: Individuals and communities are exposed to numerous stressors stemming from a variety of sources and mechanisms. Stressors can aggregate and accumulate overtime and may not be additive. In historically marginalized communities, combined exposures or cumulative impacts often increases vulnerability to new or ongoing environmental hazards, causing, perpetuating or exacerbating disproportionate harms. While governments and academia have more recently prioritized cumulative impacts research, there are still limitations in available data and sound methodologies that facilitate accurate analysis of combined quantitative and qualitative information. Indices like the Environmental Justice Index for the US are meant to rank cumulative impacts of environmental injustice on community health, but similar limitations arise in the ability of combined indices to accurately reflect burden, interpret the results in a meaningful way or conduct secondary data analysis. These national tools are based on data generated by various sources and on varying time scales and are only meant for high-level screenings.

Photo credit: Ron Lach

ACCESS TO RESOURCES

the availability and attainability of resources and suitable climates without undue burden.

For Biodiversity

Supporting wildlife to move freely across landscapes ensures access to suitable habitat and resources and allows them to avoid areas at risk of change due to climate or environmental catastrophes.

Conserving unimpeded pathways for movement is essential to maintain biodiversity now and into the future and is generally referred to as "connectivity". Connectivity can be structural (i.e., focusing on continuity of landscape elements - like forest patches) or functional (i.e., focused on landscape features that facilitate or impede species movement between habitat patches).

Photo credit: US Coast Guard

Mapping Approaches & Considerations:
Connectivity between two points is often evaluated by assigning local features (e.g., roads, powerlines) and land covers (e.g., agriculture, industrial forest) a number reflecting its relative resistance to the movement of species. Connectivity methods can focus on delineating paths between source and target areas or evaluate paths between pairwise combinations of sites (i.e., centrality). Conservation priorities will depend on the method and strategy. For example, areas where large quantities of connectivity and flow occur may be important in maintaining because they serve as a critical pinch point in a more fragmented landscape. However, more intact landscapes with diffuse flow may be priorities for preventing fragmentation. Spatial configuration of natural lands can also facilitate or impede species ability to track their optimal climatic conditions under climate change scenarios. Many conservation scientists recommend conserving a connected network of protected areas or sites to maintain biodiversity. Maps of important corridors or connectivity zones have been developed under a variety of assumptions. For example, some identify the least human-modified places between protected areas, relying on the assumption that human modification impedes movement the same way for all species.

For Equity

Providing people access to resources, money, and nature supports their livelihoods, health and well-being.

Nature is a necessity for our health and well-being. Where human activities have modified nature, there are fewer trees to filter the air and provide shade; there are fewer wetlands to clean the water and to protect communities from floods; access to cultural resources and green space is impeded. An uneven and inequitable distribution of nearby outdoor spaces for recreation, respite, and enjoyment is particularly felt by communities of color and low-income communities. Of course, for these communities, there is inequitable access to other critical resources including, but not limited to, food, healthcare, housing, education, jobs and others, many of which are essential irrespective of access to nature.

Mapping Approaches & Considerations: Similar to biodiversity, much of the mapping and spatial analysis concerning accessibility - or proximity of services to consumers - is focused on considerations of travel distance and impediments. Travel can be restricted by land use, specifically road or trail networks, as well as by travel time, public transportation availability, and others. Network analyses and servicesheds may provide more accurate measures of access than simple linear distances. Availability of resources and travel networks (e.g., location and capacity of services to meet community demand, miles of road/trail within a census unit) can also be captured through distance- or area-based measures. Additionally, there are considerations that may not be mappable, but extremely limit access to resources such as affordability, awareness, attitudes, accommodation, trust, and more.

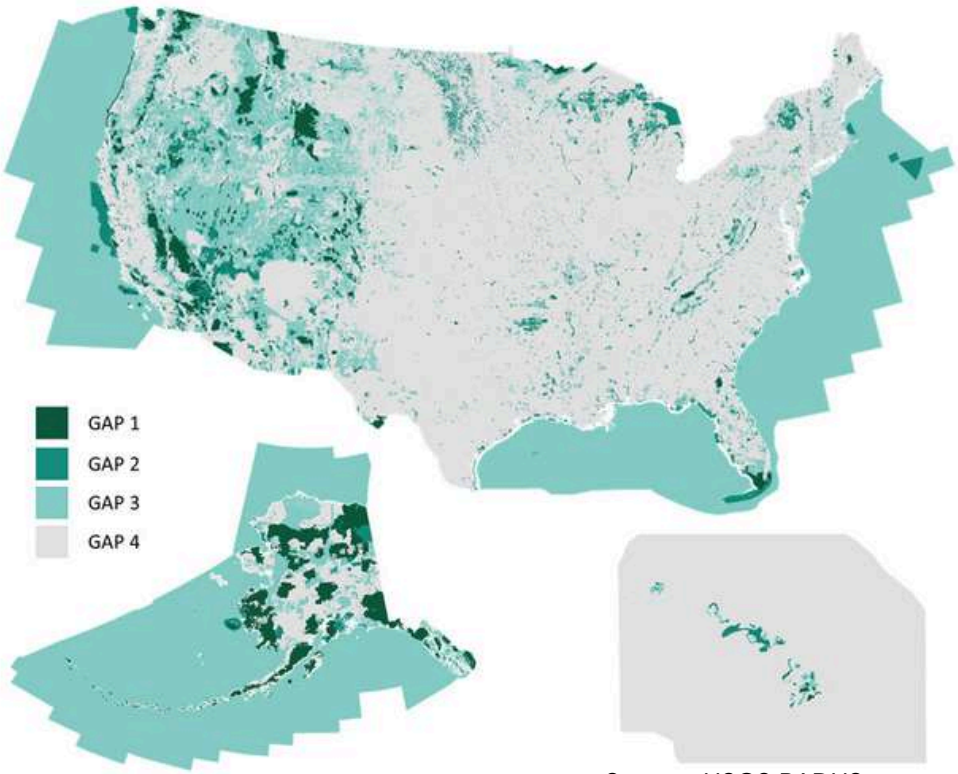
FUNDAMENTAL NEEDS

tthe conditions necessary for individuals and communities to fulfill needs related to safety and respect and to avoid serious harm. While healthy environments and other resources can provide much of what is necessary for the survival of people and wildlife, there are additional needs that can only come from human interactions with each other and their environment.

For Biodiversity

Providing areas that serve as safe haven for plants and wildlife and treating biodiversity with respect can help promote biodiversity health and climate adaptation.

It can be harder to grasp what safety and respect look like for biodiversity. Some examples include complying with environmental laws and regulations to ensure that we do not harm wildlife or degrade the ecosystems they rely on, taking action to share landscapes (e.g., use non-lethal deterrents, plant pollinator habitat, etc.), and respecting the rules of places that have been designated as important habitat or protected areas.



Source: USGS PADUS

Mapping Approaches & Considerations: Most commonly, people map protected areas, critical habitat and other land designations to determine areas where biodiversity is afforded some level of safety from many anthropogenic threats and activities. The World Database of Protected Areas is the most comprehensive available source of land ownership and management designations from authoritative sources, with codes representing the level of protections (see map). However, the update efficiency and review of codes may be inconsistent across data stewards and does not generally reflect knowledge from Tribal Nations. Additionally, the coding system has its limitations. Other helpful indicators include exposure to or intensity of anthropogenic threats (e.g., overexploitation, vehicle collisions, etc.).

For Equity

Equitable allocation of and access to fundamental needs like communal safe spaces and respect increases a community's ability to cope with uncertainty, participate in shared decision-making, and prepare for the future.
Beyond access to healthy environments and basic resources, people need to feel welcome and safe in nature to take advantage of the mental health and well-being benefits that the experiences can provide. While natural public spaces should be places where people can forge the common experiences and understandings that build respect, trust, and solidarity, many in marginalized communities feel alienated or lack a sense of belonging when existing in natural spaces. When fundamental needs are met and people feel safe and respected (see Maslow's hierarchy), motivation can be placed on acting for our environment and community.

Mapping Approaches & Considerations: Public safety is commonly analyzed, focusing on spatial patterns in crime in and around communities (e.g., pedestrian crashes). This data, as with many others, is subject to under-reporting or under-recording and can sometimes be more reflective of policing effort than crime concentrations. Proxies for safety and belonging in public natural spaces may be derived from visitor survey and demographic metrics - is someone likely to see or share the experience with other visitors of a similar demographic? Much of this data comes in aspatial formats.


Photo credit: Smithsonian

Data use and mapping can be approached in a respectful way. Data sovereignty is the right of knowledge holders to own and govern their own data including the collection, storage and interpretation of the data. Indigenous people are not only the stewards of their communities, resources, and lands, but also of their data and the research done using their data. As such, Indigenous knowledge holders have authoritative input in the application of the knowledge that derives from their data, especially when it comes to policy making.

REPRESENTATION

the opportunity and ability to speak or act on behalf of a community. It is meant to ensure the inclusion of appropriate communities and their components.

For Biodiversity

Representing the complete variety of life ensures that we have a diverse set of evolutionary history, niches and environments/climates to help species and natural communities adapt and persist. Sustaining biodiversity is a key goal of conservation. Knowing which species are present/absent is critical to implementing actions in the right places to ensure that all species are represented in a conservation plan. While all levels of biodiversity are important to maintain (from genes to landscapes), most spatial conservation planning focuses on species diversity. Recorded locations of observed species allow scientists to model and map suitable habitat, with many ways of combining habitat maps to represent and quantify biodiversity at a location.

Photo credit: 12019

Mapping Approaches & Considerations: Maps of species richness (i.e., the number of species in a location) are useful for understanding where ranges or suitable habitats of the most species overlap and for evaluating coarse patterns in biodiversity. Measures of raw species richness, assume that all species are equally distinct and important, proving potentially limited in reflecting many conservation goals. Other richness metrics weight species to account for endemism and threat, well-suited for identifying hotspots of at-risk species. With this, the user assumes that range-restricted species are more vulnerable to extinction and have fewer options for conservation solutions.

Richness maps will likely fail to identify range-limited species that don't occur in species-rich areas (e.g., black-footed ferret). A complementarity-based method, works to maximize the number of species conserved across all sites. Another way to increase representation of the unique species assemblages in conservation plans is to stratify conservation values by spatial units (e.g., ecoregions). By identifying the highest value places within geographical strata, an analyst is assured that some places in every ecoregion will be identified as important and thus represented in a broader-scale assessment.

For Equity

Meaningful involvement of marginalized communities in decision-making is essential to ensure outcomes reflect the needs and priorities of populations historically and systemically excluded from place-based investments.

Effective conservation solutions must consider the local contexts and values of the communities who are undertaking the actions or are impacted by the actions. Importantly, this work must value the lived experience of community members as its own form of expertise. By failing to account for collective and individual community perspectives, our conservation activities will likely exacerbate existing disparities already furthered by historically exclusive conservation work. To ensure more equitable allocation of benefits from federal investments to environmental justice communities, development of maps and tools have generally focused on identifying areas related to "disadvantaged" communities.

Source: CEQ CEJST

Mapping Approaches & Considerations: There are multiple environmental justice data tools meant to help identify census units where communities there face environmental burdens and/or socioeconomic disadvantages. Some are used to inform policy action or allocate funds. Each varies in geographic coverage, underlying data sources, and environmental and socioeconomic measures, many lacking data on race and ethnicity. Many tools use a composite method of combining metrics which may offer a more holistic approach, but depending on the aggregation approach, may deprioritize or overlook certain communities or environmental indicators due to methodological choices and data availability. In some cases, scores inform a binary determination of whether a community is or is not "disadvantaged" while in others, a ranking is assigned to prioritize among communities. Both have limitations. Importantly, few tools receive regular updates and many rely on national-level data sources which can miscount or undersample small rural, predominantly non-english speaking, high-minority, and low-income areas, leading to inaccurate representation of local-level realities. Furthermore, disparities in dense urban contexts can exist at scales smaller than a census block-group or tract, hiding glaring differences in resources felt at a block to block level.

DURABILITY

the ability to sustain or adapt in face of a stressor, especially those caused by climate change, globalization, and urbanization.

For Biodiversity

Having key protections and a network of healthy, connected lands and waters allows communities to persist over the longer-term. In return, biodiverse communities tend to have greater capacity to resist disturbances.
Site resilience metrics are used by conservation NGO's and agencies to identify places for long-term investment in land and water conservation. As climate change drives rapid shifts in species distributions, conservation based on current biodiversity patterns may become less effective in sustaining diversity. Site selection based on durability makes fiscal sense because land conservation is expensive and long lasting. The most durable places may qualify as climate "refugia". Refugia are areas relatively buffered from contemporary climate change over time that enable persistence of valued physical, ecological, and sociocultural resources. Conserving refugia may be an important part of planning for conservationists interested in sustaining the persistence of individual species or assemblages.

Mapping Approaches & Considerations: Although refugia can be examined over a continuum of spatial scales, they are usually classified as either macrorefugia or microrefugia. Macrorefugia are identified at coarse scales, using global climate data or models, and are large enough to maintain viable animal or plant populations. Climate models are widely used to predict the rates of future change and are useful for understanding the direction and potential magnitude of change in temperature or precipitation. These models make informed estimates about what may happen in the future based on explicit assumptions of greenhouse gas emissions. Applying climate models directly to fine-scale land management can be tricky as the models have high degrees of uncertainty and are often run at coarse scales.
Microrefugia are identified at local scales. For example, steep canyons and north-facing slopes are relatively sheltered from solar radiation and heat accumulation and hydric or mesic microenvironments (e.g. with a perched or shallow groundwater table, or fed by seeps or springs) can remain moist during droughts. As precipitation and temperature patterns change, organisms disperse locally along moisture and temperature gradients, presumably to stay within their preferred climatic regimes. Thus, the variety of microclimates present in a local neighborhood or landscape diversity is positively correlated with the capacity of the site to maintain species and functions.

For Equity

Having resources to withstand financial, climate, and other stressors strengthens communities and enhances their health in a way that will reduce the negative impacts of present and future challenges.

Current biodiversity losses and environmental injustices undermine the ability of individuals, communities and nations to cope with, and adapt to, climate change and other stressors. While recovery focuses more on the capacity of a community to bounce back from a disturbance, durability is related to the level of stress or amount of change that a community is able to endure before facing irrecoverable harms. Durable communities not only have access to resources, but are the steward of their resources, meaning that capacity and systems are built in a way that help the community to address historic harms and possible futures.

Photo credit: 12019

Mapping Approaches & Considerations: Maps can be used to assess and build capacity. Equity mapping is the use of GIS technology to make the connection between "areas of opportunity" and historically marginalized communities (adapted from National Neighborhood Indicators Partnership). While many focus on smaller geographic regions, some are national in scope (see the Opportunity Atlas and National Equity Atlas). The use of local data is meant to help inform local decisions about investment and development opportunities and target the impact of proposed projects. Additionally, some maps are used to highlight the strengths of communities, rather than focusing on disparities (see asset maps). Qualitative data, local knowledge sources, and capacity building are also essential in the co-generation of solutions. Rather than making and sharing maps, additional efforts to share mapping knowledge and skills can help build capacity and empower communities.

RECOVERY

the process of reducing or reversing the negative impacts of natural or manmade risks on communities to allow for restoration to a former or better state.

For Biodiversity

Allows communities to recover to a point where they no longer need protection, and provide a sustainable future for irreplaceable wildlife and ecosystems.
Efficient and effective ecological restoration can help counteract the negative consequences of habitat destruction and degradation for biodiversity and the functioning of natural ecosystems. Mitigation measures have resulted in quantifiable improvements in biodiversity in some areas, even while the severity of major threats to biodiversity (climate change, habitat loss, invasive species, overexploitation, and pollution) continue to worsen. Management actions and policy to support recovery may target sites at greater risk of biodiversity decline or serve to strengthen protection of the least impacted systems that serve as biodiversity strongholds.

Photo credit: Dawn Key

Mapping Approaches & Considerations: There are currently two main ways that users spatially represent biodiversity recovery. The first focuses on comparisons between past, present, and future conditions of a landscape or of a species range/habitat. For example, a species may be considered recovered if it occupies a significant portion of its historic range. However, understanding what a recovered landscape or species range should look like is not as simple as going back in history, given that climate change can result in range shifts and contractions for some. Understanding and projecting intertwining trends in biodiversity and climate change are increasingly common in spatial analyses (e.g., climate envelope models). In this case, limitations in accuracy and interpretation of results are similar to that of inputs. Another approach focuses more on the location of past, current, or proposed conservation actions. Taking into account where actions to restore or mitigate threats to biodiversity and its recovery have occurred, are underway, or should be prioritized can be helpful for tracking progress toward conservation goals. However, data on the presence or absence of conservation efforts cannot ultimately speak to the effectiveness of those efforts.

For Equity

Incorporating historic complexities to reduce vulnerabilities ensures that recovery of communities doesn't become just a return to the previous state of inequity. Recovery in this sense is similar to the concept of community resilience: the collective capacity of a community to respond to and recover from adverse situations such as natural disasters, economic crises, and social upheavals. It involves infrastructure, social and economic systems, local government responsiveness, and the community's ability to adapt and transform.

Generally, people already experiencing economic or housing insecurity, and environmental or other injustices are more likely to suffer disproportionate impacts and cascading consequences of natural or man-made crises. As such, improving equity may not be possible in achieving resilience as it is classically defined because retaining the same structure, identity and feedbacks, means that these inequities continue to persist. By improving equity and rebalancing public investments alongside other sectors, communities can create the conditions that ensure well-being now, while providing resilience against future challenges.

Mapping Approaches & Considerations: There are numerous available community resilient planning resources and tools from federal and state agencies, universities, and others. Those that mapping and indices often focus on assessing components of resilience and vulnerability. Some examples include the Federal Emergency Management Agency Community Resilience Index, the Centers for Disease Control and Prevention Social Vulnerability Index, and Environmental Defense Fund Climate Vulnerability Index.

Data in these mapping, screening, and risk assessment tools are primarily quantitative, presented as place-based indices, thresholds, or relative measures of social, economic, and/or environmental conditions. These tools can be informative for quantitatively assessing which areas to prioritize and face many of the same limitations as other equity screening tools. Significant challenges in measuring resilience or recovery contribute to both a tendency towards imperfect quantified metrics, and a quest for universal indicators that can be aggregated across projects, institutions, and geographies.

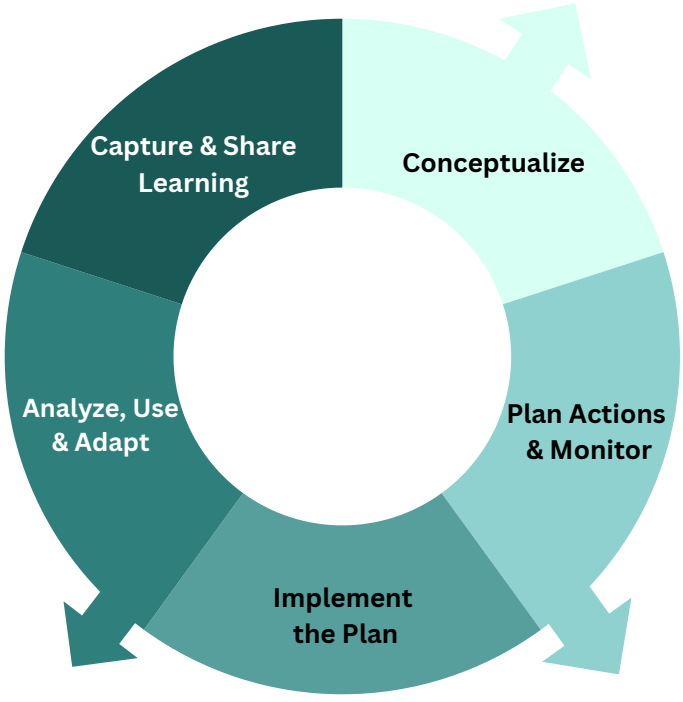
Additional consideration should be given to unintended consequences: resilience and adaptation interventions run the risk of perpetuating social and environmental inequalities if not thoughtfully planned. For example, urban green infrastructure projects are shaped by, and contribute to, environmental injustices through the uneven social distribution of green spaces and other legacy forms of systemic racism in urban planning, design, and financing. Mapping to help achieve equitable resilience entails recognition of the root causes of social vulnerabilities and disparities in resources, knowledge, and power.

SEVEN GUIDING QUESTIONS

Photo credit: USFWS

Here we describe seven main questions to guide thinking, understanding, and spatial analysis for equity-centered conservation planning. These are more specific to the role and expertise of the map developer/user and plug into the larger group planning process that is more commonly described (see figure).

What role with the map(s) play?
What are the key indicators of success?
What data is available and appropriate?
What are the current conditions of the communities/environments?
Where could the team focus additional engagement?



Where and to what extent are outcomes being achieved?

Where should outcomes be prioritized/resources allocated?

Mapping for Environmental Justice and Conservation: *7 Questions*

1. **What role will the map(s) play?** In early preparation and planning, a team will be identified and convened to agree on the project scope, rationale and outputs. Determine what decisions will be informed by the spatial data and maps. What else could they help inform?

2. **What are the key indicators of success?** Clarify the desired outcomes of the project and identify key indicators for assessing and monitoring success in terms of environmental conservation and equity. What does "better" look like and how will you know that you've made progress toward achieving it? Use the principles to guide your thought process and selection.

3. **What data are available and appropriate?** Take inventory of the available spatial data and maps that represent your indicators. Consider the underlying assumptions and limitations of the data (resolution, age, scale, methods, other premises) in data selection. Acknowledge what data isn't available or mappable and the implications.

4. **What are the current conditions of the communities and environments?** Use the selected data and analytical approach to assign values to spatial units. Conduct a retrospective analysis to identify what events of the past have shaped these conditions. Check general trends against your knowledge of the area and use it to identify additional partners to engage.

5. **Where could the team focus additional engagement?** Use the preliminary analysis to assess community representation in project participation and impact. Ensure that voices of those with relevant knowledge, those who direct conservation action, and those who are affected by that action are included. Iterate discussions on additional data needs as necessary.

6. **Where should action(s) be prioritized and resources allocated to achieve outcomes?** Identify priority areas and actions, including alternative approaches to achieving desired outcomes. Share with the project team for discussion, being clear about what the maps do and do not say based on the data and methods.

7. **Where and to what extent are outcomes being achieved?** Analyze new data to evaluate the effectiveness of the siting and implemented actions. Share results with partners to promote transparency and to enhance learning in iterative planning. Monitor outcomes on a regular basis.

WHAT ROLE WILL THE MAP(S) PLAY?

Beyond being helpful visuals for communication and storytelling, maps have also become an important tool for decision support. Whether a map is more appropriate for a given context starts with a clear definition of the question or the decision being supported, which should serve as a guide to selecting the map most suited to a user's needs. Generally speaking, a map's purpose in conservation planning and decision-making is often to inform the selection of priority areas where allocation of additional resources will help achieve some conservation goal. Resources may include funding, staff support, conservation action, and more. It is important for map users to understand the role that the map will play in the decision-making process, not only for the purposes of creating a useful output, but to learn more about the potential implications of the map's usage. Even for maps that are meant to be solely for reference, what is or is not put on a map can change the narrative and tone of the conversation that follows.

Question	Aim
What decisions will the maps support? What are the implications of those decisions?	To understand how the map is connected to the outcomes. To understand how to display or present the data for easier interpretation and communicate limitations clearly.
Who will be using the maps to make decisions? Who else will be involved?	To understand your audience and how you will need to communicate the spatial analysis and results. To understand representation of impacted communities in project development and decision-making.
What does the team hope to accomplish? What is the conservation goal?	To understand whether the goal(s) explicitly or implicitly includes improving conditions for marginalized communities. To inform the identification of indicators of success).

Mindful Design:

We recommend starting by answering the set of questions in the table above. These should set the foundation for a deeper understanding of the map's purpose and potential for alleviating or deepening disparities by means of integrating equity data. Some map developers may need to take a more active role in helping the team to define what maps should and should not be used for.

WHAT ARE THE KEY INDICATORS OF SUCCESS?

Work with the project team to define success and desired outcomes. This step should happen early on and before any spatial analysis takes place, as it will be key in selecting data inputs. Having an explicit purpose or vision statement with clearly defined goals may help with this, as can the shared principles. For example, the goal to "conserve biodiversity" is likely too broad to help someone prioritize locations or monitor outcomes and will make it difficult to narrow the large set of available maps and data that could be used. It is helpful to go through each of the principles to assess the relevance to the goals of the project and the meaning of success. Success could mean improving any or all of the shared principles, but there is still a lot of variation even within a single principle. With biodiversity representation, for example, success can be defined as increasing the total number of species benefiting from conservation efforts or increasing conservation efforts for species that are in greater need (imperiled or rare) or something else altogether. Each could require a different set of indicators for measuring outcomes and/or datasets for prioritization mapping.

Importantly, the team will need to clarify how progress toward achieving the desired outcomes can be measured. As noted, not all indicators may be mappable. While that does not mean they are not worth pursuing, identifying them and creating a plan for how to address them should be an explicit part of the discussion.
Helpful indicators are …

- easier to understand and explain for nonexperts
- proven to influence the desired outcomes
- strongly tied to the goal(s)
- trackable over space and time
- policy-relevant

Mindful Design:

Consider how the definition of success and desired outcomes for one principle may interact with those of others. For example, it may not be feasible to try to maximize the benefits of the two, but rather to optimize or explore complementarity.

Photo credit: Min An

WHAT DATA ARE AVAILABLE AND APPROPRIATE?

Use the answers from previous questions to guide your spatial data research and exploration. Data may already exist that are ready for use or need minimal pre-processing. Importantly, because it is likely that there will be multiple options to choose from, you should consider the relevance of available datasets to the selected principles and the underlying premises of the data. Selection of data and analytical approach are general points where map/data creation diverges, giving rise to multiple datasets. They also set the foundation for the assumptions and limitations of a particular map. These premises can help to clarify the benefits and challenges to using or interpreting maps and should help define appropriate usage [see mapping considerations in principles].

Mindful Design

Data Gaps

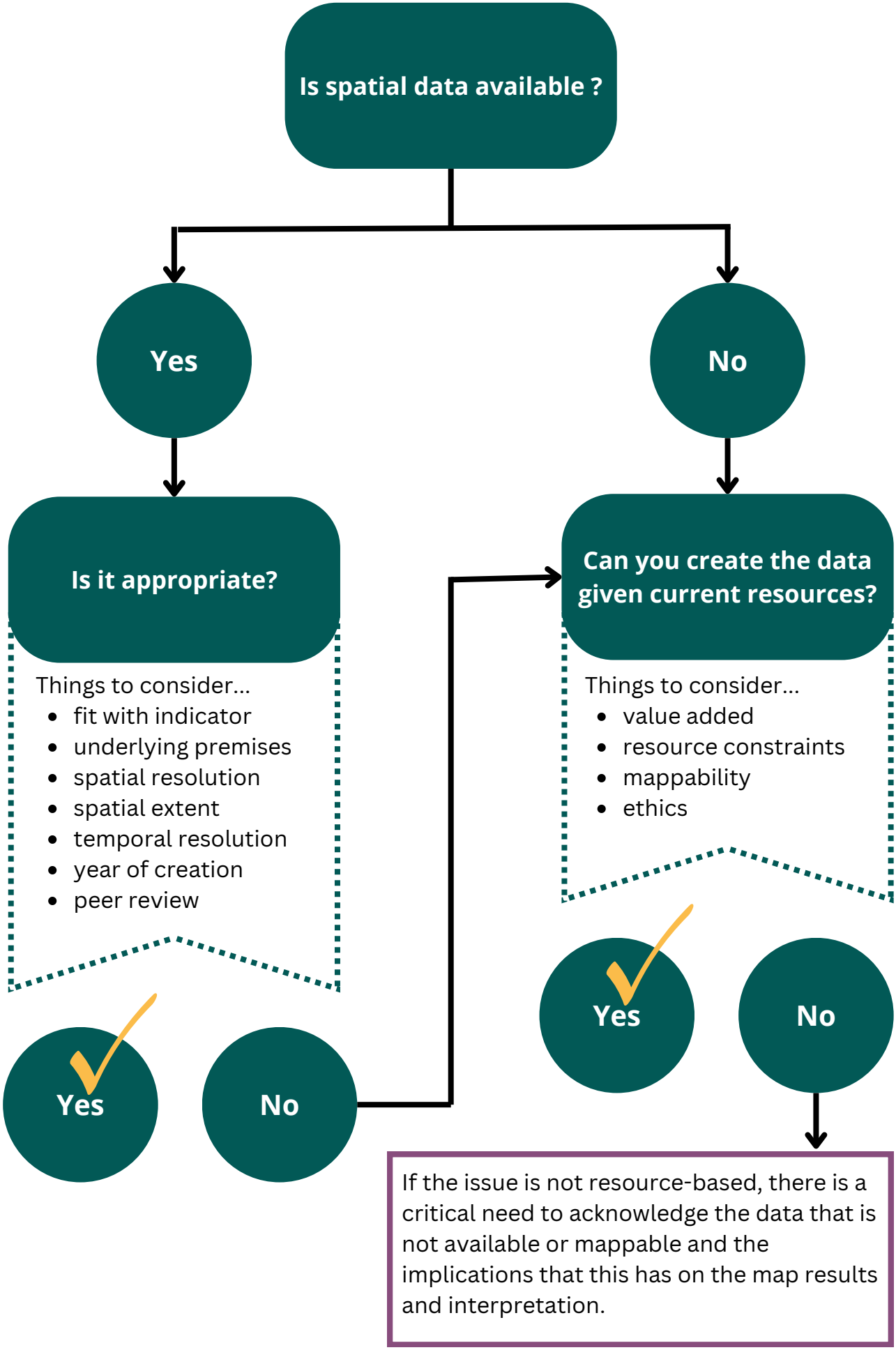
What are the options for filling those gaps (contract work, use a proxy, additional analyses, etc.). Consider what it would mean for the project if the analysis were to continue without this information and which locations or communities may be impacted. Consider ways to communicate these data gaps to audiences who will use the map to make decisions.

Combining Data

Emphasis is often placed on the areas where maps overlap. However, these rarely preserve the internal consistency of each map and are not a panacea for advancing equity or conservation. Looking beyond areas of coincidence can help exemplify the many opportunities that exist for decision-makers to enhance multiple benefits, services, and values. Additionally, a combination of datasets puts less pressure on the user to choose between mechanisms.

Data Sovereignty

Tribal communities have the right to define, collect, protect, interpret, manage and apply data in a way that respects Indigenous ethics, values and relational responsibilities. Conventional, western colonial data practices (e.g., open data, digitalization, algorithmic decision-making, etc.) do not always align with Indigenous data rights, sovereignty and governance. Map users considering engaging indigenous or other historically marginalized communities and/or collecting, analyzing or displaying information from these communities should first become familiar with CARE and FAIR principles (see Resources section).


Is spatial data available ?
Yes
No
Is it appropriate?
Things to consider...
fit with indicator
underlying premises
spatial resolution
spatial extent
temporal resolution
year of creation
peer review
Yes
No
Can you create the data given current resources?
Things to consider...
value added
resource constraints
mappability
ethics
Yes
No
If the issue is not resource-based, there is a critical need to acknowledge the data that is not available or mappable and the implications that this has on the map results and interpretation.

WHAT ARE THE CURRENT CONDITIONS?

Develop a preliminary map for discussion. If there are multiple spatial scales or resolutions under consideration given available data and conservation interest, use the larger/coarser of the options. The goal of this initial analysis is to look at general trends and be intentional in assessing the impact that the historical context of the region and the selected data have on the resulting map.

Mindful Design

Retrospective Analysis

Conditions today are a result of a long history of conservation action, land stewardship, and policy. A retrospective analysis can provide a richer understanding of the ecosystem and local communities among all partners and greater confidence in the findings and limitations of the project.

- What is the historical context that has shaped the conditions you are investigating?
- How has this work historically been done and who has it served, impacted, informed or involved?
- How is history made evident in your initial results?
- Could use of the map in decision-making potentially proliferate certain disparities?
- What communities are prioritized that may not have been before adding equity-relevant data?
- Which communities may be impacted by data gaps, geographic scale, etc.?

Answers can be explored through discussion and data analysis. Results may be used to reassess previous steps.

Photo credit: Kester

Map Display

Map developers are responsible for both the underlying data and deciding how to present it. Many choices have to be made, from how to process to how to simplify the data. Based on these choices, two maps using entirely the same data could present totally different messages. It is important to keep the audiences in mind. For other tips on map design, see this example guide.

WHERE COULD THE TEAM FOCUS ENGAGEMENT?

Using the results of the preliminary spatial analysis and correcting for inequities as necessary, identify the areas that satisfy the conditions or criteria of interest. This is not to make a final determination about which locations become priorities for conservation action or resource allocation, but rather to do additional, exploratory research to understand why these areas were highlighted in the analysis and identify the local groups and community leaders that should be engaged in further discussion.

Importantly, this step also provides an opportunity to assess and reassess the project, team composition and expertise, and gather additional information and perspectives as needed. Meetings with local conservation leaders and knowledge holders could include discussion to refine project goals and development, explore opportunities for partnership or reciprocity, listen to recommendations for additional mapping inputs, etc. This may be an iterative process to improve upon the analysis and further inform the selection of sites and/or conservation actions.

Mindful Design

Critical information comes from the knowledge, experiences and perspectives of the many community partners that interact with the landscape, could be involved in conservation efforts, or be impacted by them. To promote successful conservation planning, this information should be identified and analyzed for its relevance to the conservation problem. In some instances, it may be necessary to agree to restrictions on the use or distribution of unpublished or sensitive information. The group should also consider approaches like participatory mapping to engage local knowledge holders.

WHERE SHOULD RESOURCES BE ALLOCATED?

Select or develop a map that will help the team and partners decide where and how to implement conservation actions. The map should help focus viewers toward the specific areas where effective action is likely to facilitate desired outcomes. These are areas where the group may need to commit resources over the life of the conservation plan or effort. The map might depict the likelihood or magnitude of positive change expected by focusing on one area over another. It may also be displayed with meaningful thresholds (ex: high, medium, or low likelihood) to help decision-makers understand key differences.

Beyond sharing the map, it is important to communicate it. Be clear about the limitations of the maps and what they do and do not say based on the underlying data and methods. Provide alternatives that allow the group to understand how sensitive the map results may be based on the criteria being emphasized in the decision-making process.

Mindful Design

Be explicit about the communities that are and are not represented in these areas and by the underlying data. Even for equity data, there is important information about the people that can't be captured (e.g., values, culture, history). Be mindful about the words that you use to communicate the results and leave room for additional considerations that may not be mappable.

Photo credit: Dennis Larsen

WHERE AND TO WHAT EXTENT ARE OUTCOMES ACHIEVED?

Document your methodology, analysis, results, alternatives and suggestions in a format that can be easily accessed and understood by the project team and partners. Prepare and implement a plan for regular monitoring as appropriate to measure the progress of conservation efforts and their impact. Tracking should be closely tied to the project goals and success indicators, allowing for opportunity to learn from the process and revisit and revise as necessary.

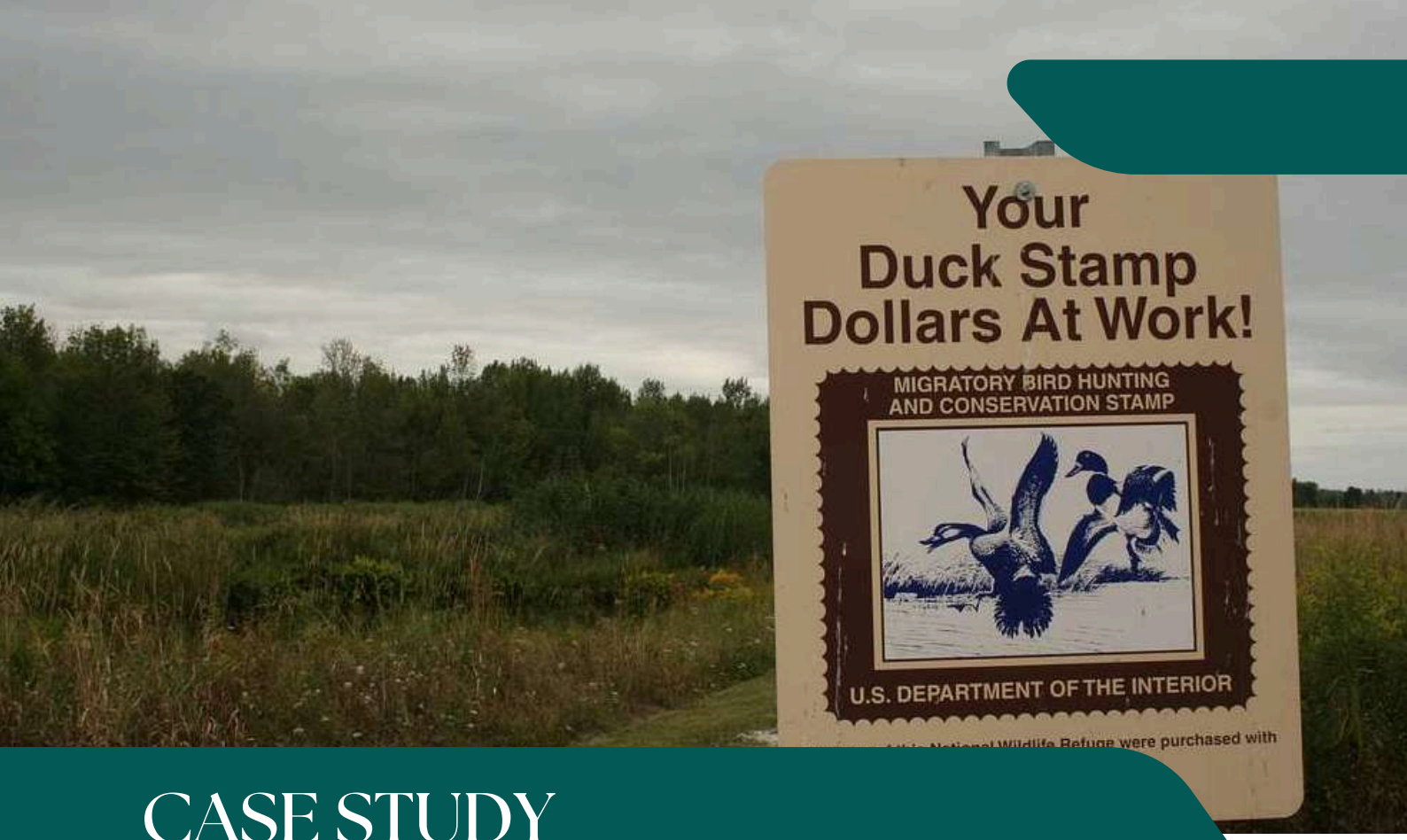
In addition to tracking conservation and equity outcomes, the team should monitor the impact of their decisions on historically marginalized communities. This may include...

Importance of accountability and closing feedback loops–make sure that community members understand how their involvement factored into the work and assess how the resulting product is aligned with their priorities.

Gathering feedback - understand areas of improvement at all steps in the process and identify obstacles to participation.

Tracking progress and measuring performance - use the indicators to assess the direction and significance of changes made to biodiversity and equity after implementation.

Photo credit: Quang Nguyen Vinh



CASE STUDY

Photo credit: USFWS

Context and Purpose

As directed by President Biden's Executive Order 14008, Tackling the Climate Crisis at Home and Abroad, agencies across the federal government are working to conserve, connect, and restore at least 30 percent of our lands and waters by 2030 for the sake of our economy, our health, and our well-being. Referred to as America the Beautiful, the initiative is meant to advance a more inclusive and collaborative conservation vision for the nation. The US Fish & Wildlife Service (FWS) has been directed to operationalize this initiative: to ensure that resources are allocated in ways that benefit biodiversity, address climate change, and advance the well-being of people, particularly those located in overburdened and disproportionately impacted communities. The question arises as to whether FWS can capture all the priorities under their current mission.

About the National Wildlife Refuge System (NWRS)

The NWRS, managed by FWS, is dedicated to conserving and restoring fish, wildlife, plants and their associated habitats, offering one of the highest levels of federal land protection for biodiversity conservation. Despite their relatively small footprint, national wildlife refuges harbor 513 endangered and threatened species in the U.S. Unlike many other public land designations, refuges are found in every state and often closer to urban and suburban areas. The Service's urban refuges program provides an opportunity distinct from other public lands designations to more thoughtfully consider how equity can contribute to the mission of FWS and remove barriers to nature. The NWRS is also unique in that the administration can add land to

existing refuges through land purchases or easements. Expansion of the NWRS can support objectives to protect biodiversity, address climate change, and improve access to nature for all people. Currently, the NWRS utilizes the Strategic Growth Policy to prioritize lands that benefit waterfowl, migratory birds of conservation concern, and threatened and endangered species listed under the Endangered Species Act. However, other factors such as refuge access and economic opportunity for neighboring communities are also considered.


Photo credit: USFWS

Here, we apply the principles and steps outlined in this user guide to determine 1) whether NWRS currently or have the potential to contribute to America the Beautiful goals given the location of refuges and the land available for expansion and 2) where additional resource allocation would make the greatest contribution beyond refuge boundaries.

What role will the map(s) play? Under America the Beautiful, maps can and have been used to inform decisions on where to allocate resources for land acquisition, measuring and tracking conservation progress in the U.S. (Conservation and Stewardship Atlas, 30x30), identifying management direction for federal lands (USDA USFS, Secretarial Memo 1077-004), allocating funds for land acquisition and jobs creation (USFWS, National Wildlife Refuge Strategic Growth Policy), and more. With NWRS regional and national land acquisition decision makers as our audience, analysis of key indicators will be used to conserve and restore public lands and waters, bolster community resilience, protect biodiversity, improve access to recreation, and address our changing climate.

What are the key indicators of success? Below, we define our principals in context with our case study, and write out some potential indicators that could be used to investigate each. There are a number of different datasets that could be used to investigate each indicator. In question three, we'll look at the available data and select one that is most appropriate.

Environmental Health**:** Establishing stronger land protections like those associated with NWRS can serve as "projects that prevent environmental damage and that harms communities and poses a risk to public health and safety" (EO 14008). However, refuge efforts can go beyond prevention of damage to facilitation of greater

health and well-being if they are sited in locations and planned in ways that bring nature experiences and healthy ecosystem services to communities in need.

- Potential indicators: relative proximity to communities with greater health risk due to environmental pollutants (biodiversity, climate change, equity)

Fundamental Needs: Opportunities to establish or expand refuges can contribute to America the Beautiful goals "to mobilize the next generation of conservation and resilience workers and maximize the creation of accessible training opportunities and good jobs" and "and spur economic opportunity for disadvantaged communities that have been historically marginalized and overburdened" (EO 14008).

- Potential indicators: relative proximity to communities with greater unemployment or lower median household income (equity)

Representation: The mission of the NWRS and the goals of America the Beautiful support conservation of biodiversity as a whole. As such, success may result from increasing the biodiversity that benefits from conservation efforts or resource allocations.

- Potential indicators: species richness (biodiversity), relative proximity to communities that have historically had less access to green space (e.g., communities of color, low income; equity)

Photo credit: USFWS

Access to Resources: Refuges may contribute to initiative goals to "protect biodiversity" and "improve access to recreation" (EO 14008). Currently, outdoor spaces are unevenly and inequitably distributed. Particularly communities of color and low-income communities have too few close-to-home parks where they are able to experience nature. Additionally, refuges can help facilitate access to resources like suitable habitat for species by serving as a corridor for movement across a landscape.

- Potential indicators: relative proximity to nature-deprived communities (equity), landscape connectivity or corridor access/quality (biodiversity, climate change)

Durability: Refuges can contribute to community durability through providing refugia, carbon sequestration, and providing green space for communities that may be more burdened by health issues. This principle includes undertaking robust actions to mitigate climate change while preparing for the impacts of climate change.

- Potential indicators: climate refugia potential (climate change), quantity/quality of carbon stored (climate change), sequestration potential, community baseline health (equity), overall climate vulnerability (biodiversity, climate change, equity)

What data is available and appropriate? There are numerous spatial models and data that can be applied to any one of the key indicators discussed above. It is important that the group explore these available data and determine the best data to match the ultimate objective of the map and the most appropriate for the key indicator. Within the appendix, you can find examples of the spatial data explored for this case study for just one indicator: species richness. The process was repeated for other indicators listed above.

Table 1. The list of data that were used in the analysis based on their fit with the principles and indicators.

Principle	Application	Indicator	Source	Justification
Representation	*Biodiversity*	T&E Listed Species	USFWS	FWS is charged with implementing the ESA and, as with all agencies, obligated to protect and recover listed species.
		Species Rarity	Hamilton et al. 2022	Rare species are likely to have less representation if conservation efforts are selected at random. Ensuring their representation supports conservation of greater diversity.
	Equity	% Person of Color	American Community Survey 5-yr. 2020	People of color and low-income communities have historically been excluded from having access to natural space.
		% Latino/a	American Community Survey 5-yr. 2020	Latino/a communities have historically lacked access to safe and accessible green space.
Fundamental Needs	*Equity*	Median Household Income	American Community Survey 5-yr. 2020	People of color and low-income communities have historically been excluded from having access to natural space.
Access	*Biodiversity*	Landscape Connectivity	Belote et al. 2016	Corridors facilitate movement of species across a landscape, providing a means for accessing habitat and other resources.
	Equity	Nature-Deprived Communities	Rowland-Shea et al. 2020	Outdoor spaces are unevenly and inequitably distributed. Particularly communities of color and low-income communities have too few close-to-home parks where they are able to get outside.
Environmental Health	*Equity*	Environmental Health & Pollution	Tee Lewis et al. 2023	Communities burdened with environmental pollutants would benefit from having access to green space.
Durability	*Climate Change*	Climate Refugia	Belote et al. 2018	Areas that are more similar (less dissimilar) may serve as climate refugia for species and conserving these areas may help contribute to their longer-term persistence.
		Landscape Diversity	Anderson et al. 2023	Greater landscape diversity may result in landscape resilience in the face of climate changes.
		Carbon Stored	Soto-Navarro 2020	Conservation of larger carbon stores is one nature-based strategy for reducing the risk of climate change.
		Irrecoverable Carbon	Noon et al. 2021	Prioritizing irrecoverable carbon reserves can contribute to long-term persistence of a landscape.
	Equity	Community Health Risk	Tee Lewis et al. 2023	Nature experiences are linked to greater physical and mental health. Green spaces can support cleaner air, water and other natural resources, bringing these benefits closer to communities that face health inequities.
		Overall Climate Vulnerability	Tee Lewis et al. 2023	Communities with existing baseline community vulnerabilities and risks from climate change would benefit from having access to green space

What are the current conditions of the communities and environments?
At this stage in the process, we're interested in understanding for which indicators refuges are already positively contributing to America the Beautiful goals. To do this, we compared refuge averages to a baseline value. Specifically, we used ecoregions (EPA level II, Figure 1) as a broad unit of comparison because 1) the large spatial variability of indicators is less meaningful at the national scale and 2) the ecological underpinnings of some indicators render political boundaries less meaningful. Biodiversity-related indicators were estimated using the refuge boundaries to capture the species and environments they encompass. Equity indicators were calculated using a buffer that represents communities within a two hour driving distance from the refuge, as a way to capture communities that would be able to reach the refuge for a day trip. We conducted a pairwise comparison of averages by associating the lands with their ecoregion.

Generally, refuges have greater biodiversity value than the ecoregion they sit within (Table 2). However, the current set of refuges is lower than the surrounding region with regard to some key equity indicators, including % people of color and environmental health and pollution. Similarly, refuges are lower on average in their capacity to serve as climate refugia.

Fig 1. Map of ecoregions used in the analysis (EPA level II). Areas in light green are approved for refuge acquisition and areas in darker green are already managed by the U.S. Fish and Wildlife Service.

Table 2. Assessment of the current refuge values for chosen biodiversity, climate change and equity indicators relative to a baseline. Results are based on a pairwise comparison of the average value of the ecoregion and the average values of refuge lands within the ecoregion. Data sources are linked.

Principle	**Application**	**Indicator**	**How do Refuges compare to Ecoregion?**
Representation	*Biodiversity*	# of ESA Species	Significantly +
		Rarity-weighted species richness	Significantly +
	Equity	% Person of Color	Significantly -
		% Latino/a	No Significant Diff
Fundamental Needs	*Equity*	Median Household Income	No Significant Diff
Access to Resources	*Biodiversity*	Connectivity Value	No Significant Diff
	Equity	# of Nature-Deprived Communities	No Significant Diff
Environmental Health	*Equity*	Environmental Health & Pollution	Significantly -
Durability	*Climate Change*	Refugia Value	Significantly -
		Landscape Diversity	No Significant Diff
		Carbon Stored	Significantly +
		Irrecoverable Carbon	No Significant Diff
	Equity	Health Risk	No Significant Diff
		Climate Vulnerability	No Significant Diff

Where could the team focus additional engagement and prioritize resource allocation?

We have a better understanding of how refuges compare to a baseline (i.e., the ecoregion that refuge sits in) and for which indicators, there is room for improvement. Now the question becomes where are there opportunities for making improvements through land acquisition? For this question, average values were compared between managed lands (those already owned by FWS) and land available for refuge expansion. Values were calculated for each refuge and aggregated to the ecoregion level to facilitate a pairwise comparison, identical to the methods for the question above. While this preliminary analysis focuses on broader spatial patterns, the same data can be used for more refined, refuge-specific comparisons (see Figure 2).

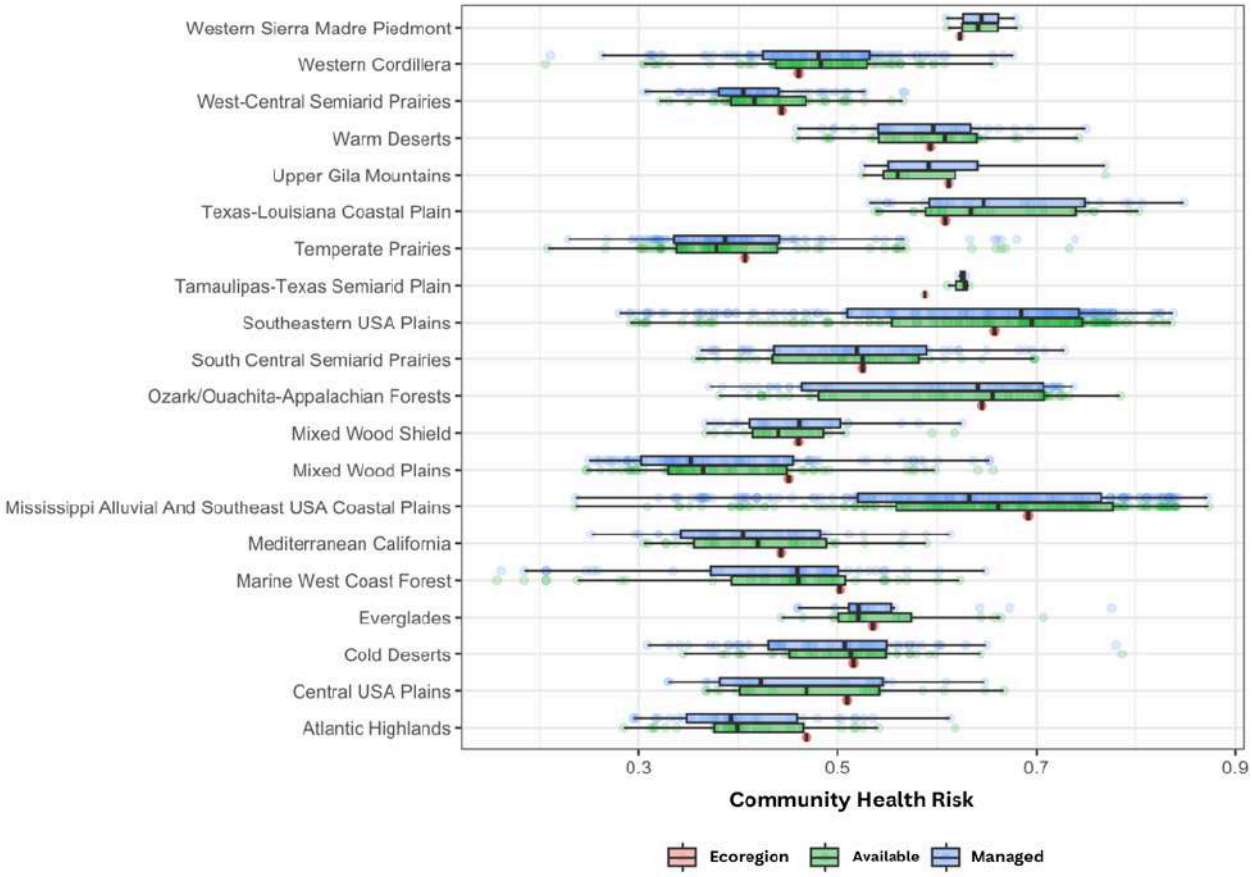


Fig 2. The distribution of values of community health risk (combines physical and mental health, access to care, etc.) for managed refuge lands (blue) and potential acquisition lands (green) across ecoregions in the contiguous United States (y-axis). On average, health risk for acquisition lands was higher than for managed lands in 15 ecoregions ($p = 0.05$). This may suggest that acquiring lands within these ecoregions could bring nature-based benefits to health-burdened communities.

Regardless of whether there were significant differences in pairwise comparisons, we point to "ecoregions of opportunity" by identifying the ecoregions with the largest positive difference in average values between managed refuge lands and those approved for refuge expansion (Table 2B). Taking a stratified approach like this can aid decision-makers working at multiple scales and may ultimately help increase representation of the unique species assemblages and services they harbor in conservation plans.

Based on the preliminary results, the NWRS could make improvements within existing refuge boundaries with respect to many of the analyzed equity indicators (Table 3). Through land acquisition, it's possible to increase access to green space for more low-income, nature-deprived, and health-burdened communities. However, refuge expansion into currently approved acquisition areas will not result in substantial improvements for the three areas where refuges were lacking in comparison to the surrounding ecoregion (i.e., % person of color, environmental health and pollution, and climate refugia).

Three ecoregions have the potential to enhance nearly all principles related to biodiversity conservation, climate mitigation and nature equity through refuge expansions (Figure 3):

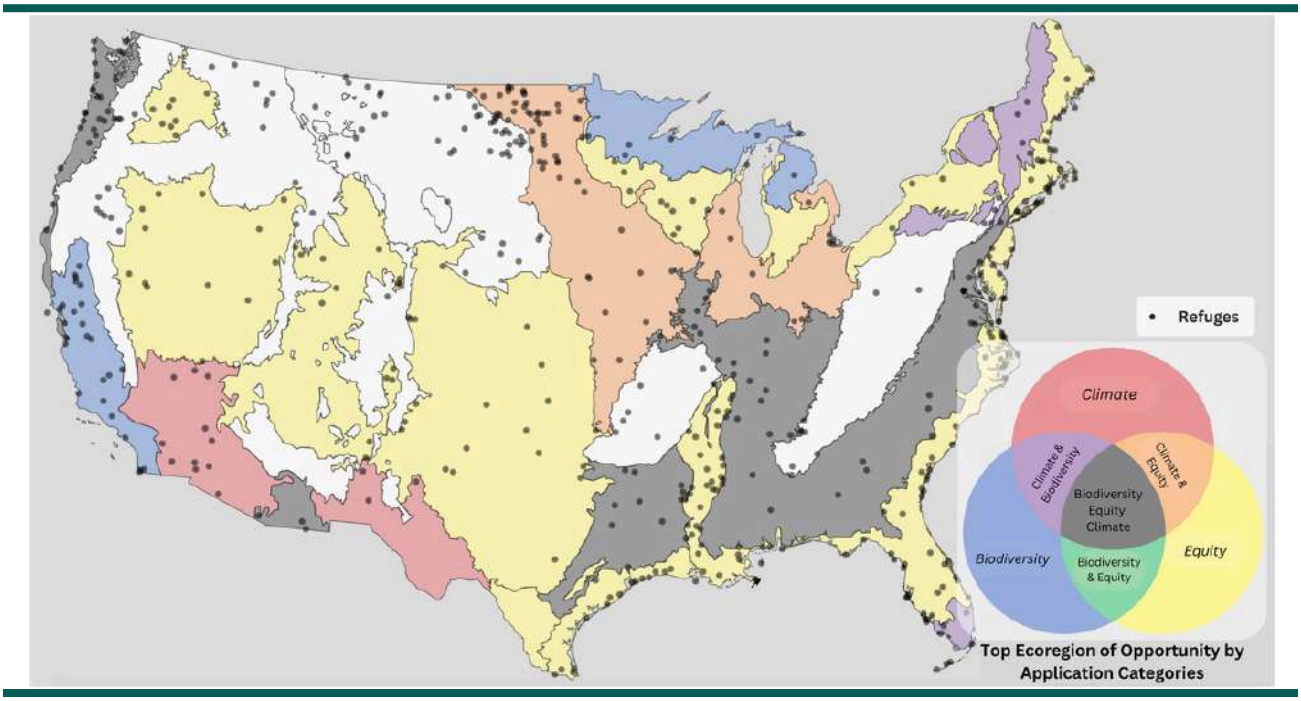


Fig 3. Map of opportunities that refuge acquisition could provide for conserving biodiversity, mitigating climate change and improving nature equity in each ecoregion based on the principles and indicators assessed.

Southeast Plains: Characteristic of the southeastern U.S. there is high biodiversity and significant carbon stored in the subtropical ecosystems. In addition, there is a relatively high concentration of communities that have been historically marginalized and that are likely to continue to feel the negative impacts of climate change. There are few, large public land units in the east, leaving opportunity for impactful investments for nature and human well-being. Refuges here are challenged by low landscape connectivity and climate resilience.

Marine West Coast: Home to some of our nation's mature and old growth forests, the Northwestern U.S. harbors significant stores of irrecoverable carbon and ecosystem-obligate species. These forests are also some of the most visible as they are well-

visited and exist near densely-populated areas. Acquisition opportunities can contribute to mitigating carbon losses, conserving diverse landscapes for resilience, and securing additional recreational opportunities for urban communities.

Sierra Madre Piedmont: A place of intersection between temperate and subtropical mountain ranges, it is one of the most biologically diverse places in the world. Beyond harboring the last undammed river and one of the most important migratory flyways in the Southwest, it is also home to a growing Hispanic population. Refuge acquisition could further benefit rare species, communities of color and carbon stores that are particularly vulnerable under changing climate regimes.

Photo credit: Roxie Crouch

Photo credit: Evangelio Gonzalez

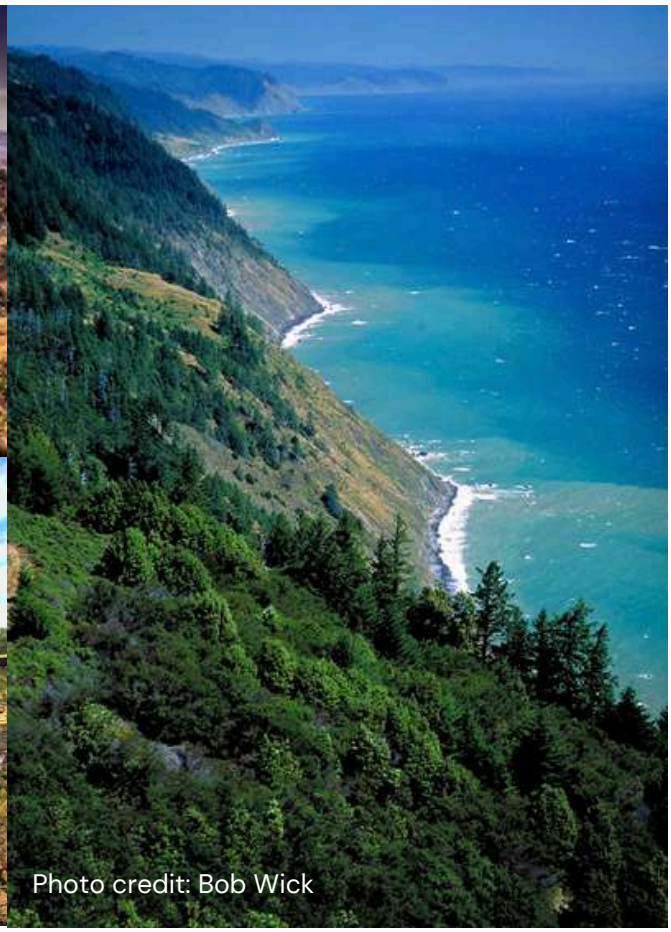


Photo credit: Bob Wick

Though not highlighted for its opportunities for improving biodiversity representation, the Central Plains ecoregion of the Midwest could provide strong opportunities for improving nature equity due to proximity to major U.S. cities like Chicago. It may also help contribute to climate mitigation and adaptation goals.

The following table builds upon the previous analysis (Table 2) to determine whether expanding refuge units would result in improved indicator values. Results are based on a pairwise comparison of the average value of managed refuge lands and the average value of potential acquisition areas within each ecoregion. Ecoregions of opportunity are those which result in the largest positive difference after potential expansion areas are factored in.

Principle	Applic	Indicator	Refuges vs Ecoregion	Improve with Acquisition?	Regions of Opportunity
Represent	*Biodiv*	# of ESA Species	+	No	Atlantic Highlands, Everglades, Marine West Coast
		Rarity richness	+	No	Everglades, Mediterranean CA, Sierra Madre Piedmont
	Equity	% Person of Color	-	No Diff	Central Prairies, Sierra Madre Piedmont, Tamaulipas-TX Plains
		% Latino/a	No Diff	No Diff	Central Prairies, Tamaulipas-TX Plains, TX-LA Coastal Plains
Fundmtl Needs	*Equity*	Median Income	No Diff	Yes	Mixed Wood Plains, MS Alluvial, SE Plains, Cold Deserts
Access to Resources	*Biodiv*	Connectivity	No Diff	No Diff	Sierra Madre Piedmont, SE Plains, Mixed Wood Shield
	Equity	Nature-Deprived	No Diff	Yes	TX-LA Coastal Plains, Temperate Prairies, Marine West Coast
Enviro Health	*Equity*	Enviro Health & Pollution	-	No Diff	Tamaulipas-TX Plains, Temperate Prairies, Sierra Madre Piedmont
Durability	*Climate Change*	Refugia Value	-	No Diff	Temperate Prairies, Warm Deserts, SE Plains
		Landscape Diversity	No Diff	No Diff	Atlantic Highlands, Everglades, SE Plains
		C Stored	+	No	Marine West Coast, Sierra Madre Piedmont, Warm Deserts
		Irrecoverable Carbon	No Diff	No	Marine West Coast, SE Plains, Temperate Prairies
	Equity	Health Risk	No Diff	Yes	MS Alluvial, Central Plains, SE Plains
		Climate Vulnerability	No Diff	No Diff	Temperate Prairies, MS Alluvial, Central Plains

Where and to what extent are outcomes achieved? This question is always the hardest, and one that can't be assessed until this framework is used in the land acquisition process within the NWRS. However, this case study shows that being deliberative with spatial data by focusing on key indicators to meet your ultimate objective can help focus the prioritization efforts. The refuge system could utilize this analysis to focus on the ecoregions identified where we could make progress toward America the Beautiful goals. The FWS could identify individual refuges with active land acquisitions that could improve one or more of the key indicators and reevaluate.

Land acquisition is a future focused conservation action for the refuge system and it will take time to evaluate any impact we have utilizing an analysis such as this. However, we have demonstrated that it is feasible to include equity, biodiversity, and climate change considerations into any prioritization map with a methodical and comprehensive assessment focused on the objective of the decision being made. In fact, a focus on just one principle or indicator could lead to a different result and, subsequently, decisions that may not holistically address the crises that instigated America the Beautiful. Combining the shared principles and the seven questions can help any organization achieve their ultimate goals by thinking about biodiversity, climate change, and equity together rather than as separate entities.

Photo credit: BLM

Photo credit: Don Woerner

ADDITIONAL RESOURCES

Photo credit: Fred Murphy

ON INDIGENOUS DATA GOVERNANCE

Indigenous Governance Database, Native Nations Institute at University of Arizona Online educational and informational resources on tribal self-governance and tribal policy reform that foster Native nation building, promote tribal sovereignty, disseminate Indigenous data, encourage tribal leadership development, and more.

FAIR & CARE

"In 2016, the 'FAIR Guiding Principles for scientific data management and stewardship' were published in Scientific Data. The authors intended to provide guidelines to improve the Findability, Accessibility, Interoperability, and Reuse of digital assets. The principles emphasize machine-actionability (i.e., the capacity of computational systems to find, access, interoperate, and reuse data with none or minimal human intervention) because humans increasingly rely on computational support to deal with data as a result of the increase in volume, complexity, and creation speed of data." You can find more here.

However, FAIR primarily focuses on "characteristics of data that will facilitate increased data sharing among entities while ignoring power differentials and historical contexts. The emphasis on greater data sharing alone creates a tension for Indigenous Peoples who are also asserting greater control over the application and use of Indigenous data and Indigenous Knowledge for collective benefit. This includes

the right to create value from Indigenous data in ways that are grounded in Indigenous worldviews and realize opportunities within the knowledge economy. The CARE Principles for Indigenous Data Governance are people and purpose-oriented, reflecting the crucial role of data in advancing Indigenous innovation and self-determination." You can find out more here
Operationalizing the CARE and FAIR Principles for Indigenous data futures

ON COMMUNITY ENGAGEMENT

Principles of Community Engagement, by CDC
Overview | Full PDF
Provides public health professionals, health care providers, researchers, and community-based leaders and organizations with both a science base and practical guidance for engaging partners in projects that may affect them. The principles of engagement can be used by people in a range of roles, from the program funder who needs to know how to support community engagement to the researcher or community leader who needs hands-on, practical information on how to mobilize the members of a community to partner in research initiatives. In addition, this primer provides tools for those who are leading efforts to improve population health through community engagement.

Capacity Building Through Effective Community Engagement, by US EPA
Full PDF
A booklet intended to help local and state government officials create or expand their plan for engaging meaningfully with the communities most affected by their actions.

The Spectrum of Community Engagement to Ownership, by Rosa Gonzalez, Facilitating Power, 2019
Overview | Full PDF
This resource draws on content from a number of public participation tools, including Arnstein's Ladder of Citizen Participation, and the Public Participation Spectrum.

SB 1000 Toolkit, July 2018
Overview | Toolkit

- This Toolkit was created by an environmental justice coalition and outlines California legislation that requires localities to adopt environmental justice elements in their plans. Chapter 4 gives a walkthrough of community engagement.
- SB 1000 is the Planning for Healthy Communities Act which ensures environmental justice is part of the land use planning process. By centering environmental justice in this process, SB 1000 works to improve equity and to reduce the higher pollution exposure and health burdens in low-income communities and communities of color.

Authentic Community Engagement - Tools, Examples, and Guiding Questions
from the Urban Institute's Community Engagement Resource Center
Overview | Full PDF

- Includes some examples of federal community engagement, in case it's a helpful reference for case studies

ON RESPONSIBLE RESEARCH

Research Within versus Outside Existing Systems - Framing and Studying the Effects of Structural Racism, Urban Institute, October 2023
Overview | Brief | Framework

- This resource provides concrete ideas to support and engage research teams in studying structural racism. We explain how research conducted through a structural racism lens (i.e., "structural racism research") differs from research conducted within a traditional empirical framework—at a minimum by going beyond racial subgroup analyses (differences in outcomes), ideally by exploring how structures and systems interact to create those outcomes (differences in inputs, exposures, interactions, and mechanisms and their relationship to differences in outcomes).
- Key takeaway: Research through a structural frame shifts focus away from an individual's race or other characteristics as associated with disparities and toward systems and structures as drivers of disparities. In partnership with affected communities, researchers name racism at varying levels (institutional, structural, systemic, cultural) as the problem to study, apply research methods that account for historical patterns or accumulation of disadvantage, and develop program interventions or policy recommendations to change the perverse incentives within those systems and structures.

Ethical Space: a term applied to capture the coming together of Western science and Indigenous worldviews with the aim of fostering more meaningful dialogues and research relationships (Almack et al., this issue, Ermine, 2007). "Extending beyond notions of equity, inclusion, diversity, and kindness, the creation and upholding of ethical and equitable space acknowledges oppressive power structures and relations, exclusionary values and positions, and requires accountability in relational work, ethical behaviors, and a culture of care." From a special issue in Journal of Great Lakes Research
Implementing "ethical space": An exploratory study of Indigenous-conservation partnerships
Enacting and Operationalizing Ethical Space and Two-Eyed Seeing in Indigenous Protected and Conserved Areas and Crown Protected and Conserved Areas

Supplemental Table. Example datasets and sources for an indicator on species richness. Sources are linked. See case study for more details.

Dataset	Objective	Process	Premise
Range-size rarity Hamilton et al. 2022	Conserve areas where the most imperiled species are present.	Weighted richness	Range-restricted species are vulnerable, have fewer options for conservation, higher risk of extinction
Species complementarity Belote et al. 2021	Conserve a set of lands that maximizes the total number of species represented.	Optimization of habitat suitability	All species are equally important and priority is to identifying a set of sites that most efficiently represent all species
Bird communities Taylor et al. 2022	Conserve areas that serve to benefit the most bird species today and under climate change.	Stratified optimization of species data	Birds are diverse and broadly distributed and representative of other species, climate change will alter distributions, conserving places that are both important today and under climate change will provide continuity.
Recognized biodiversity value Anderson et al. 2023	Conserve places recognized for their current biodiversity value to protect thriving communities and provide source areas for dispersing populations.	Compile data from 104 published TNC ecoregional assessments and state wildlife action plans	State or ecoregion-based areas of importance serve as quality examples of natural communities, intact habitats or vulnerable species populations, are supported by local politics and economies for more durable conservation
Protection-weighted range rarity Hamilton et al. 2022	Conserve areas where under-protected and range-restricted species are most likely to occur.	Weighted richness	Range-restricted species outside of protected areas are vulnerable and at higher risk of extinction because human activities are not limited
Species richness	Many versions (ex: Jenkins et al. 2015, Belote et al. 2021)	Sum binary datasets representing individual species distributions	All species are equally important and greater number of species translates to other types of diversity being higher (genetic, functional, etc)