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Investing in Nature to Fight Climate Change and Help Communities Thrive

July 2024

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BEZOS EARTH FUND

The Bezos Earth Fund commissioned preparation of this report with David J. Hayes in cooperation with Stanford Law School's Law & Policy Lab.

Investing in Nature to Fight Climate Change and Help Communities Thrive

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EXECUTIVE SUMMARY

In recent years, policy-makers and business leaders in the U.S. have been turning to nature to help combat climate change. So-called "nature-based solutions" (NBS)[1] can sequester and store carbon dioxide in trees, other forms of biomass, and/or soils—using the natural carbon cycle to remove excess carbon dioxide from the atmosphere that is causing climate change.

In addition to removing carbon from the overloaded atmosphere, NBS projects also generate co-benefits that can help nearby communities in a multitude of ways. In particular, NBS projects can increase community resilience to destructive climate impacts such as sea rise and storm surges in coastal areas (via green infrastructure projects such as coastal wetlands, mangroves, oyster beds, etc.), excessive heat (via urban greenways and forests), catastrophic wildfires (via improved forest management practices), and the like. And nature-based investments also can produce other valuable "ecosystem services" by promoting cultural values, restoring habitats and other key landscape functionality (e.g., biodiversity and clean water), and enhancing the quality of life in cities (e.g., making them cooler) and rural areas (e.g., promoting recreation, ecotourism, and amenity values).

Despite all of these positives, there is a broad consensus that nature-based solutions are not playing as prominent a role as they should, given the measurable climate benefits that they can generate and the many valuable—but typically undervalued if not ignored—ecosystem services that they generate.[2]

This Stanford Law and Policy Lab has taken a fresh look at nature-based solutions and has concluded that the failure to use advanced tools to measure and confirm the climate and other ecosystem services generated by NBS projects is holding back their deployment.

Policymakers and investors are looking for proof that nature-based solutions can deliver measurable and verifiable carbon emissions reductions and removals—and they are not getting it—even though data generated from upgraded measurement, monitoring, reporting, and verification tools (MMRV), when integrated into open-source greenhouse gas information systems, can deliver needed proof points. Simply put, stronger confirmatory data, when broadly shared and continuously improved, will unlock the power of nature to combat climate change while also delivering other highly valuable ecosystem services.

The report is divided into two parts. Part I focuses on needed improvements in quantifying and verifying carbon reductions and removals from activity-level investments in reforestation, agroforestry, and other nature-based projects.

Part I of the report spreads the good news that new MMRV technologies and methodologies are available to quantify and confirm the carbon benefits that deploying "climate-smart" practices[3]

in forestry, agriculture, and other land applications can generate with significantly more precision and confidence than is the norm today. The federal government is waking up to this fact and is beginning to more systematically identify and develop stronger MMRV tools that can validate carbon reductions and removals. It cannot do this alone, however. Close collaboration with state, tribal and local leaders, companies, NGOs, and academic leaders is needed to sharpen the focus on real world use cases and to make significant progress in this area.

Recommendations made in Part I of this report:

1. **A public/private collaborative should identify consensus-based, scientifically-sound, "high integrity" MMRV protocols that include effective data collection, modeling, and GHG information-sharing elements for high-priority activity-level practices that claim carbon reductions or removals.**

2. **A greenhouse gas data, protocol, and modeling "Information System" that provides public access to verified greenhouse gas data, protocols and models for nature-based solutions should be established.**

Part II of the report widens the lens beyond carbon to the many other ecosystem services that often flow from nature-based solutions including climate resilience, biodiversity, clean water, and stronger communities. Part II makes the case that the U.S. needs a system for crediting co-benefits that nature-based projects deliver to communities alongside the crediting of verified carbon reductions and removals. Now is the time to take advantage of the strong interest in carbon reductions and removals to sharpen how NBS co-benefits are identified, quantified and monetized.

Recommendations made in Part II this report:

3. **The President should appoint a high-level Ecosystem Services Valuation Panel (ESV Panel) comprised of key policymakers, economists, and ecologists and charge the ESV Panel with surveying and recommending methods for quantifying and monetizing ecosystem services co-benefits that flow from NBS projects.**

4. **The U.S. Department of the Interior, in consultation with the Department of Agriculture, the Office of Management and Budget, and the Office of Science and Technology Policy, should develop and pilot an ecosystem services scoring system for use in federal funding decisions and in identifying lands that meet the America the Beautiful initiative's "30X30" conservation goals.**

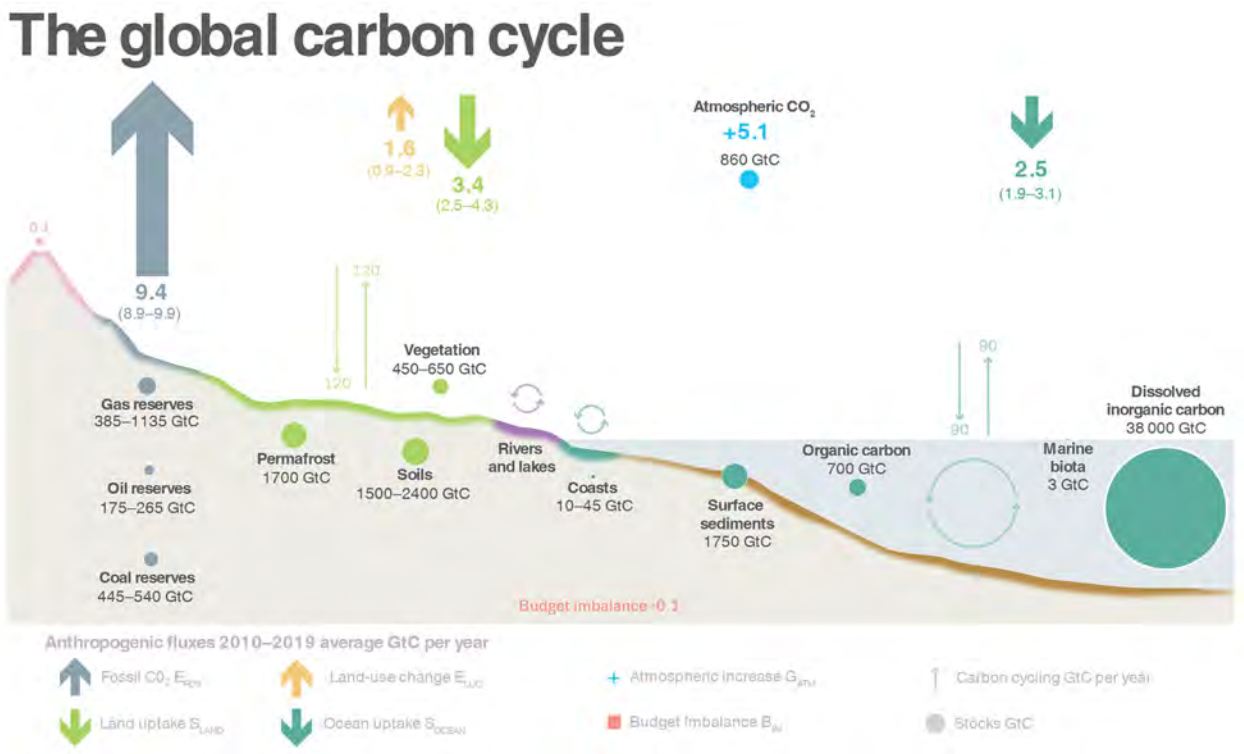
We want to thank three NGOs in particular—American Forests, the National Fish & Wildlife Foundation, and The Nature Conservancy—for sharing real-world nature-based solutions use cases with Policy Lab students. The use cases provided by American Forests, NFWF, and TNC illustrate the multiple societal benefits that can flow from investing in nature-based solutions, and the need to bring a disciplined approach to identifying, measuring and confirming the scope of those benefits for policymakers, investors, and interested citizens.

A special thanks also to the Bezos Earth Fund which commissioned preparation of this report with David J. Hayes in cooperation with the Stanford Law School's Law and Policy Lab.

BACKGROUND ON NATURE-BASED SOLUTIONS

Nature-Based Solutions Generate Climate Benefits by Sequestering Carbon in Biomass and Soils

It is undisputed that nature's remarkable photosynthesis process is playing a major role in combatting climate change by converting gigatons tons of airborne carbon dioxide into carbon that is taken up and sequestered in soils and terrestrial biomass. Currently, the world's terrestrial ecosystems sequester approximately thirty percent of annual anthropogenic carbon emissions.



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Investments in climate-smart forestry and agricultural practices such as reforestation, improved forest management, cover cropping, and agroforesty (integrating trees into crop and pasture lands[5]) can reduce or remove additional carbon.[6] One often-cited study concluded that expanding the deployment of these and other nature-based solution projects potentially could generate more than one-third of the GHG emissions reductions needed to meet a 2 °C warming target by 2030—with many of the reductions being achieved at relatively low cost.[7] (Notably, avoided forest conversion ranks as one of the highest impacts of any NBS–providing a reminder that maintaining the health of existing forests and other carbon sinks must always be a top priority.)

While scientists agree that investments in NBS projects typically sequester additional carbon in landscapes and seascapes, the photosynthesis process that converts carbon dioxide into carbon is difficult to measure and track with precision. In contrast, carbon dioxide emissions from fossil fuel combustion point sources such as power plants and automobile and truck tailpipes can be measured with precision using readily-available technologies.[8]

As discussed in Part I below, the U.S. has not, to date, invested adequate effort to generate credible and verifiable estimates of reduced or removed carbon at the NBS project level. Important initiatives are underway, however, to remedy this deficiency, as laid out in this report. They must be supported and expanded.

Nature-Based Solutions Also Generate Other Valuable Ecosystem Services Co-Benefits

In addition to combatting climate change by reducing and/or removing carbon from the atmosphere, many nature-based solutions also generate other important ecosystem services such as climate resilience, biodiversity, clean water, and other community-related benefits, as illustrated below.[9]

Climate Resilience

Nature-based investments that enhance communities' resilience in the face of climate impacts are increasing in response to the significant damage that climate change-infused extreme weather is causing in urban settings, coastal areas, and other regions. Climate resilience NBS project can produce multiple ecosystem services. For example, investing in natural landscapes rather than engineered hardscapes in cities can provide enhanced flood protection (through nature-based drainage infrastructure), reduced air pollution impacts (through natural filtration), and reduced local heat stress (through urban forestry), among many other benefits.[10] In coastal areas, maintaining and/or restoring coastal marshlands and wetlands, growing oyster reefs, and restoring or planting mangroves, sea grasses and other on-shore and near-store natural barriers stabilize soils and sediments, absorb wave energy, and mitigate damage from extreme weather events, including sea rise and storm surges.[11] These NBS projects—working alone or in hybrid combinations with more traditional approaches—often prove to be more resilient and resistant to climate impacts than sea walls or other engineered solutions acting alone.

Biodiversity, Clean Water, and other Ecosystem Services.

Habitat restoration activities such as reforestation, wetlands and grasslands restoration, and the creation of wildlife corridors can generate significant biodiversity benefits. Similarly, restored wetlands and riparian buffers can deliver water-related ecosystem services by capturing excess rainfall runoff and slowly releasing it over time—thereby greatly reducing the risk of catastrophic flooding. Likewise, conserving and restoring upland watersheds can filter

pollutants, reduce sediment run-off, and improve the quality of water in rivers, lakes, and aquifers. More information about these and other ecosystem services benefits is discussed in more detail later in this report.

As described in Part II below, these additional ecosystem services co-benefits have garnered significantly less quantification or valuation attention than carbon reductions and removals—despite the value they generate for local communities. Recommendations to rectify this situation are discussed in Part II.

I. NEW MEASUREMENT TOOLS AND AN OPEN-SOURCE INFORMATION SYSTEM ARE NEEDED TO CONFIRM NBS CARBON BENEFITS AT THE ACTIVITY LEVEL

Background

GHG measurement and verification issues traditionally have revolved around the U.S. obligation to compile an annual national inventory of GHG sources and sinks. A number of powerful new policy drivers, however, has given rise to the need to measure and monitor carbon reductions and removals at the activity or project level. This is a new challenge that needs to be met with new measurement tools that are tailored to project types, and a related open-source information system.

Inventory-Based GHG Quantification

Beginning in the early 1990s, and annually thereafter, signatories to the United Nations Framework Convention on Climate Change have been required to generate national inventories that estimate the overall GHG "emissions and sinks" within their borders.[12]

Per this obligation, the Environmental Protection Agency (EPA) prepares an annual national Inventory of Greenhouse Gas Sources and Sinks based on canvassing a large number of information sources. Inputs into the EPA process have improved over time, although their precision varies widely. For emission sources that fall within EPA's regulatory ambit such as CO2 emissions from power plants and automobiles and trucks, for example, the agency is able to collect granular data on carbon dioxide emissions.[13]

In the unregulated land sector, however, granular data inputs have not been available. In their stead, the EPA works with federal land management agencies to provide national estimates of nature-based carbon fluxes based on a variety of available databases and models. These databases and models typically provide high-level estimates of carbon stocks and emissions for agriculture, forestry, and other land-based activities.

In addition to collecting data and models for inputs to the national inventory, the Department of Agriculture has undertaken an ambitious program to develop "entity-scale inventory" methods that can enable individual farms, ranches, or forests (the "entity") to estimate their net greenhouse gases profile.[14] The USDA has invested heavily in models and software tools—such as the DayCent model and CometFarm software tool—that landowners are encouraged to use through a self-reporting mechanism to roughly quantify emissions and reductions attributable to all relevant activities conducted on a farm or other entity.[15]

Activity-Based GHG Quantification

As strategies to combat climate change have become more sophisticated, attention has shifted in the nature-based solutions context from an inventory-oriented quantification of carbon emissions and removals to activity-based quantification exercises that track greenhouse gas changes when landowners adopt climate-smart practices that are designed to reduce carbon emissions or increase carbon sequestration. To make this calculation, practice- and region-specific protocols directing how to measure baseline conditions and monitor and verify carbon changes over time for specific climate-smart practices are needed.

Multiple policy drivers are behind this shift in attention. First and foremost, policymakers and investors need activity-level GHG performance data—not information at the national inventory or entity level—to make informed, evidence-based choices among climate-smart practice options.

Second, the Congress is focusing its agriculture and forestry climate policy and funding at the activity level, where it expects the Department of Agriculture to provide proof that funding climate-smart practices is generating meaningful, measurable carbon benefits. More specifically, the Inflation Reduction Act appropriates $19.5 billion in USDA conservation activity-level grants "that the Secretary determines directly improve soil carbon, reduce nitrogen losses, or reduce, capture, avoid, or sequester carbon dioxide, methane, or nitrous oxides."[16] The Act also appropriates $300 million explicitly for MMRV-related funding for "conservation practice standards, implementation data, and training and technical guidance to increase the GHG mitigation potential of practices and [the USDA's] ability to estimate outcomes."[17]

Similarly, the REPLANT Act—which was adopted as part of the Bipartisan Infrastructure Law—now makes available more than $100 million annually to engage in reforestation efforts—a climate-smart practice that will result in carbon removals.[18] But how many tons will be removed through these efforts? Activity-level analyses focused on reforestation use cases are needed to answer that question.

Third, the Biden Administration has launched two major initiatives that emphasize the necessity of improving how GHG performance is measured, monitored, reported and verified *at the activity-level*. In particular, the USDA's Partnerships for Climate-Smart Commodities initiative

has awarded $3.1 billion in competitive grants to 141 activity-level projects that are seeking to confirm GHG benefits—often using innovative MMRV approaches that will produce more definitive validation of GHG reductions and removals.[19] The focus on activity-level MMRV in this innovative program was intentional. In the initiative's notice of funding opportunity, USDA explicitly emphasized its strong interest in funding proposals that will be piloting leading edge activity-level MMRV technologies and methodologies.[20]

Even more definitively, the National Strategy to Advance an Integrated U.S. Greenhouse Gas Measurement, Monitoring, and Information System (the "National GHG MMRV Strategy") that the White House released late last year, called out "Improv[ing] Activity-Based GHG Quantification Approaches" as the first of five "National [GHG MMRV] Objectives."[21] The National Strategy explained this choice by noting that "*activity-based* GHG quantification approaches…form the basis of emissions reduction targets and climate solutions." (Emphasis added.) When identifying "supporting tasks" that should be undertaken to advance this National Strategy Objective, the Strategy explicitly referenced "improv[ing] activity data, including information on baseline emissions that provide a benchmark for evaluating the impact of climate actions over time."[22]

Finally, compliance and voluntary carbon markets both rely heavily on nature-based, *activity-level* carbon reduction or removal projects as their bread and butter. Because of well-publicized criticism of carbon reduction and removal claims made in those markets, a major push is on to improve MMRV for nature-based solutions and certify them as "high-integrity" carbon credits—with virtually all of the focus on improving *activity-level* MMRV.[23]

Reinforcing this point, the Biden Administration underscored the importance of shoring up voluntary carbon markets in its recent Voluntary Carbon Markets Joint Policy Statement and Principles document, commenting that VCMs are needed "to support decarbonization efforts…[and] accelerat[e] net emissions reductions while reducing their cost"[24]—a goal that cannot be achieved without strong, activity-level MMRV. In a Fact Sheet that accompanied release of the Joint VCM Policy Statement and Principles, the White House pointed to multiple *activity-level* MMRV initiatives including, in particular, the National GHG MMRV Strategy "which seeks to enhance coordination and integration of GHG measurement, modeling, and data efforts to provide actionable GHG information."[25]

Recommendation #1: A public/private collaborative should identify consensus-based, scientifically-sound, "high integrity" MMRV protocols for high-priority activity-level practices that claim carbon reductions or removals.

> **Subrecommendation: The Administration should identify a few important use cases in which new MMRV protocol development already is underway and use them to inform how the U.S. government can effectively participate in and guide the development of consensus-based protocols that include effective data collection, modeling, and GHG information-sharing elements.**

To date, the U.S. government has had a very limited role in developing protocols and standards[26] that define how to measure, monitor, report, and verify carbon reductions and removals at the activity level. Because the U.S. government has chosen not to lead activity-level GHG protocol development, multiple carbon registries have been filling the void by developing their own protocols that, when followed and applied to relevant land management practices, are relied upon to justify carbon credit payments in the unregulated voluntary carbon markets.[27]

Unfortunately, the proliferation of carbon registry-based protocols has created confusion and uncertainty about the quality of the data and modeling underlying claimed carbon credits and whether they are built upon "robust, comprehensive and transparent scientific underpinnings." [28]

Congress has heard these concerns and, in the Growing Climate Solutions Act, it referenced this unfortunate state of affairs in requesting that the USDA take a more active role in evaluating protocols, providing technical support, and establishing a third-party verifier program.[29]

In responding to Congress' request, the USDA candidly acknowledged that the proliferation of privately-developed protocols has sowed confusion and factored into the loss of confidence in voluntary credit markets that have sprung up around the protocols.[30] The USDA explained that farmers, ranchers, and landowners have struggled to join VCMs because "differences in data requirements, practice eligibility, compensation, and obligation periods among the different carbon programs make it difficult for producers to understand what they need to do to access programs and what benefit they would receive from participation."

Illustrating the point, the USDA identified 55 protocols relevant to agricultural and forestry carbon credits of which 18 have been used for developing carbon credits. For optimized nitrogen management (e.g., practices that increase nitrogen availability in the soil), three carbon registries have developed four different protocols in the U.S. Similarly, for carbon sequestration from wetlands, one carbon registry (ACR) developed three protocols and a fourth protocol was developed by another carbon registry (VCS).[31]

The non-uniform approaches taken in protocols—in addition to their sheer numbers—add to the problem. For example, a recent analysis by the Environmental Defense Fund and the Woodwell

Climate Research Center compared 12 protocols being used for soil carbon sequestration practices. The approaches for measuring soil carbon differ widely among these protocols, from using soil sampling only, to adopting different modeling techniques (e.g., biogeochemical models or emissions factors), to hybrid approaches using soil sampling and models or remote sensing data and soil sampling.[32] Likewise, different soil carbon protocols adopt inconsistent methodological approaches for setting baselines (e.g., setting static vs. dynamic baselines) that may significantly impact net sequestration rates—particularly as environment-specific uncertainties can have enormous implications for the quantification and durability of baseline starting-points.[33]

In the White House Fact Sheet that accompanied release of the Voluntary Carbon Markets Joint Policy Statement and Principles, the White House referred approvingly to the USDA's decision to proceed with a program that will address the protocol credibility crisis in the agriculture and forestry sectors. The White House described the USDA's undertaking as involving the identification of "*high-integrity protocols* for carbon credit generation that are designed to ensure consistency, effectiveness, efficiency, and transparency."[34] (Emphasis added.)

The White House's and the USDA's acknowledgement of the need to weigh in on and potentially endorse "high-integrity protocols" is an important step forward in deploying new MMRV tools to confirm carbon reductions and removals from climate-smart practices.

But no one agency can or should do this on its own. As the National GHG MMRV Strategy makes clear, establishing a credible, national "measurement, monitoring and information system" must be a public/private collaborative effort that adheres to six shared principles. Specifically, it must be **Science-based**; **Sustainable**; **Collaborative** (as in "establish[ing] and nutur[ing] close collaborations between the USG, state/local/Tribal entities, academia, private sector, NGOs, and international institutions"); **Evolving** (as in "reflect[ing] advances in data, modeling, and measurement technologies" in a way that "include[s] new partners"); **Transparent (**in the "methods and data used to generate GHG estimates, as well as the quantification of uncertainties associated with those estimates"); and **Equitable and Inclusive**.[35]

The National GHG MMRV Strategy also forthrightly identified "development of science-based standards to ensure consistent and accurate GHG measurements" as one of the five National Objectives for advancing the National Strategy. As explained in the National Strategy document:

> "Standards development, dissemination, and adoptions will play a critical role in improving…GHG measurements across observing instruments, methods, and data providers. *The standards discussed in this objective refer to physical and documentary standards that specify* ***protocols, methods****, and use of specific physical standards*." (Emphasis added.)[36]

The same passage emphasizes that the federal government must work with outside stakeholders in developing MMRV protocols and methods, including "local, state, and Tribal governments; regional coordinating bodies; private sector entities; the science community; and international and nongovernmental bodies."[37]

In summary, we have seen what happens when there is not a joint commitment by governmental and non-governmental experts and policymakers to seek consensus around specific GHG protocols. It is important to move away from having well-meaning but narrowly focused organizations or governmental agencies defining whether and what data collection should be undertaken when evaluating carbon changes; whether existing models are adequate and appropriate for activity-level extrapolations; and whether and, if so, how data and conclusions generated through the use of protocols will be made publicly available in interoperable and accessible formats. The far better approach is to develop consensus-based protocols through a process that engages policymakers and experts from agencies across the U.S. government (including, in particular, from agencies like NIST that are experienced in standard-setting exercises), and representatives of states and tribes, NGOs, companies, and other stakeholders.

The White House's recent creation of a new unit in the Office of Science and Technology to oversee implementation of the National GHG MMRV Strategy provides a golden opportunity to pull together relevant federal agencies and outside experts and stakeholders and pilot the development of "high integrity" consensus-based greenhouse gas MMRV protocols.

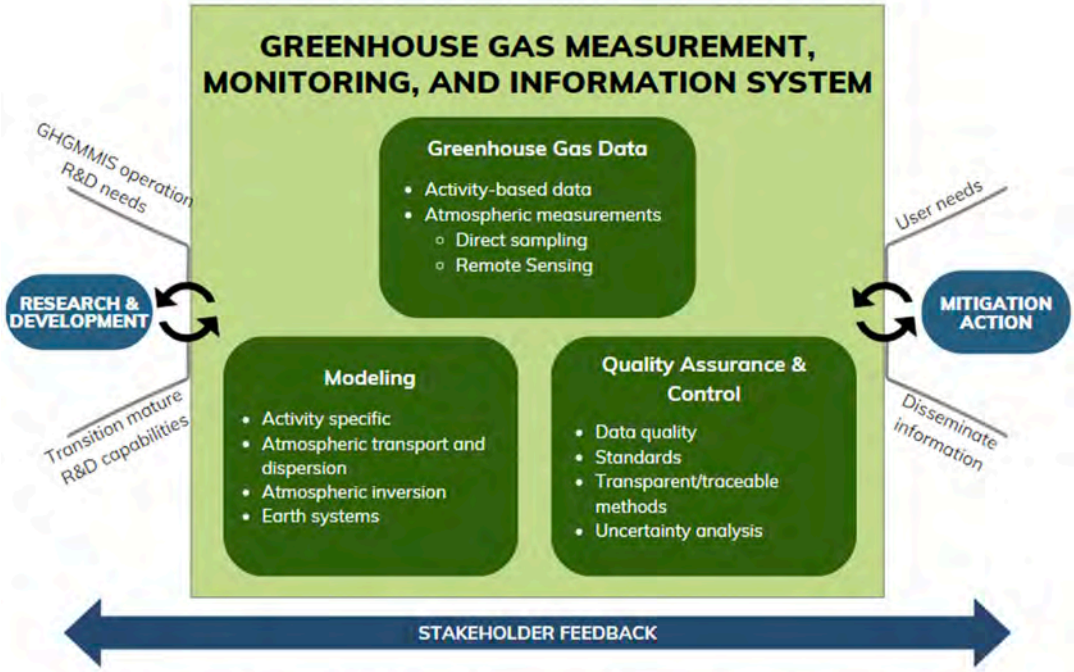

Figure 2. *The GHGMMIS will leverage and integrate USG and non-USG measurement, monitoring, and data capabilities and assets—ranging from data and modeling systems to data quality assurance and dissemination.*

[38]

Subrecommendation: The Administration should identify a few important use cases in which new MMRV protocol development already is underway and use them to inform how the U.S. government can effectively participate in and guide the development of consensus-based protocols that include effective data collection, modeling, and GHG information-sharing elements. The two use cases discussed below present excellent opportunities to implement this approach.

The American Forests/United States Forest Service Reforestation Use Case[39]

As noted above, the REPLANT Act has unlocked much-needed funding to plant trees on millions of acres in U.S. National Forests that have been devastated by wildfire, insect infestations, long-term drought, and other harms. Reforestation is the single largest natural climate solution in the U.S.,[40] with 148 million acres of the continental U.S. suitable for this practice (reforestationhub.org). The successful scaling of reforestation—with an eye to how climate change is affecting forest regeneration and resilience—could potentially increase forest sequestration in the U.S. by ~20% annually[41] and help to stave off a future in which forests become a part of the problem versus part of the solution.

Under a cooperative agreement with the U.S. Forest Service, American Forests, a U.S.-based non-profit focused on forest conservation and restoration, has been working closely to partner with the U.S. Forest Service (USFS) to address all phases of the reforestation process, including seed collection, nurseries, workforce development, contractor capacity and, importantly and relevant to this Policy Lab's topic, scaling reforestation supply chains and operational reforestation with both implementation- and outcome-oriented measurement and monitoring. Institutionalizing a monitoring & adaptive management framework through the REPLANT Initiative can support data driven decision-making at a scale relevant to management of the nation's largest national forests. Doing so also responds to the USFS's REPLANT Act National Reforestation Strategy, which calls on the agency to improve its monitoring capabilities and to expand partnerships in pursuit of adaptive management and use of innovative technologies, such as remotely sensed data.

A core focus of American Forests' reforestation partnership with the USFS is post-fire reforestation which is, by itself, an increasingly important natural climate solution, having the potential in some areas to sequester and store more carbon than other forest management interventions over the long term.[42] Not only is climate-informed reforestation crucial to maintaining forest sinks and achieving climate goals—but it is vital to the provision of water, biodiversity, and other ecosystem services and values. (*See* Appendix C for additional information about the innovative ways that the reforestation use case is spotlighting ecosystem service co-benefits of post-fire restoration.)

Post-disturbance reforestation requires its own data measurement and analysis process. Robust forest MMRV is needed to facilitate confidence in public and private investments, to support adaptive decision-making by land managers, and ultimately ensure that forests remain a climate solution—which is why National Forest System reforestation is poised to be a strategic national use case for data-driven decision making about natural climate solutions. Instituting a data collection program at the scale of the Forest Service's REPLANT Act implementation will increase the pace of learning and innovation, increasing the ability to successfully respond to climate change, and align natural climate solutions and other co-benefits with ecosystem health and resilience.

As part of its REPLANT Initiative, American Forests is working with the USFS Washington Office, USFS Office of Sustainability and Climate (OSC), and the Northern Institute of Applied Climate Science (NIACS) to develop a consensus-based modularized monitoring protocol for post-fire reforestation. The goal is to align a statistically robust protocol for ground-based and remotely sensed data collection with existing USFS monitoring protocols focused primarily on tree survival and stocking, provide a foundation for adaptive management to guide science-based management interventions, and provide a dataset for validating carbon outcomes resulting from reforestation actions. Importantly, the protocol will compare recovery outcomes in areas where no reforestation actions are taken relative to traditional and climate-informed reforestation tactics, such that the consequences of various levels of investment can be derived at a landscape- and National-Forest-System-scale.

The National Fish & Wildlife Foundation/Woodwell Climate Research Center Grasslands Use Case

The National Fish and Wildlife Foundation (NFWF) is spearheading the development of a consensus-based protocol that will use a common data gathering, modeling, and verification approach to evaluate carbon uptake and methane emissions on working lands in the U.S. northern grassland region. NFWF has contracted with the Woodwell Climate Research Center to develop the protocol—which is designed to generate region-wide estimates of GHG changes over time—and it is working with its government partners (the USDA's Natural Resources Conservation Service, among others) and subgrantees (including the Audubon Society and the World Wildlife Fund, among others) to maximize common adoption of the new protocol.

Prior to this initiative, organizations working with ranchers in the northern grasslands were using a variety of different methods to quantify carbon concentrations in grassland soils, making it difficult to evaluate whether certain NBS solutions, such as grasslands restoration or adopting different grazing management practices, were effective. By coordinating protocol development with multiple partners across an extensive landscape, the NRCS, NFWF, and their partners are poised to generate new data sets and modeling results that will generate greatly improved estimates of carbon reductions and GHG emissions reductions than are now available—while

acquiring valuable knowledge regarding how to effectively engage key stakeholders, including affected ranchers—in a consensus-based protocol development process.

Recommendation #2: Establish An Open-Source Greenhouse Gas Data, Protocol, And Modeling Information System That Provides Public Access To Verified Greenhouse Gas Data, Protocols And Models For Nature-Based Solutions.

The lack of public access to data sets and specialized modeling exercises (including decision support tools) that can reinforce or undermine carbon claims is one of the most vexing barriers in obtaining a fuller understanding of the relative performance of various carbon reduction and removal activity-level strategies and practices.

The National GHG MMRV Strategy recognizes this problem and identifies improvement of "Latency, Completeness, Interoperability, and Accessibility of GHG Data" as one of its five National Objectives. The Strategy notes that federal GHG data alone is, in many cases, "stored in different repositories, disseminated in different formats, collected at irregular schedules, and not interoperable with other datasets that could be useful to compare to or combine to provide enhanced data products."[43] As succinctly put in a recent, thoughtful paper by leading climate scientists Novick, et al[44]:

> "Data and products generated by federal agencies or through external partnerships should be openly and freely accessible to all interested parties, including nonfederal scientists, state and local government officials, and cultural and natural resource managers. Open and accessible databases are critical to drive science forward and develop next-generation approaches for MMRV…. Right now, protocols [used to monitor and verify NBS projects] vary substantially and lack rigorous standardization against common datasets which limits the system-wide equivalency of carbon credits and erodes confidence in NbCS implementation."

The federal government took an initial step forward to address the data interoperability and accessibility issue when it created the U.S. GHG Center portal a year ago, with the intent of providing policymakers and the public with "open access" to "a wide array of GHG datasets and visualizations."[45]

While the (latest of many) open-source portal(s) is a start, it a far cry from a publicly-accessible GHG "Information System" of the type referenced in the National GHG MMRV Strategy. The Strategy anticipates creation of a comprehensive open-source Information System that emphasizes activity-level GHG information, includes both federally- and privately-originated GHG data and modeling, is focused on the needs of data users, and will facilitate more informed decision-making.[46]

Federal leadership also is needed to ensure that the National GHG MMRV Strategy's call for the application of "FAIR" or "FAIRER" principles to GHG data collection and sharing efforts. (FAIR stands for Findable, Accessible, Interoperable, and Reusable; "FAIRER" adds Equitable, and Responsible.) The data "interoperability" concept—which enables data sets from similar activity-level use cases to be stacked and compared (i.e., through the use of common definitions and coding conventions) is a particularly critical component to an effective GHG Information System. Data interoperability advances inclusivity by enabling multiple users operating on different platforms —including policymakers, researchers, and the public—to easily access key GHG data and information.[47]

Likewise, leadership is needed to ensure that GHG information is presented in a way that it is "findable and accessible" by policymakers, investors, and ordinary citizens. A potential model to emulate is the GIS-based platform that NOAA developed to share climate adaptation and resilience information to a wide variety of users—the Climate Mapping for Resilience and Adaptation or "CMRA" tool.[48]

Establishing a GHG "Information System" that satisfies all of these key principles will not be easy. Add to the mix the fact that the information system needs to combine both governmentally and privately-generated data and modeling products; that curation of GHG information will be needed to make it findable and accessible; and that the information system must be responsive to multiple stakeholders' needs-driven use cases.

Undertaking a scoping exercise regarding where and how an effective GHG Information System is set up and managed should be a priority. To promote flexibility and durability, it may be appropriate to consider establishing a special purpose organization outside the government that transparently provides agreed-upon GHG information services.

II. THE U.S. NEEDS A SYSTEM FOR RATING CO-BENEFITS THAT NATURE-BASED PROJECTS CAN DELIVER TO COMMUNITIES

While nature-based solutions' ability to reduce or remove carbon commands the most (and sometimes the only) attention due to its bankable climate benefits, most NBS projects also generate other significant ecosystem services. Indeed, some NBS projects that may only accumulate modest carbon sequestration benefits over long periods of time can produce other highly valuable ecosystem services co-benefits right away. For example, while the carbon benefits of planting cover crops are modest, the practice can generate significant value by increasing croplands' resilience in the face of climate impacts (e.g., by reducing erosion and

enhancing water quality). Likewise, investing in improved forest management practices can generate significant wildlife and biodiversity benefits, in addition to increasing carbon stocks.

Despite this reality, ecosystem co-benefits typically are credited only at the margin, if at all. There are two primary reasons for this. First, characterizing and calibrating the nature and quantity of a biodiversity benefit, or an incremental improvement in water quality, and attributing it to a nature-based solution, is a difficult MMRV challenge. Second, attaching a monetary value on these types of ecosystem services also is difficult.[49] Both issues present more complex challenges than characterizing, quantifying and monetizing carbon reductions or removals.

Despite these challenges, there is no question that NBS co-benefits can provide major benefits to communities and should not be discounted or ignored. Identifying and rating co-benefits can and should be folded into decision-making processes in a disciplined way—particularly insofar as ecosystem co-benefits may be the most direct and relevant benefits for the communities that are closest to, and most impacted by, NBS projects.[50]

For these reasons, the Policy Lab urges the federal government to invest resources in identifying and rating NBS project co-benefits to the extent feasible. (We use the word "rating" to acknowledge the difficulty of having no clear quantification metric to use when evaluating co-benefits.)

Background

Key Categories of Ecosystem Services Co-Benefits

As discussed above, ecosystem services associated with NBS projects can vary significantly, depending on ecosystem and project activity types. To facilitate a productive discussion, we are focusing this report's attention on four broad categories of ecosystem co-benefits: (1) climate resilience benefits, including community protection from climate impacts; (2) cultural and social values; (3) water quantity and quality; and (4) biodiversity. A quick overview of each category follows:

Climate Resilience Benefits, including Community Protection

As mentioned in the Executive Summary, investments in NBS infrastructure projects can increase community resilience to destructive climate impacts such as sea rise and storm surges in coastal areas (via green infrastructure projects such as coastal wetlands, mangroves, oyster beds, etc.), excessive heat (via urban greenways and forests), catastrophic wildfires (via improved forest management practices), and the like.

The climate resilience benefits that can flow from NBS projects are tied to the weather and climate disasters that are taking a terrible toll on communities in every corner of the U.S. For example, NOAA has noted that the "U.S. has sustained 387 weather and climate disasters since

1980 where overall damages/costs reached or exceeded $1 billion (including CPI adjustment to 2024). The total cost of these 387 events exceeds $2.740 trillion.[51]

Communities that invest in NBS climate resilience projects are, in essence, buying insurance against the huge risk of injuries, deaths, property damage and business losses from being hit by a catastrophic climate change-infused event. Indirect tools need to be used to estimate the value of these investments but, as with many other co-benefits, no one can question the value of holding a climate resilience insurance policy.[52]

Cultural and Social Values

This broad-ranging category encompasses ecoservice services that impact human well-being. They generally fall into a few sub-categories, including job creation, urban quality of life, cultural value, and ecotourism.

NBS projects have the capacity to generate jobs in the construction industry (building green infrastructure) and in the recreation and tourism sectors, among others. These economic benefits potentially can be estimated using available economic modeling tools.

Urban quality of life benefits are most often associated with projects that increase greenspaces within urban areas. These projects can reduce the heat island effect, provide air quality benefits, and positively correlate with mental health improvements.[53]

Importantly, a lack of urban greenery is predominantly found in socioeconomically disadvantaged and marginalized communities, often as a result from historically discriminatory practices such as redlining. Typically, these communities are in the most need of re-greening. However, such projects can also result in "green gentrification"—a situation in which the presence of greenery increases a neighborhood's perceived value and drives gentrification.[54] Unintended consequences such as this must be flagged and carefully considered when evaluating potential NBS projects.

Cultural values that can arise from NBS projects are many-fold and rely heavily on knowledge and input from nearby stakeholders. For example, indigenous groups may derive cultural value from the landscapes being affected. Maintenance and restoration of such landscapes may thus be supportive of this value, although well-intentioned project efforts also could serve the opposite effect.

The quantification of cultural ecosystem services for indigenous communities may require different approaches than accounting for other ecosystem services. Cultural ecosystem services may be more accurately accounted for through a holistic view of nature-human relationships, and through benefits to a collective rather than to an individual.[55] For this reason, is it critical to engage in dialogue in collaboration with nearby indigenous communities to both assess the value of potential activities on the landscape and understand how project activities can be scoped to help provide additional cultural value, rather than detract from it.

Water Quantity and Quality

A multitude of water benefits can arise from NBS projects. These include climate resilience and adaptation measures, such as flood protection, discussed above. Here, we divide these benefits into two groups: increases in available water quantity and improvement in water quality.

Water quantity improvements can come about from vegetation thinning in areas with rivers and other bodies of water. Vegetation thinning may serve the purpose of decreasing wildfire risk, and simultaneously can increase available water, through decreased storage and evapotranspiration by living brush and small trees.[56]

Additional water quantity increases—as measured in the timing of available water flows—also can accrue through projects that support ecosystems that store water, such as areas with snowpack[57] and meadows.[58] These types of restoration efforts may not increase available water per se and may even decrease the availability of water at certain points in the year, but will generally allow for longer-term storage of water, producing longer-lasting streamflows and also reducing the risk of flash flooding.

Water quality improvements may come in the form of chemical improvements or floating particulate matter (e.g. sediment) improvements. Some ecosystems, including wetlands, naturally filter water, allowing for previously contaminated water to become once again usable for humans as drinking water, in the home, or in agriculture.[59] Soil stabilization, through activities such as reforestation,[60] can help to decrease erosion and thus sedimentation in watersheds; this is particularly important in the case of landscapes that have been ravaged by catastrophic wildfire.

Biodiversity

Biodiversity, and the numerous benefits associated with it, often has the potential to be improved through NBS projects. Differing locations and project types will differentially affect species and overall biodiversity of an area and, in turn, the other benefits associated with an increase in biodiversity.

Many argue that biodiversity itself has an intrinsic value,[61] and the authors of this report support this position as well. Beyond this intrinsic value, however, biodiversity offers numerous benefits directly applicable to people.

Biodiversity, in the form of pollinators[62] and crop variety,[63] for example, supports food security worldwide. Species may also hold medicinal value,[64] inspirational value for biomimicry projects,[65] and even aesthetic value.[66] Furthermore, a healthy, biodiverse system is much more resilient to external forces including climate change that otherwise may trigger reduced ecosystem functioning.[67] This is critical to communities as many of the processes we depend on to exist as a species are reliant on healthy, functioning ecosystems near and far from our homes.

Constructing a System for Rating Co-Benefits That Nature-Based Projects Can Deliver To Communities

There is no checklist for rating the relative co-benefits from NBS projects. A holistic assessment should be made, first by scoping potential project co-benefits, ideally in conjunction with local stakeholders who have strong knowledge of the landscape, and then by applying available measurement techniques as discussed further below.[68] *See generally* Appendix A.

A good starting point for the scoping process is to ask a battery of questions that may help identify and define relevant co-benefits for specific NBS projects. To illustrate, the types of questions below can help tease out co-benefit information for forestry projects:

Climate Resilience and Cultural and Social Value:

- *Wildfire Risk Reduction:* Is there a high risk of wildfire in the forest, either due to historic fire suppression practices, climate change, or otherwise? Is the project focused on a wildland-urban interface in such a way as it might mitigate wildfire risk to surrounding communities? Note that reductions in wildfire also may produce public health benefits from reduced exposure to wildfire smoke.
- *Indigenous Cultural Value:* Are there indigenous communities near the proposed area for forestry work who place cultural value on the landscape? Consider both federally recognized tribes and non-federally recognized tribes. If there are communities in the area, are they interested in the work being done? What opinions do they have on the planned project, or on how planning should proceed?
- *Recreational Value:* Is this a recreation-heavy area? If so, what activities (hiking, skiing, biking, fishing, rock climbing) are frequently conducted in the area? How might the proposed forestry activities improve (or worsen) conditions for recreation?

Water Quantity and Quality:

- *Quantity - Tree Thinning:* Will tree thinning be occurring? This can generate increases in water from reduced water uptake from vegetation and evapotranspiration.
- *Quality - Soil Stabilization:* Will replanting be occurring? Increased presence of vegetation can help stabilize landscapes and reduce, particularly barren landscapes that have recently experienced wildfire and are experiencing erosion.
- *Quantity - Meadow and Snowpack:* Will meadows be restored? Will activities benefit existing snowpack? Each of these activities have the potential to increase water storage for stabilized year-round flows.

Biodiversity:

- *Snag Reduction:* For forest projects with snag density reduction, are enough snags left over to maintain necessary habitats?[69]
- *Endangered Species:* Is the project occurring in the habitat of endangered species? If so, how is it affecting that species?
- *Previously Lost Habitats:* Will the project be restoring habitats that were previously lost from the area?

Similar questions can provide a helpful starting point for grasslands and coastal resilience NBS projects, as illustrated in Appendix B.

Moving from the scoping process to rating ecosystem services co-benefits requires blending use of traditional economics tools to calibrate ecosystem services and with experiential learning drawn from specific use cases. Each line of inquiry is reviewed below, in turn.

Using traditional economics tools to rate ecosystem services co-benefits

While President Biden's Executive Order 14072 on "Strengthening the Nation's Forests, Communities, and Local Economies" is primarily known for promoting forest health and nature-based solutions,[70] it also requested the Director of the Office and Management and Budget (OMB) to "issue guidance related to the valuation of ecosystem and environmental services and natural assets in Federal regulatory decision-making." [71] This led to OMB's publication of "Guidance for Assessing Changes in Environmental and Ecosystem Services in Benefit-Cost Analysis" on February 28, 2024.[72]

The OMB Ecosystem Services guidance reinforces key points set forth in this report. For example, it confirms, at the outset, that "[n]ature-based solutions typically provide benefits to people through flows of ecosystem services."[73] Because the value of these services can be significant, it recommends that when the U.S. government is considering proposed regulatory or investment decisions, it should undertake an analysis of "anticipated ecosystem service effects along with other effects, including obvious and additional effects," using traditional economics tools to calibrate the value of non-carbon ecosystem services.[74]

In particular, the OMB guidance recommends that "[a]s with other effects, ecosystem service effects should be (in order of preference) *monetized, quantified, or described*. They can then be reported directly with other effects that are treated similarly."[75] (Emphasis added.)

The OMB guidance goes on to reference general tools that economists typically use to measure the value of ecosystem services, including the revealed preference method (which uses market prices pertaining to the choices made by consumers to estimate the values of non-market items) and the stated preference (or contingent valuation) method (which poses questions to people with a set of choices to see which alternative they prefer).[76]

Relatedly, another White House review undertaken alongside development of the OMB ecosystem services guidance acknowledges the challenge of applying traditional economic tools to monetize and quantify ecosystem services benefits. Specifically, the National Science and Technology Council issued a report in December 2023 that laid out an "Advancing this Frontier" research agenda to test real-world application of conventional economic tools to measure different types of ecosystem services benefits from nature-based solutions.[77]

The Policy Lab applauds the OMB guidance which, if developed fully, will require agencies to come forward with disciplined analyses of ecosystem co-benefits. As the National Science and Technology Council's report emphasized, however, much more work is needed before traditional economic tools can be used to confidently monetize or quantify NBS project co-benefits.

In any event, it is clear that advances in co-benefits valuation work are needed and should be prioritized—which leads to our first recommendation in Part II of this report.

Recommendation #3: The President should appoint a high-level Ecosystem Services Valuation Panel (ESV Panel) comprised of key policymakers, economists, and ecologists and charge the ESV Panel with surveying and recommending methods for quantifying and monetizing ecosystem services co-benefits that flow from NBS projects.

As the Presidential ESV Panel goes about its work, it will be important that the Panel evaluate use case experience in calibrating the value of ecosystem services. As described in Appendix A, there are many different approaches that are being taken in applying specialized modeling and measurement tools in the ecosystem services context. Many nations' use of the National Capital Project's InVEST modeling program provides a pertinent example in this regard.[78] The InVest modeling tool is well-suited for increased use in the U.S. Its unique capabilities could help federal and state land management agencies like the Department of the Interior in identifying and rating ecosystem benefits from the deployment of NBS projects on public lands.

The Policy Lab also has identified three nature-based use case clusters from three prominent NGOs that offer important experiential use case learning on rating ecosystem co-benefits for the Presidential ESV Panel. They include the reforestation use case work that American Forests is undertaking with the United States Forest Service; the National Fish and Wildlife Foundation's northern grasslands use case work with the NRCS and other partners; and the coastal resilience use case that The Nature Conservancy has been implementing in Florida.

These three use case clusters are described in detail in Appendix C.

Recommendation #4: The U.S. Department of the Interior, in consultation with the Department of Agriculture, the Office of Management and Budget, and the Office of Science and Technology Policy, should develop and pilot an ecosystem services scoring system for use in federal funding decisions and in identifying lands that meet the America the Beautiful initiative's "30X30" conservation goals.

Piloting an Ecosystem Services Scoring System for Funding Decisions

To further the goal of developing a system to credit ecosystem co-benefits from NBS projects, the Policy Lab recommends early adoption of an ecosystem services scoring system that assigns points based on the anticipated climate resilience benefits, cultural and social benefits, water quality and quantity improvements, and biodiversity enhancements that are expected to flow from carbon-oriented NBS projects. Projects with higher ratings should receive priority funding. Over time, valuation metrics will improve, enabling the scorecard system to be continually updated and refined.

Developing a scoring system for benefits that are difficult to quantify will require case-by-case reviews of co-benefits by using tools like the scoping inquiries discussed above to identify co-benefits and surveying of benefit-specific tools that may provide useful reference inputs, as illustrated below:

- ***Climate Resilience and Cultural and Social Value:*** Metrics such as reduction in heat island effect (using LiDAR and Earth observation analytics), improved air quality (using Earth observation analytics), and preservation of cultural practices (using citizen science platforms and social surveys) should be prioritized. Scoring systems such as American Forests' Tree Equity Score may provide helpful examples for how to score such co-benefits.[79]

- ***Water Quantity and Quality:*** Metrics such as soil moisture levels (using soil measurement tools and UAV/Drones), water filtration rates (using LiDAR and hyperspectral imaging), and groundwater recharge rates (using stream gauging stations and Earth observation analytics) should be emphasized. Proposed scoring systems for water quantity and quality have been proposed in multiple papers, including the Ecosystem Service Indicator[80] and the methodology proposed by Grizzetti et al. [81]

- ***Biodiversity:*** Metrics such as species richness and abundance (using eDNA and camera traps), habitat quality scores (using UAV/Drones and habitat quality models), and pollinator species diversity (using airborne eDNA and hyperspectral imaging) should be considered. One well-known scoring system used for biodiversity is the Global Biodiversity Standard Assessment.[82]

- **Performance-Based Incentives:** We also recommend introducing performance-based incentives for NBS projects that exceed co-benefit targets. Projects that demonstrate exceptional outcomes in biodiversity conservation, water management, and community engagement should be eligible for additional funding and recognition.

After the initial creation of a scoring system, ongoing prediction and during- and post-project validation will be necessary to ensure an accurate scoring system. This is particularly true in the case of the performance-based initiatives described above, which will require benchmarking expected ecosystem service values and then comparing during- and post-project values to reward exceeded targets.

Piloting an Ecosystem Services Scoring System for Use in Identifying "Conserved" Working Lands for Inclusion in the America the Beautiful Initiative's 30x30 Goal

The Biden-Harris Administration's America the Beautiful initiative, which aims to conserve at least 30 percent of U.S. lands and waters by 2030,[83] provides an opportunity to integrate co-benefit evaluations into conservation efforts.[84]

Specifically, the ecosystem services scoring system can be used to identify "conserved" working lands that count toward the American the Beautiful initiative's 30x30 goal. This includes evaluating and rating climate resilience, cultural, social, water quality, and biodiversity benefits. Qualifying lands could then be identified on the American Conservation and Stewardship Atlas,[85] enabling stakeholders to visualize and track the progress of conservation projects, ensuring that areas providing significant co-benefits are prioritized. The Atlas includes data on biodiversity, climate change impacts, and equity, making it a valuable tool for comprehensive project evaluation.

Use of an Ecosystem Services scoring system for the America the Beautiful initiative potentially can provide the missing criteria for determining when working lands—such as farms, ranches, forests, and fisheries—are generating the type of net benefits to qualify as being "conserved" within the meaning of the 30x30 conservation goal. As laid out in Section 216(a) of E.O. 14008, the President intended that some working lands would meet this conservation standard. But in the absence of a scoring system such as the one proposed here, the Administration has yet to identify any working lands or waters as being "conserved" and therefore meriting inclusion in the American Conservation and Stewardship Atlas.

CONCLUSION

This Stanford Law and Policy Lab has taken a fresh look at nature-based solutions and has concluded that the failure to use advanced tools to measure and confirm the climate and other ecosystem services generated by NBS projects is holding back their deployment.

Simply put, stronger confirmatory data, when broadly shared and continuously improved, will unlock the power of nature to combat climate change while also delivering other highly valuable ecosystem services.

The good news is that new MMRV technologies and methodologies are available to quantify and confirm the carbon benefits that deploying "climate-smart" practices in forestry, agriculture, and other land applications can generate with significantly more precision and confidence than is the norm today. The federal government is waking up to this fact and is beginning to more systematically identify and develop stronger MMRV tools that can validate carbon reductions and removals. It cannot do this alone, however. Close collaboration with state, tribal and local leaders, companies, NGOs, and academic leaders is needed to sharpen the focus on real world use cases and to make significant progress in this area.

To take advantage of this opportunity, this Policy Lab recommends the following actions:

- A public/private collaborative should identify consensus-based, scientifically-sound, "high integrity" MMRV protocols that include effective data collection, modeling, and GHG information-sharing elements for high-priority activity-level practices that claim carbon reductions or removals.

    - As a corollary, the Policy Lab recommends that the Administration identify a few important use cases in which new MMRV protocol development already is underway and use them to inform how the U.S. government can effectively participate in and guide the development of consensus-based protocols that include effective data collection, modeling, and GHG information-sharing elements.

- A greenhouse gas data, protocol, and modeling "Information System" that provides public access to verified greenhouse gas data, protocols and models for nature-based solutions should be established.
    - Undertaking a scoping exercise regarding where and how an effective GHG Information System is set up and managed should be a priority. To promote flexibility and durability, it may be appropriate to consider establishing a special purpose organization outside the government that transparently provides agreed-upon GHG information services.

Because most NBS projects also generate other significant ecosystem services, identifying and rating co-benefits can and should be folded into decision-making processes in a disciplined

way—particularly insofar as ecosystem co-benefits may be the most direct and relevant benefits for the communities that are closest to, and most impacted by, NBS projects.

For these reasons, the Policy Lab urges the federal government to invest resources in identifying and rating NBS project co-benefits to the extent feasible. Toward that end, the Policy Lab recommends the following actions:

- The President should appoint a high-level Ecosystem Services Valuation Panel (ESV Panel) comprised of key policymakers, economists, and ecologists and charge the ESV Panel with surveying and recommending methods for quantifying and monetizing ecosystem services co-benefits that flow from NBS projects.

- The U.S. Department of the Interior, in consultation with the Department of Agriculture, the Office of Management and Budget, and the Office of Science and Technology Policy, should develop and pilot an ecosystem services scoring system for use in federal funding decisions and in identifying lands that meet the America the Beautiful initiative's "30X30" conservation goals.

Taking these actions will enable nature-based solutions to play a significantly larger role in combatting climate change than they are now while, at the same time and as a bonus, generating significant economic, social and ecosystem benefits for communities throughout the U.S.

ENDNOTES

[1] The White House Office of Management and Budget recently defined nature-based solutions as "actions to protect, sustainably manage, or restore natural or modified ecosystems to address societal challenges, simultaneously providing benefits for people and the environment." *See* Office of Information and Regulatory Affairs, Office of Management and Budget, *Guidance for Assessing Changes in Environmental and Ecosystem Services in Benefit-Cost Analysis* (Feb. 28, 2024) at 4. https://www.whitehouse.gov/wp-content/uploads/2023/08/DraftESGuidance.pdf. *See also* Section 4 of Executive Order 14072, *Strengthening the Nation's Forests, Communities, and Local Economies* (April 22, 2022)(nature-based solutions include "actions that protect coasts and critical marine ecosystems, reduce flooding, moderate extreme heat, replenish groundwater sources, capture and store carbon dioxide, conserve biodiversity, and improve the productivity of agricultural and forest lands to produce food and fiber). https://www.whitehouse.gov/briefing-room/presidential-actions/2022/04/22/executive-order-on-strengthening-the-nations-forests-communities-and-local-economies/

[2] Section 4(a) of Executive Order 14072 commissioned a cabinet-level analysis "to identify key opportunities for greater deployment of nature-based solutions across the Federal Government, including through potential policy, guidance, and program changes." (*See* Section 4(a)). This led to a wide-ranging Report to the National Climate Task Force: *Opportunities to Accelerate Nature-Based Solutions: A Roadmap for Climate Progress, Thriving Nature, Equity, & Prosperity* (Nov. 2022) https://www.whitehouse.gov/wp-content/uploads/2022/11/Nature-Based-Solutions-Roadmap.pdf

[3] "Climate-smart agriculture and forestry is an integrated approach that enables farmers, ranchers, and forest landowners to respond to climate change by reducing or removing greenhouse gas emissions (mitigation) and adapting and building resilience (adaptation), while sustainably increasing agricultural productivity and incomes. With support from NRCS, producers and land managers can engage in climate-smart agriculture and forestry to adapt to the impacts of climate change and contribute to solutions that help to limit future climate change." *See generally* USDA, *Climate-Smart Agriculture and Forestry* (Feb. 2023) https://www.nrcs.usda.gov/sites/default/files/2023-04/ClimateSmart%20Agriculture%20and%20Forestry%20factsheet.pdf

[4] Friedlingstein et al., *Global Carbon Budget 2020* (2020). Figure 2 shows a "schematic representation of the overall perturbation of the global carbon cycle caused by anthropogenic activities, averaged globally for the decade 2010–2019." https://essd.copernicus.org/articles/12/3269/2020/

[5] Thevathasan, et al., *Agroforestry* (Aug. 2023). https://www.sciencedirect.com/science/article/abs/pii/B978012822974300269X

[6] *See* note 3.

[7] Griscom et al, *Natural Climate Solutions* (Oct. 2017). https://www.pnas.org/doi/10.1073/pnas.1710465114

[8] *See generally* Environmental Protection Agency (EPA), *Climate Change Indicators: U.S. Greenhouse Gas Emissions* https://www.epa.gov/climate-indicators/climate-change-indicators-us-greenhouse-gas-emissions

[9] *See generally* A Report to the National Climate Task Force, *supra* note 2.

[10] Frantzeskaki et al., *Mainstream Nature-Based Solutions for Urban Climate Solutions* (Oct 2021). https://academic.oup.com/bioscience/article/72/2/113/6381261

[11] *See* note 9.

[12] EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks* https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks

[13] *Id.*

[14] USDA, *Methods for Entity-Scale Inventory* (Updated April 2024). https://www.usda.gov/oce/entity-scale-ghg-methods#:~:text=2024%20Update%20to%20USDA%27s%20Entity,%2C%20and%20land%2Duse%20change

[15] *See* David J. Hayes et al, *Data Progress Needed for Climate-Smart Agriculture,* Stanford Law School Policy Lab Report (2023) https://law.stanford.edu/publications/data-progress-needed-for-climate-smart-agriculture/

[16] *See* Section 21001 of the Inflation Reduction Act.

[17] *See* Section 21002 of the Inflation Reduction Act. *See also* Natural Resources and Conservation Service, *USDA Investment in Improved GHG Measurement, Monitoring, Reporting and Verification for Agriculture and Forestry through the Inflation Reduction Act* (July 2023) https://www.nrcs.usda.gov/sites/default/files/2023-07/nrcs-ira-mmrv-factsheet-23.pdf

[18] *See generally* American Forests, *The Replant Act: Restoring our National Forests* https://www.americanforests.org/our-programs/policy/replant-act/;

Carbon 180 blog, *Spotting carbon removal in the Infrastructure Investment and Jobs Act* (Nov. 17, 2021) https://carbon180.medium.com/spotting-carbon-removal-in-the-infrastructure-investment-and-jobs-act-522fb5f5683d

[19] *See generally* USDA, *Partnerships for Climate-Smart Commodities* https://www.usda.gov/climate-solutions/climate-smart-commodities

[20] Notice of Funding Opportunity for the Partnerships for Climate-Smart Commodities Program https://apply07.grants.gov/apply/opportunities/instructions/PKG00274212-instructions.pdf

[21] White House, *National Strategy to Advance an Integrated U.S. Greenhouse Gas Measurement, Monitoring, and Information System – A Report by the Greenhouse Gas Monitoring and Measurement Interagency Working Group* (Nov. 2023) at 14. https://www.whitehouse.gov/wp-content/uploads/2023/11/NationalGHGMMISStrategy-2023.pdf.

[22] *Id.* at 15-16

[23] *See generally* Carbon Direct & Microsoft, *Criteria for High Quality Carbon Dioxide Removal* (2024 Edition) https://www.carbon-direct.com/insights/2023-criteria-for-high-quality-carbon-dioxide-removal *The Integrity Council for the Voluntary Carbon Market* https://icvcm.org/

[24] White House, *Voluntary Carbon Markets Joint Policy Statement and Principles* (May 2024) https://www.whitehouse.gov/wp-content/uploads/2024/05/VCM-Joint-Policy-Statement-and-Principles.pdf

[25] White House, *Fact Sheet: Biden-Harris Administration Announces New Principles for High-Integrity Voluntary Carbon Markets* (May 28, 2004) https://www.whitehouse.gov/briefing-room/statements-releases/2024/05/28/fact-sheet-biden-harris-administration-announces-new-principles-for-high-integrity-voluntary-carbon-markets/

[26] *See* USDA, *Report to Congress: A General Assessment of the Role of Agriculture and Forestry in U.S. Carbon Markets* (Oct. 2023) at 9-10 https://www.usda.gov/sites/default/files/documents/USDA-General-Assessment-of-the-Role-of-Agriculture-and-Forestry-in-US-Carbon-Markets.pdf: ("Protocols are the criteria and standards under which carbon credits are generated. They include requirements for participant eligibility and what sources of emissions must be included. They also include procedures for the measurement, monitoring, reporting, and verification of GHG reductions or carbon sequestration.")

[27] *Id.*

[28] Buma et al., *Expert review of the science underlying nature-based climate solutions* (2024) https://www.nature.com/articles/s41558-024-01960-0

[29] Beveridge & Diamond, *Congress Passes and Funds Support for Nature-Based Greenhouse Gas Reductions* (Jan. 13, 2023) https://www.bdlaw.com/publications/congress-passes-and-funds-support-for-nature-based-greenhouse-gas-reductions/

[30] USDA, *Justification Report: USDA Intent to Establish the Greenhouse Gas Technical Assistance Provider and Third-Party Verifier Program* (Feb. 2024) https://www.usda.gov/sites/default/files/documents/GCSA-JustificationReport.pdf

[31] *See* note 26.

[32] Moore, et al., *State of the Science: Cropland Soil Carbon Sequestration* (2021) https://www.edf.org/sites/default/files/documents/ag-soil-C-state-of-the-science.pdf?_gl=1*ggu2kj*_ga*MTYzOTM1MTM3OS4xNzE2MDUzMjMy*_ga_2B3856Y9QW*MTcxNjA1MzIzMS4xLjAuMTcxNjA1MzIzNC41Ny4wLjA.*_ga_Q5CTTQBJD8*MTcxNjA1MzIzMS4xLjAuMTcxNjA1MzIzNC41Ny4wLjA.*_gcl_au*MTQ2Njg1NTk2NC4xNzE2MDUzMjMz

[33] *See* note 28.

[34] *See* note 25.

[35] *See* note 21 at 13-14.

[36] *Id.* at 25-26.

[37] *Id.* at 25, fn. r.

[38] *See* note 21 at 11 for the graphic below.

[39] The narrative in this section was drawn from an unpublished American Forests summary document that was prepared by Brian Kittler and his team at American Forests.

[40] Fargione, et al., *Natural climate solutions for the United States* (Nov. 2018) https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6235523/

[41] Domke et al., *Tree planting has the potential to increase carbon sequestration capacity of forests in the United States* (Sept. 2020) https://www.pnas.org/doi/10.1073/pnas.2010840117

[42] Marvin, et al, *Natural climate solutions provide robust carbon mitigation capacity under future climate change scenarios* (2023). https://www.nature.com/articles/s41598-023-43118-6
[43] *See* note 21 at 24-25.
[44] Novick, et al, *We Need a Solid Scientific Basis for Nature-Based Climate Solutions in the United States* (Mar. 2024) https://www.pnas.org/doi/10.1073/pnas.2318505121
[45] White House, *Fact Sheet: Biden-Harris Administration Hosts White House Methane Summit to Tackle Dangerous Climate Pollution, while Creating Good-Paying Jobs and Protecting Community Health* (July 26, 2023)(*see* section entitled: "Developing data products to improve public understanding of methane emissions"). https://www.whitehouse.gov/briefing-room/statements-releases/2023/07/26/fact-sheet-biden-harris-administration-hosts-white-house-methane-summit-to-tackle-dangerous-climate-pollution-while-creating-good-paying-jobs-and-protecting-community-health/; https://earth.gov/ghgcenter
[46] *See* note 21 at 24-25; *See generally* Novick et al., *Informing Nature-based Climate Solutions for the United States with the Best-Available Science* (March 2022) https://onlinelibrary.wiley.com/doi/abs/10.1111/gcb.16156
[47] *Id.*
[48] *See* www.resilience.climate.gov.
[49] A fledging voluntary market is assigning per-ton costs to GHG reductions and removals. In addition, economists have been developing a "social cost of greenhouse gases" metric. *See generally EPA's Report on the Social Cost of Greenhouse Gases: Estimates Incorporating Recent Scientific Advances* (Dec. 2023) https://www.epa.gov/environmental-economics/scghg These approaches are much more difficult to apply for ecosystem services that do not manifest in numerical quantities.
[50] *See generally* Dunlop et al., *The evolution and future of research on Nature-based Solutions to address societal challenges* (March 2024) https://www.nature.com/articles/s43247-024-01308-8
[51] See NOAA, *Billion Dollar Climate & Weather Disasters* https://www.ncei.noaa.gov/access/billions/
[52] PwC, *Climate Risk and Insurance: the Case for Resilience* https://www.pwc.com/us/en/industries/financial-services/library/climate-risk-and-insurance.html
[53] Report prepared by the EKLIPSE Expert Working Group on Nature-based Solutions to Promote Climate Resilience in Urban Areas, *An impact evaluation framework to support planning and evaluation of nature-based solutions projects* (2017) https://ora.ox.ac.uk/objects/uuid:3ecfc907-1971-473a-87f3-63d1204120f0
[54] University of Minnesota, *Green Gentrification* https://create.umn.edu/wp-content/uploads/2020/02/Green-Gentrification.pdf
[55] Normyle et al., *Aligning Indigenous values and cultural ecosystem services for ecosystem accounting: A review* (Feb. 2023) https://www.sciencedirect.com/science/article/pii/S2212041622000985
[56] Guo et al., *Valuing the benefits of forest restoration on enhancing hydropower and water supply in California's Sierra Nevada* (June 2023) https://www.sciencedirect.com/science/article/pii/S0048969723014523#:~:text=Forest%20restoration%20can%20reduce%20surface,making%20the%20forest%20more%20resilient
[57] Boisrame, et al., *Relationships between snowpack, low flows and stream temperature in mountain watersheds of the US west coast* (May 2024) https://onlinelibrary.wiley.com/doi/full/10.1002/hyp.15157
[58] Hunt, et al, *Meadow Restoration Increases Baseflow and Groundwater Storage in the Sierra Nevada Mountains of California* (Aug. 2018) https://onlinelibrary.wiley.com/doi/abs/10.1111/1752-1688.12675
[59] Reddy, et al, *Wetland Processes and Water Quality: A Symposium Overview* (Sept. 1994) https://acsess.onlinelibrary.wiley.com/doi/abs/10.2134/jeq1994.00472425002300050003x
[60] Marden, *Effectiveness of reforestation in erosion mitigation and implications for future sediment yields, East Coast catchments, New Zealand: A review* (Apr. 2012) https://onlinelibrary.wiley.com/doi/full/10.1111/j.1745-7939.2012.01218.x
[61] Himes et al., *Why nature matters: A systematic review of intrinsic, instrumental, and relational values* (Jan. 2024) https://academic.oup.com/bioscience/article/74/1/25/7499505
[62] Jeroen P. van der Sluijs, et al., *Pollinators and Global Food Security: the Need for Holistic Global Stewardship* (May 2016) https://link.springer.com/article/10.1007/s41055-016-0003-z
[63] Grant, *The Importance of Biodiversity in Crop Sustainability: A Look at Monoculture* (Oct. 2008) https://www.tandfonline.com/doi/abs/10.1300/J477v01n02_07
[64] Bernstein, et al., *The Importance of Biodiversity to Medicine* (Nov. 2008) https://jamanetwork.com/journals/jama/article-abstract/182891

[65] Lebdioui, *Nature-inspired innovation policy: Biomimicry as a pathway to leverage biodiversity for economic development* (Dec. 2022) https://www.sciencedirect.com/science/article/pii/S0921800922002476
[66] Braz, *The Value of Biodiversity* (Nov. 2008) https://www.scielo.br/j/bjb/a/6hjsXCC8VGQkWzLNykjP43k/?lang=en
[67] Oliver et al., *Biodiversity and Resilience of Ecosystem Functions* (Oct. 2015) https://www.cell.com/trends/ecology-evolution/abstract/S0169-5347(15)00218-9
[68] The specifics of how to identify and then calibrate the significance of non-carbon NBS ecosystem services can vary widely based on project and ecosystem type. There is no one right way to assess projects; one project may have limited carbon sequestration or climate-related benefits but provide important co-benefits that are deemed necessary for surrounding communities, while another may have excellent carbon sequestration or climate adaptation capabilities but not offer many co-benefits. Importantly, however, a NBS project should *not* be conducted if it *harms* the surrounding ecological and/or social systems, regardless of the benefits to climate that it may provide. Ellis, et al., *The Principles of Natural Climate Solutions* (Jan. 2024) https://www.nature.com/articles/s41467-023-44425-2.
[69] Baldwin et al., *Prescribed fire and thinning influence snag density and size in the southern Appalachian Mountains* (Apr. 2023) https://www.sciencedirect.com/science/article/pii/S037811272300097X
[70] White House, *Executive Order on Strengthening the Nation's Forests, Communities, and Local Economies* (Apr. 22. 2022) https://www.whitehouse.gov/briefing-room/presidential-actions/2022/04/22/executive-order-on-strengthening-the-nations-forests-communities-and-local-economies/
[71] *Id.* at Section 4.
[72] *See* Office of Information and Regulatory Affairs, Office of Management and Budget, *Guidance for Assessing Changes in Environmental and Ecosystem Services in Benefit-Cost Analysis* (Feb. 28, 2024) https://www.whitehouse.gov/wp-content/uploads/2023/08/DraftESGuidance.pdf.
[73] *Id* at 4.
[74] *Id.* at 14.
[75] *Id.*
[76] *See* note 72 (OMB guidance document) at 6. *See generally* NOAA summary document entitled "*Measuring the Value of Ecosystem Services*" https://coast.noaa.gov/data/digitalcoast/pdf/measuring-value-ecosystem-services.pdf
[77] *See* "Advancing the Frontiers of Benefit-Cost Analysis: Federal Priorities and Directions for Future Research." https://www.whitehouse.gov/wp-content/uploads/2023/12/FINAL-SFBCA-Annual-Report-2023.pdf. Chapter 2 of the report recounts difficulties that agencies are having in fully monetizing or quantifying some ecosystem services, despite their relevance.
[78] Green Policy Platform, https://www.greenpolicyplatform.org/tools-and-platforms/invest-integrated-valuation-ecosystem-services-and-tradeoffs (Nov. 2021). *See* Natural Capital Project/Stanford University, *Where We Work Map* https://naturalcapitalproject.stanford.edu/projects
[79] American Forests, *Help Create Tree Equity in Cities Across America* https://www.treeequityscore.org/
[80] Shaad, et al., *Integrating Ecosystem Services Into Water Resource Management: An Indicator-Based Approach* (Jan. 2022) https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9012719/
[81] Grezzetti, et al., *Assessing water ecosystem services for water resource management* (July 2016) https://www.sciencedirect.com/science/article/pii/S1462901116300892
[82] *The Global Biodiversity Standard* https://www.bgci.org/wp/wp-content/uploads/2023/03/Scoring-system-English.pdf
[83] President Biden adopted the "30X30" initiative in Section 216(a) of Executive Order 14008: *Tackling the Climate Crisis at Home and Abroad*. *See* https://www.whitehouse.gov/briefing-room/presidential-actions/2021/01/27/executive-order-on-tackling-the-climate-crisis-at-home-and-abroad/
[84] *See* White House, *Biden-Harris Administration Launches Conservation.gov, Showcasing and Supporting the Rapid Acceleration of Locally Led Efforts to Conserve, Protect and Restore Lands and Waters across America* (April 19, 2024). Conservation.gov, launched under this initiative, serves as a hub for resources and tools that support conservation projects across the United States. The integration of a co-benefit scoring system could enhance the effectiveness and transparency of this effort.
[85] *See* https://www.conservation.gov/pages/atlas-and-data

APPENDIX A

Representative Measurement and Modeling Tools for Rating Ecosystem Services Co-Benefits

NBS projects can use a variety of ground-truthing and modeling tools to help rate the co-benefits associated with ecosystems and project activities. This section provides a review of tools and associated metrics that can help assess some of the ecosystem services co-benefits referenced in the main text of this report.

Representative Modeling Tools for Calibrating Ecosystem Services Co-Benefits

- **InVEST (Integrated Valuation of Ecosystem Services and Trade-offs):** A suite of models developed by the National Capital Project are used to map and value the goods and services from nature: [1]
    - **Crop Pollination:** Assesses the impact of land use on pollination services, linking biodiversity to agricultural productivity.
    - **Habitat Quality:** Evaluates the impact of land use on habitat quality and biodiversity. Metrics include habitat suitability indices and biodiversity scores, essential for conservation planning.
    - **Recreation:** Estimates the recreational value of natural areas. Metrics include visitor numbers and recreational activity benefits.
    - **Seasonal Water Yield:** Estimates water yield from different land uses and vegetation types. Metrics include annual water yield, runoff, and infiltration rates, important for water resource management.
    - **Sediment Retention:** Evaluates the role of vegetation in preventing soil erosion. Metrics include sediment retention rates, which impact water quality.
    - **Urban Cooling:** Assesses the cooling effect of vegetation in urban areas. Metrics include temperature reduction and heat island mitigation.
    - **Urban Nature Access:** Evaluates access to natural areas in urban environments. Metrics include green space availability and usage rates.
    - **Water Purification:** Models the role of ecosystems in filtering pollutants from water. Metrics include nutrient removal and water quality improvement.

[1] Natural Capital Project (Stanford University) *InVEST User Guides. See, e.g.,* https://naturalcapitalproject.stanford.edu/invest/crop-pollination

- **Impact/Risk Modeling:** Models that assess potential impacts and risks of NBS projects including wildfire risk, flood preparedness, and climate resilience. Associated metrics include broad risk reduction estimates from NBS implementation and recognition of climate adaptation benefits.[2]
- **Microsoft & Planet Labs Collaboration:**
    - **Microsoft Azure AI and Machine Learning:** With recent specialization for environmental applications, Microsoft Azure offers a suite of machine learning tools capable of processing vast amounts of remote sensing data: [3]
        - **Automate Biodiversity Metrics Analysis**: Using Azure's machine learning capabilities, users can automatically analyze biodiversity metrics such as species presence, abundance, and habitat quality. For example, Azure AI can process eDNA data to detect and quantify species in aquatic and terrestrial ecosystems.
        - **Predictive Modeling**: Azure AI can predict future trends in biodiversity and ecosystem health based on historical data, enabling proactive management and conservation strategies. This predictive capability is crucial for understanding the long-term impacts of NBS projects.
        - **Anomaly Detection**: By continuously monitoring environmental data, Azure AI can detect anomalies such as illegal logging activities, changes in water quality, or unexpected shifts in wildlife populations. This real-time detection supports immediate intervention and mitigation efforts.
    - **Planet Satellite Data:** Planet's constellation of high-resolution satellites provides daily imagery and data that monitor NBS project impacts:
        - **Land Cover and Vegetation Monitoring**: Planet's satellite imagery can track changes in land cover and vegetation health over time. Metrics such as NDVI (Normalized Difference Vegetation Index) can be derived to assess plant health, biomass, and carbon sequestration potential.
        - **Water Quality Assessment**: Satellite data can monitor water bodies for indicators of quality and pollution levels. By analyzing the spectral signatures of water bodies, Planet's technology can detect pollutants and assess the effectiveness of NBS projects in improving water quality.

[2] Kumar, et al., *An overview of monitoring methods for assessing the performance of nature-based solutions against natural hazards* (June 2021) https://www.sciencedirect.com/science/article/pii/S0012825221001033
[3] Planet, *Planet, Microsoft, And Researchers Build New AI-Focused Resource For Environmental Reporting* (Jan. 23, 2024) https://www.planet.com/pulse/environmental-reporting-solutions/

- **Wildlife Habitat Mapping**: High-resolution imagery allows for detailed mapping of wildlife habitats. This is particularly useful for projects focused on habitat restoration and conservation, providing data on habitat extent, fragmentation, and connectivity.

Representative Measurement Tools for Rating Monitoring Ecosystem Services Co-Benefits

- **eDNA (Environmental DNA)** [4]
    - ***Aquatic eDNA:*** Used to monitor aquatic species by detecting DNA fragments in water bodies. Metrics measured include species presence, abundance, and biodiversity indices in rivers, lakes, wetlands, and coastal systems. This tool is crucial for understanding how NBS projects impact aquatic biodiversity and water quality.[5]
    - ***Terrestrial eDNA:*** Samples soil and other physical materials to assess presence and abundance of species in terrestrial ecosystems like grasslands, forests, and arid regions.[6] It is a relevant strategy for measuring species diversity, soil health, and habitat restoration progress.[7]
    - ***Airborne eDNA:*** Collects DNA from the air to monitor terrestrial biodiversity, particularly useful for tracking pollinators and other insects. It measures the presence and diversity of airborne species, providing insights into ecosystem health and pollinator populations, which are key for biodiversity assessments. Given the abundance of airborne DNA, it has potential to be one of the most efficient methods of biodiversity analysis.[8]
- **LiDAR (Light Detection and Ranging):** An active remote sensing methodology providing high-resolution information on vegetation structure, biomass, and topography.[9] LiDAR can illustrate canopy height and vegetation density, which are vital metrics for extrapolating carbon sequestration potential and overall ecosystem integrity.[10]

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[4] *See generally* World Wildlife Fund, *How Scientists use eDNA to Monitor Biodiversity* (Summer 2022) https://www.worldwildlife.org/magazine/issues/summer-2022/articles/how-scientists-use-edna-to-monitor-biodiversity

[5] Nature Metrics, *eDNA & biodiversity monitoring solutions* https://www.naturemetrics.com/

[6] Norgaard et al., *eDNA metabarcoding for biodiversity assessment, generalist predators as sampling assistants* (March 2021) https://www.nature.com/articles/s41598-021-85488-9

[7] *See* note 5.

[8] Dnair.ch, *Respect begins with knowledge: Revealing life through the analysis of airborne environmental DNA* https://www.dnair.ch/

[9] Potapov et al., *Mapping global forest canopy height through integration of GEDI and Landsat data* (Feb 2021) https://www.sciencedirect.com/science/article/pii/S0034425720305381

[10] Drake, et al., *Sensitivity of large-footprint LiDAR to canopy structure and biomass in a neotropical rainforest* (Aug. 2002) https://www.researchgate.net/publication/222679699_Sensitivity_of_large-footprint_LiDAR_to_canopy_structure_and_biomass_in_a_neotropical_rainforest

- **Hyperspectral & Multispectral Imaging:** This imaging technology works across multiple wavelengths to identify plant species, stress, and overall health. Thus, hyperspectral and multispectral imaging can deduce metrics including NDVI (vegetation index), species composition, and several plant health indicators. It is used for interpreting plant biodiversity and detecting invasive species.[11]

- **Bioacoustic Monitors:** Records sounds of terrestrial wildlife, an especially useful practice for monitoring bird, bat, and insect populations in grassland and forest ecosystems. These devices can also determine odd inflections in bioacoustic patterns, illustrating when illegal logging or other damaging practices occur. They can determine metrics of species presence, diversity, and abundance based on their unique auditory signatures.[12]

- **Camera Traps:** Automated cameras triggered by motion to capture images of wildlife. Certain modeling platforms can also autotag images to species and deduce health indices of individuals using AI recognition technology. This data is used to monitor wildlife populations, assess habitat use, and evaluate the effectiveness of conservation efforts.[13]

- **Citizen Science Platforms:** Engages local communities in data collection, such as biodiversity monitoring and reporting of species sightings. Metrics include species observations, geographic distribution, and community engagement levels. Platforms like iNaturalist and eBird enhance data collection, promote community involvement, and provide large datasets for biodiversity assessments.[14]

- **Soil Measurement Tools:** Tools to measure soil carbon content, moisture levels, and soil health indicators. Metrics include soil organic carbon, nutrient levels, and groundwater retention. These tools are critical for assessing the impact of grassland and forest restoration on soil quality and carbon sequestration.[15]

- **Telemetry:** Tracking devices attached to animals to monitor their movements and behavior. Metrics include movement patterns, habitat use, and migration routes. Telemetry provides detailed data on wildlife corridors, species interactions, and the impact of landscape changes on animal behavior.[16]

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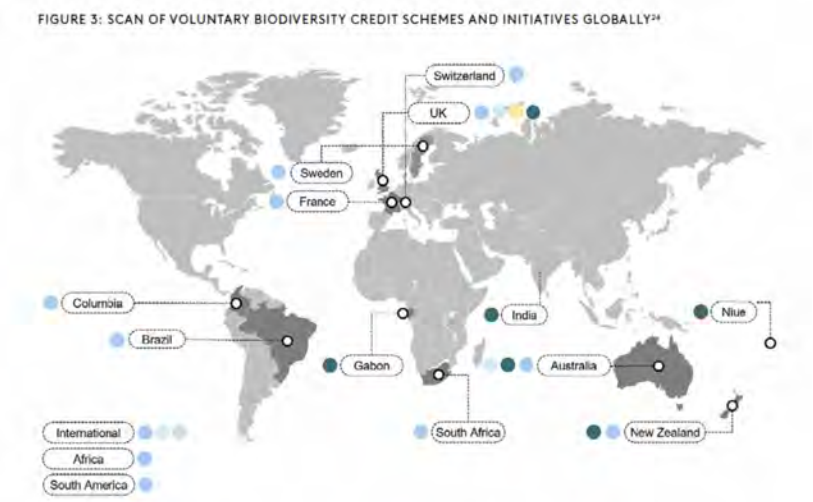
[11] Stamford, et al., *Development of an accurate low cost NDVI imaging system for assessing plant health* (Jan. 2023) https://plantmethods.biomedcentral.com/articles/10.1186/s13007-023-00981-8
[12] Rainforest Connection, *How our System Helps Preserve Rainforests*, https://rfcx.org/
[13] Wildlife Insights, *Bringing Cutting-Edge Technology to Wildlife Conservation* https://www.wildlifeinsights.org/; Conservation Labs, *AI for the frontlines of the biodiversity crisis* https://conservationxlabs.com/the-sentinel
[14] Cornell Lab, *eBird* https://ebird.org/home; https://www.inaturalist.org/
[15] Billings, et al., *Soil organic carbon is not just for soil scientists: measurement recommendations for diverse practitioners* (Jan. 2021) https://esajournals.onlinelibrary.wiley.com/doi/10.1002/eap.2290
[16] *See* https://conbio.onlinelibrary.wiley.com/doi/epdf/10.1111/cobi.13519

Additional Nature-based Solutions Models and Framework Tools to Measure Ecosystem Services Co-Benefits

Several nations have established methodologies for creating, certifying, and trading biodiversity credits and have implemented successful projects like Costa Rica's Payment for Ecosystem Services (PES) and China's Grain-for-Green program. These models offer valuable insights for the U.S. to potentially adopt and adapt, emphasizing the integration of Traditional Ecological Knowledge (TEK) into modern ecosystem management.
The global community has developed various frameworks and approaches for valuing ecosystem services which can be highly relevant for U.S. government (USG) implementation. Countries like Australia and Colombia have developed notable initiatives within the voluntary biodiversity credit market, each showcasing unique approaches to fostering biodiversity conservation through market mechanisms.

FIGURE 3: SCAN OF VOLUNTARY BIODIVERSITY CREDIT SCHEMES AND INITIATIVES GLOBALLY[24]



Source: This figure is based on desktop research by Pollination (as of September 2023).

Australia's Biodiversity Offset Scheme, initiated in 2016, includes a Credits Supply Task Force and a $106 million Biodiversity Credits Supply Fund to enhance landholder participation and improve biodiversity outcomes. This scheme supports the creation of credits that represent conserved and restored habitats, purchased by entities seeking to offset their environmental impacts.[17] More recently, The Nature Repair Act came into effect on December 15, 2023 establishing a framework for a world-first legislated, national, voluntary biodiversity market. The Act provides legislative rules to support transparency and integrity and to foster collaborative efforts to address environmental decline.[18]

[17] *Velástegui, The State of the Global Biodiversity Credit Market* https://medium.com/@ClimateCollective/the-state-of-the-global-biodiversity-credit-market-0f1e283d01ac
[18] Australian Government, *Nature Repair Market* https://www.dcceew.gov.au/environment/environmental-markets/nature-repair-market

In Colombia, the Habitat Banks approach, developed by Terrasos, generates quantifiable biodiversity gains through projects like the El Globo Cloud Forest Habitat Bank. This initiative focuses on conserving vital ecosystems and selling credits to industries such as oil, energy, and transportation, ensuring financial support for long-term conservation efforts.[19] Both countries' schemes illustrate how voluntary biodiversity credits can mobilize private and public sector resources to achieve nature-positive outcomes and support local communities.

In addition, many countries are pioneering innovative methods for creating, certifying, and trading biodiversity credits, working with local communities and stakeholders to incentivize conservation. For instance, the EU Biodiversity Strategy for 2030 aims to invest €20 billion annually in biodiversity through multiple funds,[20] including Natura 2000. In addition, the EU Corporate Sustainability Reporting Directive (CSRD) compels large companies with business in the EU to disclose their impacts, risks, and opportunities related to biodiversity and ecosystems as part of their broader sustainability reporting obligations helping with the shift towards nature positive outcomes.[21] In Costa Rica, the Payment for Ecosystem Services (PES) project leverages fuel tax revenues to pay landowners for conservation efforts. Specifically, the program "bundles together the provision of four main environmental services: carbon sequestration, biodiversity protection, water regulation and landscape beauty and creates direct cash transfer to private landowners for five or 10-year contracts for different activities of forest protection, reforestation, sustainable forest management and agroforestry."[22]

China's Grain-for-Green program incentivizes farmers to convert agricultural lands into forests and grasslands helping to reduce ecological degradation of eroded soils while increasing rural job opportunities.[23] These international models highlight diverse funding mechanisms and incentive structures. Furthermore, Traditional Ecological Knowledge (TEK) offers invaluable insights into ecosystem services and Nature-based Solutions, linking ancient practices to modern environmental management. Integrating TEK into US ecosystem management can enhance sustainability and resilience, aligning with global standards like the Corporate Biodiversity Footprint (CBF) and Global Biodiversity Score (GBS). By examining the potential adoption and/or adaptation of these international frameworks, the U.S. may be able to leverage proven strategies to enhance its ecosystem service valuation and conservation efforts.

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[19] *See* note 17.
[20] European Commission, *Biodiversity strategy for 2030* https://environment.ec.europa.eu/strategy/biodiversity-strategy-2030_en
[21] Planet, et al., *Accelerating Biodiversity And Ecosystem Reporting* (Jan. 2024) https://planet.widen.net/s/hfzqrvkgdq/2401.22-2_mar-9078-whitepaper-on-biodiversity-reporting-at-wef
[22] United Nations, Payments for Environmental Services Program | Costa Rica https://unfccc.int/climate-action/momentum-for-change/financing-for-climate-friendly-investment/payments-for-environmental-services-program
[23] Zhiyong, *A policy review on watershed protection and poverty alleviation by the Grain for Green Programme in China* https://www.fao.org/4/ae537e/ae537e0j.htm#:~:text=The%20Grain%20for%20Green%20Programme%2C%20as%20a%20CDM%20activity%20of,history%20and%20across%20the%20globe.

APPENDIX B

A similar scoping approach can be used for grasslands and coastal resilience NBS projects:

Grasslands NBS Projects

Climate Resilience and Cultural and Social Values:

Indigenous Communities and Cultural Value

- Are there indigenous communities near the grassland ecosystem? Do these communities have specific cultural or spiritual practices involving grasslands?
- Is the grassland historically or culturally significant to these communities?
- What are the opinions of these communities on the planned project, and how should planning incorporate their perspectives?

Recreation

- What recreational activities are currently enjoyed in the grassland area (e.g., hiking, birdwatching)? How might the restoration or protection of the grassland enhance or affect these recreational activities?
- Is the grassland known for any specific recreational benefits that need protection or enhancement?

Water Quantity and Quality:

Water Retention and Infiltration

- How will the restoration project enhance water retention and infiltration in the soil? Will the project involve practices that improve soil structure and water-holding capacity?

Riparian and Buffer Zone Restoration

- How will riparian and buffer zone restoration improve water filtration in nearby waterways?
- Are there specific plans to restore associated wetlands with the grassland? What is the potential of these wetlands for water retention and filtration?

Impact on Hydrological Cycles

- How will the project influence local hydrological cycles, including groundwater recharge and surface water flow?

Biodiversity:

Species Inventory

- Is there a comprehensive inventory of plant and animal species in the grassland area? Will baseline surveys be conducted to document current biodiversity?

Habitat Restoration

- How will the habitat be optimized for the conservation of endangered or vulnerable species?
- Will the project restore habitats that were previously degraded or lost?

Wildlife Corridors

- Does the grassland project support or expand wildlife corridors, especially through agricultural zones? How will these corridors enhance connectivity for wildlife populations?

Pollinators

- What is the potential benefit of the project for pollinators such as bees, butterflies, bats, and birds?
- Will the restoration target critical flowering plants that support pollinators?
- What is the proximity of the grassland to agricultural sites, and how might this affect native pollinators?

Citizen Science

- Are there existing citizen science projects in the area that can contribute to monitoring biodiversity? How will the project engage local communities in biodiversity conservation efforts?

Coastal Resilience NBS Projects

Climate resilience:

- How do coastal ecosystems mitigate the risks of wildfires, flooding, and storms?
    - What natural features (e.g., mangroves, dunes, coral reefs) provide the most effective protection against storm surges and coastal erosion?
- What is the impact of climate change on coastal food security?
    - How are changing ocean temperatures and acidification affecting local fish stocks and marine biodiversity?

Cultural values:

- What cultural practices and traditions are linked to coastal ecosystems?
    - How do indigenous and local communities use coastal resources for traditional ceremonies or rituals?
- What recreational activities are important for the local community and how do they depend on the health of the ecosystem?

Carbon benefits:

- What are the current rates of carbon sequestration in local coastal ecosystems?
    - How do coastal ecosystems such as mangroves, salt marshes, and seagrasses contribute to carbon sequestration?
    - How can we enhance carbon sequestration efforts in the area - considering the restoration and conservation efforts around coastlines.
- How can we involve local communities in carbon sequestration projects to ensure their success and sustainability?

Water (quantity and quality):

- How do coastal ecosystems influence the availability and quality of freshwater resources?
- How do coastal wetlands and mangroves filter pollutants and improve water quality?
- What are the sources of water pollution in the coastal area, and how can ecosystem services mitigate them?
    - What are the major pollutants affecting coastal waters, and what are their sources (e.g., agricultural runoff, industrial discharge, urban wastewater)?
    - How can natural buffers like wetlands and mangroves be used to reduce nutrient and sediment runoff?

Biodiversity:

- What are the key species in the coastal ecosystem and their roles in maintaining ecological balance?
- How do coastal ecosystems support pollination and food production for local communities? What risks are there of trophic collapse, and how can they be mitigated?
    - What measures can be taken to prevent overfishing and protect key species to avoid trophic collapse?

Urban quality of life:

- How do coastal greenspaces contribute to urban cooling and reduction of heat islands?

At-Large:

- How can we ensure that nature-based solutions are inclusive and benefit all segments of the community?
- What are the potential trade-offs and unintended consequences of implementing these solutions, and how can they be minimized?
- How can local knowledge and expertise be integrated into the planning and execution of nature-based solutions?

APPENDIX C

I. American Forests' Reforestation Case Study

American Forests recently created an Integrated Post-Fire Resilience Strategy for South Central Oregon.[24] This strategy focuses increasing post-fire resilience in forests in South Central Oregon—potentially to serve as a model for post-fire resilience projects in other areas. While the strategy does not explicitly frame or propose a particular NBS project, it references such projects as an important element driving the need for post-fire resilience, noting that without increasing resilience on post-fire landscapes, these landscapes cannot be leveraged for natural climate solutions in the future.

The South Central Oregon Post-Fire Resilience strategy has been selected as a case study because it explicitly discusses how to consider and integrate valuable ecosystem services into post-fire project planning and prioritization. For example, it describes a way in which fuel breaks can be leveraged not just for wildfire suppression and firefighter safety, but also to increase habitat and biodiversity in different forest types. Emphasis is placed on reducing hazardous fuels loads to reduce future wildfire risk, but explicit reference is made to need to consider tradeoffs between mitigating wildfire risk and ensuring that habitats and biodiversity are maintained. While this strategy is focused on post-fire reforestation on forests, meadows and other habitats will also require post-fire restoration work. The strategy advocates for consideration and prioritization of those habitats that provide high value ecosystem services, particularly in terms of water filtration and storage and habitat and biodiversity conservation. There is is emphasis on restoring habitat types to ensure holistic landscape resilience and allowing for forests and their surrounding ecosystems to continue working together to provide multiple ecosystem services for the landscape.

The strategy outlines a method for prioritizing areas for reforestation. The prioritization includes two important ecosystem co-benefits that are frequently associated with forestry projects: recreation and habitat. The strategy prioritizes areas near trails and campgrounds for more immediate deforestation practices. Also prioritized for deforestation activities are areas with rare trees such as white bark pine and sugar pine so as to increase tree presence and resilience in those area. Meanwhile, areas having winter forage habitat for ungulates (elk and deer) have been deprioritized.

Fuel break prioritization in this strategy was weighted more highly when cultural and social co-benefits were present, in this case meaning higher weightings were applied to areas closer to nearby communities and on privately owned lands.

[24] American Forests, *Integrated Post-Fire Resilience Strategy* https://d3f9k0n15ckvhe.cloudfront.net/wp-content/uploads/2023/07/Integrated_Post-Fire_Resilience_Strategy.pdf

The strategy also defines and sets goals for reforestation, including goals to: "restore ecosystem services (e.g., wildlife habitat—such as mule deer winter range cover, watershed function and carbon sequestration) and meet management objectives….balance conifer re-establishment with wildlife needs [and] restore riparian vegetation."

These goals focus on thoughtfully balancing trade-offs between reforestation and wildlife needs, protecting and creating wildlife habitat, preserving cultural resources for the Klamath Tribes in the area, working with the Klamath Tribes Natural Resource Department and consulting scientists to identify watersheds with highest storage and yield capacity, reforesting around watersheds with the goal of preventing sedimentation, and identifying and prioritizing areas of high carbon sequestration levels.

Lastly, the strategy includes a section about invasive species management, indicating the need to manage and remove invasive species to prioritize native biodiversity.

These strategic goals indicate how co-benefits can be considered and factored into restoration strategies at a high level, as well as giving specific, place-based examples of co-benefits being considered, including the focus on cultural value to the Klamath Tribes and accommodations for the local ungulate fauna's winter foraging needs.

II. NFWF's Great Plains Case Study[25]

As explained above, the National Fish and Wildlife Foundation (NFWF), a non-profit organization working to sustain, restore, and enhance fish, wildlife, plants, and their habitats in the U.S., is supporting extensive grassland restoration and conservation program work across the Great Plains. NWFS's primary focus is on biodiversity enhancement, with carbon sequestration, water retention, and livelihood improvements treated as key co-benefits. Two aspects of NFWF's grasslands initiative feature different approaches but yield similarly symbiotic and expansive co-benefits in the grassland ecosystem context.

The Rainwater Basin Joint Venture:[26] Removing Invasive Eastern Red Cedar Trees to Restore Native Prairie in the Sandhills of Nebraska

Biodiversity: By mulching invasive eastern red cedar trees on-site and allowing native prairie to recover, this project directly improves habitats for grassland-obligate wildlife. Even one tree per acre can deter most grassland wildlife from utilizing the area due to the perches they provide for

[25] Information in this use case was obtained by interviewing Holly Bamford, NFWF's Chief Conservation Officer.
[26] The Rainwater Basin Joint Venture is a voluntary cooperative partnership that works "with landowners, conservation agencies, researchers, agriculture businesses and associations, and others, in pursuit of …demonstrate[ing] that wildlife and agriculture can not only co-exist, but thrive together." https://www.rwbjv.org/about-us/who-we-are/

birds of prey, which threaten native species. Removing these trees allows grassland songbirds, prairie chickens, and other native fauna to return to the restored habitat, promoting biodiversity.

Water quality and quantity: The project enhances soil health by allowing native prairie vegetation to recover, which stabilizes the soil and increases its organic matter content. Improved soil health contributes to better water retention and infiltration, which is essential for the ecosystem's resilience.

Cultural and Social Values: The U.S. Department of Agriculture estimates that producers experience up to a 75% decline in forage production as grasses are replaced by bare ground under trees, translating to approximately $320 million in lost forage for ranchers. By removing woody invasive eastern red cedar trees, ranchers can significantly improve their forage production and economic bottom line.

Carbon Sequestration: The removal of invasive trees and restoration of native prairie can increase the sequestration of soil organic carbon, turning the grasslands into effective carbon sinks.

Conservation Ranching Program

Biodiversity: The Audubon Society is implementing a conservation ranching program under a NFWF grant which involves drafting Habitat Management Plans (HMPs) that focus on supporting grassland-obligate species such as songbirds. These plans optimize land management practices to create and maintain habitats for these species. Ongoing bird monitoring provides feedback on the success of these management actions, ensuring that habitat goals are being met.

Cultural and Social Values: The conservation ranching program provides technical support to ranchers through state-based rangeland ecologists. This includes workshops, community-led conservation partnerships, and connecting ranchers to technical assistance programs. By improving land management practices, the program helps ranchers achieve their land management goals, leading to more sustainable and profitable operations.

Carbon Sequestration: The program uses soil health monitoring to evaluate the effectiveness of grazing practices and make necessary adjustments to improve soil structure and resilience. Improved grazing practices promote the sequestration of carbon in the soil by maintaining healthy grassland ecosystems.

Monitoring and Additional Support

NFWF has supported hundreds of similar grants over the past eight years, emphasizing the integration of biodiversity, ecosystem resilience, carbon sequestration, and supporting rancher livelihoods. For example, NFWF works with the Bird Conservancy of the Rockies to conduct bird monitoring on five focal species identified in the Northern Great Plains Business Plan: Baird’s sparrow, Sprague’s pipit, chestnut-collared longspurs, thick-billed longspur, and lark

buntings. Monitoring to date has shown statistically significant higher densities of chestnut-collared longspurs on sites on which NFWF has supported improved grazing management practices, as compared against local and regional control sites.

These case studies exemplify the multifaceted benefits of grassland restoration projects, emphasizing the importance of integrating biodiversity, ecosystem resilience, carbon sequestration, and supporting rancher livelihoods to achieve sustainable and resilient outcomes.

III. The Nature Conservancy's Coastal Resilience Projects Case Study

Coastal ecosystems, encompassing diverse habitats such as mangroves, salt marshes, seagrass beds, and coral reefs, play a crucial role in the implementation of nature-based solutions (NBS) to address contemporary environmental and socio-economic challenges. These ecosystems provide invaluable services, including carbon sequestration, shoreline stabilization, and biodiversity support, which are essential for mitigating climate change impacts, enhancing resilience to natural disasters, and sustaining local livelihoods. Their ability to naturally buffer against coastal erosion, reduce flood risks, and filter pollutants underscores their significance in fostering sustainable development and ecosystem-based management strategies. Leveraging the intrinsic benefits of coastal ecosystems through nature-based solutions offers a holistic approach to environmental stewardship, emphasizing the integration of natural processes into climate adaptation and mitigation frameworks.

The Nature Conservancy (TNC) is spearheading several demonstration projects in Florida that showcase the benefits of nature-based solutions and natural infrastructure for coastal resilience, flood risk reduction, and climate adaptation. In Miami's Morningside Park, TNC is collaborating with the city to restore the waterfront using a living shoreline. This project, supported by the Chubb Charitable Foundation, involves the restoration of mangroves, creation of elevated berms with native vegetation, and installation of limestone rip-rap to reduce wave energy. It aims to protect the park and nearby residents from extreme high tides and heavy rainfall, enhancing the park's resilience and providing significant savings by preventing future flood damage.[27]

In Miami Beach, TNC partnered with the city and Florida Power & Light Company on the Brittany Bay Park Living Shoreline project. This initiative included improvements to the existing seawall and bulkheads, establishment of an intertidal basin for mangroves, and planting of native vegetation along the shoreline. The project aims to mitigate the impacts of sea level rise and severe weather, enhance natural habitats, and demonstrate how integrating green infrastructure with traditional gray infrastructure can create resilient urban environments.

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[27] *See generally* The Nature Conservancy, *Coastal Resilience: Using nature-based solutions to protect Florida's coasts* https://www.nature.org/en-us/about-us/where-we-work/united-states/florida/stories-in-florida/florida-coastal-resilience/

A large component of this project is ensuring complete community buy-in to the project. This means ensuring the project is one that the community wants and needs, and even more importantly it involves heavy community engagement at each step of the process. Rather than a project implemented in a community, it is a project co-designed with the community. As explained, this process often includes thorough communication—in some cases "overcommunication"—and ensuring the language used to communicate the project is accessible and often uses more colloquial words and phrases. This allows for longer term sustainability and maintenance of the sites themselves.[28]

Additionally, the Palm Beach Resilient Island project in the Lake Worth Lagoon combines oyster reefs and mangrove plantings to create a natural breakwater. Supported by the Batchelor Foundation and the Carrier Corporation, this project aims to stabilize intertidal sediments, limit erosion, and protect upland areas. By minimizing the use of limestone rip-rap and utilizing oyster reefs, the project seeks to establish mangroves and improve coastal resilience.

This innovative layered approach is the first of its kind in South Florida and, if successful, could serve as a replicable model for protecting natural habitats and built environments from destructive waves, storm surges, and rising seas.[29] Within Florida coastal resilience projects in particular, research is still being done around the feasibility of using a planned mangrove restoration to market blue-carbon credits.[30] While this can definitely be a major source of carbon sequestration, mangrove restoration will need to be completed at a larger scale in order to effectively use this source in the blue carbon credit market. The Everglades in Florida would be the largest current carbon sequestration source being used within the carbon credit market.

These TNC projects not only aim to protect and beautify urban coastal areas but also serve as models for future climate adaptation efforts, influencing policy and showcasing the practical benefits of nature-based solutions.

[28] Interview with James Bryne (TNC) in June 2024.
[29] *See generally* The Nature Conservancy, Coastal Resilience: Using nature-based solutions to protect Florida's coasts https://www.nature.org/en-us/about-us/where-we-work/united-states/florida/stories-in-florida/florida-coastal-resilience/
[30] NOAA, Fast Facts: Blue Carbon https://coast.noaa.gov/states/fast-facts/blue-carbon.html#:~:text=In%20Florida%2C%20Rookery%20Bay%20Research,trade%20on%20the%20carbon%20market.