# Principles and Safeguards for Natural Climate Solutions

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# INTRODUCTION

This document offers science-based principles to guide implementation of natural climate solutions (NCS) at national and sub-national scales. These principles broadly support the inclusion of NCS among measures needed to meet targets associated with the Paris Climate Agreement that establishes a global framework to limit warming to less than 2°C.

NCS employ "negative emissions," or GHGs removed from the atmosphere, and have a significant role to play in limiting warming along with emissions reductions. Land, inland waters, and coastal ecosystems currently remove about 30% of global annual carbon dioxide emissions, and have the potential to continue or even increase this critical carbon sequestration function—they could potentially deliver up to one-third of net emission reductions needed to remain within a 1.5- or 2-degree Celsius warming pathway by 2030 (Adams et al. 2021). Solutions that abate emissions using NCS are also estimated to be highly cost-effective when compared to engineered solutions, such as carbon capture, utilization, and storage (Griscom et al. 2020). Many forms of NCS are available to deploy immediately, at scale, without technological breakthroughs.

An advantage of NCS is that if carefully designed, the activities can have substantial co-benefits such as conserving biodiversity and protecting water supplies. However, realizing this potential will require careful analysis of options for deploying NCS, as well as monitoring of results which may be impacted by climate change.

The following principles are intended to help avoid specific unintended consequences of NCS implementation. Although the principles were developed with U.S. policies and programs in mind, the scope is not limited to U.S. borders, particularly considering that agricultural and forest products are internationally traded commodities, and that protecting biodiversity and reducing greenhouse gasses are globally recognized priorities.

The framework underlying these principles includes considerations of the time, space, and human dimensions:

- The time dimension recognizes that NCS involve changes in ecosystems and ecosystem management that have impacts spanning decades to centuries. The effectiveness of a particular climate solution will vary over these timeframes—some will be effective in the short term, and some in the long term—as the climate changes and other factors evolve. The expected benefits as well as co-benefits need to be evaluated both now and in the future.
- The spatial dimension reflects the fact that ecosystems are highly variable geographically, as are the various factors that influence ecosystems. For example, natural disturbances such as fire are much more common and severe in areas where drought and high temperatures are prevalent. Management practices also differ considerably by region, with some regions dominated by agriculture, some by silviculture, and some by protection from human-caused disturbances. Potential solutions will be different for these categories, as will the effectiveness of each solution for reducing greenhouse gas emissions to the atmosphere.
- The human or community dimension is critical because NCS will be implemented by people within specific social and economic contexts. All solutions have consequences that go beyond the goal of reducing greenhouse gasses, and people will be affected in different ways. Impacts may be positive, such as providing jobs and temperature regulation by planting trees in urban environments, or negative, impacting specific economic sectors such as agriculture and the forest products industry. Therefore, it is essential to evaluate how the different NCS will affect different communities, over different time frames, and in different regions.

## OVERVIEW OF PRINCIPLES

1. **Protect, manage, and restore ecosystems to maintain or increase climate benefits.**

   Protecting threatened high-carbon ecosystems can avoid emissions and help protect biodiversity; the benefits are immediate and difficult to replace once lost, making ecosystem protection a top priority. Improved management can be applied at low cost over large areas, and can have substantial and enduring co-benefits. Restoring degraded land to native vegetation can increase biodiversity while increasing carbon stocks to levels consistent with the potential of the site over the long term. While important, restoration should not be viewed as an alternative to or replacement for protection.

2. **Consider risks from climate extremes, natural disturbances, and socioeconomic events.**

   Many NCS will take time to reduce net greenhouse gas emissions; exceptions are avoiding deforestation and forest degradation, delaying harvest, and reducing emissions from agricultural soils. Calculations of expected benefits must consider climate change and other factors that are likely to impact the outcomes of NCS.

3. **Engage Indigenous Peoples and local communities, and work to mitigate inequalities and injustices.**

   Natural climate solutions should be implemented with full engagement of Indigenous Peoples and local communities in ways that respect land, culture, and human rights. The historical legacies and ongoing effects of institutional racism necessitate particular care to include the knowledge and interests of these communities. Participatory engagement, negotiations, and consent are critical.

4. **Enhance human welfare and "do no harm."**

   Natural climate solutions should aim to generate a net enhancement to human welfare, while doing no harm to impacted parties. If the tradeoffs between the private and public benefits from policy choices are clearly defined and quantified, potential negative outcomes can be identified and mitigated to the greatest extent possible. Unless natural climate solutions can be demonstrated to have clear overall benefits to society and impacted stakeholders, and private costs mitigated, they are unlikely to be adopted.

5. **Practice full-system accounting so that all effects on the carbon cycle are assessed, and the contributions of a given natural climate solution can be evaluated.**

   Assessing the climate impacts of natural climate solutions requires a systems approach because of the connections between agriculture, forests, land use, food and fiber production, and energy production. It is therefore essential to practice full-system carbon accounting, including the effects of activities on ecosystems and their ability to maintain or increase carbon stocks, as well as impacts on fossil fuel emissions from related economic sectors. Full-system accounting should be complemented with effective monitoring and reporting.

6. **Ensure that carbon credits used to finance natural climate solutions meet the highest standards of quality, integrity, and offset eligibility.**

   There are numerous financing models for natural climate solutions. Regulatory and voluntary carbon markets could be a significant source of funding for scaling up NCS, but their use needs to follow strict guidelines to ensure real climate benefits. Offsetting should only be used as a complement to—not substitute for—rigorous decarbonization efforts; this includes both immediate use as emissions are being reduced, as well as long-term use to offset hard-to-abate emissions. All carbon credits must be backed by thorough monitoring and accounting of both risks and benefits (as outlined in previous sections) to ensure quality and integrity.

# 1

# Protect, manage, and restore ecosystems to maintain or increase climate benefits.

Prepared by Richard Birdsey and Wayne Walker

## SUMMARY

Protecting threatened high-carbon ecosystems can avoid emissions and help protect biodiversity; the benefits are immediate and difficult to replace once lost, making ecosystem protection a top priority. Improved management can be applied at low cost over large areas, and can have substantial and enduring co-benefits. Restoring degraded land to native vegetation can increase biodiversity while increasing carbon stocks to levels consistent with the potential of the site over the long term. While important, restoration should not be viewed as an alternative to or replacement for protection.

## INTRODUCTION

Natural climate solutions can be categorized in terms of three broad classes of activities: protecting, managing, and restoring. According to a recent synthesis by Cook-Patton et al. (2022), these interventions can be prioritized in terms of their magnitude, immediacy of mitigation potential, cost-effectiveness, and the co-benefits they offer. Here we describe each and provide some examples.

## PROTECTING HIGH VALUE AND HIGH CARBON ECOSYSTEMS

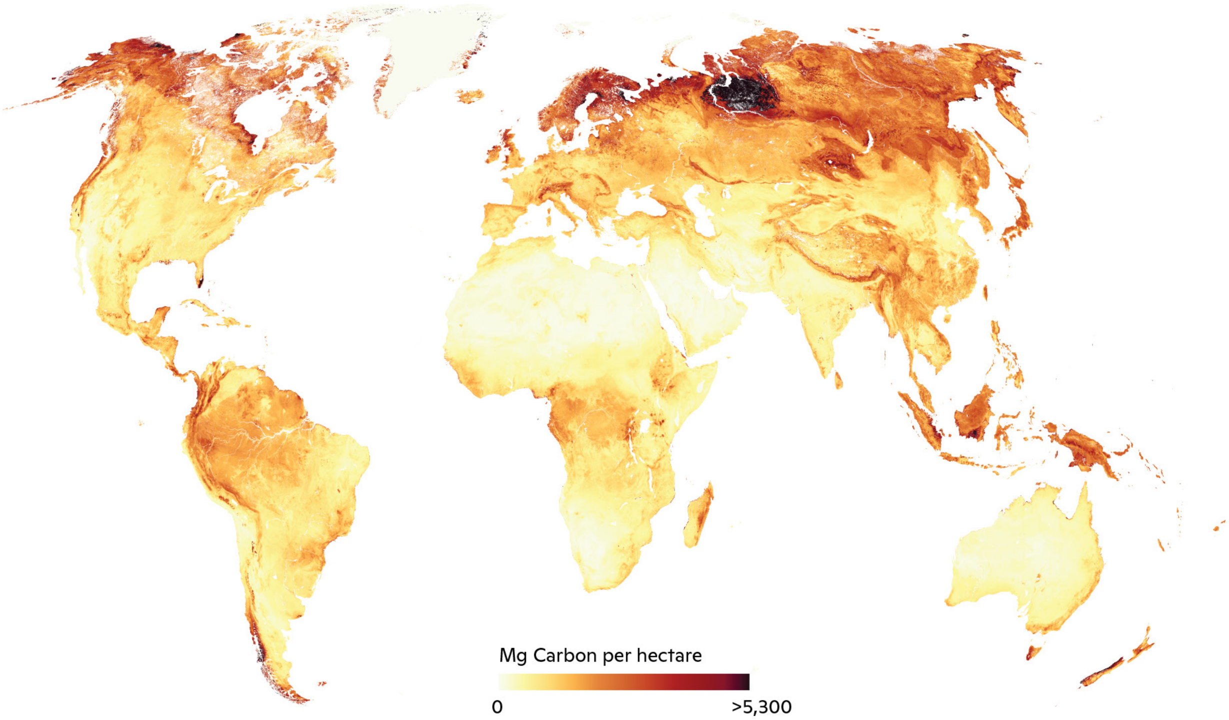

**Figure 1.** Carbon, stored both above and belowground in vegetation and soils, varies greatly around the globe. This map shows current carbon (ca. 2016; megagrams per ha) in aboveground biomass, below-ground biomass, and soil under baseline climate (Walker et al. 2022).

Plants naturally remove carbon dioxide from the atmosphere through the process of photosynthesis, converting $CO_2$ to carbon that is then stored in the biomass of leaves, branches, stems, roots, and soil. The carbon stored in the biomass and soils of high-carbon ecosystems can be lost quickly (e.g., through forest clearing) and take decades to centuries to replace. Protecting high-carbon ecosystems from degradation, logging, or conversion to other land uses can avoid emissions of stored carbon and retain their capacity to remove $CO_2$ from the atmosphere (Birdsey et al. 2023; Walker et al. 2022).

- **Older forests** with high carbon stocks can continue to remove $CO_2$ from the atmosphere for many decades or centuries depending on tree species, geography, climate, and natural disturbances (Curtis and Gough 2018). It has also been shown that rates of carbon accumulation in most tree species increase continuously with tree size, such that the largest 1% of trees globally store half of the aboveground biomass (Stephenson et al. 2012; Lutz et al. 2018).

- Among the planet's forest biomes, **tropical forests** store the most above-ground biomass, remove the most $CO_2$ from the atmosphere, and include the greatest area of primary forest (Mackey et al. 2020; Pan et al. 2011; Walker et al. 2022). They also provide significant biophysical cooling in addition to the effect of removing and storing carbon (Lawrence et al. 2022). When implementing NCS strategies, avoiding the fragmentation or degradation of existing tracts of primary tropical forest and protecting the largest trees—wherever they occur—should be prioritized.

- **Terrestrial wetlands** (i.e. non-tidal freshwater wetlands) cover about 71 million hectares in the U.S. About half of this area is forested wetland and 23% is peatland, which contains very high carbon stocks (Kolka et al. 2018). Terrestrial wetlands are significant carbon sinks, sequestering about 55 million metric tons of carbon per year both above- and below-ground. The main threats to terrestrial wetlands have been vegetation removal, surface hardening, and drainage (U.S. EPA 2016). Despite policies in the U.S. and elsewhere designed to avoid wetland conversion, losses to development and other competing land uses still occur.

- **Coastal/tidal wetlands and estuaries** also store large amounts of carbon. These are extremely dynamic ecosystems since they receive large quantities of soil and organic matter from adjacent terrestrial ecosystems, storing a portion within the area and exporting some to the coastal ocean (Windham-Meyers et al. 2018). Tidal wetlands in particular are among the strongest long-term carbon sinks per unit area because carbon accumulates continuously in sediments (Chmura et al., 2003). Tidal wetlands (including mangroves) and estuaries are threatened by rising sea levels, chemical runoff from the land, and disturbances such as hurricanes and drainage for development.

- **Arctic and boreal ecosystems** store large quantities of carbon in soils. This carbon is vulnerable to being released to the atmosphere, due to warming temperatures and increases in natural disturbances, such as wildfire and insect outbreaks (Miner et al. 2022; Schuur et al. 2018, 2022). This is especially true in frozen soils (permafrost), which in total store twice as much carbon as is found currently in the atmosphere (Zimov et al. 2006). The circumpolar permafrost zone is warming roughly 3-4 times faster than the rest of the planet—this warming is thawing perennially frozen ground and causing the release of stored carbon as carbon dioxide and methane (Chyleck et al. 2022; Romanovsky et al. 2016; Watts et al., 2023). Wildfires are also of particular concern and degraded boreal forests may be more vulnerable to their impacts (Euskirchen et al., 2022). Human influence is increasing in some areas, and more intensive land management near communities may be needed to reduce the risk of wildfire or to suppress fires after ignition (Breen et al. 2016).

High-carbon ecosystems may also be of great value for biodiversity. For example, mangrove ecosystems store some of the highest amounts of carbon on earth, and are critical habitats for a range of marine and freshwater species (Sanderman et al. 2018). Biodiversity helps sustain ecosystem services by supporting their health and resilience, which enables them to resist or quickly recover from disturbances (Seddon et al. 2021).

### IMPROVING LAND MANAGEMENT

Improving land management has large global potential for increasing carbon sequestration and can be applied broadly where management intensity is high, including across tropical and temperate regions where agriculture and forestry constitute significant land uses (Walker et al. 2022). However, the potential gains in carbon removal or reduced emissions from improved land management tend to be smaller on a unit-area basis than gains from activities that protect ecosystems (Fargione et al. 2018; National Academy of Sciences 2018). With small emission reductions per unit area, a larger total area of intervention is required to achieve net emission reductions equivalent to those of an activity that has a larger impact per unit area (Birdsey 2021).

Many strategies exist for improving land management (Figure 2). Some of the more promising ones include accelerating regeneration of forests after disturbance or harvest, increasing the productivity of degraded forests through stocking enhancement, extending rotation lengths (harvest intervals) of commercial forests, improving grazing land management, organic matter amendment on croplands, improving annual cropping systems (numerous options exist), and biochar (Bossio et al. 2020; Cook-Patton et al. 2021; National Academy of Sciences 2018). Reducing the risk of wildfire is also of global concern, though how to approach that without increasing emissions from fuel reduction treatments is a challenge. In tropical regions, some forests—such as those occupying floodplains—may never recover from fire events, suggesting that fire suppression may be an effective treatment (Garcia et al. 2021). In temperate forests, there is a general consensus that in many areas, thinning from below followed by periodic prescribed burns can be effective at both reducing emissions and restoring ecosystems (Prichard et al. 2021). In boreal zones, fire management may also be a cost-effective way to limit emissions (Elder et al. 2022; Phillips et al. 2022).

Many land management strategies have the potential to be implemented at lower cost than other natural climate solutions (Cook-Patton et al. 2021). Yet, there are significant barriers to widespread deployment of improved land management practices, such as the relatively low rate of additional carbon storage (mentioned above), the need to motivate millions of landowners/managers, inadequate monitoring capacity, and evolving carbon markets and registries (National Academy of Sciences 2018).

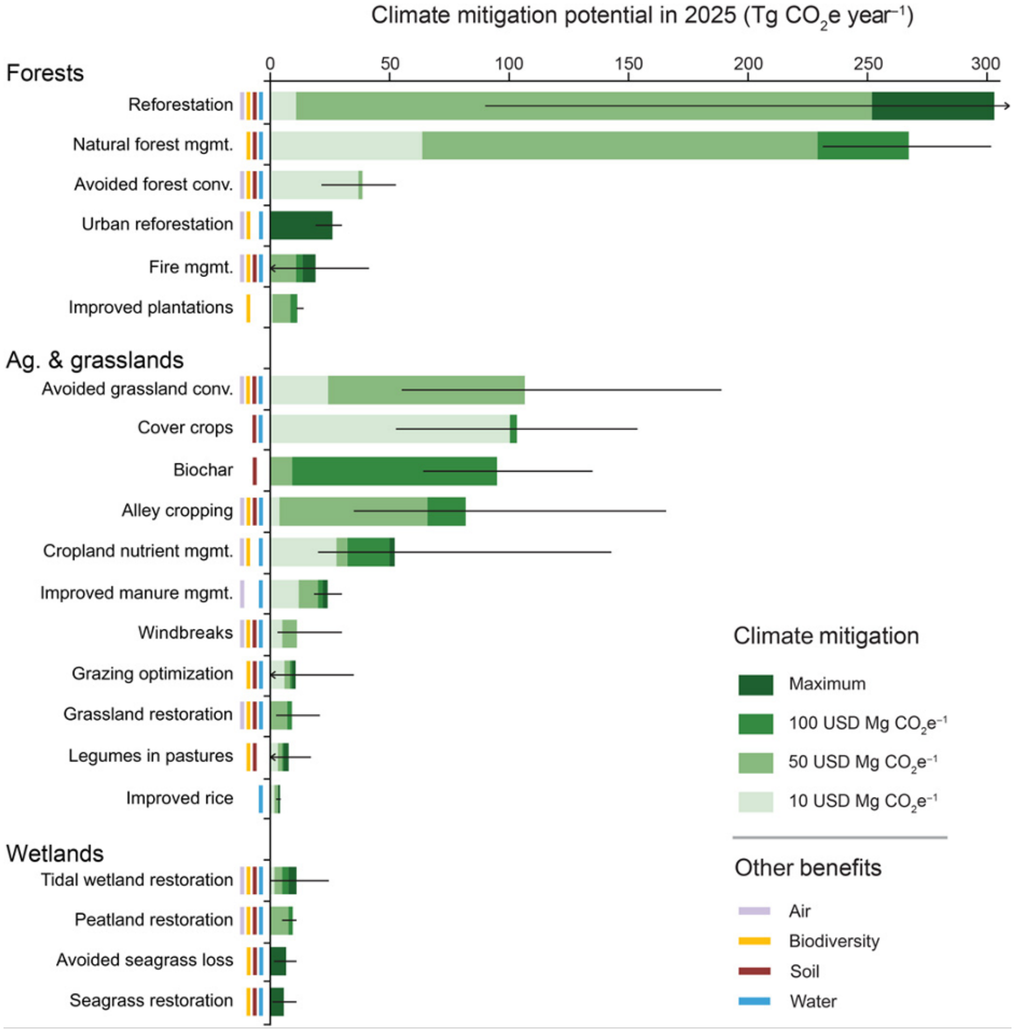

**Figure 2.** Climate mitigation potential of 21 NCS in the United States (Fargione et al. 2018).

### RESTORE DEGRADED AND LOW-CARBON ECOSYSTEMS

One of the most effective and intensive land management activities to increase climate benefits is to restore the functions of degraded ecosystems (Cook-Patton et al. 2021; Griscom et al. 2017). It may not be possible to restore degraded ecosystems to a previous state because of climate change or other environmental changes; nonetheless, ecosystem functions may be restored or rehabilitated. This work may be costly but has the potential to provide long-lasting climate benefits, especially if the restoration enables restored functions to persist indefinitely in the face of a changing climate. Restoration can take many decades to be effective—for example, benefits accrue over longer timescales for wetland restoration than for any other ecological restoration (Xu et al. 2019).

Ecosystem restoration may have significant co-benefits and/or tradeoffs (Strassburg et al. 2019). For example, restoration could increase removal of $CO_2$ from the atmosphere and reverse biodiversity decline, but could also reduce food production if cropland is converted to another land use (e.g., forest), imposing financial costs on farmers (Brancalion et al. 2012).

## HOW THE PRINCIPLE MAY BE APPLIED TO PRIMARY FORESTS

Primary forest is often defined as any naturally occuring forest of native species characterized by little to no human disturbance, and may include intact, old-growth, and ecologically mature forest (Mackey et al. 2020). In many parts of the world, ‘primary’ forest is synonymous with ‘high carbon’ forest, i.e., a relatively long-lived and largely undisturbed forest that has been accumulating and storing carbon for long periods of time.

Reforestation (replacing forest on deforested land) and afforestation (planting new forest) are well-known, forest-based NCS approaches that both depend on the availability of land and the survival of small trees. In comparison, maintaining and managing existing forests that have long-established carbon storage and larger, older trees with a high carbon sequestration capacity can have an immediate and large effect, avoiding emissions from disturbing biomass and soils (DellaSala et al. 2022). Avoiding logging of primary forest, which can take decades to centuries to replace, is not only a more immediate and cost-effective approach to achieving forest-based negative emissions (Houghton and Nassikas, 2017), but it also serves to maximize associated co-benefits, including biodiversity enhancement, improved resistance to natural disturbances and improved resilience following them, improved air and water quality, control of floods and erosion, and enhanced human health and well-being (Moomaw et al. 2019).

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# 2

# Consider risks from climate extremes, natural disturbances, and socioeconomic events.

Prepared by Zach Zobel and Dave McGlinchey

## SUMMARY

The carbon stored in high-carbon ecosystems may take decades to centuries to replace if the stocks are lost. Avoiding the fragmentation or degradation of these ecosystems can result in an immediate reduction in emissions and can help protect biodiversity. When possible, restore degraded land to native vegetation and biodiversity while increasing carbon stocks to levels consistent with the potential of the site.

## DESCRIPTION AND RATIONALE

The impacts of climate change are already being felt and will only worsen, with direct ramifications for natural systems throughout the United States. These impacts will then affect—to a greater or lesser degree—the ability of those natural systems—forests, grasslands, wetlands, and soils—to store carbon and mitigate climate change.

While developing NCS policies, risks should be considered for the range of potential climate change perils: drought, precipitation extremes, flooding, hurricanes, heat stress, invasive species, and wildfire. These hazards were identified as the prevalent risks in the United States out to mid-century—a timeframe that is relevant for both mitigation efforts and near-term policymaking. This information should be understood and internalized by policymakers to avoid implementing or investing in NCS that will not remain viable long-term, though some activities like reducing deforestation and forest degradation could help guard against future hazards. For example, climate risk modeling could help identify areas that will become more prone to drought—and thus, unsuitable for certain NCS—in coming decades.

Changing climate conditions will also shift ecological zones. For example, climate change is projected to alter the distribution of tree species as a result of environmental changes that will affect growth, mortality, reproduction, disturbances, and biotic interactions (Rogers et al. 2017). A region that currently sustains certain tree species could become inhospitable, or overrun by invasive species that outcompete native species, or could become warm enough for migrating pests. These projected changes will affect the net greenhouse gas balance of ecosystems in the future and could result in less net emissions reductions from a given NCS than expected.

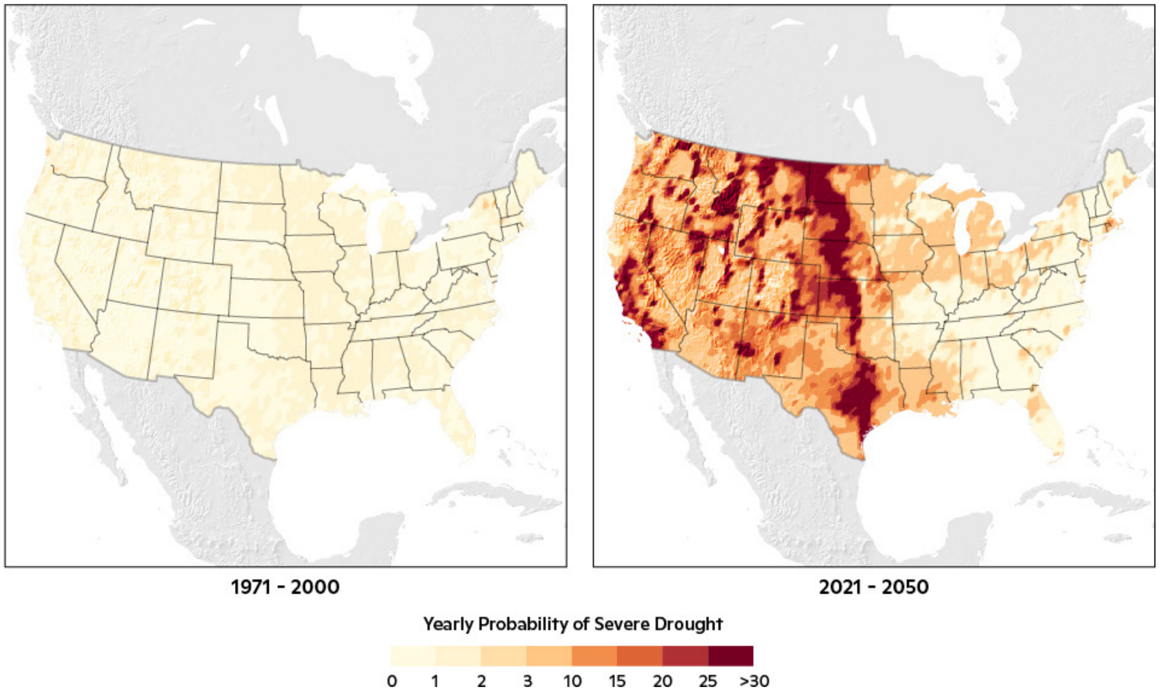
## HOW THE PRINCIPLE MAY BE APPLIED TO SPECIFIC CLIMATE RISKS—DROUGHT AND WILDFIRE

### 1. DROUGHT

Since the 1980s, droughts have been the second-most costly weather/climate disaster in the United States, generating an average $9.4 billion loss per event (NCEI NOAA). California and much of the western United States are arid regions, historically prone to drought (Bolinger 2019). The 2012-2016 California drought, driven primarily by record high temperatures and less than normal precipitation, was by some measures the state's most extreme drought of the past century with the 2014 peak being the driest period over the last 1,200 years (Griffin & Anchukitis 2014). The drought caused a widespread mortality event of 48.9% of the state's trees across 102 million acres of forests in 2014-2017 in the central and southern Sierra

Nevadas, which may lead to forest type conversion or even a long-term shift to grassland (Fettig et al. 2019).

In the future, drought frequency and severity is expected to worsen as global temperatures increase and precipitation becomes more variable (Cook et al. 2015; Huang et al. 2017). By 2021-2050, the probability of extended severe drought increases to at least 3 times more likely (>3%) across most locations of western and central U.S, with severe drought becoming more than 20 times more likely in many locations (darker reds in Figure 1). Such widespread drought in these regions would affect all ecosystems, including those essential to sustain food supplies, and could severely impact NCS designed to reduce net GHG emissions by enhancing carbon sequestration in forests and soils.



1971 - 2000

2021 - 2050

**Figure 1.** Yearly Probabilities (%) of a Severe Drought in 1971-2000 and 2021-2050. A severe drought is defined as a 6-month average of extreme drought.

## 2. FIRE

Fire is a natural process in many healthy forest ecosystems, but longer fire seasons, hotter and drier conditions, and the legacy of fire suppression and exclusion to reduce property loss, has resulted in a trend toward more, larger, and more intense wildfires.

The American Southwest is a prime example. The average acreage burned per year in the United States more than doubled from 2000-2019 relative to 1980-1999, and wildfire size has increased in most of the western United States (Center for Climate and Energy Solutions). In addition, the wildfire season is lengthening throughout much of the western United States, with increases in high-fire-danger days exceeding two weeks in some areas of California (Figure 2).

The increasing risk of wildfire poses a significant threat to forest-based NCS. However, conservation of large trees in mature and old-growth forests affords the greatest potential for growing carbon stocks while enhancing fire resilience.

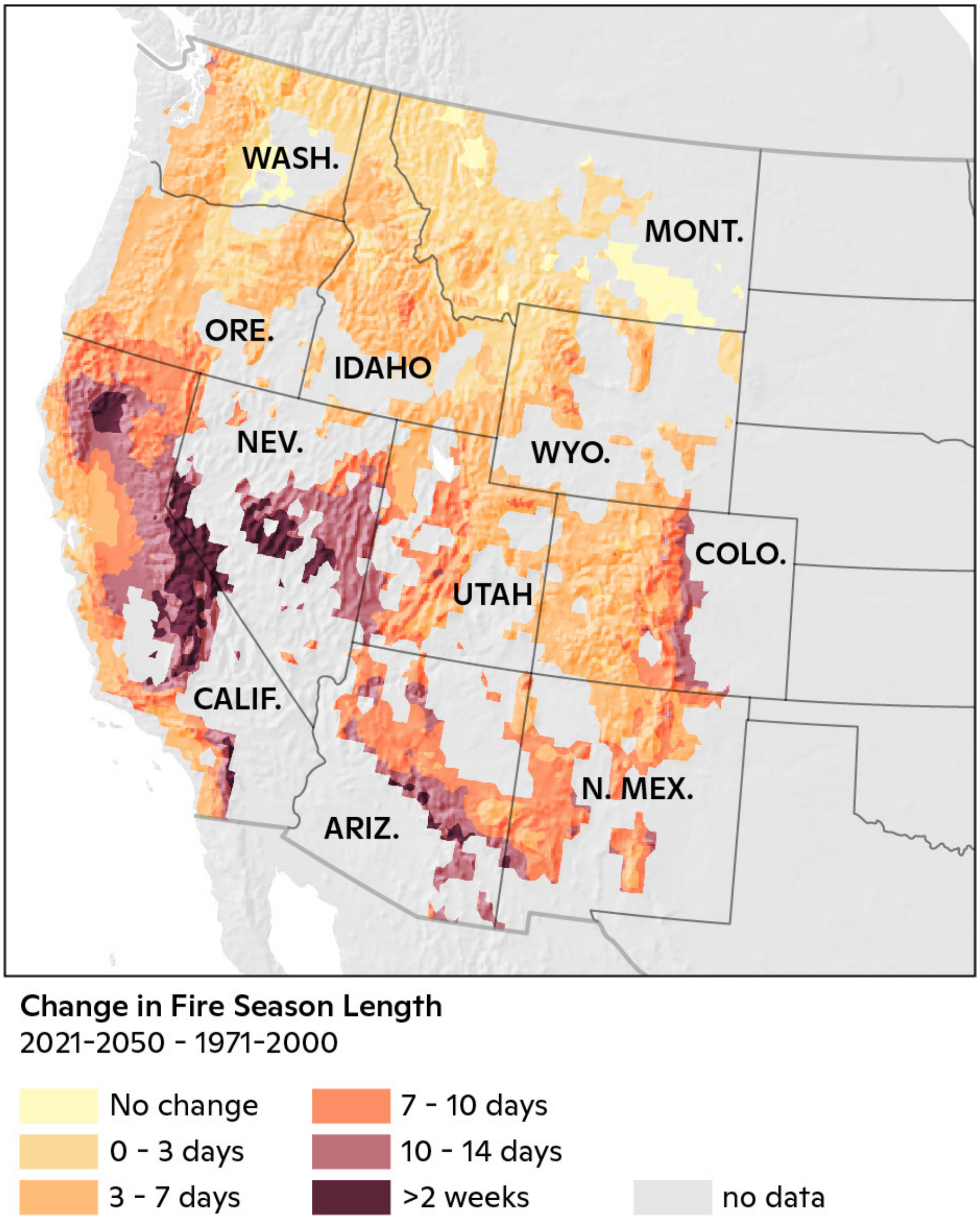


**Figure 2.** Increase in fire danger days in 2021-2050 relative to 1971-2000 in western United States. Areas lacking adequate vegetation or fuel along with areas where the fire weather index has low predictive skill historically have been masked out.

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# 3

# Engage Indigenous Peoples and local communities, and work to mitigate inequalities and injustices.

Prepared by Natalie Baillargeon and Sue Natali

## SUMMARY

Natural climate solutions should be implemented with full engagement of Indigenous Peoples and local communities in ways that respect land, culture, and human rights. The historical legacies and ongoing effects of institutional racism necessitate particular care to include the knowledge and interests of these communities. Participatory engagement, negotiations, and consent are critical.

## DESCRIPTION AND RATIONALE

*Mitigating Existing Impacts.* Due to institutional racism and inequity, minority and low-income communities have been disproportionately harmed by environmental hazards (Bullard 1993; Schlosberg & Collins 2014). While this document primarily focuses on U.S. examples, we recognize that this holds true in varying forms around the world. Natural climate solutions (NCS) should consider locally relevant history and attempt to mitigate legacy, ongoing, and potential future impacts.

For example, in the same city, redlined communities had 2.4 times the rate of hospitalization for asthma compared to non-redlined communities (Nardone et al. 2020). While Executive Order 12898, “Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations” was signed over 20 years ago, much of its mandate to consider environmental justice in decision making has yet to occur and/or has weakened over time (Provost & Gerber 2018). Antiracist policies and processes should be incorporated into NCS; for example, redlined communities suffering from asthma, heat, and other environmental hazards should be intentionally prioritized for restoration effects.

In 2010, the Environmental Protection Agency created a mapping tool (EJSCREEN) that combines environmental and demographic indicators, to make environmental justice decision making more available (U.S. EPA 2014). Yet, this tool is underutilized and does not consider granular environmental hazards or impacts of climate change. While the tool is not perfect, it can be used to identify minority and/or low-income populations and environmental issues (if any); ideally, this tool is combined with other tools that map future climate risks (U.S. EPA 2014). States, like California, have built more comprehensive mapping and utilize the tool in decision making (Rodriquez & Zeise 2017).

Further, uses of environmental goods (e.g., animals, fungi, and plants) for food, medicine, and other purposes play an important role in the cultures and economies of many Indigenous peoples and local communities (Hurley and Halfacre 2011, Lynn et al. 2013, Vogesser et al. 2013); such values are further explored in Principle #4. Natural climate solutions should avoid disrupting these uses and seek opportunities to enhance them where possible. Where it has been retained, the knowledge developed through these practices can be an important source of information for design (Lake et al. 2018), implementation, and monitoring of natural climate solutions.

Finally, it should be acknowledged that Indigenous Peoples have been stewards of their lands for thousands of years and they continue to have rights and interests in many of those lands. As of 2020, there are 574 federally recognized tribes and 63 state recognized tribes in eleven states (NCAI 2020), many of which have legal rights to access resources for fishing, gathering, hunting, and trapping on designated federal and state lands (Emery and Pierce 2005). In addition, more than 18 million acres of tribal forest lands are held in trust by the United States (IFMAT 2013). Many natural climate solutions, such as prescribed burning, are Indigenous practices that successfully protect and manage the environment. These may be disrupted or enhanced by natural climate solutions.

### HOW THE PRINCIPLE MAY BE APPLIED

*Indigenous Leadership.* As mentioned above, Indigenous Peoples have been stewards of land for thousands of years. Therefore, their cultural and traditional knowledge should be respected, and Indigenous-led solutions should be prioritized. For example, Indigenous Peoples in the Western U.S conduct prescribed burning, as well as cultural burning, to control wildfires. This is a NCS as it reduces the intensity and frequency of wildfires. Over the decades, they have lost the ability to do such burning due to regulation. This is how, by reversing and allowing Indigenous-led solutions to be utilized, NCS can fully engage with Indigenous Peoples and mitigate inequalities/injustices.

If practices do not involve Indigenous-led practices and solutions, NCS should be implemented after consultation, participatory engagement, negotiations, and consent; an approach under the principle of Free, Prior, and Informed Consent (FPIC) laid out in the United Nations Declaration on the Rights of Indigenous People. While FPIC, in the context of U.S public lands, does not yet have a consensus around definition and implementation, the FPIC approach is still important when considering NCS.

*Consultation.* Successful implementation of NCS requires prior knowledge of the relevant groups or communities, including Indigenous Peoples and local communities, who will be impacted by the NCS policy. For example, EPA's EJSCREEN can be utilized to understand the communities that reside in the area, and the environmental hazards (if any) that are in the community. Jurisdictions implementing NCS should communicate and engage with stakeholders prior to developing NCS implementation plans in order to understand the impacts of the NCS and to identify ways of mitigating potential negative impacts and maximizing positive outcomes. The consultation process should allow proper and culturally appropriate engagement for impacted communities to understand the process and proposed NCS practice, and to provide input, which should be incorporated into NCS planning and implementation.

*Participatory engagement*. Consultation provides an opportunity to share information and seek advice, while participatory engagement takes this a step further by involving Indigenous Peoples and local communities in the decision making and integrating their input into the NCS implementation plan through an iterative process. Consultation and participatory engagement also provides an opportunity to seek guidance from Indigenous Peoples and local communities who have a deep understanding of land management and preservation, leading to more effective NCS practices that can simultaneously protect the local environment and economies, and reduce greenhouse gas emissions.

*Negotiations and Consent*. With active consultation and participatory engagement, less emphasis is required for negotiation or consent; however, those actions do not replace consent. Consent requires the option to withhold consent, and Indigenous Peoples and local communities having a clear understanding of the agreement. To gain consent, the correct and representative stakeholders should be included as well as the appropriate method to have it given.

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# 4

## Enhance human welfare and “do no harm.”

Prepared by Glenn Bush and Richard Birdsey

### SUMMARY

Natural climate solutions should aim to generate a net enhancement to human welfare, while doing no harm to impacted parties. If the tradeoffs between the private and public benefits from policy choices are clearly defined and quantified, potential negative outcomes can be identified and mitigated to the greatest extent possible. Unless natural climate solutions can be demonstrated to have clear overall benefits to society and impacted stakeholders, and private costs mitigated, they are unlikely to be adopted.

### IMPACTS AND BENEFITS OF NATURAL CLIMATE SOLUTIONS

Natural climate solutions (NCS) involve land and aquatic ecosystems that provide a wide array of services to society, in addition to carbon sequestration, such as providing timber products, maintaining biodiversity, protecting endangered species, sustaining food supply, providing water and erosion control, and maintaining soil productivity (Millennium Ecosystem Assessment 2005). Although these services may be altered to reduce carbon emissions, increase carbon sinks, reduce risk or adapt to climate change, it is highly desirable to avoid reducing the capacity of land and water to sustain life on earth.

Several recent studies of NCS have considered the impact on ecosystem services. The U.S. National Academy of Sciences consensus study report on negative emission technologies (NAS 2018) focused on assessment of the potential of different technologies and research needs that would be necessary to reach net zero emissions by 2050 while avoiding harm to the world’s food supply or biodiversity. It was found that competition for land limits the expansion of some terrestrial-based negative emissions strategies, and that a significant investment in research is needed to reduce their negative impacts and costs. A comprehensive global analysis of NCS by Griscom et al. (2017) imposed constraints to safeguard the production of food and fiber and habitat for biological diversity, and found that they also can offer co-benefits such as water filtration, flood buffering, soil health, biodiversity habitat, and enhanced climate resilience. Similarly for the US, Fargione et al. (2018) estimated the potential of NCS after imposing constraints to safeguard food and fiber production, and highlighted potential co-benefits.

### ENVIRONMENTAL VALUATION; AN OPERATIONAL FRAMEWORK FOR MEASURING SOCIAL PERFORMANCE

Do no harm is an objective to be assessed through environmental cost benefit analysis. Where adverse effects to a specific group can be predicted, a NCS scheme could still go ahead if the net benefits to society are clear. Implementing NCS requires systematic changes to land use involving multiple entities: private landholders, communities, local and national governments, and Indigenous Peoples (Principle #3). NCS also involves complex institutions; policies, laws, customs and cultural preferences; technical solutions governing land use outcomes inevitably lead to trade-offs (losses and gains between actors) from selected courses of action. Applying an ecosystem services approach to explicitly value links between environmental and social impacts can help to objectively identify effective policy mechanisms (taxes/subsidies, voluntary agreements or regulations) to manage outcomes (USDA 1998). Ecosystem services are public benefits, largely provided at no private cost, meaning they go unvalued and therefore unpriced in consumer markets, until such time as their decline in quality begins to critically impact on human wellbeing (a market externality).

## 4

### ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT; AN EXISTING INSTITUTIONAL ARRANGEMENT FOR PERFORMANCE APPRAISAL IN THE USA AND BEYOND

Globally, environmental impacts assessment (EIA) is well established as a best practice for economic development projects in the public and private domain (Eccelston, 2011). The United States National Environmental Policy Act of 1969 (NEPA) established a policy of environmental assessment (EA) for federal agency actions, federally funded activities or federally permitted/licensed activities. Specifically, within the broad EIA framework, social impact assessment enables the qualitative and quantitative appreciation of the social and financial costs and benefits of proposed NCS measures. Globally, there is general consensus that EIA can play an instrumental role in fostering sustainable development (Del Campo et al., 2020). EIA for projects and its policy program equivalent, strategic environmental assessment (SEA) can support the delivery of the UN-Sustainable Development Goals (to which the US is a signatory) by integrating the relevant considerations pertaining to the goals through setting up, clarifying, or enhancing SDG-relevant targets to be achieved as part of development plans/programs.

There is strong international consensus on best practices in social impact assessment (SIA) (Esteves et al. 2012). This consensus requires a comprehensive inventory of directly and indirectly affected communities and activities, and an assessment of the economic costs and benefits from the proposed changes; the objective being to estimate the net benefits and distributional impacts between involved parties from potential landscape outcomes. In the United States, the 2003 version of “Principles and Guidelines for Social Impact Assessment” (Burge et al. 2003) provides guidance for the conduct of SIA within the context of the U.S. National Environmental Policy Act of 1970. Guidelines are integrated within six principles focusing on: 1) understanding of local and regional settings; 2) dealing with the key elements of the human environment; 3) using appropriate methods and assumptions; 4) providing quality information for decision making; 5) ensuring that environmental justice issues are addressed; and 6) establishing mechanisms for evaluation/monitoring and mitigation.

By valuing ecosystem services in addition to private financial losses and gains from NCS adoption, implementing agencies can make decisions that may strengthen both a project’s performance, and community and social resilience. Systematically evaluating ecosystem services in the EIA/SEA process will help implementing agencies understand how a project may affect priority ecosystem services, as well as how the project’s performance or success may depend on certain ecosystem services. By better understanding project impacts and dependence, implementing agencies can better identify and manage a project’s environmental and social risk which may also be critical barriers to uptake of NCS. Valuation can enhance the EIA/SEA process by providing decision makers with a quantitative equivalency framework for comparing the disparate potential effects of a proposed action.

### TOTAL ECONOMIC VALUATION; A WELL-ESTABLISHED TOOL TO EXAMINE THE PUBLIC AND PRIVATE TRADE-OFFS IN NCS ADOPTION

Through total environmental valuation (TEV), the net welfare impacts from adopting NCS can be estimated for a broad range of goods and services. Values can be imputed for a specified time frame under “business as usual” conditions and compared to those gained from alternative NCS implementation through a process of environmental cost benefit analysis (Hanley and Barbier 2009; U.S. EPA 2010). For example, the benefits of forest resources have historically been valued in terms of their direct benefits such as jobs in the economy, timber harvesting, tourism and other non-timber forest products. However, there are also a multitude of indirect benefits and costs. It is the sum of all these values that accrue at local, regional, and national levels that generates the total economic value of an NCS strategy in a given location (Ashford 2012). Increasingly in the U.S. and internationally, there are a growing number of voluntary social standards frameworks governing best practices for private sector financial performance, business practices and international development programs incorporating the principle of "do no harm." In the private sector, these are framed as environmental and social governance standards[1] and business practices[2]. In international development circles, there are examples of the International Finance Corporation social standards framework[3], and the 2030 UN sustainable development agenda[4]. The TEV framework can be directly applied to measurement of performance against such standards.

The TEV concept is well established as an analytical framework (Turner 1993). Since the publication of the Millennium Ecosystem Assessment (MEA) (Overpeck et al. 2013), there has been renewed interest in ecosystem services valuation, which provides a broader temporal and spatial framework to understand the human welfare benefits generated from biodiversity and ecosystem goods and services (Groot et al. 2011) e.g. pollination services from insects, wild food, climate regulation and cultural values. In addition, the ecosystem services approach (Groot et al. 2011) also identifies the property rights and institutional arrangements governing the system. The combined result is a biologically, socially, and economically integrated framework to understand externalities in policy and management of natural capital. The MEA aggregates the different economic benefits from biodiversity and ecosystems under categories of different socio-ecological functional roles (provisioning, regulating, cultural and supporting). The socio-ecological categories then correspond directly to different economic categories of benefits (Table 1).

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[1] https://www.bcaresearch.com/reports?r=322d4d23bea0db9e4279371abdec618e

[2] https://www.emerald.com/insight/content/doi/10.1108/CG-01-2018-0030/full/pdf?title=do-no-harm-and-do-more-good-too-connecting-the-sdgs-with-business-and-human-rights-and-political-csr-theory

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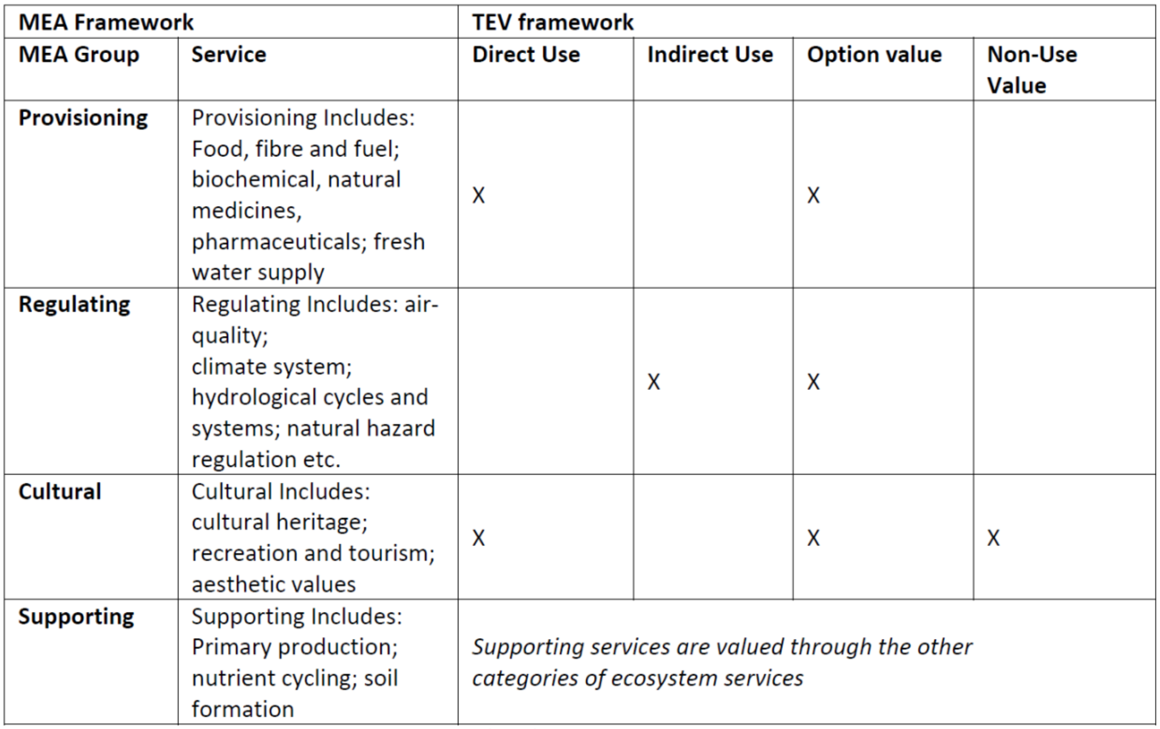
[4] https://www.2030spotlight.org/sites/default/files/spot2019/Spotlight_Innenteil_2019_web_chapter_IV_Lent.pdf



| **MEA Framework** | | **TEV framework** | | | |
|---|---|---|---|---|---|
| **MEA Group** | **Service** | **Direct Use** | **Indirect Use** | **Option value** | **Non-Use Value** |
| **Provisioning** | Provisioning Includes: Food, fibre and fuel; biochemical, natural medicines, pharmaceuticals; fresh water supply | X | | X | |
| **Regulating** | Regulating Includes: air-quality;<br>climate system;<br>hydrological cycles and systems; natural hazard regulation etc. | | X | X | |
| **Cultural** | Cultural Includes: cultural heritage; recreation and tourism; aesthetic values | X | | X | X |
| **Supporting** | Supporting Includes: Primary production; nutrient cycling; soil formation | *Supporting services are valued through the other categories of ecosystem services* | | | |

*Source: Department for the Environment and Rural Affairs (2007). An introductory guide to valuing ecosystem services. UK Government.*

**Table 1.** Coordination of the Millennium Ecosystem Assessment (MEA) and Total Economic Value (TEV) frameworks.

The TEV framework is a useful way of categorizing different types of value as they accrue to human beings. In the Millenium Ecosystem Assessment context, TEV is complementary as it presents categorized ecosystem values at the point of terminal human impact in the broader ecological context. These are the final values, which must be determined before other spatial and temporal scaling can be made upon which to assess the welfare impacts of ecosystem changes because of policy or management changes. Importantly, the TEV framework also helps valuation practitioners to define and categorize the appropriate valuation techniques to estimate the costs and benefits of ecosystem services (DEFRA 2007).

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# 5

# Practice full-system accounting so that all effects on the carbon cycle are assessed, and the contributions of a given natural climate solution can be evaluated.

Prepared by Richard Birdsey and Richard Houghton

## SUMMARY

Assessing the climate impacts of natural climate solutions requires a systems approach because of the connections between agriculture, forests, land use, food and fiber production, and energy production. It is therefore essential to practice full-system carbon accounting, including the effects of activities on ecosystems and their ability to maintain or increase carbon stocks, as well as impacts on fossil fuel emissions from related economic sectors. Full-system accounting should be complemented with effective monitoring and reporting.

## DESCRIPTION AND RATIONALE

Assessing the climate impacts of natural climate solutions (NCS) requires a systems approach because of the connections between land use and management, production of goods and services, and energy production (Kurz et al. 2016, Lemprière et al. 2013, Nabuurs et al. 2007). For example, as described by Nabuurs et al. (2007), the forest sector is embedded in a much broader array of societal activities (Figure 1). Activities that occur within the forest sector including forest ecosystems and harvested wood products are linked with other sectors of the economy and have impacts on greenhouse gas (GHG) emissions from those sectors. The same can be said for other ecosystems including wetlands, croplands, grazing lands, inland waters, and coastal ecosystems. An essential element of accounting is to include effects of activities on ecosystems and their ability to maintain or increase carbon stocks; this element is often ignored in Life Cycle Analyses (LCAs) that evaluate impacts of activities on emissions from the supply chain and production processes, but ignore how land management affects net emissions.

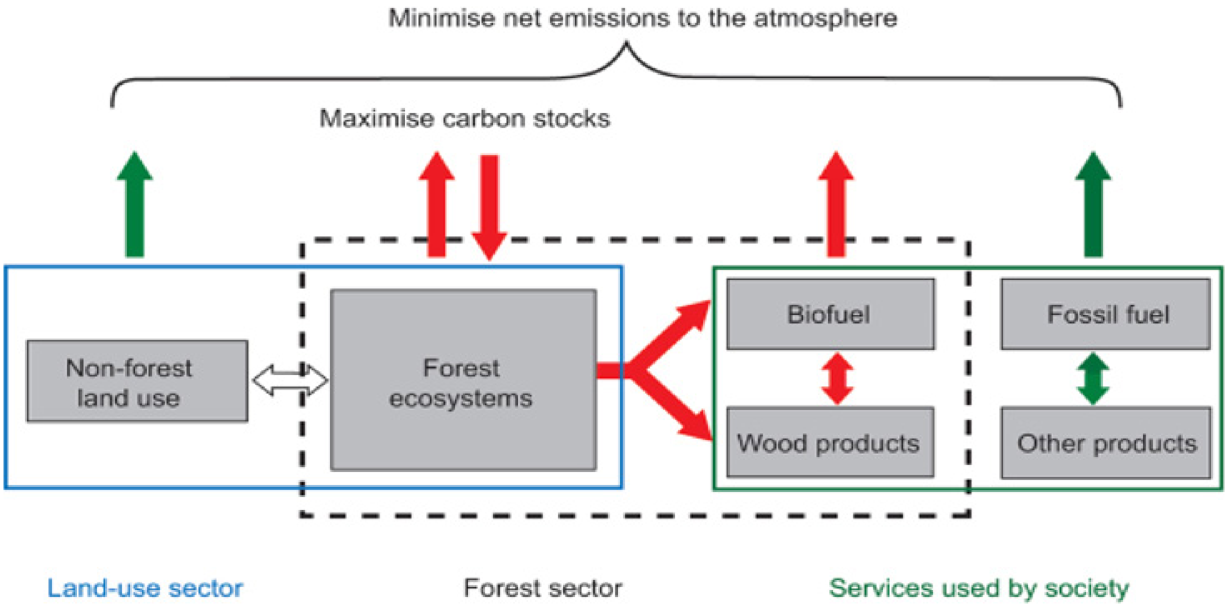

**Figure 1.** The forest sector in relation to land use, wood products, and energy. Full and accurate accounting for the impacts of forestry activities on greenhouse gases requires estimates of changes in all of these linked systems. Graphic reproduction from Nabuurs et al. (2007), IPCC Assessment Report 4, Working Group 3.

It is critically important that accounting for increases or decreases in $CO_2$ and other GHGs from specific activities be based on the concept of additionality, i.e., estimating changes in GHG emissions relative to a business-as-usual baseline so that mitigation benefits resulting from changes in behavior can be more clearly measured (Böttcher et al. 2008, Kurz et al. 2016). Assessing effects of NCS on GHG emissions requires comparing specific pathway scenarios with a projected reference scenario to accurately estimate the incremental net change in emissions. Applying this additionality concept ensures that estimated impacts of pathways are relative to what would have happened in the absence of proposed activities.

### HOW TO ATTRIBUTE RESULTS TO SPECIFIC ACTIONS

This principle involves the accounting and reporting of emissions and removals of carbon as a result of direct anthropogenic activity (e.g., land management). The UNFCCC initially intended to award carbon credits to countries that demonstrated reduced emissions of carbon from land use, land-use change, and forestry (LULUCF). That is, credits or debits would be awarded based on the effects of management and not based on the effects of natural disturbances or indirect anthropogenic effects (e.g. $CO_2$ fertilization). The effects of management would be counted; the effects of environmental change would not.

Unfortunately, it is nearly impossible to distinguish between direct anthropogenic effects and indirect or natural effects based on observations alone. For example, a re-growing forest following harvest is accumulating carbon, in part, because it was harvested (management) and in part because of $CO_2$ fertilization. As a result of this difficulty, the IPCC introduced the concept of the “managed land proxy” (IPCC 2010). Under this concept, all emissions and removals of carbon on lands designated as managed are counted, while the emissions and removals from unmanaged lands are not counted. This distinction based on areas (rather than processes—directly and indirectly anthropogenic) makes it simpler to distinguish and report (direct) anthropogenic emissions and removals. In the US, most lands are considered managed if activities such as fire suppression or infrastructure such as road networks are present (Ogle et al. 2018). As a result, most of the land area of the conterminous states is considered managed, while the more remote and inaccessible parts of Alaska are not. These designations follow IPCC guidelines that are designed to be commensurate with the state of science regarding attribution of effects to causes, which is an evolving field of research (IPCC 2010).

Assessing impacts of NCS is sensitive to spatial scale. For example, how much carbon is removed by forest *stands* that were actually harvested, and how much carbon is removed by the *forests in the region*? Harvesting a forest stand releases stored carbon to the atmosphere except for the amount that is retained temporarily in wood products. It takes some time for the forest regrowth to re-accumulate the amount of carbon lost. It is often claimed that these emissions should not be counted if the forests in a larger landscape or region are, on average, accumulating more carbon than is being released by harvest (e.g. Dwivedi et al. 2019). This logic conflates the effects of specific activities by entities in small domains with larger regional trends that broadly reflect the wide range of land management decisions that collectively comprise business as usual.

Full-system accounting and attribution to actions by specific entities should be linked with effective monitoring and reporting at the entity scale. The uncertainty of estimates should be minimized by following guidelines for estimating carbon stocks and rates of removal by ecosystems (U.S. Department of Agriculture 2014). Without a monitoring system that reflects the various accounting elements shown in Figure 1, the impacts of different solutions on GHG emissions and sinks cannot be assessed or would only be partially assessed, potentially leading to biased or highly uncertain representation of the effectiveness of mitigation policies.

Likewise, reporting should strive to identify the additional reduction of net emissions that can be attributed to specific pathways, and if possible, separate the effects of natural and anthropogenic drivers of change.

### HOW THE PRINCIPLE MAY BE APPLIED TO SPECIFIC PATHWAYS (EXAMPLES)

*Avoid using biomass instead of fossil fuel to generate electricity* — Assessments of the mitigation benefits from substituting biomass for fossil fuel sometimes fail to consider the effects of harvesting trees on forest carbon stocks and sequestration (Birdsey et al. 2018; Ter-Mikaelian et al. 2015). This mistake is typically propagated by claiming "carbon neutrality"—that is, claiming that $CO_2$ emitted from combustion is completely and immediately offset by regrowing forests either in the project area or in a larger landscape or region in which other factors also affect carbon stocks and sequestration. Full system accounting should include additional impacts on the forest from increased harvesting or removal of logging debris, emissions from the supply chain, and net change in emissions from burning the biomass instead of fossil fuel.

*Use more wood in building construction* — Substituting wood products for steel and concrete in building construction will almost always have less GHG emissions when compared directly with steel and concrete using LCA methods. Nevertheless, most of the LCAs for substituting wood products underestimate emissions by failing to account for the effects of harvesting on ecosystem carbon stocks because only a small percentage of the harvested wood ends up in product, and rates of carbon accumulation are lower in the forest when fewer live trees are left standing (e.g. Gu and Bergman 2018; Puettmann et al. 2018).

*Increase stocking of understocked forests* — This is one of several "improve forest management" activities whereby actions can be taken to increase stocking of live trees in cases where forest ecosystems have been degraded because of partial harvesting or other disturbances that involve reduction in tree density. Actions may involve tree planting, control of competing non-tree vegetation, reduction in browsing that prevents regeneration of young tree seedlings, or removal of unhealthy trees that are not accumulating carbon and preventing others from doing so (Hoover et al. 2014; Vasievich and Alig 1996). Estimates of reductions in GHGs should be made relative to a dynamic baseline that estimates how the forest would have grown in the absence of the actions.

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# 6

# Ensure that carbon credits used to finance natural climate solutions meet highest standards of quality, integrity, and offset eligibility.

Prepared by Glenn Bush, Jonathan Sanderman, and Wayne Walker

## SUMMARY

There are numerous financing models for natural climate solutions. Regulatory and voluntary carbon markets could be a significant source of funding for scaling up NCS, but their use needs to follow strict guidelines to ensure real climate benefits. Offsetting should only be used as a complement to—not substitute for—rigorous decarbonization efforts; this includes both immediate use as emissions are being reduced, as well as long-term use to offset hard-to-abate emissions. All carbon credits must be backed by thorough monitoring and accounting of both risks and benefits (as outlined in previous sections) to ensure quality and integrity.

## INTRODUCTION

Well-made investments in nature can provide emissions abatement, as well as an array of co-benefits (Cook-Patton et al. 2021), including improved biodiversity, soil health, and water quality (Lawrence et al. 2022). Carbon markets offer a near-term source of financing for scaling up NCS that can subsequently help close the biodiversity finance gap, which was recently estimated at $722–$967 billion per year over the next 10 years (Adams et al. 2021). At 7 $GtCO_2$ in annual potential by 2030, with an illustrative average price of $20 per ton, capital flows toward NCS could exceed $100 billion by 2030.

Opportunities to deploy these funds exist across the world, especially in tropical, less-developed countries. In particular, rural communities can benefit from the climate resilience that NCS can create, as well as from potential direct investment in sustainable livelihood and rural enterprise activities that address the local drivers of deforestation and land degradation. Restored coastal wetlands, for example, can absorb incoming wave energy, reduce flood damage, and provide protection from storms (Lovelock and Duarte 2019); healthier soil increases the resilience of cropland (Kane et al. 2021; Rojas et al. 2016); and fire management can mitigate the risk of catastrophic wildfires (Elder et al. 2022; Phillips et al. 2022).

However, voluntary carbon markets have faced intense scrutiny and criticism for a lack of transparency and integrity. These problems are real, but not insurmountable. Data and guardrails are needed to ensure carbon market investments in NCS produce the intended benefits—and do not cause harm to communities or ecosystems. Specifically, to be effective as a tool for global decarbonization, carbon offsetting with NCS should only be used to complement—not substitute for—rigorous decarbonization efforts; this includes both immediate use as emissions are being reduced, as well as long-term use to offset hard-to-abate emissions. Furthermore, the carbon and co-benefit performance of NCS must be assessed and monitored rigorously.

## OFFSET ELIGIBILITY

NCS are explicit pathways to lower greenhouse gas emissions and increase carbon storage across both natural landscapes and working lands. Scaling up natural climate solutions requires significant funding, and carbon markets could be a substantial source of capital. These markets are of interest to entities facing challenges in meeting net-zero decarbonization commitments.

However, the effectiveness of carbon crediting as a tool for decarbonization is only achieved when it follows a set of narrow carbon accounting constraints, and when credits are appropriately priced.

A carbon offset credit represents an emission reduction of 1 metric ton of carbon dioxide ($CO_2$) or carbon dioxide equivalent ($CO_2e$). An individual, a business, or government can compensate for their carbon emissions by paying another entity to reduce or remove a matching quantity of greenhouse gasses from the atmosphere. When the number of carbon offset credits an individual or organization has obtained is equal to their residual carbon footprint, that person, activity, or organization is considered carbon neutral. Carbon offset revenue is typically invested into land management activities that provide durable mitigation outcomes. Critically, the reduction in greenhouse gas emissions from these projects counts toward the carbon balance of the person or government buying the offset, rather than the entity operating the project or the place where it is implemented.

### CARBON CREDIT QUALITY AND INTEGRITY

A buyer should have high confidence that a carbon credit is in fact equivalent to 1 ton of $CO_2$. There has been a rapid evolution of guidelines and best practices to define high-integrity carbon credits from natural landscapes; perhaps the most comprehensive are issued by the Integrity Council for the Voluntary Carbon Market (ICVCM). ICVCM is an independent governance body for the voluntary carbon market established to set and enforce definitive global threshold standards so that high-quality carbon credits channel finance towards genuine and additional greenhouse gas reductions and removals. The ICVCM's Core Carbon Principles (CCPs) set threshold standards for high-quality carbon credits with the objective to define which carbon-crediting programs and methodology types are CCP-eligible, i.e., meet or exceed the minimum set of CCP standards[5]. The CCPs consist of 10 components focusing on the supply of carbon from project/program operations:

1. Quality and risk of reversal
   i. Additionality
   ii. Permanence
2. Impacts in achieving climate and social objectives
   i. Mitigation activity information
   ii. Robust quantification of emission reductions and removals
   iii. Sustainable development impacts and safeguards
   iv. Transition towards net-zero emissions
3. Accountability
   i. No double counting
   ii. Programme governance
   iii. Registry
   iv. Robust independent third-party validation and verification

The CCPs establish a consistent and standardized guide to assess high quality carbon credits issued under voluntary schemes, such as Verra and Gold Standard. This is an essential step to drive alignment across the voluntary carbon market programs by establishing a definitive and consistent global benchmark for high-integrity carbon credits. In order to maintain the legitimacy of "off-setting"—using carbon credits to support net zero or carbon neutral goals—it is critical that integrity is at the heart of future market development. Increasingly, there will be greater focus from regulators, investors and broader civil society on the quality of the

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[5] https://icvcm.org/wp-content/uploads/2023/03/CCP-Book-FINAL-27Mar23.pdf

credits that are being used for these purposes. Corporations seeking to purchase carbon credits need to be aware of the increased scrutiny that is likely to occur in relation to claims about the use of credits and the quality of the credits that underpin those claims.

While global benchmark standards for carbon market integrity such as the CCPs are critical, once established, the next challenge is accurate, verifiable measurement and reporting of performance against the standards. Market uncertainty stemming from concerns about permanence, leakage, and accountability is already apparent with regard to decarbonization commitments, and the lack of transparency exacerbates investor reticence.

Verification methodologies can be strengthened and processes streamlined. Independent assessment and oversight would build investor confidence. Clearer demand signals would help give suppliers more confidence in their project plans and encourage investors to better understand the value proposition (carbon quality, social and environmental co-benefits) of the variety of credits in the market. That in turn will lead to a clearer understanding of a credit's value and variable pricing due to "known" quality and risk surrounding investment. On the supply side, actors in the landscape would be able to better align their investments to deliver credits of a given standard and be able to make informed decisions about the cost effectiveness and prospects of engaging in the carbon market compared to other land uses.

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