# Principles and Safeguards for Natural Climate Solutions

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**The goal of this document** is to offer a concise list of science-based principles to guide deployment of natural climate solutions (NCS) at national and sub-national jurisdictions. The audience includes public policy makers, the private sector, non-government organizations, and donors, all of whom have expectations that NCS can achieve their stated impacts on net greenhouse gas (GHG) emissions without negatively impacting the many services expected from the land and waters of the U.S., especially biodiversity and food production.

These principles represent a consensus of leading organizations with expertise in developing and implementing climate mitigation strategies involving ecosystems and management. In addition, the principles will help avoid specific unintended consequences that could result from deploying NCS. Although the list of principles was 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 have many connections around the world, and that protecting biodiversity is of global concern.

The principles broadly support the inclusion of natural climate solutions that are being formulated by the U.S. government to meet anticipated national targets associated with the Paris Climate Agreement that establishes a global framework to avoid dangerous climate change by limiting warming to less than 2°C. Since it is very unlikely that emissions from fossil fuels can be reduced sufficiently to reach a net zero target by 2050, and since it is becoming necessary to remove some of the carbon dioxide that has already been emitted, “negative emissions” have a significant role to play in limiting warming along with reductions in emissions associated with ecosystem management and land-use change. Land, inland waters, and coastal ecosystems that on balance are now removing about 30% of emissions of carbon dioxide each year have significant potential to continue or even increase this critical function, though it will require careful analysis of options for deploying these natural climate solutions over the next few decades, and monitoring of results which may be affected as impacts of climate change evolve.

The framework underlying these principles includes considerations of time, space, and community. The time dimension recognizes that NCS involve changes in ecosystems and ecosystem management that have impacts that span decades and 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 climate changes and other factors evolve. Likewise, some will be ineffective at times and so the expected benefits as well as co-benefits need to be evaluated now and for the future.

The spatial dimension reflects that ecosystems are highly variable geographically, as are the various factors that influence ecosystems. For example, natural disturbances such as wildfire are much more common and severe in areas where drought and high temperatures are prevalent. Existing management practices are also highly variable, with some regions dominated by agriculture, some by forest management, and some by protection from human-caused disturbances. Potential solutions will be different for these categories, as will the effectiveness of each for reducing greenhouse gas emissions to the atmosphere.

The community or human 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 gases, and people will be affected in different ways. Impacts may be positive such as providing jobs or cooling communities by planting trees near buildings, or negative by increasing the costs of goods and services or 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. **Natural climate solutions are identified and designed with full consideration of risks from climate extremes, natural disturbances, and socioeconomic events.**

   Many natural climate solutions will take time to reduce net greenhouse gas emissions, exceptions being reducing deforestation and forest degradation, delaying harvest, and reducing emissions from agricultural soils. If benefits are expected to accrue decades into the future, the solutions must consider that climate and other factors will likely be very different and so the expected benefits may not be as great as predicted by current conditions.

2. **Avoid degrading ecosystems that have high carbon stocks or biodiversity value, and restore those that have already been degraded.**

   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 which can improve biodiversity while increasing carbon stocks to levels consistent with the potential of the site.

3. **Natural climate solutions are implemented with full engagement of 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 a way that ensures respect for their land, culture, and human rights. The historical legacies and ongoing effects of institutional racism will require particular care to include the knowledge and interests of these communities. When implementing natural climate solutions consultation, participatory engagement, negotiations, and consent should be received.

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 stakeholders. If the tradeoffs between the private and public benefits from policy choices are clearly defined and quantified, 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 linked with effective monitoring and reporting.

# 1

# Natural climate solutions are identified and designed with full consideration of risks from climate extremes, natural disturbances, and socioeconomic events.

Prepared by Zach Zobel and Dave McGlinchey

## SUMMARY

Many natural climate solutions will take time to reduce net greenhouse gas emissions, exceptions being reducing deforestation and forest degradation, delaying harvest, and reducing emissions from agricultural soils. If benefits are expected to accrue decades into the future, the solutions must consider that climate and other factors will likely be very different and so the expected benefits may not be as great as predicted by current conditions.

## DESCRIPTION AND RATIONALE

The impacts of climate change are already being felt and will only worsen, with direct ramifications on natural systems throughout the United States. These impacts will then affect 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 several 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 after 20 or 30 years, though some activities like reducing forest degradation could help guard against future hazards. For example, climate risk modeling could help avoid incentives for reforestation in areas that will become more prone to drought 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. 2016). 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 than expected.

A mid-century focus requires the use of global climate models (or Earth system models) and we use a ‘business as usual’ scenario for this purpose—RCP8.5 in the vernacular of climate scientists. This scenario is within 1% of total carbon dioxide emissions from 2005 to 2020—even after accounting for a worst case COVID-19 lockdown—and is the closest match out to mid-century as compared to the World Energy Outlook 2019 forward scenarios from the International Energy Agency (Schwalm et al., 2020).

## 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 the driest period over the last 1200 years (Griffin & Anchukitis 2014). The drought caused a shocking 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 of 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 at least doubles to 20% across most of the US. Such widespread drought would affect all ecosystems including those essential to sustain food supplies, and could severely impact efforts to reduce net GHG emissions by enhancing carbon sequestration in forests and soils.

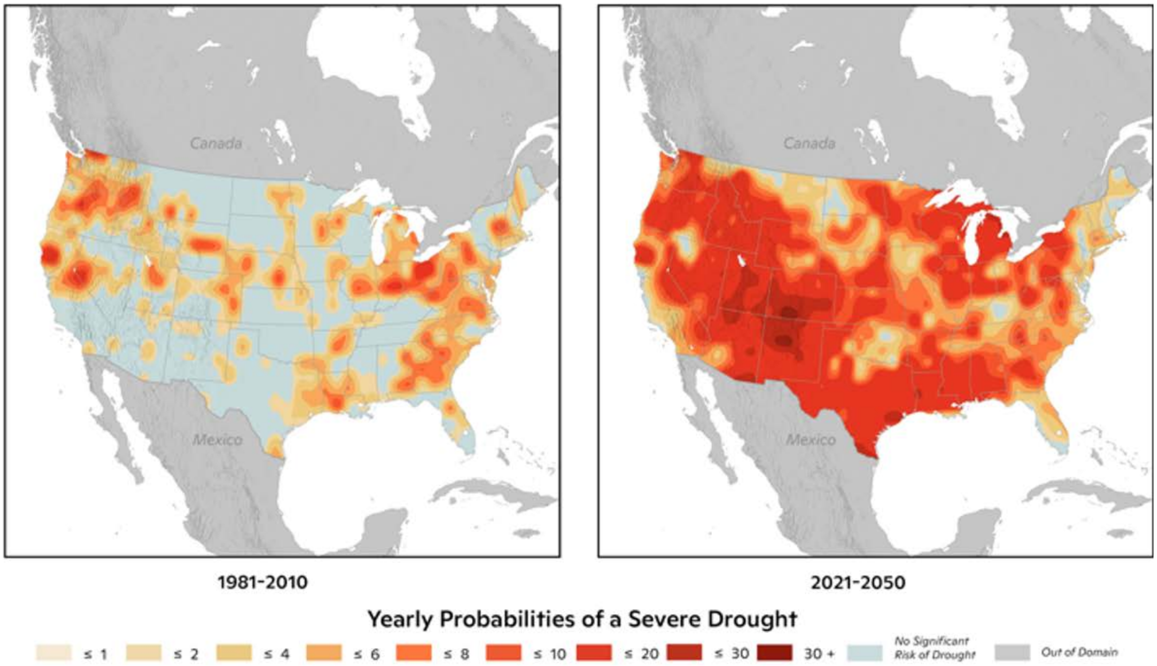

**FIGURE 1.** *Yearly Probabilities of a Severe Drought in 1981-2010 and 2021-2050. A severe drought is defined as a 6-month average sc-PDSI value of -4 or less. The sc-PDSI is calibrated in 1951-1980, which serves as a reference period. The sc-PDSI is corrected for $CO_2$ fertilization from increasing $CO_2$ concentrations, which enhances plant water retention and decreases drought risk (Swann et al. 2016).*

### 2. WILDFIRE

Fire is a natural process in healthy forest ecosystems but a longer fire season, hotter and drier conditions, and a century of fire suppression and exclusion to reduce infrastructure loss, has led to a trend toward more and larger wildfires.

The average acreage burned per year in the United States more than doubled from 2000–2019 relative to 1980–1999. Wildfire size has also increased in most of the western United States (Center for Climate and Energy Solutions). The total acreage burned in the United States during the 2010s alone (68.5 million acres) is about the size of the state of Colorado. The 2020 fire season in California toppled the state’s record for acres burned, at 4.1 million acres, by mid September—months before the end of the fire season (Cal Fire). Three of the top four largest wildfires in recorded history burned in 2020; notably, the first, third and fourth largest burned concurrently in the absence of seasonal winds (Cal Fire). These trends reflect a reduction in wildfire incidence throughout the 20th century caused in part by successful fire suppression leading to a buildup of fuel (Marlon et al. 2012).

The wildfire season will increase throughout much of the western United States, with varying degrees of regional change. In the areas of Idaho, Oregon, and Wyoming where the fire season was historically longest, the number of high fire danger days increases by more than 10 days, with greatest increases exceeding two weeks in southeastern Oregon, southern Oregon and much of Wyoming. The wildfire season increases on average by two weeks in the southwestern United States, with increases exceeding a month in parts of Arizona, southern Nevada, and southern California. By 2021–2050 if these trends continue, the wildfire season will increase by three or four weeks to nearly 5 months in California along the Sierra Nevadas and Transverse Ranges, north of Los Angeles where Santa Ana winds occur. Even just an extra few fire danger weeks increases the likelihood that fire-friendly conditions exist during weather events capable of starting fires and promoting rapid spread (Fire Weather Research Laboratory; Guzman-Morales et al. 2016).

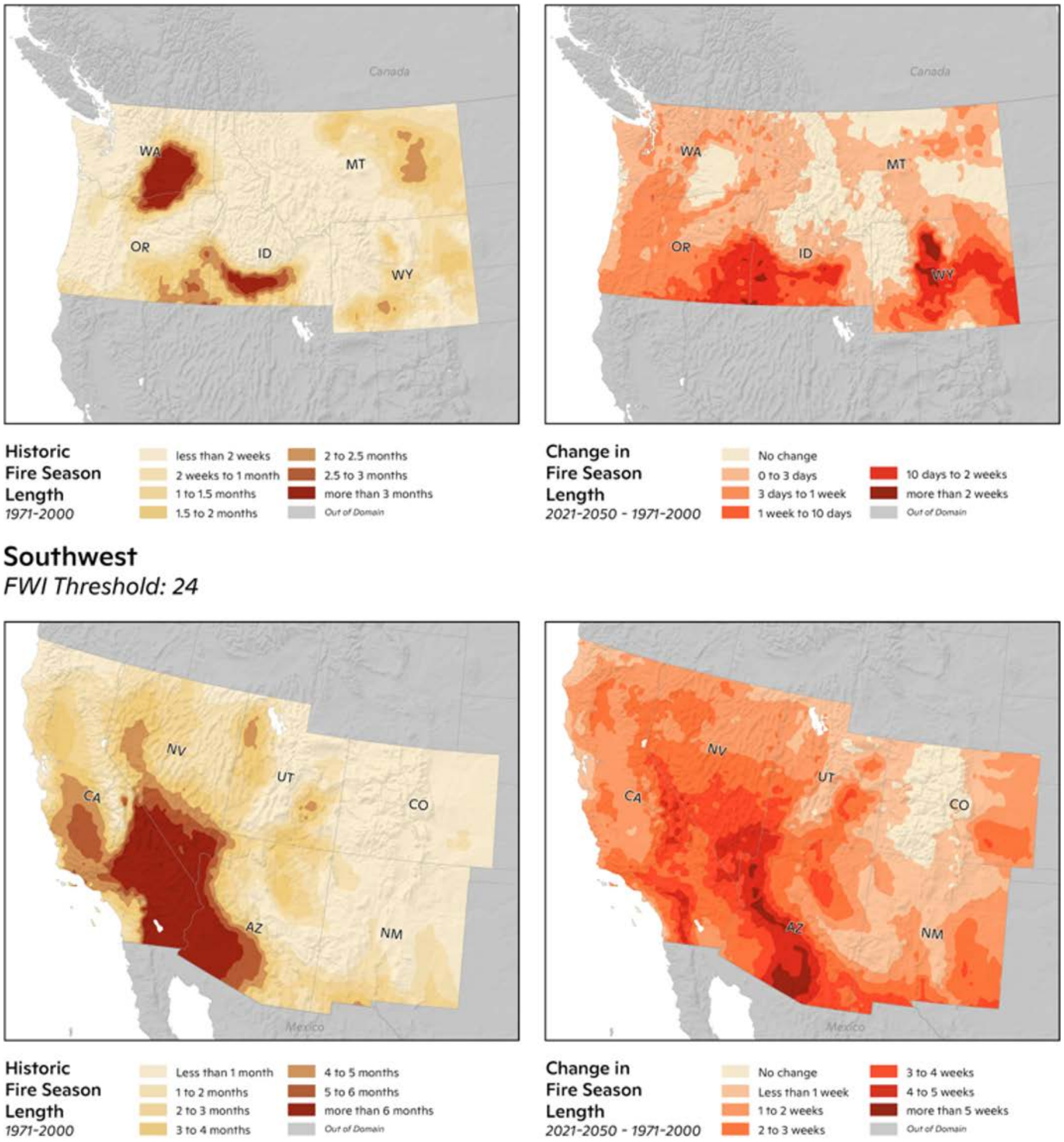

**FIGURE 2.** *Change in fire danger days in 2021-2050 relative to 1971-2000 in the northwestern and southwestern US.*

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# 2

# Avoid degrading ecosystems that have high carbon stocks or biodiversity value, and restore those that have already been degraded.

Prepared by Wayne Walker and Richard Birdsey

## 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.

## HIGH VALUE AND HIGH CARBON ECOSYSTEMS

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 and take decades to centuries to replace. Because high-carbon ecosystems are relatively rare, they may also have great value for biodiversity. For example, mangrove ecosystems store some of the highest amounts of carbon on earth, and are critical habitats for many different marine and freshwater species (Sanderman et al. 2018). Biodiversity helps sustain ecosystem services by supporting the health and resilience of ecosystems, enabling them to resist or quickly recover from disturbances (Seddon et al. 2021). Both protecting high-carbon ecosystems from degradation or conversion to another land use, and restoring those that have been degraded, can avoid emissions of stored C or increased removal of $CO_2$ from the atmosphere

*Older forests* with high carbon stocks can continue to remove $CO_2$ from the atmosphere for many decades or centuries depending on 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 (Stephenson et al. 2012) such that the largest 1% of trees globally store half of the aboveground biomass (Lutz et al. 2018). Avoiding the fragmentation or degradation of existing tracts of primary forest, and protecting the largest trees where they occur outside of primary forest, should be prioritized when implementing NCS strategies.

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

*Tidal wetlands and estuaries* constitute additional areas with high carbon density. These areas are extremely active ecosystems since they receive large quantities of soil and organic matter from the land, some of which is stored and some is exported 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 development.

*Arctic and boreal ecosystems* store large quantities of carbon in soils that is vulnerable to release to the atmosphere from warming temperatures and increases in natural disturbances such as wildfire and insect outbreaks (Schuur et al. 2018). This is especially true in the frozen soils (permafrost), which store twice as much carbon as is found in the atmosphere (Zimov et al. 2006). The circumpolar permafrost zone is particularly vulnerable to warming temperatures that can thaw perennially frozen ground and cause the release of stored carbon as carbon dioxide and methane (Romanovsky et al. 2016). Wildfire is of particular concern and degraded boreal forests may be more vulnerable to severe impacts. The human influence is increasing in some areas, and near communities, more intensive land management may be needed to reduce the risk of wildfire or to suppress fires that ignite (Breen et al. 2016).

### HOW THE PRINCIPLE MAY BE APPLIED TO PRIMARY FORESTS

Primary forest is often defined as any naturally regenerating forest of native species characterized by relatively modest levels of 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. Compared to well-known forest-based NCS approaches such as reforestation (replacing forest on deforested land) and afforestation (planting new forest), which both depend on the availability of land and the survival of small trees, restoring and maintaining existing forests with long-established carbon storage and the sequestration capacity of the larger, older trees growing within them can have an immediate and large effect by avoiding emissions from biomass and soils. 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 resilience after events, improved air and water quality, flood and erosion control, and human health and well-being (Moomaw et al. 2019).

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# 3

# Natural climate solutions are implemented with full engagement of 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 a way that ensures respect for their land, culture, and human rights. The historical legacies and ongoing effects of institutional racism will require particular care to include the knowledge and interests of these communities. When implementing natural climate solutions consultation, participatory engagement, negotiations, and consent should be received.

## 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). With this history in mind, natural climate solutions (NCS) should consider and attempt to mitigate these hazards. 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). To do this, antiracist policies and processes should be incorporated into NCS; for example, redlined communities suffering from asthma, heat, and other environmental hazards should be systematically targeted 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 plays 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 below. 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 11 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 when possible, Indigenous-led solutions should be incorporated. For example, Indigenous Peoples in 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 definitional and implementation, the FPIC approach is still important when considering NCS.

*Consultation.* Successful implementation of NCS requires prior knowledge of the relevant stakeholders, 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 stakeholders. If the tradeoffs between the private and public benefits from policy choices are clearly defined and quantified, 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 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 ecosystems 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 technologies, 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 can be predicted to a group of stakeholders, 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 stakeholders: 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).

### 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) requiring a comprehensive inventory of directly and indirectly affected stakeholders and activities, assessment of the economic costs and benefits from the proposed changes; the objective being to estimate the net benefits and distributional impacts between stakeholders 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 environmental valuation, 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 (TEV) of an NCS technology 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 (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 Millennium Ecosystem Assessment 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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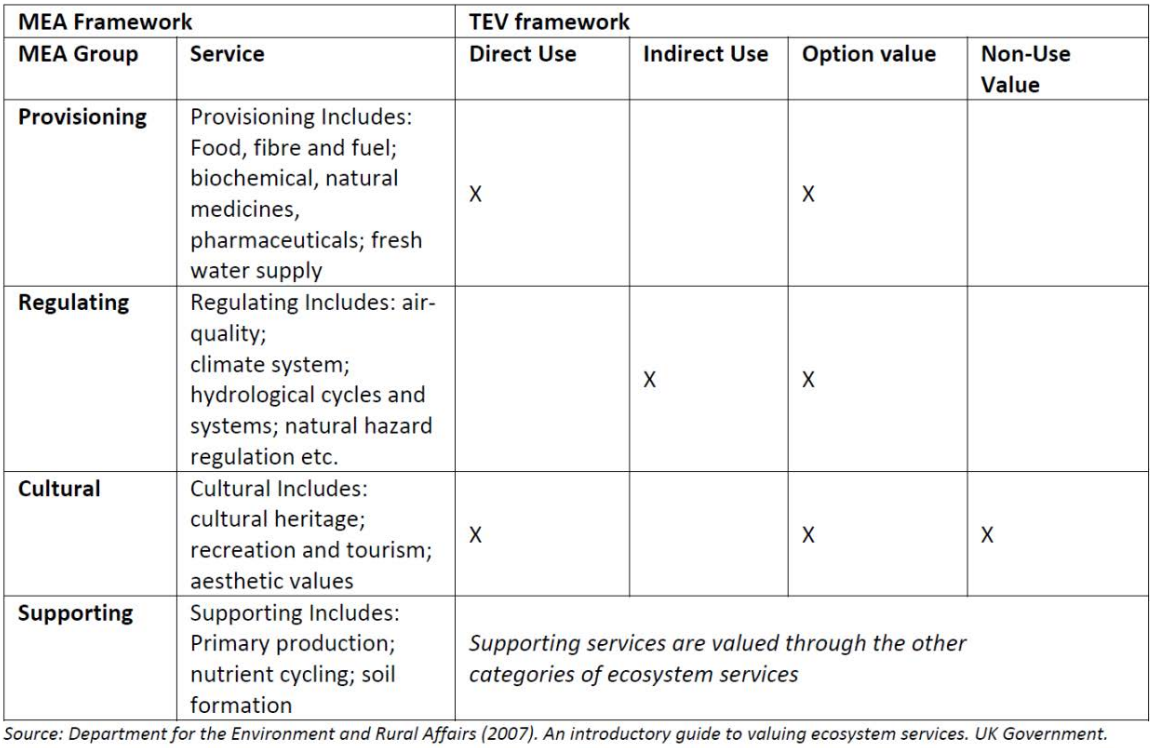
[1] https://www.bcaresearch.com/reports?r=322d4d23bea0db9e4279371abdec618e

[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

[3] IFC—social safeguards standards: https://www.ifc.org/wps/wcm/connect/c02c2e86-e6cd-4b55-95a2-b3395d204279/IFC_Performance_Standards.pdf?MOD=AJPERES&CVID=kTjHBzk

[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 and Total Economic Value frameworks.*

The TEV framework is a useful way of categorizing different types of value as they accrue to human beings. In the MEA 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 categorise 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, and fossil fuel emissions from related economic sectors. Full system accounting should be linked 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.

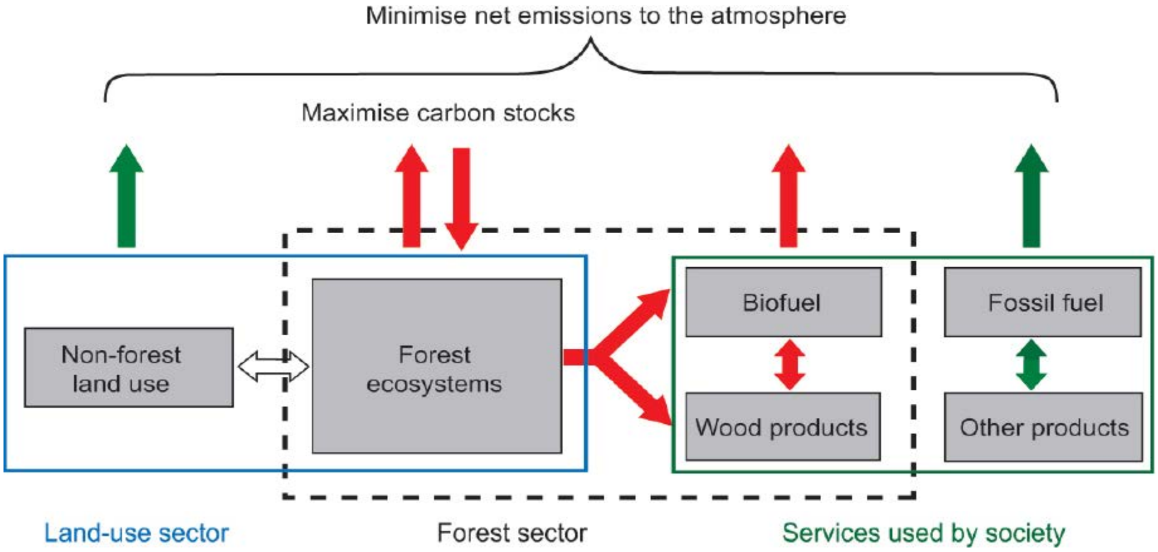

*FIGURE 1. The forest sector in relation to land use, wood products, and energy. Full and accurate accounting for the impacts of forestry activities on greenhouse gases requires estimates of changes in all of these linked systems. Graphic reproduced fro Nabuurs et al. (2007), IPCC Assessment Report 4,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

It is critically important that accounting for increases or decreases in $CO_2$ and other greenhouse gases 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 (i.e., 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 with observations. 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 (C) 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 C 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)

*Use 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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**Reviewer status does not constitute an endorsement.*

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The research and writing for this report were made possible by the generous support of the Doris Duke Charitable Foundation.

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