Climate Resilience, Carbon Dioxide Removal, and Geoengineering Policy-Preface

Welcome to the Climate Resilience, Carbon Dioxide Removal, and Geoengineering Policy document. Introductions and backgrounds are provided within each of the three major topic areas and their companion sections and subsections as appropriate. Please note that this document only provides new policy on Climate Resilience, Carbon Dioxide Removal, and Geoengineering. Existing Sierra Club policies related to these topics are referenced, with links to the policies. Where relevant, topic subsections are cross-referenced with internal links.

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Climate Resilience, Carbon Dioxide Removal, and Geoengineering Policy

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Overall Introduction

Section 1-The Imperative for Enhancing Climate Resilience and Carbon Dioxide Removal

1.1 The Global Climate Crisis is Here and Getting Worse

Despite longstanding efforts by the Sierra Club and our allies to prevent a climate crisis, greenhouse gas emissions continue to increase while natural carbon sinks such as forests and wetlands continue being degraded and destroyed. The Sierra Club's Clean Energy for All campaigns to end use of dirty fossil fuels and move to 100% clean energy in the U.S. have helped slow the rate of global heating by shutting down major carbon polluters such as coal-fired power plants and supporting additional renewable energy capacity. Our campaigns to protect natural ecosystems have also helped offset climate impacts. But as atmospheric greenhouse gas concentrations increase and climate disruptions are felt worldwide, the growing scientific consensus is that greenhouse gas emission reductions on their own will be insufficient to prevent a climate crisis. Even if all greenhouse gas emissions were stopped today, the concentrations of accumulated short- and long-lived greenhouse gases exceed the levels regarded to be safe by the scientific community. In 2019, the average atmospheric concentration of carbon dioxide (CO_2) was about 411 parts per million (ppm), well above the 350 ppm threshold judged to be necessary to protect life on Earth as we have known it, to avoid major climate disruption, and begin to restore the climate. (For a reference, pre-industrial revolution maximum CO_2 concentration of less than 280 ppm was the baseline for more than 800,000 years) The Sierra Club supports a target of less than 350 ppm CO_2 equal to about 1.0°C warming in 2100. The Sierra Club has numerous other policies on climate-related issues discussed in this document. (Sierra Club Policies) This document presents the most current policies related to enhancing climate resilience, carbon dioxide removal, and geoengineering.

According to the U.S. Global Research Program's *Fourth National Climate Assessment* (2018), U.S. heat waves, heavy precipitation events, wildfires, and other weather- and climate-driven events rose in frequency and intensity in recent decades due to human-caused climate disruption. Extreme weather, sea level rise, and other impacts "are projected to intensify in the future—but the severity of future impacts will depend largely on actions taken to reduce greenhouse gas emissions and to adapt to the changes that will occur." This federal government report projects that by the end of this century, even under a "very low" scenario requiring immediate, substantial and sustained emissions reductions, average annual temperatures would rise by 0.4°–2.7°F (0.2°–1.5°C) relative to the 1986–2015 average. Cumulatively this could exceed the safe temperature targets explained below. The 13 federal agencies that authored this report concluded: “While Americans are responding in ways that can bolster climate resilience and improve livelihoods, neither global efforts to mitigate the causes of climate change nor regional efforts to adapt to the impacts currently approach the scales needed to avoid substantial damage to the U.S. economy, environment, and human health and well-being over the coming decades.”

1.2 Building Climate Resilience

As the climate continues to change, impacts are disproportionately affecting low-income, disadvantaged human populations across the nation and the world. Similarly, the climate crisis and its initial global temperature increases have already led to the disappearance of glaciers, death of coral reefs, and dislocation or decimation of climate-sensitive species and ecosystems. In light of this, it is necessary that all levels of government, private sector, and non-governmental organizations (NGOs) plan for and implement solutions that will enhance the climate resilience of all people and all ecosystems, especially the most vulnerable. In the U.S., many (but far from all) cities, Tribal governments, regions, states, and land management agencies have led the climate adaptation planning and implementation movement, in some cases demonstrably improving the life of residents, wildlife, and ecosystems while reducing the risks associated with climate disruption. Some are doing it in anticipation of projected climate impacts, and some are doing it in response to climate impacts that have already disrupted livelihoods, natural systems, social cohesion, economies, cultural assets, and more.

The direct economic costs of climate change induced “natural” disasters has risen. According to the U.S. National Oceanic and Atmospheric Administration (NOAA) in September 2019: “The U.S. has sustained 250 weather and climate disasters since 1980 where overall damages/costs reached or exceeded $1 billion (including CPI adjustment to 2019). The total cost of these 250 events exceeds $1.7 trillion.” Given that climate disruption will increase the severity and duration, and shorten the return interval between disasters, we can only expect these costs to rise. And these are just the economic costs that we calculate that don’t take into consideration the loss of lives, long-term mental and physical health toll, degraded ecosystem functions, or hard-to-quantify impacts such as social disruption and loss of cultural identity and assets. This is why the World Economic Forum’s 2019 Global Risk Report found that “extreme weather events” and “failure of climate change mitigation (emissions reductions) and adaptation” were tied with “weapons of mass destruction” as the world’s greatest threats.

Given these realities, it is imperative that the Sierra Club develops, spurs, and collaborates on strategies that foster greater climate resilience. This means integrating greenhouse gas emissions reductions and carbon dioxide removal with climate adaptation and preparedness strategies and prioritizing the needs of our disadvantaged and most vulnerable populations.

As we advance our climate resilience initiatives, both the built environment and the natural world must be considered, since these two "ecosystems" are intrinsically linked. Our solutions should be designed to benefit, protect and restore the natural world while simultaneously protecting human life and livelihoods and evolving to a more sustainable and climate-smart way of living in harmony with nature. Enhancing climate resilience is not a luxury, it's a necessity.

1.3 The Need for Carbon Dioxide Removal

The 2018 Intergovernmental Panel on Climate Change (IPCC) Special Report on Global Warming of 1.5°C notes the scientific consensus that the average global temperature increase agreed to in the Paris Climate Accord, no more than 2°C, is more dangerous than the original models projected and that a maximum 1.5°C target is now a necessity. IPCC concludes that to avoid exceeding 1.5°C we must not only stop all greenhouse gas emissions but also urgently deploy programs and technologies to remove the CO_2 already in the atmosphere while concurrently investing in efforts to adapt to existing and projected future changes in climate. It is very important to note that "net zero as soon as possible" and atmospheric removal of CO_2 are both compulsory. Emissions reductions alone are inadequate to meet the 1.5°C target, as well as the Sierra Club's target of less than 350 ppm CO_2 and 1°C warming in 2100. This same report notes that we have until 2030 to cut in half global greenhouse gas emissions or else face significant and irreparable harm to society, natural systems, the economy, and life as we generally know it.

A National Academies of Sciences, Engineering and Medicine report, released in October 2018, also states that technologies that remove CO_2 out of the atmosphere will likely be crucial to meeting global climate goals.

Some of the methods for carbon dioxide removal (CDR) are relatively inexpensive and ready for implementation such as nature-based solutions, including preserving healthy ecosystems, maintaining forests and planting trees, restoring wetlands and other aquatic habitats, and managing forests and agricultural lands to store more carbon. Because nature-based solutions are low-cost, low-risk, ready for implementation, and provide multiple co-benefits (or ecosystem services), they should be prioritized for both CDR and their climate resilience values. Other CDR methods being developed, such as Bioenergy with Carbon Capture and Storage (BECCS), Direct Air Capture, and enhanced carbon mineralization, rely on new as well as already developed industrial processes and technologies. These methods are relatively more expensive and will require further research, investment, and testing before being implemented at scales large enough to reduce existing and future climate impacts, and some, such as bioenergy, have potential to undermine climate crisis emission reduction goals and biodiversity conservation, depending on the source of the bioenergy and the nature of the facility.

It is important to note that to return our atmosphere to below the 350 ppm CO_2 and 1°C warming target for 2100 that the Sierra Club supports will require more CDR than is suggested by the 1.5°C targets.

1.4 Geoengineering

Geoengineering, such as solar radiation management, has also been proposed by some as a possible solution, but the Sierra Club opposes this approach and it is discussed in this policy as well.

1.5 Avoiding the Moral Hazard

Any consideration of taking action on climate resilience and CDR requires the Sierra Club and civil society to address the so-called "moral hazard" problem. This is the very valid concern that investments in resilience and adaptation, CDR, and geoengineering provide an excuse to avoid cutting greenhouse gas emissions. If people believe that we can counteract the climate crisis through adaptation, CDR, and geoengineering, governments, businesses, and individuals might ratchet down the urgency of reducing emissions, and countries could slow or even cease efforts to get off dirty fuels and rapidly phase out other major greenhouse gas emitters by no later than mid-century. This is simply unacceptable and must be avoided.

Because atmospheric CO_2 is already above safe concentrations, societies must rapidly reduce and eliminate their greenhouse gas emissions and concurrently draw down excess CO_2 from the atmosphere. They must do this while working to foster resilience to climate impacts that are already happening and will inevitably worsen until atmospheric CO_2 and other greenhouse gas concentrations are returned to safe levels. Moreover, reducing emissions is the most cost-effective and environmentally sensitive way to address high greenhouse gas levels. Failure to halt greenhouse gas emissions will compound the costs and impacts of the climate crisis, even with adaptation, CDR, and geoengineering actions. Therefore it is imperative that we reduce energy usage by increasing energy efficiency; drastically reducing emissions of methane, nitrous oxide, and refrigerants; and rapidly move to 100% clean, renewable energy across all sectors.

For these reasons, any commitment by the Sierra Club and other parties to promote ramping up adaptation and CDR must be accompanied by a firm commitment to redouble and accelerate all emission reductions programs. These are not mutually exclusive approaches and activities; they are complementary and compulsory. CDR should be used to draw down the existing high level of accumulated CO_2, not to allow the continuation of carbon emissions.

We cannot wait until we have ceased all new emissions before we start deploying adaptation and

CDR approaches to deal with existing accumulated, long-lived emissions that are already disrupting the human and natural environment. It would be morally hazardous and irresponsible to begin concentrating on adaptation and CDR but simultaneously ease up on emission reduction efforts.

There are also risks if we refuse to engage in adaptation and CDR out of fear that it might reduce emission reduction momentum. Investments in resilience and adaptation, including preparedness and response, need to happen now. Failure to do so will cause greater losses of human lives as well as plant and animal species, and lead to higher costs for disaster recovery. Also, failure to act now would preclude adaptation and CDR options that might limit harm to human communities and natural systems but are only available before climate disruption progresses much further. Resilience and adaptation are more effective and affordable when taken on proactively, and the right set of acceptable CDR programs requires research, development, and deployment starting immediately to get to scale and to start getting us back below 350 ppm atmospheric CO_2.

In sum, we must pursue emission reductions with renewed vigor and full commitment while simultaneously ramping up and bringing to scale appropriate climate resilience, adaptation, and CDR efforts.

1.6 The Requirement of Addressing Climate Justice

The climate crisis has already had a huge negative impact on societies and communities worldwide, and the impact is disproportionately felt by low income communities, Indigenous people (including Tribes, Native Americans, and Federally Recognized Tribes), people of color, the elderly and children, those with chronic illnesses and disabilities, and others who have been marginalized. Rich and largely white segments of societies in power have contributed most of the historic greenhouse gas emissions that are causing the problems, and the people least responsible for the climate crisis bear the greatest burdens. As these communities and advocates interact with policymakers, their voices must be amplified so they can meaningfully participate in decisions, get their needs addressed, and ensure that climate equity and justice are guiding principles of all resilience, adaptation, and CDR programs globally.

The Jemez Principles and Precautionary Principle should guide all Sierra Club, climate movement, and government efforts to address the climate crisis. Therefore the climate policies listed below were developed while looking through the lens of equity and justice and adhering to the Sierra Club's Environmental Justice Policy (adopted September 19, 1993). The Sierra Club supports all of the Jemez principles including inclusiveness and individual self-transformations to ensure just relationships with all people. The Sierra Club has numerous programs and efforts to continue its forward trajectory toward a more equitable, inclusive, and just organization. The work doesn't stop there; we also must strive to ensure that communities that rely on extractive industries for economic support can justly transition into meaningful employment that will sustain them. Such efforts will promote a truly community-centered approach to addressing the climate crisis.

The Sierra Club will continue to partner with other NGOs addressing equity, inclusiveness, and justice. The Sierra Club supports the Equitable and Just National Climate Platform (EJNCP) which advances the goals associated with economic, racial, climate, and environmental justice issues in improving the health and well-being of all communities. The platform signatories include many organizations that have made equity and justice a cornerstone of their environmental and social justice efforts. The EJNCP highlights include principles associated with no community left behind; an inclusive, just, and pollution-free energy economy; access to affordable energy; and anti-displacement, relocation, and the right to return.

The Club recognizes that we have a duty to stand with- and provide resources and support for- those who are facing climate-related persecution on the basis of their race, religion, gender, sexuality, type of employment, or other marginalized identity. By doing so, we are aware that our climate movement influence will broaden, our potential partnerships will increase, and we expect to have more success in addressing climate-related issues globally.

1.7 Systems Approaches to Addressing the Crisis

As we promote climate resilience and CO_2 removal goals, it is vital that we think in systems and life cycles; recognize context; safeguard people; safeguard nature; achieve equitable outcomes; use best available science and knowledge (including indigenous knowledge); use projections about future conditions; avoid harm; support adaptation; network and learn together; ensure flexibility, robustness, and redundancy; align incentives and penalties to promote ideal outcomes; use windows of opportunity; use existing promising practices; and collaborate. Relevant systems differ across the nation. Climate adaptation plans must be locally developed and tailored to meet the needs and capabilities of communities, and to achieve local support; Sierra Club's policy recommendations at the national level can provide guidance, tools, and urgency for these efforts.

1.8 Funding Climate Adaptation

Climate adaptation and resilience plans alone, even great plans, won't solve this problem. It is vital that there is adequate on-going funding provided to allow full public participation by all parties in the decision making and then to implement and follow through on these plans. Climate resilience, adaptation, and CDR will not be cheap, but the cost of not preparing, adapting, and drawing down sufficient amounts of carbon will be far higher. No single party or level of government can be expected to provide all the funds. Governments at all levels as well as intergovernmental bodies will need to invest in these solutions. Also corporations and other non-governmental organizations and philanthropic organizations need to significantly contribute to this joint effort.

It is especially vital that the richer industrialized nations, starting with the U.S., contribute to assist poorer developing nations so that they can adapt to the climate crisis and help with CDR strategies globally. The industrialized nations caused most of the problem by their historic and on-going emissions and destruction of natural carbon sinks. As a result, they have the largest obligation to provide finances and share knowledge and technologies with the vulnerable nations and people who are suffering the consequences of the climate crisis that they did not create. Similarly, in the U.S. and other developed nations, it is essential to assist and fund the most vulnerable lower income communities that are bearing the brunt of the climate crisis and lack the resources to adapt and protect themselves on their own.

Topic I- Sierra Club Climate Resilience Policy

Section 1- Introduction

1.1 Resilience Policy Context

People have inhabited the Earth for a relatively short period, and over that time we have adapted to numerous changes. Now, the rapidity of climate disruption threatens the ability of nearly all species, including humans, to adapt and survive. Some species, communities, and ecosystems—especially those already decimated by pollution, exploitation, and habitat destruction—now depend on intervention to increase their chances for survival.

For many of the world's people, surviving the climate crisis depends on fundamental societal transformation. Opportunities to adapt to climate disruptions—for example, by moving to a location less vulnerable to climate impacts such as drought, high heat, sea level rise, or inland flooding—are constrained by unequal wealth and power. Moreover, the most vulnerable populations are those least responsible for the current climate crisis.

Avoiding emissions of greenhouse gases and implementing adaptation and social equity measures are the best ways to build climate resilience in our local communities and ecosystems. The Sierra Club calls for urgent actions by all sectors of society to simultaneously:

A. Halt the practices causing the global climate crisis, especially fossil fuel combustion and activities that release naturally stored carbon or damage the carbon storage capacities of soils, aquatic systems, forests and other ecosystems.
B. Restore atmospheric greenhouse gases to safe levels using carbon dioxide removal (CDR) methods that do not further harm people or natural ecosystems.
C. Democratically and equitably plan and implement adaptation programs to maximize resilience and minimize harm from climate impacts to natural and human communities, with priority on enhancing the adaptive capacity of the most vulnerable communities.

This Climate Resilience Policy addresses both human and natural communities, and includes stewardship of natural carbon sinks. CDR, with a strong emphasis on nature-based solutions, is addressed in the next section of this policy (see Carbon Dioxide Removal Policy). Ending fossil fuel use and stopping other greenhouse gas emissions are addressed in other Sierra Club Policies, especially the Energy Resources Policy.

1.2 Policy Organization

Because the climate crisis is global and affects all life on Earth, the scope of this Climate Resilience Policy is necessarily broad. The topical categories in this policy are:

A. Extreme Weather Climate Adaptation
B. Local Communities Climate Resilience
C. Rural and Agricultural Lands Climate Resilience
D. Freshwater Resources and Habitats Climate Adaptation
E. Coastal Resilience
F. Wildlands and Natural Environments Climate Adaptation

The first topic, Extreme Weather Climate Adaptation, addresses ways to prepare for and respond to increasingly severe climate-related storms, drought, and temperature events affecting all parts of the planet. The five following sections highlight why climate adaptation action is urgently needed, and provide policy guidance to enhance the resilience of our built, social, natural, cultural, and political systems.

1.3 Common Themes Across Policy Topics

Each of the topical sections within this Climate Resilience Policy is intended to stand on its own, but readers will find several themes running throughout:

1.3a Advance Social Equity, Justice, and Inclusion

The Sierra Club recognizes that effective climate adaptation plans and programs must advance social equity and the UN Sustainable Development Goals, and be developed via inclusive, democratic, community-based methods according to the Jemez Principles for Democratic Organizing. The 2019 Equitable and Just National Climate Platform, of which the Sierra Club is a co-author and signatory, articulates this principle:

> Because of the continued delay to act at the scale needed to curb carbon pollution, the risks to communities at home and around the globe are increasing at unprecedented levels, including more intense heat waves, more powerful storms and floods, more deadly wildfires, and more devastating droughts. To achieve our goals, we will need to overcome past failures that have led us to the crisis conditions we face today. These past failures include the perpetuation of systemic inequalities that have left communities of color, Tribal communities, and low-income communities exposed to the highest levels of toxic pollution and the most burdened and affected by climate change. The defining environmental crisis of our time now demands an urgency to act. Yet this urgency must not displace or abandon the fundamental principles of democracy and justice. To effectively address climate change, the national climate policy agenda must drive actions that result in real benefits at the local and community level, including pollution reduction, affordable and quality housing, good jobs, sustainable livelihoods, and community infrastructure.

1.3b Prioritize Nature-Based Solutions

The Sierra Club favors measures that do no further environmental harm, repair damage already done, and protect biodiversity. Such approaches provide multiple co-benefits to human and natural communities, and are often comparatively cost-efficient and long-lasting. Where practicable, these plans and programs should integrate adaptation, greenhouse gas emissions reductions, and CDR measures. By conserving nature and restoring ecosystems, we reduce vulnerability, increase resilience, and raise the quality of human life.

1.3c Find Adaptation and Emissions Reduction Synergies

Whether nature or technology-based, climate responses should not only help communities and ecosystems adapt but also help reduce greenhouse gas emissions. Where that's not possible, adaptation actions must be designed to avoid increasing greenhouse gas emissions and other environmental and social harms.

1.3d Integrate Climate Issues into all Planning, Funding, and Decision-making

While some communities and agencies may create standalone climate action or adaptation plans, not all will have resources to do so. Moreover, effective adaptation actions require multi-sectoral approaches reaching all areas of government, commerce, and community organizations. To address the climate crisis, decision makers should integrate climate-informed assessments and adaptation measures into all types of federal, state, local and regional policies, plans, and decision-making frameworks (e.g., land-use and transportation, natural resource management, public health, economic development, healthcare, education, emergency preparedness, and master plans). Jurisdictions and agencies should collaborate across boundaries locally, regionally and nationally to foster greater resilience. Funding must be developed to support and implement planning decisions.

The process of planning and implementing climate-related actions needs to be locally driven, both to involve local stakeholders and to reflect local priorities and sensitivities. While the concept of climate adaptation may not be immediately embraced in some communities, there should be widespread support for protecting health and property in the face of growing threats of extreme weather conditions and related disasters. Too many communities around the nation have been devastated by wildfires and flooding, as well as poor air and water quality. Plans and actions which build resilience and preparation are cost effective and save lives.

Section 2 - Extreme Weather Climate Adaptation

2.1 Background

2.1a Extreme Weather

Climate-related extreme weather threats have increased over the last several years and will continue to grow in the future, necessitating extreme weather planning, preparation, recovery, and relocation. These all require actions now. The following policy recommendations aim to increase awareness for, guide, and strengthen such actions.

The U.S. Global Research Program's 2018 Fourth National Climate Assessment (NCA) highlighted record-breaking, climate-related weather extremes, including heatwaves, heavy precipitation events (especially rainfall), hurricanes, and droughts. Extreme weather events contribute to more floods, wildfires, landslides and land erosions; power and other infrastructure failures; worsening public health; and other disasters. The NCA expressed high confidence that climate disruption will continue, with extreme weather events increasing in frequency and intensity and causing unprecedented impacts. Additionally, the experts noted studies suggesting that tornadoes, hail and thunderstorms "are also exhibiting changes that may be related to climate change."

Similarly, the National Oceanic and Atmospheric Administration (NOAA) reported that the U.S. in 2018 experienced:

A. The 22nd consecutive warmer-than-average year;
B. 14 weather and climate disasters, each with losses exceeding $1 billion and all totaling around $91 billion in damages; and
C. Record-high precipitation across much of the contiguous U.S. east of the Rockies

Extreme weather adversely impacts human health, quality of life, agriculture, ecosystems, infrastructure and other properties, and many other sectors. Analysis of deaths and illnesses from heat waves, floods, and hurricanes have shown that certain populations are especially vulnerable to extreme weather, including the poor, minorities, elderly, chronically ill and disabled, and people with acute medical conditions.

2.1b Adaptation for Extreme Weather

While communities need to adapt to the impacts of higher average temperatures, plans and actions must focus on projections and vulnerabilities of the harms of climate-related extreme weather. Increased and worsening extreme weather events point to the need for more emergency preparedness and management actions. Threats that had been treated as small and "normal", such as "1 in 100 years" heavy rainfalls, are much more likely to occur now, and future climate-related extreme weather will likely accelerate and damage communities across the nation.

2.2 Policy - Extreme Weather Climate Adaptation

1. Community members should be encouraged to participate in preparing for and recovering from extreme weather events, including relocation planning and actions where necessary.
2. All such plans and actions should focus on: protecting people and nature; elevating under-represented groups; and supporting efforts to provide data, tools, volunteer labor, model practices, and other resources to supplement the capabilities of government agencies and other groups.

2.2a Extreme Weather Assessments

1. Because extreme weather events have become more frequent and severe with climate disruption around the nation, all communities, counties, states, Tribal governments, land and wildlife management agencies, and other organizations should develop climate adaptation, emergency management, and other such plans with a focus on increased numbers of extreme, recurring, unprecedented weather events. The first steps in developing such plans are to conduct area-specific assessments identifying the potential frequency and intensity of extreme weather events and the vulnerability of key sectors to those events.
    a. Federal funding should support such assessments. This planning should be open, transparent and inclusive, including under-represented groups.
    b. To build such capacity in these organizations, planning experts, national and regional environmental groups, and others should provide data, tools and model practices to supplement the capabilities and actions of government agencies, public health departments and healthcare providers, and other organizations.
2. Each plan should assess an area's exposure to various types of climate-related extreme weather, including heat waves, heavy precipitation events (especially rainfall), hurricane intensity, and droughts. The assessments should reflect an area's recent experiences and be forward-looking based on expert projections for extreme weather.
3. The plans should assess how these extreme weather events contribute to other threats applicable to an area, including floods, wildfires, landslides and land erosions, power and other infrastructure failures, and other disasters. With worsening conditions, some climate-related threats need to be assessed even if an area has been historically safe from them.
4. Using the assessments of extreme weather events and related threats, the plans should analyze the likely—as well as projected and unprecedented—impacts on key sectors, including healthcare, energy, transportation, access to clean water and food, waste management, agriculture, social services, natural areas and wildlife, and governance.

5. The process should include special efforts to include and address the needs of populations that are especially vulnerable to extreme weather impacts, including the poor, minorities, elderly, chronically ill or disabled, and people with acute medical conditions.

2.2b **Preparation for Extreme Weather Events**

Following assessment of an area's vulnerabilities to extreme weather, each adaptation plan, emergency management plan, and other such plan should specify strategies, processes, actions, and groups' responsibilities to increase a community's resilience to, and ability to recover from, these impacts. Federal, state and other funding should support such planning. Relevant objectives:

1. In designing and implementing actions, all members of the community should be able to participate along with government leaders, public health officials and healthcare professionals, major businesses and institutions, and experts. Particular effort should be made to include the poor, minorities, elderly, chronically ill or disabled, people with acute medical conditions, non-English speaking, and other under-represented people.
2. Particular attention should be given to safeguarding people with high vulnerabilities from extreme weather impacts. Preparations should consider improving warning systems; developing emergency centers with backup energy, water, food, and communications services; providing transportation to these facilities; ensuring access to safe food and water; and protecting or relocating hazardous waste sites.
3. Preparations should prioritize ways that natural systems could help an area deal with floods, wildfires, landslides and land erosions, power and other infrastructure failures, and other disasters.
4. Preparation should include strategies, processes and responsibilities for communicating risks and helpful actions to the public, and providing public training on resilience and responses to emergencies.

2.2c **Recovery from Extreme Weather Events**

1. Adaptation preparations should facilitate recovery from the impacts of extreme weather and related conditions. Federal and state funding, trained personnel, and resources should support such recovery. Effective responses require cooperation across government agencies, public and private institutions, businesses (including communications services providers), and volunteer organizations.
2. Extreme weather events have long-term impacts on people, communities, and ecosystems. Recovery must provide long-term support for people who suffer in health, property loss, or social and economic disruption, especially people with high vulnerabilities. As a specific example, flooded homes often require professional mold remediation. Natural areas may need multi-year efforts for restoration of species and habitat.
3. Recovery should go beyond trying to recreate buildings, infrastructure, and landscapes. Recovery actions should raise community resilience by reflecting the

increasing frequency and severity of extreme weather, sea level rise, and other climate-related conditions. Strategies for more resilient recovery should consider replacing vulnerable, polluting power grids with more resilient electric systems using renewable energy; improving water runoff and soil permeability; applying building codes and zoning to make structures less vulnerable to floods and fires; preventing rebuilding and further development in high risk areas; and using natural systems to reduce flooding and erosion.
4. Post-disaster efforts should include assessing the strengths and shortfalls of prior extreme weather plans and preparations. Recovery actions should aim at improving resilience to climate-related threats.

2.2d <u>Relocation Plans and Programs to Raise Resilience to Extreme Weather Events</u>

In light of climate-related threats, plans and programs should consider relocations for residences, healthcare facilities, transportation and power infrastructure, historical and cultural structures, and other community assets that will face repeated and inescapable impacts from extreme weather events. Federal and state funding and planning tools should support such relocation. Alternatives should be considered that are both more resilient and better for human health and welfare, including green infrastructure, complete streets, transit, infill for urban areas, and urban forests.

1. Maps and land use decisions for floods, wildfires, landslides and land erosions, power and other infrastructure failures, and other climate-related risks should reflect recent experiences and be forward looking based on expert projections and planning tools.
2. Strategies should address new needs that go beyond traditional resilience planning and consider projected extreme, recurring, unprecedented weather events.
3. Government programs (such as disaster assistance and flood insurance) should not encourage residences or businesses to spend on maintaining or expanding infrastructure and buildings, rebuild or remain in areas vulnerable to extreme weather impacts.
4. Rebuilding in such areas often is not cost effective and leads to more human suffering in the future. Instead, programs should provide incentives and aid for individuals and communities to relocate to safer areas.
5. Natural ecosystems should be restored in many areas to raise resilience to extreme weather.
6. Particular attention should be paid in relocations to the needs of people with high vulnerabilities.
7. Short-distance relocations within the local region, as well as in-migration from communities outside the local region, should be considered.

Section 3- Local Community Climate Resilience

3.1 Background

The global climate is changing and these impacts are already being felt acutely at the local community level. From flooding and damage to physical infrastructure, to heat waves, natural disasters and the physical and social disruptions that ensue, local communities are already experiencing the impacts of a changing climate. Such impacts are projected to become more intense, frequent, and of longer duration in a climate altered future. While all communities are or soon will be affected by the climate crisis, such impacts vary with many factors, including the location, geographical features, demographic groups, economic and social activities, socioeconomic status, healthcare resources, and other community characteristics. Although climate resilience plans and actions are needed in all communities (urban, suburban or rural; coastal or inland; etc.), effective plans and actions will be community-specific and developed through community participation.

A national strategy should be developed for local community resilience, with three core elements: 1) reducing greenhouse gases, including atmospheric greenhouse gases and emissions, to the fullest extent possible; 2) preparing for the existing as well as projected future impacts associated with a changing climate (climate adaptation); and 3) placing social equity at the center of all climate-related work. It is only by avoiding the unmanageable impacts associated with a changing climate, managing the unavoidable impacts, and focusing on the needs of the most vulnerable, that we will meaningfully enhance local community resilience to climate disruption.

3.2 <u>Policy - Local Community Climate Resilience</u>

3.2a <u>Prioritize Green Infrastructure</u>

1. Impervious pavement in cities exacerbates the urban heat island, leads to more localized flooding, disrupts natural systems, and generally reduces the overall quality of life for nearly all residents (i.e., humans, animals, and plants). As such, local communities should prioritize the installation and maintenance of green infrastructure (e.g., bioswales, rain gardens, green streets, parks and street trees, green roofs, green ways, and permeable pavements) to manage stormwater, mitigate heat, increase biodiversity, increase CDR, and enhance the overall quality of life.
2. Emphasis should be placed on installing and maintaining green infrastructure in underserved and flood prone areas.

3.2b Limit Sprawl and Invest in Complete Streets

In the United States, transportation emissions are rapidly growing and are expected to become the largest source of emissions in the near future. Moreover, a large amount of infrastructure within cities is dedicated to cars (i.e., parking garages, roads, street parking).

1. By limiting sprawl, investing in density that is right sized for a given location and close to transit corridors (see Sierra Club's Urban Infill Policy), and encouraging alternative forms of transit, local communities should repurpose some land currently reserved for vehicles, such as parking lots, and turn it into affordable housing, stormwater retention features, green infrastructure, community spaces, or other features that will help enhance community resilience to a changing climate.
2. In addition, local communities should embrace a complete streets approach for all existing and to-be-developed roads, thereby ensuring they are safe for all users, especially pedestrians, bicyclists, and transit riders of all ages and abilities. Complete streets should also integrate green infrastructure principles to help mitigate heat and flooding impacts associated with a changing climate.

3.2c Work Locally and Collaborate Regionally

Climate impacts do not stop at geopolitical boundaries but often political control does.

1. Local communities should work collaboratively with their neighboring jurisdictions to enhance regional resilience to projected impacts and to mitigate greenhouse gas emissions, all while implementing policies locally that are within their political control.
2. When working regionally, local communities should promote regional transportation and land use decisions, food production, renewable energy systems, floodplain management, wildlife corridors, natural system preservation, and emergency response, among other things.

3.2d Integrate Climate Concerns into All Planning and Decision Making

The climate crisis will affect nearly all aspects of local community operations and quality of life.

1. Local communities should integrate climate considerations into all local and regional planning and decision making. This includes master plans; as well as, land use and transportation planning, economic development planning, education planning,capital improvements planning, water resource planning, parks and recreation planning, emergency management and disaster response planning, sustainability planning, health and safety planning, and more.
2. When choosing which climate projections to integrate into planning, the use of both business-as-usual scenarios as well as higher-emissions scenarios is recommended. The reason for this is that emissions globally and in many areas of this nation are tracking at or above business-as-usual scenarios and climate science continually

demonstrates that the system is changing much more rapidly than previously anticipated. Using an abundance of caution and planning for more extreme impacts than may happen will have far more co-benefits than underestimating the amount of change that will take place, and suffering health and property losses that could have been avoided.

3.2e Work With Residents – Especially Frontline Populations

The climate crisis will impact everyone; but not everyone will be impacted equally.

1. Local communities need to work with residents, especially their frontline and most vulnerable populations, to craft resilience solutions that are respective of local circumstances, prioritize the needs of the most vulnerable, and lead to solutions that reduce local risks and enhance adaptive capacity. This type of outreach needs to be deeper than education, including engagement, active listening, and power transfer so that residents have real ownership of solutions identified and implemented (see Jemez Principles). Environmental and social justice organizations are strong potential partners in this work (see this NAACP guide for additional tips).

3.2f Set a Vision, Establish Goals, and Implement

The climate crisis is already causing significant impacts that disrupt lives and livelihoods for millions of people.

1. Local communities should not wait for what is deemed "perfect" information before acting but should, instead, immediately begin implementing actions that have a multitude of co-benefits, actions that are considered low-hanging fruit, and actions that lay the foundation for more challenging steps that will take significant time, capital, and/or political will to implement.
2. As part of this work, local communities should set a vision of what local resilience/ sustainability/a healthy climate looks like and how all residents and businesses can be a part of achieving that vision.
3. Then these visions should be implemented. As part of implementation, local communities should work hard to create a culture that accepts the fact that sometimes we will fail. But as long as we fail fast, learn from our failures, grow, and continue to move aggressively towards solutions that enhance local community resilience we will be progressing.

3.2g Ground Work in Local, Indigenous, and Scientific Knowledge Systems

1. Knowledge, be that experiential, scientific, Indigenous, or other forms, should be the foundation upon which local community resilience actions are built. This means listening to residents, learning from lived experience, using scientific climate projections and revisiting those projections over time, and creating flexible and iterative feedback loops so that learning is a continual element of local community resilience planning and action.

3.2h Urban Forestry

Forests as well as other trees and vegetation in urban areas provide important benefits in climate adaptation--in addition to sequestering CO_2. These benefits include reducing the heat island effects of buildings and pavement as well as the use of energy and costs for cooling; managing stormwater to decrease flooding and infrastructure costs; and lowering the ambient concentrations of ozone, nitrogen oxides, and other air pollutants. Urban forestry offers opportunities for the Sierra Club to advocate for the planting of trees in urban parks, along streets, and in other public and private properties; support green roofs for government and private buildings through laws, ordinances and programs; and help educate government officials, property owners, and other citizens on the benefits of trees and other vegetation in climate adaptation.

1. Urban forestry projects should consider the adaptation benefits--such as heat reduction and stormwater management--as well as the climate benefits of vegetation planting.
2. The projects should provide municipalities and private landowners the resources they need to determine the appropriate species to plant in the appropriate settings, and should include public outreach and education components.
3. Projects should consider planting trees along sidewalks and roadways; within suspended pavement applications, plazas, and parking lots; and in parks, school properties, and public spaces.

Section 4- Rural and Agricultural Lands Climate Resilience

4.1 Background

The Intergovernmental Panel on Climate Change (IPCC) Special Report on Climate Change and Land, published in August 2019, sounded a wake-up call on how our use and abuse of land and water are accelerating the climate crisis. Human use directly affects 70% of global ice-free land surface, and since 1961 changes in population growth and per capita consumption of food, fiber, feed, timber and energy have caused "unprecedented" rates of land and freshwater use. Agriculture accounts for an estimated 70% of freshwater use. Continued urban expansion is expected to lead to cropland losses, posing additional risks to the food system, with adverse ripple effects on natural environments.

The IPCC's prior report, the 2018 Special Report on Global Warming of 1.5℃, demonstrated that the Paris Agreement target of 2°C is too high to prevent catastrophic, irreversible climate impacts. However, 350 ppm CO_2 (about 1°C) exceeds the levels regarded to be safe by the scientific community and judged to be necessary to protect life on Earth as we have know it. Much of current science shows, and the Sierra Club believes, that 350 parts per million (ppm) CO_2 and less than 1°C is the maximum safe level of warming. The 2019 IPCC Special Report on Climate Change and Land built on that call to action by explaining the role of land use in the Earth's carbon cycles; how land degradation relates to food security; how improving land stewardship can help mitigate climate impacts and draw down atmospheric carbon; and how these approaches support sustainable development more broadly.

The 2019 IPCC Special Report on Climate Change and Land showed that many land-related responses that contribute to climate adaptation and emissions reductions can also combat desertification and land degradation, and enhance food security. Sustainable land and forest management can maintain land productivity, contribute to emissions reductions and adaptation, slow biodiversity loss, and sometimes reverse the adverse impacts of climate disruption. At scales from individual farms to entire watersheds, sustainable management practices can provide cost-effective, immediate, and long-term benefits to communities. However, some land-based climate responses, such as carbon dioxide removal using bioenergy, can increase demand for land conversion with adverse side effects on food security and natural environments. The report also highlights the urgent need to reduce food loss and food waste, and change dietary choices worldwide.

Climate impacts threaten food production, rural populations, and rural economies. The U.S. as a whole relies heavily on food and other resources produced in rural areas—places with relatively low population densities and smaller communities. Rural areas are experiencing climate impacts such as intensified flooding, heatwaves, wildfires, drought, invasive species, and disease risk. Because so many goods and services originate outside cities, rural climate disruptions not only harm communities locally, but also threaten food security and economic well-being broadly.

Rural areas are highly vulnerable to climate impacts. Many of our country's most vulnerable communities, minorities, and people of color live and work in rural places, where there is lower media visibility and fewer resources for healthcare, social, and emergency services. Some rural areas, especially in the Midwest, Great Plains and Northeast, have experienced population declines and economic contraction in recent years. For these reasons, rural counties and small- to mid-size communities often lack sufficient resources to plan, prepare for, respond to, and recover from climate threats.

Rural economies are generally less diversified and more directly dependent on natural resources (local land, water, and wildlife) than are urban economies. Many rural jobs are based in agriculture, forestry, fisheries, and tourism as well as mining and energy extraction/generation—livelihoods subject to seasonal uncertainties or boom-bust cycles. Many of these sectors rely on healthy, functioning ecosystems to remain economically viable—and climate change is disrupting those ecosystems. Some also depend on direct and indirect government assistance such as farm subsidies and permits to graze or extract resources from public lands. Native American trust (or reservation) lands and culturally important places are largely outside cities, many in remote areas with limited financial and public infrastructure.

The climate crisis is compounding pressures and uncertainties already faced by rural communities such as job losses to mechanization, water shortages, crop failures, tree mortality, fishery depletion, and more. As climate disruption worsens, some agricultural lands could face development pressure from businesses and residents relocating from coastal areas inundated by rising sea levels. Formerly productive agricultural lands may become unusable due to changing water and weather regimes. Competition for water among agricultural, industrial, municipal and in-stream users will intensify.

Rural and agricultural lands and watersheds provide great opportunities to draw down atmospheric CO_2. Soils, trees, and other vegetation can be managed to retain existing carbon stores, and in many cases absorb and store more carbon (see Carbon Dioxide Removal Policy). Where appropriately sited, renewable energy developments may help boost local incomes, reduce energy costs, and provide tax benefits to rural communities.

4.2 Policy - Rural and Agricultural Lands Climate Resilience

4.2a Community and Regional Adaptation Planning

Urban, rural, and natural areas are interdependent. Rural economies vary widely from place to place, so climate adaptation solutions are not "one size fits all."

1. All local and regional policy plans (e.g., land-use, economic development, natural resource management, and emergency preparedness plans) should integrate "climate smart" vulnerability assessments, emissions reductions, and adaptation measures.
2. To ensure that these plans address everyone's needs equitably, they must be developed via inclusive, transparent, democratic, community-based methods and genuinely engage low-income and other vulnerable communities.
3. When local jobs will be lost to implement climate-benefitting programs such as forest and wetland conservation, funding and training should be provided to ensure a just transition for affected workers and communities.
4. Because the climate crisis affects all populations, resources, and sectors, adaptation planning should consider all natural communities and major economic sectors in a community or region.
5. Plans should apply evolving best practices and science-based approaches to deal with climate uncertainty and, where practicable, integrate adaptation with emissions reductions and CO_2 removal measures. Plans should incorporate accurate accounting of carbon sequestration and storage and other climate-related benefits of rural and agricultural lands.
6. Local and regional plans should proactively designate degraded or marginal areas suitable for ecological restoration or conversion to climate-impacted uses (e.g., managed retreat from coastal and fire-prone areas, renewable energy/CDR projects).
7. Consistent with existing Sierra Club Guidelines, renewable energy installations and transmission lines should prioritize already-disturbed, developed or degraded areas and minimize conversion of intact habitats. Potential negative impacts to natural

carbon sinks and climate impact buffering should be among the siting considerations. Similarly, CDR projects should be carefully planned to avoid adverse impacts on food systems, water, and natural lands.

8. Resource management plans for agricultural lands, watersheds, fisheries, and forests should incorporate climate resilience goals for long-term sustainability. Federal, state, county and nongovernmental assistance programs should support smaller-scale, locally owned and managed farms, fisheries, forestry and other rural businesses. Industrial-scale, fossil fuel- and chemical-intensive logging, fishing, ranching and farming practices should be discouraged. Incentives should provide for long-term resource stewardship, local ecosystem restoration, more family-supporting jobs, and better diversification of crops and forestlands.

4.2b **Agricultural and Grazing Lands**

Sustainable and regenerative principles for agricultural and grazing lands are addressed in the Soil Carbon Restoration and Sequestration section of this policy, in the Sierra Club's comprehensive Agriculture and Food Policy, and in the Grazing on Public Lands Policy. These principles provide a sound foundation for rural climate adaptation and carbon sequestration on agricultural and grazing lands. Cautions related to land and water competition from Bioenergy with Carbon Dioxide Capture and Storage (BECCS) are addressed in that section of this policy (see BECCS).

1. Measures that increase the resilience of our food production system under changing temperatures, precipitation patterns, and other growing conditions are especially relevant--for example, reducing monoculture, chemical inputs, water wastage, and livestock densities. Agricultural education and training curricula must be updated to include restorative practices, climate vulnerability analysis, and adaptation best practices.
2. While the Sierra Club supports research and development of more drought- and pest-resistant crops, food, and fiber sources, we oppose genetic modification for those purposes. As stated in the Agriculture and Food Policy, "the Sierra Club calls for a ban on the propagation and release of all genetically engineered organisms, including field crops, orchard and forest trees, fish, etc. (whether or not currently approved by the FDA)."

4.2c **Extreme Weather and Wildfire**

Climate disruption is escalating threats to rural economies and public health from extreme weather events. These issues are addressed in a separate section of this policy (see Extreme Weather and Fire Management in Forest Carbon Dioxide Removal sections). Examples of measures that could be prioritized for rural areas include designating public cooling and extreme weather shelters for at-risk populations, subsidizing indoor air filters for smoky days, and developing energy and communications systems that are resilient to power outages.

1. Public policy should limit construction of housing and other structures in fire-prone wildlands. We favor wildfire protection programs and investments that focus on

making homes and communities more fire-resistant, rather than on reducing wildland vegetation (logging and thinning) far away from settlements.

2. Vulnerable rural habitations should have evacuation routes and emergency services available in the event of wildfires, early warning systems should be improved so communities can mobilize quickly if a fire is nearby, and personnel should be increased to prevent unplanned human ignitions near communities during high fire conditions (see Extreme Weather section of this policy).

4.2d Water Availability, Watersheds and Floodplains

Note: Adaptation for Freshwater Resources and Habitats is addressed below and in a separate section of this policy. Adaptation for Sea Level Rise impacts (Coastal Resilience) is addressed in a separate section of this policy. Also see Wetlands Carbon Dioxide Removal section of this policy.

As the climate warms, water availability is becoming less reliable; droughts alternate with extreme precipitation in many areas. Flooding of settlements and agricultural lands is increasing in severity and frequency, while surface and groundwater supplies are being overdrawn during dry times. Core elements of the Sierra Club's Water Policy, adopted in 1995, are more relevant than ever in a climate-altered world. These policies emphasize conservation and sound management of all water resources for the benefit of people and nature.

1. Climate adaptation requires holistic management of watersheds. Healthy forests, grasslands, wetlands and aquifers must be protected and monitored to ensure reliable, clean water supplies for all communities. Groundwater recharge is preferable to additional surface reservoirs to store more water to address the climate crisis. Heavy precipitation events increase the risks related to runoff from land treated with fertilizers and pesticides. Water pollutants should be eliminated to protect aquatic life and drinking water.
2. In areas in which water resources from precipitation, groundwater and aquifers are declining; U.S. Department of Agriculture, Bureau of Reclamation, state and other agencies must develop new planning, training, pricing and allocation methods to maximize the value of these resources and provide equitable access to them.
3. Water conservation and efficiency measures should be widely adopted to deal with water shortages and the increased competition for water between users and the needs of the natural environment.
4. Streams and rivers with impoundments and diversions should be managed to provide adequate flows and water temperatures to protect aquatic ecosystems downstream.
5. Floodplain management should move away from engineered containment in favor of allowing space for floods to spread out, also providing wildlife habitat and recreation opportunities along watercourses.
6. In inland flood-prone areas, homes and other structures should be relocated out of harm's way and new vulnerable structures disallowed.

7. Inland steep slopes subject to landslides and mass movement during extreme weather should be off limits to development and vulnerable homes and structures should be relocated to safer ground.

4.2e Forests and Shrublands

See the Climate Adaptation for Wildlands and Natural Environment and Forest Carbon Dioxide Removal sections of this policy.

4.2f Ocean Health, Marine Fisheries and Aquaculture

Policies for farming of fish and other aquatic organisms are found in the Agriculture and Food Policy. Policies for sustainable marine fisheries are found under Marine Conservation Policy. Also see the Ocean Carbon Dioxide Removal and Adaptation for Wildlands and Natural Environment sections of this policy.

Section 5- Freshwater Resources and Habitats Climate Adaptation

5.1 Overview

Globally, marine waters make up 97% of all waters and freshwater makes up approximately 3%. Freshwater is essential for much of life on Earth and is found in rivers, lakes, streams, ponds, reservoirs, wetlands, glaciers/ice, and groundwater reservoirs. The majority of global freshwater is in the form of ice and the rest is in groundwater and surface water.

Even though freshwater ecosystems are small relative to saltwater, their importance to people, plants, and other creatures is profound. Life on land and some marine life depend on freshwater delivered via the hydrologic cycle of freshwater flowing into the oceans, evaporating into the atmosphere, and falling back to the Earth in the form of precipitation. Thus, freshwater is an integral part of Earth's climate feedback loop.

Flooding from climate crisis-enhanced precipitation and incidents of drought are both on the rise and will increase with further warming, creating unprecedented risks to humans, plants, and animals, the built environment, and the natural world.

5.2 Freshwater Resources - Background

Resources that freshwater systems provide include: clean and potable water, food, climate control, recreation, tourism, and transportation conduits. Additional ecosystem services that freshwater habitats provide include agricultural and wildland soil building materials, groundwater reservoirs and aquifer replenishment, irrigation, and corridors for animal and plant migration. Natural plant migration involves the transportation of seeds by winds, freshwater streams and rivers, and animals.

Rivers and lakes provide passageways for boats, ships, and recreational water-craft. Thus, these waters are important for the critical functions, economic stability, and recreation within urban centers that have large rivers serving them. Point source and nonpoint source discharges and emissions from urban centers can introduce pathogens, solids, particulates, pollutants, and contaminants that may impact these freshwaters; human, plant and animal health; micro-organisms; and the broader environment. Also, these rivers are prone to sedimentation and debris buildup, and many are periodically dredged to keep them functional as transportation conduits. The dredging of these large rivers releases greenhouse gases such as CO_2, methane, and nitrous oxide that were stored in the sediments back into the water and ultimately the atmosphere. Any contaminants stored in the dredged sediment may be released and/or transported to the dredge material dumpsite. The "beneficial use" of dredge material to address sediment deposition, which is essential for shallow water habitats to keep their elevations commensurate with sea level rise, can provide needed sediment in designated areas for that purpose.

In rural areas; rivers, lakes, streams, ponds, and wetlands provide regional freshwater resources including most of the ecosystem services listed above. In addition, these areas support recreational hunting, fishing, hiking, and other outdoor activities.

The climate crisis impacts associated with freshwater resources include more frequent violent storms which result in more pollution from runoff and increased turbidity, erosion, flooding, and aquatic debris. Also these impacts include increased warming and acidity of the waters resulting in degradation of the habitats; reduced animal and submerged aquatic vegetation (SAV-which are plants that are always under water) biodiversity; reduced populations of native fish, insects, waterfowl, and other animals; and increased incidents of harmful algal blooms (HABs) such as blue green algal blooms from the proliferation of cyanobacteria. Lastly, climate crisis impacts may support the proliferation of invasive species of plants and animals. These impacts affect the local and regional economies, the area recreational and tourism appeal, and the subsistence of indigenous and vulnerable communities that may use hunting and fishing as a means to support their quality of life.

5.3 Policy - Freshwater Resources

1. Because of the climate crisis, treatment protocols for wastewater discharged into rivers and lakes being used as potable water sources should be more stringent than prior treatment protocols. This is because more pathogens and other harmful microorganisms thrive in warmer water conditions. They may become more virulent, and often the pretreatment involves dilution to meet the desired pathogen/contaminant concentration. The dilution protocol for the efficient operation of the treatment system using outdated pathogen/contaminant concentration standards may no longer be suitable for protecting humans, animals, and the natural environment in a warmer climate.

2. Also, because of the climate crisis, the pretreatment of discharges of sewage effluent from installed toilets on all vessels (recreational, commercial, and military) should be more stringent because discharges of this effluent (pretreated to prior standards) into warmer aquatic ecosystems may result in the increased viability of any concentration of pathogens. Therefore, a smaller concentration of such pathogens in the device effluent may pose a greater health risk now than it did prior to the climate crisis.
3. Best management practices, using available science-based modeling, should be developed for addressing the dredging of rivers, bays, harbors, and ports that have been identified as having a significant amount of carbon stored in their sediments. These practices should include provisions associated with the placement of dredge materials to prevent further release of stored carbon into the atmosphere.
4. In order to provide necessary sediments to help shallow water habitats maintain appropriate elevations in the face of sea level rise and increased chronic flooding, the Army Corps of Engineers should prioritize, over all other disposal options, the ”beneficial use” of clean dredge material for the purposes of protecting, restoring, and creating aquatic ecosystem habitats and for stabilizing stream systems and enhancing shorelines. In order for dredged material to be considered for reuse, it should be cleaned of all contaminants that may pose a health risk to humans, animals, plants, and microorganisms that may come into contact with it. (See Coastal Resilience Policy)

5.4 Freshwater Habitats - Background

Freshwater habitats include: rivers, lakes, streams, ponds, and wetlands. These habitats support aquatic animal and plant diversity and provide many of the same ecosystem services mentioned in the Freshwater Resources section, as well as, other areas in this policy document. In addition, they provide nurseries for countless terrestrial and aquatic animals, including fish, birds, and insects. These habitats also support the survival of aquatic microorganisms in the water, sediments, and muds. The ecosystem services that healthy stream and riparian ecosystems can provide include: mitigating erosion from increased flood intensity, reducing nonpoint source stormwater pollution runoff degradation, improving water quality, and reducing water and local soil temperatures. The services provided by healthy intact wetlands include water purification, carbon sequestration and storage, reduced incidents of HABs, reducing chronic flooding from storm events, aquifer replenishment, and many others. For more information on wetlands, please see the Wetlands, Coastal and Shallow Marine Habitats Carbon Dioxide Removal Policy section in this document.

Freshwater habitats are impacted by sedimentation, drought, HABs, pollution, and climate impacts such as violent weather, prolonged and intense precipitation, increased acidity in the precipitation, and higher daily average temperatures. Climate impacts during this crisis threaten the survival of native species inhabiting these ecosystems and facilitate the proliferation of invasive species.

Human activities within freshwater habitats such as development, draining, dam construction, and others can impact the biodiversity of rivers, lakes, streams, ponds, and wetlands by altering the hydrology of the systems. These alterations in hydrology may impact the ability of the animals and plant seedlings to relocate into areas where climate conditions are more suitable for their survival. Freshwater habitats are also threatened by climate crisis impacts such as flooding, erosion, drought, salt-water intrusion in marine coastal regions (affecting animal and plant viability), and degrading or destroying wetlands (which may impact potable water supplies).

5.5 Policy - Freshwater Habitats

1. Because of the climate crisis, freshwater habitats supporting all aquatic plants, animals, and beneficial microorganisms will be under increased stress; therefore, it becomes even more essential to remove or reduce the non-climate stressors like stormwater runoff pollution, other water pollutants, dams and some unnecessary surface reservoirs, watershed logging practices, water diversions, culverts and conveyances that don't effectively support animal and plant migration, and some point source discharges into these habitats.
2. Floodplain management should protect wildlife habitat along watercourses. Efforts to protect minimum stream flows for the natural environment should be encouraged.
3. Because of climate disruption, the conservation and restoration of freshwater rivers, lakes, streams, and ponds should be a priority at all levels of planning and management. Also, this disruption will cause range-shifts of many native species seeking more suitable areas to live. Local and regional managers must be aware of this and balance it with efforts to prevent and minimize invasive species proliferations.
4. Measures should be put in place to reduce the potential proliferation of invasive species of plants, animals, and microorganisms within freshwater habitats. Such measures should include the avoidance of any initial invasion of such species. Evolving best practices, science, and professional judgment should guide efforts to conserve individual species and biodiversity, and maintain basic ecosystem functions.
5. Also, because of warmer temperatures; riparian zones and permanent cover of grasslands (permanent cover address the fact that grassland systems very rarely have riparian buffers) of at least 100 feet should be incorporated for protecting water quality of rivers and lakes, and shaded riparian zones established to help reduce stream temperatures to support aquatic and plant life, as well as, beneficial microorganisms.
6. Because of warmer temperatures, reduced precipitation in some areas, and aquifer replenishment issues, federal, state, and local governments and agencies should adopt and implement policies to preserve and restore wetlands associated with freshwater rivers, lakes, streams, and ponds. (See Wetlands Policy under Water Resources Policies).
7. Flood prevention strategies should conserve freshwater and riparian habitats and stream channelization should be avoided. Where channelization is unavoidable, stream habitat should be restored using native plants and natural stream restoration strategies. More efforts to protect minimum stream flows for the natural environment should be encouraged.
8. Agricultural riparian preservation practices should be strengthened to avoid increased erosion and habitat degradation from increased flood elevations associated with the

climate crisis. Overland runoff agricultural conservation practices should be expanded to prevent increased erosion from intense storms.

5.6 Freshwater Supply and Aquifers - Background

Natural freshwater is replenished globally by the processes of the hydrologic cycle. Due to global heating, a significant part of the hydrologic cycle is now affected by the melting of glaciers and icebergs. Because of the climate crisis, freshwater availability is being changed in various ways. Some areas are getting too much water during storm events (including sea level rise) resulting in chronic flooding; and some areas are facing droughts during times of prolonged higher temperatures without adequate precipitation. Areas that rely on snowmelt to replenish their waters are seeing runoff commence and end earlier in the year because of earlier arrival of the warm season that reduces available water later in the season.

Aquifers are underground layers of porous material saturated with water. This water can be transmitted for use from a well or spring as groundwater. In some areas where there are dump sites containing contaminated material such as coal ash or landfills and/or pollutant-housing lagoons such as hog farms lagoons, contaminated runoff (during precipitation events) may seep into the groundwater reservoirs and aquifers and these freshwater resources may become contaminated with pollutants, nutrients, and minerals. Hydraulic fracturing, which the Sierra Club opposes, and the underground disposal of wastewater from oil and gas operations are also sources of contamination for underground aquifers. See the Sierra Club policy on Fracking for Natural Gas and Oil.

Clean water is a human right and an environmental and commercial necessity. In the U.S., groundwater is the primary source of drinking water for approximately half of the total population and most of the rural population. For agricultural purposes alone, groundwater supplies approximately 50 billions gallons per day. Also in the U.S., groundwater depletion has resulted in areas not historically viewed as water-stressed such as in the Northwest and Mid-Atlantic coast to become water-stressed due to the climate crisis. In many parts of the world, particularly in geographical areas prone to high temperatures and profound dryness, more groundwater is used than is replenished naturally. In areas facing prolonged dry spells, the drought issue is compounded by the depletion of water in aquifers from irrigation, farming, common use by residents and industry, some aquifers not being properly recharged by precipitation, and other factors associated with the local hydrogeology. The climate crisis causes increased competition for water. The challenge will be in trying to address the potential water conflicts. Governments should enter into agreements to ensure that the available water is shared equitably depending on the availability of water in the area, including in some cases by assigning stewardship and fiscal responsibility for the maintenance and distribution of water within specific aquifers. However, there are concerns regarding assigning stewardship responsibilities of water use and water availability because, in many cases, the water consumer may be significantly removed spatially from the point of extraction of the water.

Since wetland habitats can be a vital source of freshwater for replenishing the aquifers that supply water to communities, freshwater availability may be negatively impacted by the degradation of wetlands and the disturbance of their associated soils. Also, many marine coastal areas are having to address the reduction in available potable freshwater from their aquifers due to saltwater intrusion into them from sea level rise.

The climate crisis will only make the drought and freshwater aquifer and reservoir replenishment issues worse because of less precipitation in some areas and periods, warmer temperatures, and sea level rise causing saltwater contamination of reservoirs. There are existing Sierra Club Water Resources Policies that address some basic water supply issues and will not be addressed here.

5.7 Policy - Freshwater Supply and Aquifers

1. In areas experiencing drought conditions due to the climate crisis, in regards to freshwater supply and aquifers, water sharing agreements consistent with the Sierra Club's policy on water commodification (see Water Commodification and Corporate Privatization of Municipal Water/Sewer Services) should be established. Such agreements should be equitable and all communities should be part of the process for their establishment.
2. Government and private funding should be made available to develop more complete data on aquifers, the projected amount of water available in each, boundaries of the aquifer, aquifer contamination risks, sustainability limits of withdrawal from aquifers, and the protection of the ecological value of the local water resources.
3. Reclaimed water should be considered as part of the solution only if the proper science-based procedures and policies to address public health and wildlife integrity, as well as environmental degradation from contamination are adopted and strictly implemented.
4. The use of reclaimed water for irrigation and other agricultural purposes should take into consideration potential environmental degradation from the impacts of contaminants on the viability of crops, safety of public consumption or use of such crops, surrounding plant and animal life, as well as surface waters and groundwater resources exposed to those irrigation waters.
5. The use of reclaimed water in industrial processes should take into consideration potential environmental degradation from the impacts of contaminants on surrounding plant and animal life, as well as, surface waters and groundwater when such reclaimed waters are discharged (without pretreatment) as a point source into the environment.
6. Effluent from sewage treatment facilities should never be considered for reuse as reclaimed waters. There are too many pathogens and other contaminants in such waters that could impact human health, wildlife, and overall ecosystem viability. The Sierra Club's national policy on the Precautionary Principle, which states that "lack of full scientific certainty shall not be used as a reason for postponing measures to prevent environmental degradation," should be applied to avoid reusing wastewater from sewage treatment facilities.

5.8 Chronic Inland Flooding - Background

Some areas of the U.S. have already seen the historic standard 100-year (1% likelihood in any year) storm transformed into a more frequent 25-year (4% likelihood in any year) storm because of increased precipitation extremes. The Midwest experienced unprecedented flooding in 2019 due to record spring rains and early snowmelt. Hurricane Harvey created significant new national weather records with over 60 inches of rain in southeast Texas in 2017. The National Oceanic and Atmospheric Administration's (NOAA) recent evaluations of increasing rainfall intensity from climate warming helps engineers and planners design to this new flooding reality, but current engineering and planning design criteria have not fully captured the magnitude of recent trend changes and are likely understated. In addition, these flooding extremes will increase nonlinearly with additional warming, creating even more unprecedented flooding than we are already experiencing.

This new reality of increased flooding in some areas has created the need for a tool called managed (or planned) retreat: efforts to relocate people and resources out of repeatedly flooded areas to save lives and stop continued losses. See more on managed retreat here.

Currently, the National Flood Insurance Program (NFIP), which is administered by the Federal Emergency Management Agency (FEMA), is projected to have more claims to pay out than the amount of insurance money it collects. This trend is expected to grow during the climate crisis. NFIP insurance can be obtained only through entities from townships to Native nations participating in the NFIP by enacting flood management rules. The NFIP by definition tends to perpetuate and encourage rebuilding in flood prone areas indefinitely. Some NFIP participating Floodplain Managers disallow further rebuilding unless structures are adequately elevated, and in some cases completely disallow rebuilding and implement buyout programs (managed retreat) with local and federal funds.

5.9 Policy - Chronic Inland Flooding

1. Stormwater runoff policies should be frequently revised based on the latest NOAA rainfall intensity criteria. NOAA should perform rainfall frequency evaluations more frequently than in the past to better address the rapidly increasing precipitation intensity trend. The Sierra Club's chronic freshwater flooding policies including floodplain restrictions can be found at Coastal Resilience and Rural & Agricultural Lands policies.
2. Climate adaptation plans should be developed that include vulnerability analyses, natural adaptive solutions (i.e., restoration and protection of wetlands, seagrasses, and submerged aquatic vegetation (SAV)), and managed retreat options.
3. The NFIP should stop providing incentives to developers and homebuyers who continue to build or rebuild in areas proven to be flood prone. The Sierra Club supports the NFIP program using cost/benefit analysis to transition NFIP covered properties from flood insurance to managed retreat. See NFIP policy discussion under Coastal Resilience.

4. FEMA should increase the rate at which their floodplain elevations are reevaluated. By increasing the floodplain elevation data frequency, the data would better correlate to the projected increase in precipitation and extreme storms associated with the ongoing climate crisis.
5. NOAA and FEMA should immediately transition planning policy for flood events from the 100-year to the 500-year storm to minimize low biases in rainfall precipitation analyses because of recently increasing trends.
6. Minimum structure elevation of two to four feet or more above the 500-year floodplain elevation should be adopted by national and local floodplain managers to reduce risks from outsized flood events caused by increasingly extreme rainfall.
7. Offline flood prevention structures, or flood prevention structures that are not located directly in the stream bed, should be considered first to prevent degradation to natural stream habitats.
8. Floodplain management should allow space for floods to spread out, also providing wildlife habitat and public recreation opportunities along watercourses.
9. Impervious cover should be strictly limited in critical headwater reaches to allow natural ecology to function as flood mitigation. Wherever possible these critical lands should be permanently set aside to perform flood prevention.
10. Managed retreat from floodplains should be incorporated into climate adaptation planning and funding, since flood hazards can be expected to increase with continued global heating that will occur with 1.5°C warming targets, and be even more extreme with Sierra Club's supported 350 ppm CO_2 and 1°C by 2100 target. (For more information on managed retreat, see Coastal Resilience Policy Section)

5.10 The Great Lakes Region-Background

The Great Lakes consist of Lakes Superior, Michigan, Huron, Erie, and Ontario. They are located in the North Central region of the U.S. and the South Central region of Canada. The Great Lakes cover an area of 94,250 square miles, which is the largest surface area of freshwater in the world. They contain approximately 20% of the Earth's and 84% of the U.S. 's freshwater. Their drainage basin (the lakes themselves and their connecting waterways) covers 295,710 square miles.

The Great Lakes region is home to over 40 million people who rely on the lakes for drinking and potable water, fisheries, recreation, tourism, commerce, and industry. These waters also provide transportation conduits supporting commerce for large urban areas in this region. Additional ecosystem services provided by the Great Lakes are similar to those listed above for freshwater habitats; however, they also include forest and agricultural products. The climate in this region is influenced by "lake-effect" precipitation, when warm moist air rising from the lakes mixes with cold dry air overhead, causing heavy downwind rain or snowfall.

5.10a Climate Crisis Impacts in Great Lakes Region

The climate crisis impacts in the Great Lakes region have led to it being significantly warmer and wetter than other regions of the contiguous U.S. Impacts of these changes include:

A. Chronic flooding, which degrades transportation, water supply, and building infrastructure;
B. Increased periods of droughts and heavy precipitation, causing significant variability in Great Lakes water levels;
C. Changes in the direction of seasonal wind patterns and"lake-effects" storm events;
D. Shifts in animal and plant species vitality and biodiversity, particularly in those species dependent on cold climates;
E. Increased incidents of harmful algal blooms (HABs)- which are proliferations of species of algae that decrease oxygen concentrations in the waters resulting in "dead zones" and may produce toxins that are harmful to humans and animals- resulting in increased incidents of fish kills;
F. Greater proliferation of invasive species of microorganisms, plants, fish and other animals; and
G. Adverse impacts to local and regional economies that are dependent on winter recreational and tourism income.

Climate-related chronic flooding in the Great Lakes region is degrading water quality in urban centers by increasing pollution from stormwater runoff and burdening the freshwater and wastewater treatment systems. Elevated concentrations of lead, other contaminants, E.Coli, and other pathogens are being found in urban drinking water supplies. In rural areas, chronic flooding degrades regional water quality by increasing runoff from concentrated animal feeding operations (CAFOs) such as hog and chicken farms and heavily worked agricultural soils containing farming-related contaminants (herbicides, pesticides, fertilizers, and others). Surface water pollution from these non-point sources include pathogens, sediments, nutrients, lead, minerals, and many other contaminants. Groundwater basins connected to the Great Lakes are also receiving these contaminants and spreading pollution impacts throughout the watershed.

During the climate crisis, the rural areas of the region are negatively affected by lower water levels in the Great Lakes and their associated rivers and streams. In periods of drought, the natural aquifers' replenishment is significantly reduced while water usage increases, possibly resulting in severe limitations on the availability of potable water in this region.

5.10b Need for Increased Great Lakes Protection

Currently, the Great Lakes support diverse populations of plants, birds, fish, and other animals and may be visited by the public for fishing, swimming, and other recreational uses. Yet, the Great Lakes waters and habitats are being degraded by pollution from point source and nonpoint source discharges mentioned above. These waters also have heavy commercial and recreational vessel traffic. The vessels may discharge the contents of their marine sanitation devices (installed toilets) in Great Lakes waters that are not designated as no-discharge zones (NDZs) for vessel sewage. Such discharges contain fecal

coliform bacteria, E. Coli, other pathogens, and other contaminants that pose human and animal health risks and degrade aquatic ecosystems. Portions of each of the Great Lakes have been designated as NDZs. Since the climate crisis impacts is exacerbating pollution impacts, more NDZs should be established covering most or all of the Great Lakes region.

Also, additional portions of the Great Lakes should be designated as Marine Protected Areas (MPAs) as the lakes come under greater stress from the climate crisis. There are over 1600 MPAs established nationally. They include aquatic sanctuaries, estuarine research and aquatic wildlife preserves, and areas to sustain fisheries. Currently, there are 76 MPAs in the Great Lakes region. Additional MPAs should be established to help address climate crisis aquatic degradation.

5.10c Great Lakes Region Requires a Cooperative Approach

The Great Lakes region could represent a good model of cooperation among the public, non-governmental entities, municipalities, Tribes, states, federal governments, and nations (Canada, U.S., First Nations, and Federally Recognized Tribes) addressing the climate crisis. A comprehensive and coordinated plan to address Great Lakes region climate crisis is needed because:

A. Climate crisis impacts associated with water quality, aquatic habitats, water supply, water levels, and temperature cross municipal, Tribal, state, regional, and in some cases national boundaries;
B. For the most part, current actions are isolated to a particular area and not tailored to the ecosystem and watershed level;
C. It would save money and time by avoiding duplication of actions and engaging in contradictory efforts, as well as sharing lessons learned; and
D. Such a coalition would be a good model for other states, Federally Recognized Tribes, provinces, and nations to use to address water quality, emissions reductions, and resilience efforts at the watershed level.

Developing a comprehensive Great Lakes Climate Adaptation Plan should engage partners at all levels; address issues identified in previous government-initiated vulnerability assessments; incorporate data generated from other research; and lean on local, regional, governmental, Indigenous, and other expertise. Bi-national coordination would require a shared vision, coordinated actions, and appropriate funding from the U.S. and Canada. Below is some additional information regarding ongoing partnerships and coalitions to address the climate crisis in the Great Lakes region.

The Great Lakes Restoration Initiative, established in 2010 and receives significant federal funding annually, has improved or provided the following in the Great Lakes: water quality and shoreline protection; wetlands restoration; native habitats and species protection and restoration; invasive species reduction; toxic sediments cleanup; and nutrient runoff reduction.

In a study conducted by the U.S. and Canada in 2017, the Great Lakes were assessed as "Fair and Unchanging". The study found that more work is necessary to address growth, development, and land use impacts, invasive species, and nutrient runoff. All of these impacts may be exacerbated by the climate crisis.

5.11 Policy- The Great Lakes Region

1. Local, state, Federally Recognized Tribes, and federal governments of the U.S., as well as provinces, First Nations, and the national government of Canada should continue to work collectively to ensure that the Great Lakes watershed is restored to be healthy, unpolluted, and ecologically productive. This effort should include a comprehensive and coordinated Great Lakes Climate Adaptation Plan with ecosystem and/or watershed level goals. Such goals should include:

   a. determining where the greatest investments of environmental conservation will be most effective in providing necessary protections from climate crisis species extinctions and habitat degradations;
   b. ecosystem and watershed protection initiatives that reflect patterns of change and planning for them;
   c. addressing chronic flooding and stormwater runoff impacts; and
   d. incorporating measures to safeguard the economic viability associated with recreation and tourism, commerce, subsistence fishing and hunting, agricultural production, and aquatic farming in the Great Lakes region.

2. Federal funding and state and province agendas should be aligned and give priority to climate crisis issues. These issues should include addressing the drinking water supply, as well as, water and transportation (terrestrial and aquatic) degraded infrastructures.
3. Funding should be increased for the Great Lakes Restoration Initiative with emphasis on addressing invasive species; nutrient runoff; and impacts associated with growth, land use, and development.
4. Regulations must be created and enforced to reduce the point source discharges into Great Lakes waters from municipalities, from installed toilets on all vessels (recreational, commercial, and military), and industries.
5. Non-point source discharges such as stormwater runoff must be regulated and monitored. Statutory requirements for addressing agricultural runoff are needed and should be sought. These efforts should be at the ecosystem and-in some cases- the watershed level.
6. Because of the climate crisis, additional portions of the Great Lakes should be considered to be designated as No Discharge Zones for vessel sewage requiring all vessels that operate on these waters and have installed marine sanitation devices (toilets) or porta potties to have to pump out their sewage tanks or dump their porta potties at official pumpout and dump stations instead of discharging/dumping their contents into the designated waters. All portions of the Lakes should ultimately be included, beginning with fragile waters where E. Coli or other sewage-generated

pathogens may pose public health risks (fishing areas, beaches and swimming areas, etc.) and risks to wildlife.

7. Because of the climate crisis, additional portions of the Great Lake waters should be designated as Marine Protected Areas (MPAs) to protect fisheries (to support Indigenous communities' subsistence), submerged aquatic vegetation (SAV) (to reduce erosion and increase biodiversity), and shellfisheries (to enhance water quality). The associated restrictions may not include subsistence fishing or other activities that may target Indigenous or marginalized communities.
8. Measures should be strengthened and enforced to reduce the potential proliferation of invasive species of plants, animals, and microorganisms within the Great Lakes basin. Such plans should include implementing strong ballast water protection and other appropriate measures.

5.12 Freshwater Environmental Justice Issues - Background

Vulnerable communities may be disproportionately impacted by the degradation and/or destruction of freshwater habitats because such communities, which may include people of color, Indigenous people, and Tribal communities (including Federally Recognized Tribes, Tribes, and other Native Americans), usually rely heavily on the natural resources associated with the freshwater ecosystems for food, water, transportation, commerce, and recreation.

5.13 Policy - Environmental Justice

1. Ensure that freshwater habitats are maintained, protected, and restored in vulnerable communities or in other areas where they are heavily used for fishing, transportation, and recreation by these communities.
2. Ensure that such communities have a representative as part of the decision-making process associated with the maintenance and restoration of freshwater resources and habitats including the Great Lakes.
3. Ensure that community representatives are part of the decision-making process associated with the destruction, modification, and/or degradation of freshwater resources and habitats.
4. Potable water availability should be equitably addressed. It should not be the most powerful or those with first right to the water prevail.
5. Managed retreat from floodplains should address inequitable impacts to low income communities.

Section 6- Coastal Resilience

6.1 Background

6.1a What is Coastal Resilience?

Coastal Resilience is the term used to describe the varied approaches society may take to respond to the impacts of Sea Level Rise (SLR) and its associated factors such as storm surges and high tides, as will be described below.

Resilience can seek to preserve coastal communities by using hard structures such as levees and seawalls. These tools are for the most part destructive to aquatic habitats and ultimately may prove inadequate. Other resilience efforts seek to resist SLR through the reinforcing of natural habitats such as beaches, tidal marshes and mangrove forests and using sediment accretion to help raise the elevation of these habitats. Finally, managed or planned retreat is the resilience measure that recognizes that some communities, and perhaps most under the higher SLR scenarios, will simply need to be abandoned when neither of those tools prove feasible or adequate. Through a well-structured managed retreat scenario, communities will have time to determine what relocation (either as a community or individually) means and how to undertake and fund it, and to ensure that such relocation is undertaken through the prism of social equity, allowing all members of the community to play a part in decision-making. Managed retreat is also the most effective tool for ensuring the continued existence of coastal aquatic habitats as it allows beaches and marshes to move inland as sea level rises.

It is important to note, IPCC, Adaptation and Vulnerability 2014 states the maximum rate of our ability to adapt to sea level rise is three feet per century. In other words, projected very high rates of sea level rise exceeding three feet per century will create conditions where resilience and adaptation options are limited.

6.1b General Impacts of Sea Level Rise (SLR)

Climate disruption due to significant and rapid increases in the atmospheric concentrations of heat-trapping greenhouse gases is already impacting coastal lands and waters. On average, oceans are becoming warmer and more acidic, and their ecosystems are being negatively altered around the globe. Sea levels are rising due to the expansion of warmer waters and melting of glaciers and continental ice sheets. The warming of the oceans, alone, can result in a 20% increase in the height of the oceans. This rise has resulted in, and will continue to increase, coastal erosion, flooding, sedimentation, salt water intrusion into freshwater aquifers and ecosystems, destruction of properties and infrastructure, and degraded public services.

Shallow water habitats such as mudflats (tidal plains), tidal marshes and mangrove forests exist in a narrow tidal range. The vegetation and benthic organisms found in these habitats need to be inundated by tides for part of the day and then exposed to the air for some varying daily time period. As the sea level rises and causes these habitats to have less and less time free of inundation, these habitats ultimately can drown and disappear. Complete and permanent inundation of low elevation coastal areas is likely unless adequate sediment accumulation takes place that raises the elevation of these habitats.

Because of saltwater intrusion, ghost forests (degraded or destroyed forest habitats) are increasing in number and the ecosystems of freshwater wetlands are degrading.

"Chronic sunny day tidal flooding" ("chronic tidal flooding") has been identified by the National Oceanic and Atmospheric Administration (NOAA, Sea Level Rise Scenarios, Sweet 2017) as the first manifestation of SLR impacts. Chronic tidal flooding events are caused by natural non-storm tides that are significantly higher, as a result of SLR, than the average Mean High Water (MHW). MHW is the average over the past 19 years of all high tide heights at any particular location. This historic floodplain technique based on long-term averages is not adequate to address the rapidly increasing rates of SLR and chronic tidal flooding, especially when determining future floodplain elevations for construction or reconstruction zoning and permitting issues. For example, historically regulations allowed new development one foot above the 100-year floodplain while recent regulations are moving towards requiring two feet above the 100-year floodplain. But floods are exceeding new floodplain elevations in ever increasing numbers and 100-year storms are now happening every few years. In response to this, new tools have been developed to predict the impacts of SLR and chronic tidal flooding. New maps that include SLR projections as well as other factors such as storm surges and high tides are being created. These maps, usually created by NOAA in conjunction with other organizations, include several projections of impacts based on the variations in the predictions of SLR.

As SLR increases, high tides become higher and can spread further inland in low elevation coastal areas because these areas are flatter than the immediate beach zone. Low elevation coastal areas make up most of the Gulf and East Coast areas. NOAA has projected a 9 to 14 inch SLR by 2030 in a worst-case scenario. This amount of SLR will create conditions where chronic tidal flooding events will increase from once every five years to once every 2.4 months, on average. As this level of flooding increases (such as reaching ten percent of the area of any coastal community), selective community abandonment (people abandoning their homes and businesses) will start to take place. When impacts from these non-storm related high tides increase by this amount, adaptation and restoration efforts may be overwhelmed, and large-scale community abandonment may result. This abandonment may occur in 170 U.S. coastal cities by 2035 assuming this worst-case scenario level of SLR. (Union of Concerned Scientists, Spanger-Siegfried 2017)

Along with chronic tidal flooding, more violent storms exhibiting heavy and lingering precipitation are causing inland inundation of coastal plains. Under ordinary conditions, coasts represent a landscape that is under constant change due to wave action, tidal influences, and storm events. However, climate change has significantly ramped up those dynamics.

The contiguous United States has over 13,000 coastal miles on which, as of 2013, about 42% of our population lives. From a global perspective, it is estimated that over 400 million people live within 32 miles of a coast. Human activities such as development, draining and filling of wetlands, and road construction (to name a few) have negatively influenced the resilience of U.S. coasts. Therefore, the coastal impacts mentioned above have direct impacts on millions of people and countless ecosystems, and raise critical issues for decision makers globally.

SLR, which may be the most visible and damaging impact of climate disruption, threatens all of the coastal areas of the world as well as their estuaries and tidally influenced river systems. Nationally, due to differing ocean currents, weather systems, and coastal geography and topography, the United States East Coast and Gulf Coast are expected to experience higher tides and greater increases in sea level than the West Coast. However, the types of impacts on all coasts will be similarly challenging and devastating.

The Gulf of Mexico coast is influenced by a different set of littoral (coastal) variables than either of the East and West coasts. The Gulf and East coasts, with flatter shorelines, seem to be more susceptible to flooding, erosion, sedimentation, and wetlands ecosystem threats. These coasts also have a system of barrier islands that are very susceptible to SLR impacts. The West Coast, although also suffering impacts to beaches, tidal marshes and mudflats, has extensive seagrass meadows and kelp forests and substantially more bluffs adjacent to the ocean shoreline, which face erosion and collapse from SLR. Coasts of Hawaii, Puerto Rico and U.S. Territories also face similar types of climate impacts. However, these islands face proportionally greater impacts because they are completely surrounded by oceans and their tidal fluctuations. Thus, the island coasts decision-makers have to develop plans immediately and be prepared for more contingencies due to their constrained land areas which limit adaptation and resilience options. Alaska and the Arctic coast face their own issues as global warming decreases the amount of sea ice and that, in turn, results in increased shoreline wave action that significantly increases coastal erosion beyond historic levels.

SLR is not the only climate-related problem faced by coastal communities and natural systems. Coastal and riverine water levels can increase as a result of wind, waves, storm surges, nearby river discharges, sedimentation, and other events. Underwater benthic profiles (sediment organisms), beach and shore profiles, projected shoreline erosion, and other shoreline characteristics affect both the deepwater and nearshore wave forms (wave height and energy levels) as well as freshwater systems. Combined with chronic tidal flooding from SLR, these factors can greatly increase impacts to coastal and some inland areas.

According to the Union of Concerned Scientists, more than 300,000 of our nation's coastal homes, with a collective market value of about $117.5 billion today, are at risk of chronic inundation in 2045.

The State of California, in its Fourth Climate Change Assessment, 2018, estimates that, under mid to high SLR scenarios, 31% to 67% of Southern California beaches may completely erode by 2100 without large-scale human interventions. Statewide damages could reach nearly $17.9 billion from inundation of residential and commercial buildings under 50 cm (~20 in) of SLR, which is close to the 95th percentile of potential SLR by the middle of this century. A 100-year coastal flood, on top of this level of SLR, would almost double the costs.

6.1c Specific SLR Coastal Impacts

Vulnerability assessments across the U.S. associated with SLR due to climate change have identified the following impacts from SLR and chronic high tides:

A. Coastal shallow (intertidal) water resources such as mudflats, tidal marshes and adjacent freshwater wetlands and the fisheries they support face damage and possible total destruction by inundation;
B. Terrestrial and freshwater ecosystem would be degraded by saltwater intrusion, as well as, a reduction in the ecosystem services they provide;
C. Transportation issues include damage by inundation to thousands of miles of roads and railways as well as damage to airports and harbors;
D. Coastal utilities such as wastewater treatment and electricity generating plants, as well as, chemical and refining facilities are threatened by SLR and may face reduced or entire operating failure impacting the public services they provide;
E. Health and educational facilities sited near coasts will be threatened with possible damage or destruction resulting in reduction of the services they provide;
F. Coastal agricultural and farming activities will be impacted and a reduction in the availability of potable water from aquifers intruded by salt water;
G. Residential and commercial properties may become uninhabitable or inoperable due to flooding and subsequent erosion and sedimentation as well as potential permanent inundation;
H. Recreational and entertainment sites may be destroyed or reduced in efficacy due to increased flooding or inundation; and
I. Municipal governments will experience a reduction in tax revenue resulting from the relocation of residents, commercial services, and industry (i.e. community abandonment).

Chronic high tides provide early examples of the impacts of SLR that result in damage to community infrastructure, long before infrastructure is inundated. For example, temporary inundation requires commuters to drive through salt water that rapidly degrades their automobiles. Those commuters choosing not to drive through temporary tidal flooding have their lives and jobs disrupted.

6.1d Essential Services Provided by Coastal Shallow Water Habitats

Our nation's coastal shallow waters are among the most biologically and economically productive habitats. Tidal marshes, mudflats, seagrass beds and kelp forests support over 70% (some estimate as high as 90%) of commercial fish and shellfish species, providing both feeding and nursery habitats. Beaches and mudflats provide essential habitat to millions of shorebirds and other waterbirds, as well as for shellfish and other invertebrates. Tidal marshes and mangrove forests play an important role in cleaning our coastal waters by removing contaminants. These areas also provide important recreational opportunities for human communities.

Tidal marshes, mangrove forests, and beaches act as barriers to storm surges and wind-driven high tides; and thus provide important protections from SLR and extreme weather impacts to human communities.

6.1e Carbon Sequestration

Tidal marshes, mangrove forests, seagrass beds and kelp forests are some of the most effective habitats for sequestering carbon, thus helping reduce climate disruption (see Wetlands, Coastal, and Shallow Marine Habitats Carbon Dioxide Removal policies). All of these ecosystems are threatened with destruction by drowning as ocean levels rise.

6.2 Planning for Coastal Resilience - Background

6.2a Tools to Achieve Coastal Resilience

Currently, three tools are being used to respond to SLR and chronic tidal flooding: natural infrastructure, also called “living shorelines” such as oyster reefs, seagrasses, mangrove forests, and wetlands; planned or managed retreat; and constructed barriers such as levees, seawalls, and floating structures. The Sierra Club believes that when planning adaptation responses to SLR and/or chronic tidal flooding, local governments and regional and state agencies should, as described below, first consider natural adaptation tools (such as living shorelines and tidal marsh restoration), followed by managed retreat, and only if both these prove infeasible consider the application of hard-edged structures such as seawalls and levees. In all cases, the best available climate science should be used at all times. See more on managed retreat here.

6.2b Natural Infrastructure Solutions

Natural infrastructure solutions are a more ecologically productive and less environmentally impacting mechanism than constructed barriers for protecting coasts from SLR and chronic tidal flooding. Living shorelines use plants or other natural elements, sometimes in combination with harder shoreline structures, to stabilize coasts, bays, estuaries, and tributaries. For example, downed trees and other natural elements can be placed on beaches to reduce wave energy and thus extend the life of a beach and possibly let it increase its elevation by trapping sand and gravel. Oyster reefs off of the shoreline can reduce wave energy and allow for dune and beach nourishment--the trapping of sediments on the beach or mudflat.

Tidal marshes and sea grasses play an important role in reducing storm surges and trapping sediments, thus reducing inundation. Restoring tidal marshes, wetlands, and/or sea grasses wherever feasible can reduce the impacts of SLR and chronic tidal flooding while also sequestering substantial amounts of carbon (see Sierra Policy on Wetlands). Installing very low berms outboard of tidal marshes can help trap incoming sediments from the waves and increase tidal marsh elevations.

Dredge material can be a very useful tool in helping shallow water habitats maintain or increase their elevation in the face of SLR. This is called the "beneficial use of dredge material." Such dredge material is often produced by the need to maintain adequate navigation depths in ports, lakes, rivers and other water bodies. The U.S. Army Corps of Engineers regulates dredging and is currently funding pilot projects nationwide for this purpose.

6.2c Managed (Planned) Retreat

An alternative to protecting shorelines with armoring, or adaptive design (e.g., living shorelines), is a retreat-based approach. If the landward elevations are appropriate and the SLR rate is slow enough, the coastal ecosystem and its landforms including tidal marshes, transition zones, mangrove forests, mudflats, beaches, dune fields, and other coastal habitats can naturally migrate inland. Managed retreat is the most effective tool available to ensure the continued functioning of coastal shallow water habitats.

Managed retreat also refers to varying approaches to respond to coastal hazard risk by allowing for the relocation of human structures and/or abandonment of development. These strategies can result in a landward redevelopment pattern and a managed realignment of development along the coast so that natural erosion and other coastal processes, including beach formation/creation and habitat migration, can continue.

When shoreline communities are abandoned, structures should be demolished and removed and contaminants should be remediated to avoid poisoning the ocean and to help preserve and restore coastal habitats.

Managed retreat has an enormous human component. Moving entire communities will be difficult, controversial and expensive. People who live in an area that has been identified as high risk for SLR and/or chronic tidal flooding impacts will need to be educated about those future risks before they will begin to consider relocation. Plans for such relocation must involve them or their representatives so that their needs and concerns are addressed.

While all members of these communities will face the very difficult economic and social impacts of dislocation and relocation, vulnerable communities will have additional burdens to address such as:

A. Whether the vulnerable community members will be welcomed into a new community;
B. Whether the vulnerable community members will have the resources to move into a new community;
C. Whether there are employment opportunities for someone whose skill sets are associated with the aquatic area especially if the transition is from a shoreline or coastal area to an inland area; and
D. Whether the transition is to an area that is appropriate for the quality of life that the vulnerable communities members have been accustomed to.

Managed retreat is a combination of resilience and adaptation efforts that address personal and commercial property and infrastructure together, to define the best economic, physical and emotional pathway for the controlled abandonment of resources. It may be difficult to convince communities to undertake managed retreat until chronic flooding and frequent inundation take place. The challenge is not one that is addressed with a general prescribed plan but is region, site, and resource-specific. Along with financial hurdles, the main challenge is justice and equity. Whether it is undervalued cultures, individuals and or businesses, or major infrastructure and industrial projects that service a geographic region much larger than the area being considered for relocation, the key is to provide a pathway that is just and equitable, by working directly with those affected or their authorized representatives.

6.2d <u>FEMA and NFIP</u>

The Federal Emergency Management Agency (FEMA) and its National Flood Insurance Program (NFIP) play key roles in addressing the impacts of SLR and chronic flooding on local communities susceptible to flooding. FEMA adopts maps that identify flood prone areas. In Special Flood Hazard Areas, all structures financed with federally associated financial assistance (Housing and Urban Development loans) must be insured.

According to NFIP, "The National Flood Insurance Program aims to reduce the impact of flooding on private and public structures. It does so by providing affordable insurance to property owners, renters and businesses and by encouraging communities to adopt and enforce floodplain management regulations. These efforts help mitigate the effects of flooding on the [built] environment. Overall, the program reduces the socio-economic impact of disasters by promoting the purchase and retention of general risk insurance, but also of flood insurance, specifically. (https://www.fema.gov/national-flood-insurance-program)."

NFIP insurance can be obtained only through entities from townships to Native nations participating in the NFIP by enacting flood management rules. The NFIP by definition tends to perpetuate and encourage rebuilding in flood prone areas indefinitely. Some NFIP participating Floodplain Managers disallow further rebuilding unless structures are adequately elevated. In some cases the NFIP completely disallow rebuilding in those areas and implement buyout programs (managed retreat) with local and federal funds.

"Homecoming" is a term used to describe what happens when catastrophe creates temporary forced migration during the period when resource abandonment is not yet accepted as necessary. Many individuals who have been evacuated or have fled from catastrophe cannot afford to return to and restore their former homes. This creates early abandonment and attendant economic and social stresses. By providing homecoming assistance, these stresses can be reduced, benefiting the community. But repeated instances of flooding followed by the restoration of physical structures is costly and ultimately useless and harmful to the environment if the community is faced with unavoidable inundation in the future.

Federal government (NFIP/FEMA), state and local governments and private insurance companies should regularly (at a minimum every ten years) consult with updated SLR and flood mapping produced by NOAA (National Oceanic and Atmospheric Administration) and others that apply the latest SLR and chronic tidal flooding predictions to determine the feasibility of maintaining communities when such predictions indicate unavoidable inundation. At this time, managed retreat options should be identified and implemented. Also, NFIP should no longer allow structures in these areas to be insured.

6.2e Constructed Barriers and Floating Structures

Constructed barriers have been used to address SLR and storm surge events in many coastal communities in the U.S. Some constructed barriers include:

A. Barriers such as dams, gates, or locks that address temporary managed water flow to reduce flooding associated with storm surges and significant tidal fluctuations;
B. Levees and seawalls that affix the shoreline in its current place; and
C. Elevated development with coastal armoring used to raise the height of land or development to reduce flooding impacts.

Constructed barriers can negatively affect the natural environment. Flood prevention barriers can limit, reduce and/or degrade water exchange currents. Wave energy reflected off constructed barriers can erode beaches and tidal marshes. Seawalls can reflect wave energy to neighboring parcels causing erosion and beach or marsh destruction. Sea walls also prevent beaches and tidal marshes from migrating upland and thus can result in the complete destruction of beaches and marshes. Finally, seawalls themselves provide only temporary solutions to SLR as has been demonstrated in New Orleans and elsewhere when these structures fail. Barriers not only keep water out, they also keep water in. During storms with intense rain, stormwater runoff flooding will increase since inboard water cannot pass the barriers into the outside waters (which may, in any case, be higher than the interior land/stormwater height). To address this flooding, significant pumping must be undertaken. This in turn requires the expenditure of large amounts of energy. The risks of pump failure or of the system being overwhelmed by wildly unprecedented rainfall amounts--as with the 60 plus inches recorded with Hurricane Harvey in Southeast Texas--will result in significant and long duration flooding.

Although constructed barriers to SLR and chronic tidal flooding such as levees, sea walls, and other hard shoreline and floating structures can be very destructive to shallow water habitats, some municipalities and/or local communities may resort to these adaptation measures to avoid or postpone relocating.

The cost of such barriers is very large and many communities, particularly low income and disadvantaged communities, will not be able to afford them without large federal and state support.

6.3 Policy - Planning Coastal Resilience

The Sierra Club adopts the following policies and urges local, regional and state governments to implement these policies when adopting SLR resilience ordinances and zoning policies for coastal shorelines and floodplains. The following policies are based on the 30-year maps of future mean high water and floodplains, as revised every decade.

1. Federal, state and local funding sources must be developed in order to provide government assistance in planning and implementing responses to SLR and chronic tidal flooding, including providing financial aid for the relocation of individuals and communities.
2. Adaptation measures to address SLR and chronic tidal flooding should ensure the continued functioning of aquatic and adjacent upland habitats. The first, and preferred, adaptive strategy to be considered when planning for SLR and chronic tidal flooding should be the use of natural infrastructure. The preservation and restoration of natural habitats -- tidal marshes, seagrass meadows, mangrove forests, beaches, sub-tidal living shorelines; as well as, freshwater wetlands, seasonal rain-fed ponds, coastal vernal pools, coastal groundwater resources, and riparian areas -- should, wherever possible, be the preferred approach for resilience.
3. The NFIP should stop providing incentives to developers and homebuyers who continue to build or rebuild in areas proven to be flood prone. The Sierra Club supports the NFIP program using cost/benefit analysis to transition NFIP covered properties from flood insurance to managed retreat.
4. Managed retreat should be considered as the second, and ultimately the most effective, adaptive strategy when planning for SLR and/or chronic tidal flooding.
5. Wherever possible, managed retreat planning should provide for wetland and beach upland migration through the preservation of adequate adjacent uplands for that purpose.
6. Municipalities and local and state governments should avoid the installation of hard infrastructure, such as sea walls or levees, whenever possible.
7. When it is decided that constructed barriers should be used, they must be deployed in a manner that protects citizens from unreasonable health and/or safety risks. Impacts to natural resources must be minimized and offset.
8. The destruction of existing habitats should be avoided whenever possible when planning and implementing near-term solutions. There should be a commitment that any proposed adaptive strategies include ecological connections between habitats.
9. Where freshwater wetlands, seasonal rain-fed ponds, coastal vernal pools, and coastal groundwater resources currently exist but are threatened by SLR and/or chronic tidal flooding, managed retreat plans should include efforts to recreate these important habitats.
10. Even though some communities in the U.S. and internationally have resorted to the use of floating communities to avoid relocating to address SLR and/or chronic tidal flooding, more information is needed to determine whether communities should resort to this measure. Significant habitat impacts result from this technique. The Sierra Club is presently not supportive of the creation of floating communities.
11. The Army Corps of Engineers should institute a program of beneficial use of dredge material that emphasizes projects that result in net resilience improvements and avoids projects that result in net increase in greenhouse gas emissions. Sources of material that can provide sediment for beach nourishment and to sustain mudflats, salt pannes

and tidal marshes into the future should be identified. Often sediments placed in shallow water habitats for this purpose minimize further carbon emissions and help sustain those habitats in the face of SLR.

6.4 Planning for the Next 30 Years - Background

According to the Ocean Protection Council, "Prior to 2050, differences in sea-level rise projections under different emissions scenarios are minor. This is because near-term sea-level rise has been locked in by past greenhouse gas emissions and the slow response times of the ocean and land ice to warming," State of California Sea-Level Rise Guidance, 2018 Update, Ocean Protection Council.

Thus, community chronic tidal flooding and SLR inundation within the next 30 years is relatively predictable, and mapping of the impacts of estimated SLR within the next 30 years is being undertaken by NOAA and other entities. Yet, such predictions and maps are only the first step for climate adaptation; local communities must undertake specific vulnerability assessments and actions to reduce harms by engaging with disadvantaged groups and other local stakeholders.

6.5 Policy - Planning for the Next 30 Years

The following policies address how planning decisions should be made for those areas that have a serious risk of flooding and/or inundation within this 30-year time span. Beyond 2050, the differences in SLR predictions become much more significant and difficult to use for planning purposes. Decisions need to reflect scenarios of high SLR in order to address threats.

1. For undeveloped and developed non-urban shorelines, no new development or structures should be permitted.
2. For urban coastal shorelines, no new development or structures should be permitted unless there is full protection for future coastal flooding for the lifetime of the structure. Financial liability that would assure that there is the capability for managed retreat, structure removal, and the removal/remediation of hazardous material should be the developer/owner's responsibility. The developer/owner must also provide assurance that any new structure will not adversely impact adjacent habitats.
3. For locations with coastal bluffs, local governments and regional agencies should require communities to identify those bluffs expected to erode over the next 30 years and either deny permits for new buildings or require full assumption of liability by the landowner.
4. All property owners of structures within the 30-year floodplain map must inform their occupants and prospective buyers or tenants that their building is likely to face inundation and explain the issues associated with that location.
5. Professional judgment, in conjunction with new maps projecting SLR and chronic tidal flooding under various global heating scenarios, should be included in floodplain evaluation processes (such as for zoning and permitting), especially when determining future floodplain elevations for construction or reconstruction. For example,

historically regulations allowed new development one foot above the 100-year floodplain while recent regulations are moving towards two feet above the 100-year floodplain.

6.6 Policy- Equity and Justice when Addressing Coastal Resilience

Addressing the impacts of SLR and chronic tidal flooding requires prioritizing social and environmental justice concerns. The Sierra Club recognizes that all people have a right to access the essential public services and natural resources that help to define a good quality of life and ultimately survival.

1. Responses to SLR and chronic tidal flooding must ensure that adaptation tools are available for the most vulnerable communities. Also, whenever there are adaptation measures possible for advantaged communities, their implementation should not result in negative impacts to neighboring or more distant disadvantaged communities.
2. Federal, state and local funding sources must be developed for the protection and adaptation or, if necessary, relocation of disadvantaged communities in response to SLR and chronic tidal flooding.
3. Disadvantaged communities must be part of the discussion when facing the need for SLR and/or chronic tidal flooding adaptation strategies. Resources and space must be provided to allow them to participate in those discussions.
4. Laws, policies, rules, regulations, and evaluation criteria should be applied in a nondiscriminatory manner, including measures for adapting to SLR and chronic tidal flooding. Measures that result in disproportionate impacts, such as inequitable loss of housing or access to beaches, are discriminatory, whether or not such a result was intended, and should be corrected. We support measures that redress environmental inequities.
5. Policies developed to address managed retreat of vulnerable community members should ensure that they can participate in the National Flood Insurance Program (NFIP) either through subsidies to pay their insurance premiums or such premiums are prorated on a sliding scale reflecting household income.

6.7 Policy - Risks and Resilience Measures for SLR and Chronic Tidal Flooding

1. Local jurisdictions should develop and utilize for SLR resilience planning purposes, 30-year maps of future mean high water lines based on high SLR predictions, including all factors (storm surges, wind, etc.). These maps should be updated every ten years at a minimum. This mapping should supplement and take precedence over Federal Emergency Management Agency (FEMA) 100-year floodplain mapping.

    a. This process should include vulnerability and risk assessments that identify and quantify the impacts associated with SLR in each community.

b. FEMA 100-year floodplain mapping should be brought into consistency with new risk assessment maps of coastal areas.

2. Local jurisdictions should develop risk and/or vulnerability assessments addressing the potential impacts of SLR and chronic tidal flooding and then undertake programs to educate residents regarding the potential impacts of SLR. These assessments and education efforts should highlight the risks to, and needs of, disadvantaged communities, and involve these groups.
3. All levels of government should convene commissions or task forces to develop resilience recommendations. Such a task force should have representation from various professional, academic, non governmental organization (NGO), business, healthcare and social equity sectors relevant to this issue. Also, representation should include professionals in the fields of mental health, housing, economics, aquatic resources, city or local government planning, and others.
4. All levels of government should also undertake efforts to educate citizens about the potential impacts of SLR and chronic tidal flooding, and identify land-use and other adaptation proposals to address those risks. Governments should begin discussing funding mechanisms to determine how and if the policies can be successfully implemented.
5. Public education should include not only impacted communities, but the broader population base as well. Impacts to human infrastructure as well as community relocation will create "large cascading economic losses" (*Fourth National Climate Assessment* (2018)) that not only impact those flooded, but the inland population with direct and indirect relationships with the displaced populations, including at the national and global levels.

Section 7- Wildlands and Natural Environment Climate Adaptation

7.1 Background

7.1a Overview

The environmental and humanitarian crises of our time are entwined. Even if nations, regions, communities and individuals act decisively to cut greenhouse gas emissions, harmful impacts of the climate crisis will get worse before they get better. Therefore, our policies must build resilience of natural and human communities by combining measures that help mitigate climate disruption, buffer climate impacts, remove greenhouse gases from the atmosphere, and advance social equity. Overall, our policy strategy is to reconnect with, protect, and wisely manage our country's wildlands and natural environments not only to build climate resilience, but to help reduce greenhouse gas emissions and reverse global heating. To remedy the climate and extinction crises, we believe that as a society we must:

A. Reconnect human communities with their fundamental natural life support systems;

B. Strengthen protections for all natural places while advancing social equity; and
C. Wisely manage natural land and aquatic areas for climate resilience, to help them adapt, retain biodiversity, and maintain ecosystem functions during the climate crisis.

7.1b **How the Climate Crisis Harms Nature and People**

Climate disruption is here worldwide, not off in the distant future. People in all nations suffer from environment-related illnesses, oppression, dislocation, war, food and water insecurity, and poverty. All things wild—plants, animals and their habitats—are being wiped out by people at an unprecedented scale. According to the 2018 World Wildlife Fund *Living Planet Report,* between 1970 and 2014, human-caused losses in vertebrate species—mammals, fish, birds, amphibians and reptiles—averaged 60%. The 2019 Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) Report warns that a million species are at risk of extinction because of our actions, including climate disruption. Similarly, the August 2019 IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse Gas Fluxes in Terrestrial Ecosystems—more simply referred to as the IPCC Special Report on Land—underscores the interconnections between land use, climate impacts, food systems, and potential land-based climate solutions.

7.1c **Nature is Key to a Healthy Climate and People are Key to Protecting Nature**

Many people now recognize the urgent need to end fossil fuel use, but too few understand why preserving ecosystems of all types is equally urgent. Healthy, preserved ecosystems buffer the impacts of the climate crisis and enhance people's quality of life under changed conditions. Through expanding its outings and advocacy work, by ensuring the participation and focus on traditionally marginalized communities, the Sierra Club can help build an effective climate movement and shift the public narrative. Communities and policymakers are most likely to support "climate smart" conservation when it's clearly connected with vital ecosystem services such as clean water, clean air, temperature moderation, and buffering from extreme weather and sea level rise.

The North American Intergovernmental Committee on Cooperation for Wilderness and Protected Area Conservation (NAWPA) explains in simple terms six important ways wilderness and other protected areas can help people respond to the climate crisis: conserving biodiversity, protecting ecosystem services, connecting landscapes (air, water, and land), capturing and storing carbon, building knowledge and understanding, and inspiring people.

7.1d **Ecosystems, Biodiversity and Climate Adaptation**

As explained in the Carbon Dioxide Removal section of this policy, scientists are finding that all natural ecosystems play a role in the amount and location of carbon in the Earth's atmosphere, lands, and waters. Some, including lakes, rivers, wetlands, deep and shallow ocean habitats, tundra, and forests, have the ability to sequester and store, or transport, high densities of carbon in plant materials, soils and sediments. Grasslands and arid lands may store less carbon per acre than wetlands or forests, but protecting their ecological health is important because they are so extensive across the Earth.

Carbon storage is only one of many values and services provided by natural ecosystems; each contributes in countless ways to our present wellbeing and our future ability to recover from compounding climate impacts. Yet, as the Earth warms, all natural ecosystems are adversely impacted. A critically important way to slow and reverse the climate crisis is to protect as much as possible, as well as possible, of all remaining ecosystems, and to recover natural ecosystems where feasible.

7.1e <u>Reconnect human communities with fundamental natural life support systems - Background</u>

Protecting wild nature begins with valuing people and their communities. Unless people recognize that our well-being depends on healthy ecosystems, they will not join and lead a movement to steward, protect and restore our natural world. Healthy ecosystems provide clean air and water, places for relaxation and exercise, medicines, food, and a variety of services essential for human survival. They also help offset climate disruption by storing carbon, moderating temperature and humidity, absorbing stormwater and storm surges, and more. As the Sierra Club's Outdoors for All Campaign points out, "our nation is on the cusp of a historic transformation—we will either unite to create a future where all people benefit from a healthy, thriving planet and a direct connection to nature, or we will succumb to the dangerous impact created by irreversible damage to our environment and further oppression of people living in the margins." Connecting people with nature is for the benefit of both, especially as people and nature alike are stressed by the climate crisis.

7.2 <u>Policy - Reconnect Human Communities with Fundamental Natural Life Support Systems</u>

In its outings and advocacy work at all levels, the Sierra Club commits to fostering respect for people and ecosystems, and building awareness of our interdependence.

1. Social equity considerations must be incorporated into all climate adaptation decision-making, and local communities should be involved in determining how their natural lands are preserved and restored.
2. Public policies and climate adaptation plans for human communities should be participatory and:

    a. Prioritize the engagement, needs and concerns of vulnerable groups, low-income populations, and communities of color—people likely to be most harmed by climate disruption;
    b. Support educational and volunteer programs to engage communities in making wildlands more resilient and effective in addressing the climate crisis;
    c. Support full access for vulnerable communities, minorities, and people of color to experience and enjoy wildlands;

d. Emphasize protection and restoration of natural systems to address climate impacts, since natural approaches provide multiple co-benefits and are often cheaper and longer lasting than constructed or technological measures;
e. Integrate the protection of wildlands into plans and actions to slow and stop greenhouse gas emissions, adaptation (to avoid or reduce harm caused by climate disruption), and CO_2 removal from the atmosphere.

3. Climate adaptation plans and projects in Tribal communities should be led by those communities, honor Tribal sovereignty, and incorporate traditional ecological knowledge. The federal government should offer financial support and scientific information upon request to assist Tribes in climate adaptation.

7.3 Strengthen protections for natural places while advancing social equity - Background

The warming of our planet and related disruptions are stressing people, plants and animals—in some cases making their homes and habitats unlivable. Animals and people under stress will try to adjust or move, but for many animals there are few places to go because people have altered too much land and water with developments and other habitat disruption. Plants may adapt over time to their climate-altered environment or be carried to new more habitable areas by land, air, water and/or animal vectors. Native plants have an uncertain path when trying to survive the climate crisis and many will not.

The climate crisis also compounds existing stressors such as pollution and overexploitation of water, forests and fisheries. Some ecological damage from climate disruption has already occurred, will inevitably increase, and is irreversible. But preserving remaining ecosystems in their native or near-native states, and restoring native biological systems of formerly disturbed lands and waters, can add to biosphere resilience under the climate crisis. Large, connected land and water areas must be protected so that habitats and creatures can evolve under unstable climate conditions while retaining their basic ecosystem functions. In cities and other developed areas, adding green spaces, growing food, restoring natural stream flows, planting trees, and encouraging pollinators and other wildlife can help offset climate impacts locally.

7.4 Policy - Strengthen Protections for Natural Places While Advancing Social Equity

The ongoing catastrophic loss of wild nature in the U.S., abroad, and in the world's oceans must be stopped in order to preserve basic life support systems for all.

1. Recognizing that past environmental laws and policies have been inadequate and in some cases exacerbated ecosystem and climate impacts, the Sierra Club calls for bolder protection measures by supporting the development of a legal framework for the Rights of Nature and aligning with the Nature Needs Half Network, which calls for the restoration and protection of half of the Earth's lands and waters.

2. Supporting the development of a legal framework for the Rights of Nature is consistent with the Earth Charter, which the Sierra Club Board of Directors endorsed in 2000. The Board affirmed the Sierra Club's desire "to bring forth a sustainable global society founded on respect for nature, universal human rights, economic justice, and a culture of peace." Without stronger legal standing, many natural places and lifeways will continue being destroyed.
3. The Sierra Club has endorsed the long term goal of restoring and protecting half of the Earth's lands and waters in its natural state to protect human societies including indigenous cultures and nature. Nature Needs Half is fully committed to carrying out this global rescue and recovery effort in a just and equitable manner that lifts up the voices of those communities most dependent on those lands and waters. As an interim goal, we seek to protect 30% of the lands and waters by 2030 domestically and globally.
4. We will prioritize preservation and restoration of U.S. biodiversity hotspots and our country's currently most untouched and natural environments, regardless of whether those areas are considered beautiful or iconic. We strongly oppose the construction of new roads in Earth's remaining roadless areas except where demonstrably essential for the well-being of local communities.
5. To strengthen climate resilience of natural ecosystems both in remote wild public lands and in close proximity to communities, we strongly support protecting large core natural habitats (climate refugia), establishing connecting corridors (in the air, water, and on land), re-establishing native apex predators wherever possible, and reducing non-climate stressors such as pollution and resource extraction.
6. To protect corridors for traditional migratory routes and pathways to safer, more climate suitable habitats for all plants, fish, birds, mammals, and other animals, we oppose construction of new barriers (such as dams, pipelines, roads, fencing and walls, and tall industrial smoke stacks), and support removal of unnecessary existing ones.
7. Consistent with existing Sierra Club Guidelines, renewable energy installations and transmission lines should prioritize already-disturbed, developed or degraded areas and oppose conversion of intact habitats. Similarly, carbon dioxide removal projects should be carefully planned to avoid adverse impacts on food systems, water, and natural lands.

7.5 Wisely Manage Natural Lands and Aquatic Areas for Climate Resilience

The climate crisis has created new challenges and uncertainties for the field of conservation management. For managed lands and waters, the Sierra Club favors an integrated, science-based approach that incorporates evolving best practices of adaptive management for modeling alternative futures and dealing with imperfect information. The goals may be different than in the past. Managers of public and private lands/waters cannot necessarily hope to fully preserve ecosystems that existed before the climate crisis. Instead, they must apply judgment and science in an effort to maintain biodiversity and basic ecosystem functions.

7.5a Species Survival and Invasives - Background

Some migrating animal and plant species will thrive in their new, climate-altered environments, outcompeting native species. When plant and animal climate migrants threaten native ecosystems or become a nuisance to people, they are considered invasives. Climate disruption is increasing the extent, frequency, and severity of invasive species, as well as facilitating a shift toward invasion in species that have not historically been invasive. The problem of invasive species is not new, but the climate crisis adds to the challenges already faced by farmers and natural resource managers. One well-known example is cheatgrass, which is now present in all 50 states and dramatically increases the wildfire vulnerability of arid western lands. Other examples include Asian Carp and zebra mussels, which have invaded the Great Lakes and other freshwater systems in North America, devastating native aquatic communities.

7.6 Policy-Species Survival and Invasives

1. Only as a last resort should we look at species relocation, captive breeding, and actively managing habitats to promote species survival. Priority should be given to preserving and restoring core habitats and connecting corridors and reducing non-climate stressors so that species can adapt on their own in a natural ecosystem.
2. A primary focus of invasive species management in a changing climate is increased monitoring programs designed to record the spread of invasion across regions, ecosystems, and protected areas, and to provide warning for managers in landscapes that have not yet been invaded. Similar monitoring programs are needed to identify and act to preserve threatened and endangered native species. This active monitoring requires information sharing across agencies and regions, and between the public and private sectors, in addition to increases in public education and outreach programs.
3. Climate disruption inevitably will cause range-shifts of many native species, which managers must recognize and balance with efforts to prevent and minimize invasive species. Evolving best practices, science, and professional judgment should guide efforts to conserve individual species and biodiversity, and maintain basic ecosystem functions.
4. For species extirpated from their historic ranges, science-based best management practices for reintroducing them into such areas should be developed. Plans for introducing such species outside their historic ranges should only be implemented if proven not to have negative ecosystem impacts.

7.7 Policy-Wilderness Areas

1. In wilderness areas (including those designated or identified as wilderness study areas (WSAs), roadless areas and wilderness-quality lands), the Sierra Cub favors a management approach consistent with the 1964 Wilderness Act and existing Sierra Club policy. Within the context of the Wilderness Act, the primary wilderness management objective should be to protect "an enduring resource of wilderness" from significant degradation by human influence and use. “In wilderness management,

natural ecological processes should be allowed to operate freely to the maximum extent feasible to promote, perpetuate, and, where necessary, restore the wilderness character of the land. Minimal manipulation may be allowed in order to restore human-disturbed environments or offset human-induced restrictions on natural processes. The managing agencies should develop site-specific wilderness management plans for each wilderness. Development and adoption of such plans should require maximum public involvement at all stages, and the Sierra Club urges all concerned citizens to participate. In all instances the minimum tool for management should be used." (Sierra Club Wilderness Management Policy)

2. Wilderness designation best preserves ecosystem functions including carbon sequestration and best prevents direct human harm to land and wildlife. Wherever possible, eligible lands should be designated and legislative language should not increase human manipulation of land and habitat beyond what is allowed in the Wilderness Act.

7.8 Freshwater resources and habitats - Background and Policy

See separate section on Freshwater Resources of this policy. See also Rural and Agricultural Lands Adaptation and Ocean Carbon Dioxide Removal sections.

7.9 Oceans - Background

Globally, oceans are being warmed, oxygen-depleted and acidified because of human greenhouse gas emissions from land use change and fossil fuels. Oceans absorb approximately half of the excess CO_2 in the atmosphere and over 90% of the heat from global warming. But these climate buffering services come at a high cost to marine ecosystems and people. Consequences of ocean changes include:

A. Exposure of coastal communities to multiple climate-related hazards, including hurricanes and tropical cyclones, extreme sea levels and flooding, marine heatwaves, sea ice loss, and permafrost thaw;
B. Bleaching and dying coral reefs;
C. "Dead zones" caused by oxygen depletion where aquatic animals and microorganisms cannot survive;
D. Decreasing populations of fish and other ocean life;
E. Breakdown of calcium carbonate found in shellfish exoskeletons and animal egg shells; and
F. Increased harmful algal blooms (HABs), such as red tides.

"Dead zones" are proliferating, particularly in the Gulf of Mexico. These zones originally supported healthy fisheries and robust aquatic biodiversity. Surface waters of the world's oceans are now nearly 30% more acidic than they were in 1850. These climate-related impacts--combined with other human-caused stressors such as overexploitation of fisheries, destruction of estuarine ecosystems by development, and dumping massive quantities of plastic and other toxic pollution into streams, rivers and oceans--are devastating marine ecosystems such as coral reefs and all the creatures that depend on them. Worldwide, ocean warming and acidification pose an existential threat to millions of people who depend on healthy oceans for their livelihoods.

7.10 Policy-Oceans

Policies for farming of fish and other aquatic organisms are found in the Agriculture and Food Policy. Policies for sustainable marine fisheries are found under Marine Conservation Policy. See also the Coastal Resilience and Ocean Carbon Dioxide Removal sections of this policy.

1. Substantially increase marine protected areas; enforce sustainable fish and shellfish harvest levels (national and international issue).
2. Encourage restoration of kelp beds, seagrass and other native aquatic plants within their historic/anticipated ranges. Where compatible with the health of existing ecosystems, encourage the growth of these aquatic plants in new locations to enhance carbon dioxide removal and increase aquatic habitats.
3. Protect coral reefs from non-climate stressors such as overfishing and pollution. Promote research and development of interventions to restore coral reefs and other marine habitats damaged or destroyed by ocean acidification due to the climate crisis.

7.11 Deserts and Drylands - Background

Deserts and drylands are some of the most extensive land habitats on Earth, and help mitigate climate disruption by sequestering carbon in their soils and plants over vast areas. Climate disruption is raising temperatures, reducing precipitation, and increasing invasive species and wildfire vulnerability. Combined with existing pressures from mining, grazing, off-road vehicle recreation and urbanization, these climate impacts are further stressing the plants, animals and people that live in deserts and drylands.

7.12 Policy-Deserts and Drylands

To strengthen desert/dryland climate resilience, the Sierra Club supports regulations and practices that:

1. Prevent disturbance of fragile soils, increased vulnerability to wildfire, overexploitation of surface and groundwater, or construction of new roads and infrastructure in areas not already degraded or developed; and
2. Promote the health of shrub and woodland species.

7.13 Grasslands - Background

See the Rural and Agricultural Lands Adaptation and Soil Carbon Restoration and Sequestration sections of this policy.

7.14 Policy-Grasslands

1. The Sierra Club favors preservation and restoration of native perennial grasslands, both for their carbon sequestration value and their importance for wildlife habitat.
2. Some land areas grazed by domestic livestock or used for cropland should be restored as natural habitat (forest, wetlands, perennial grasslands) to provide for wildlife movement and climate refugia.
3. Where farming or grazing continues, regenerative practices should be implemented to optimize carbon storage and soil health. See also the Rural and Agricultural Lands Adaptation and Soil Carbon Restoration and Sequestration sections of this policy.

7.15 Tundra and Taiga (Boreal Forest) - Background

Polar regions of the northern and southern hemispheres are warming more rapidly than other parts of the Earth, causing loss of ice sheets, sea ice and permafrost (frozen ground). As these areas thaw, the warming is further accelerated by exposure of darker land and water surfaces, and release of formerly-trapped greenhouse gases such as methane. Permafrost can be over 3,000 feet deep and covers 24 percent of the land surface in the Northern Hemisphere. Permafrost melt is a threshold process; such melt is extremely difficult to reverse once it begins and causes a complete, or near-complete collapse of tundra and taiga ecosystems. Current warming will continue to degrade frozen soils faster as heat accumulation in frozen soils rises, producing a global warming gas emissions feedback. Reduction of future warming through resilience strategies is not guaranteed to reverse the permafrost melt threshold. Known climate adaptation options for plants and wildlife in these regions are minimal. The only known way to reverse frozen lands degradation from permafrost melt is to reverse warming from today's levels.

7.16 Policy-Tundra and Taiga (Boreal Forest)

Known climate adaptation options for wildlife in these regions are minimal.

1. The Sierra Club supports vigorous efforts to reduce non-climate stressors such as resource extraction and pollution, and intensified research and development on interventions to best maintain ecosystem functions as the polar regions warm.
2. Efforts should be made to include at-risk frozen grounds in planning efforts to steer land and infrastructure development away from these critical areas.
3. Planning efforts should include resource allocation to address infrastructure repair and relocation, and include managed retreat activities in areas at risk of permafrost melt (see 6.2c Managed (Planned) Retreat).
4. We support climate restoration to a temperature below current levels in 2020 as the only known way to reverse warming-caused ecological collapse in frozen ground regions.

7.17 Forests and Shrublands - Background

Intact, natural, and healthy forests provide habitat for diverse plants and animals, food and water for humans, wood products, and recreation opportunities. Forests can provide increased access to nature for lower-income communities that is essential for good quality of life and survival of local communities and global society. Deforestation undermines important carbon sequestration functions of forests. Approximately 15% of all global greenhouse gas emissions are the result of deforestation. Due to logging, the amount of carbon that U.S. forests sequester annually is 35% lower than it would otherwise be.

Forest thinning and logging is often promoted as a method for reducing the emissions from forest fires. Forest fire releases some portion of stored carbon. Disturbances like high-severity fire and insect outbreaks result in tree mortality that temporarily reduces carbon sequestration until the forest regrows. However, forest thinning is highly unlikely to reduce carbon emissions from forest fire because the fuels effects of thinning are temporary. Any theoretical carbon benefit would be realized only if a fire occurs in the thinned area in the short period of years before the fuels regrow, and if the fire consumed more carbon than was removed by thinning, which is unlikely given the small levels of tree consumption (typically 3%, or less) that occur even in large forest fires. Furthermore, thinning operations reduce forest carbon stores and the resulting debris must eventually be released as carbon emissions. In the U.S., commercial logging results in far more carbon emissions than fire and bark beetle outbreaks combined.

Protecting and maintaining forest ecosystems in their natural, functioning state will best preserve and maintain ecosystem services that we use and enjoy, as well as increase stored carbon pools.

7.18 Policy-Forests and Shrublands

For additional forest policy information, see Forest Carbon Dioxide Removal in this document.

1. The Sierra Club supports forest protection, restoration, reforestation, proforestation , afforestation, and urban forestry as primary methods to address the climate crisis. These measures can provide sustainable livelihoods; moderate extreme weather, including temperature and humidity; reduce air pollution; and protect biodiversity—in addition to drawing down atmospheric carbon.
2. We will work to end the commercial logging program on federal public forestlands in the U.S ., and will support increased acquisition of private forestlands into protected federal public ownership, focusing on areas and regions where public forestlands are lacking and lower-income communities, particularly communities of color, are being impacted by widespread clearcutting for lumber and wood pellets, especially the southeastern U.S.
3. Plantings in domesticated rural areas should utilize tree and shrub species that are best adapted to anticipated changes in climate.

4. In natural rural areas, reforestation and afforestation should prioritize native tree and shrub species most likely to be adapted well to anticipated changes in climate.

Topic II- Carbon Dioxide Removal Policy

Section 1- Introduction

1.1 Background

The concentration of long-lived carbon dioxide (CO_2) and other greenhouse gases in the Earth's atmosphere already exceeds the levels required to sustain the human and natural environment and restore a climate compatible with life as we know it. We are already experiencing dangerous and deadly extreme weather, sea level rise, adverse impacts on agricultural production, ecosystem shifts, and dramatic reductions in the vitality of wildlife and native plants. Human suffering from heat, water scarcity, food shortages, and related conflicts is increasing in many parts of the world. If greenhouse gas concentrations continue to rise, as is projected under current modeling scenarios, the climate crisis will threaten life as we know it.

The best way to return our climate to livable levels is to immediately stop human-caused greenhouse gas emissions from fossil fuels, deforestation, wetland destruction and other land use changes, and activities such as industrial farming and livestock production/consumption, and to remove some of the already-emitted climate pollution from our atmosphere. Awareness is growing that these and other societal shifts—such as dramatic reductions in waste of food, energy and materials—are necessary, but these transformations are not happening quickly enough. So the first order of business is to reach zero net greenhouse gas emissions as soon as possible, and to simultaneously remove some of the CO_2 from our atmosphere to reach a safe level of CO_2 of less than 350 parts per million (ppm). This can be achieved by a combination of rapidly shifting to 100% clean energy, reducing or eliminating other greenhouse gas emissions from non-energy sources, and drawing down the built up CO_2 that is already in the atmosphere with carbon dioxide removal (CDR) strategies and techniques.

Excess CO_2 in the atmosphere is already being partially taken up and stored through natural biological and geological processes. For example, recent estimates show that 26% of all the carbon released as CO_2 from fossil fuel burning, cement manufacturing, and land-use changes over the decade 2008–2017 was absorbed by the oceans Le Quéré 2018. Some proposed CDR methods, referred to as "natural climate solutions" or "nature-based" CDR, rely on preserving, restoring, or amplifying those processes. Other CDR methods rely primarily on technology to capture and store CO_2 either before or after it is released during human activities like manufacturing, transportation, and industrial-scale agriculture. These two categories are not discrete, but represent the ends of a continuum, as described below.

The National Academies of Sciences, Engineering and Medicine report "Negative Emissions Technologies and Reliable Sequestration, A Research Agenda" (2019) states that technologies that suck CO_2 out of the air coupled with eliminating as much greenhouse gas (GHG) emissions as possible will likely be crucial to meeting global climate goals, and these technologies need more investment to reach scale. The report further states that in order to keep global warming less than 2°C above pre-industrial levels, carbon removal techniques worldwide will likely have to remove and permanently store about 10 gigatons (Gt) of CO_2 per year by the middle of this century and 20 Gt per year by 2100. This study concludes that natural systems can probably only draw down carbon by 5 gigatons per year worldwide without severely impacting food production or causing significant equity issues. The amount of permanent CDR removal that is possible through natural systems is debatable, and some argue that natural systems can accomplish the entire 10 gigaton goal Hawken 2017.

Rather than attempt to resolve this debate, the Sierra Club advocates for maximizing natural solutions first, but also supporting a diverse portfolio of environmentally acceptable and just CDR technological options to back up and supplement the natural systems solutions.

1.2 Nature-based CDR methods

One of the beauties of the Earth's natural systems is that living things, through photosynthesis and microbial processes, remove CO_2 from the atmosphere and store it in plant tissues and soils, while releasing oxygen as well as a smaller amount of CO_2. This process happens naturally, but it can be accelerated and magnified by protection; better management and restoration of carbon rich environments such as forests, wetlands, peatlands, shallow and deep water marine plant farms; agricultural farms; and the soils associated with each of these sectors. Soils, plants, wetlands, and trees currently have tremendous capacity to take up and store great amounts of additional CO_2. Years of mismanagement of our soils, wetlands, and forests have led to these natural resources, on average, releasing more stored carbon than they otherwise would. But with proper climate-smart protection, management, and restoration, they can be more effective carbon sinks.

Oceans are warming and becoming more acidic due to the climate crisis, but still have the capacity to take in more carbon if people restore fisheries, conserve and expand seaweed habitats and kelp forests, and take steps to increase populations of native phytoplankton. In general, further warming is expected to degrade the ability of nature-based solutions to absorb greenhouse gases, but this is dependent upon the exact ecology. Some areas will see increases in greenhouse gas absorption with further warming. Complexities of both ocean and land absorption of CO_2 however, are such that future trends with greater atmospheric CO_2 concentrations and greater warming are not clear.

1.3 The Nature-Based CDR Topics in this Policy

All natural ecosystems help store carbon and should be protected. However, this policy document will focus on the following natural systems:

A. Soils and Agriculture
B. Forests

C. Wetlands and Freshwater Ecosystems
D. Oceans

1.4 Technology-Based CDR Methods

In addition to these nature-based CDR methods, there are also technologies that can remove and store atmospheric carbon. In these cases, the carbon is captured and stored in soil, geologic formations or as stable CO_2-rich aggregates in construction materials where it should remain for very long periods. There are also emerging markets for using captured CO_2, including converting it to liquid fuel for transportation, or using it in industrial processes. Using CO_2 to produce more carbon-based fuels, such as through enhanced oil recovery, is questionable at best as it needs to account for the CO_2 that is released back into the atmosphere and it continues our reliance on dirty and dangerous fossil fuels that the Sierra Club does not support. (see Technology-Based CDR 3.1)

1.5 The Technological CDR Topics in this Policy

The following technological CDR topics will be covered in this policy document:

A. Bioenergy with Carbon Capture and Storage (BECCS)
B. Biochar
C. Direct Air Capture and Carbon Sequestration (DACCS)
D. Enhanced Mineralization

Section 2- Nature-Based CDR Policy

2.1 Soil Carbon Restoration and Sequestration

2.1a Background

The 2018 Intergovernmental Panel on Climate Change (IPCC) Special Report on Global Warming of 1.5°C warned that to avoid catastrophic climate impacts we must remove significant amounts of CO_2 from the atmosphere. This report highlighted soil carbon sequestration as one of the most important, beneficial, economic and impactful ways to do the job. The world's cultivated and grazed soils have lost 50-70 percent of their original carbon stock, and in the process released an estimated 133 gigatons of carbon into the atmosphere. The UN warned that we have only 60 more years of productive farming left if current levels of soil degradation continue, but if we rebuild soil carbon we can help reverse this trend and head off climate catastrophe and a food production crisis.

2.1b Agricultural Soil Restoration and Carbon Sequestration

The most ecological way to restore soil carbon on agricultural lands while keeping them for food production is through regenerative agricultural practices: low-till or no-till agriculture, cover-cropping, reducing or eliminating nitrogen fertilizers (a major source of the very potent greenhouse gas nitrous oxide), eliminating overgrazing, minimizing soil erosion, and restoring soil carbon through compost and biochar. This approach is central to the Sierra Club Agriculture and Food Policy. Soil carbon can also be restored by taking degraded soils and restoring the native ecosystem or planting and maintaining non-agricultural vegetation such as trees. Warmer and generally drier climates are negatively correlated with existing soil carbon stocks permanence and soils' abilities to absorb additional carbon.

Over 1 billion acres of farmland has been abandoned due to land degradation worldwide. Project Drawdown (2017) estimated that by instituting abandoned farmland restoration, approximately 424 million acres could be restored by 2050, creating an opportunity to draw down and sequester 14.1 gigatons of CO_2. Regenerative agriculture strategies are another major soil sequestration category that enhances the carbon storage capacity of agricultural lands that remain in production. This is done through compost application, cover crops, crop rotation, green manures, no-till or reduced tillage, and/or organic production. Project Drawdown estimates that 108 million acres of agricultural lands across the globe already use regenerative techniques; if regenerative techniques were applied to one billion acres, 23.1 gigatons of greenhouse gases could be sequestered by 2050. There are other soil carbon enhancing strategies, but these two are the biggest. Combined, they represent the capacity to sequester 37.2 gigatons of greenhouse gases by 2050, or 1.24 gigatons per year on average for the next 30 years.

One advantage of soil carbon sequestration is that it relies primarily on the natural process of photosynthesis and soil microbial processes; not some expensive, energy-consumptive technology requiring years of research and development. Plants take in CO_2, extracting it from the air by photosynthesis. The plants and associated microorganisms then transfer the carbon to the soil. Living organisms and fresh organic matter provide short term carbon storage, and a smaller percentage becomes persistent carbon that resides in the soil for decades or longer depending on how the soil is managed or left relatively intact in the future. Soil organisms naturally respire and return CO_2 to the atmosphere, but if managed properly a larger portion of the soil carbon remains sequestered.

This potential lack of permanence is the principal drawback of soil carbon sequestration. As long as soil is managed so that it is sequestering more than it is respiring, the soil will provide a net carbon benefit. However, if environmental conditions change or a land manager reverts to farming or grazing practices that release more carbon than they store, the gains can be lost. The benefit persists only as long as the regenerative practices are implemented. Policies are needed to promote agricultural land management practices that build up and then retain soil carbon concentrations.

The Sierra Club joined an international campaign to promote soil carbon sequestration called "4 per 1000." This joint governmental and non-governmental organization (NGO) initiative calls for increasing soil carbon by 4 parts per thousand per year as a way to provide food security and climate stability. Farmers, local governments, Tribes, states, and countries can all take the pledge and adopt programs to help soils solve a major part of the climate crisis.

2.1c Potential Beneficial Impacts of Soil Restoration

Rebuilding soil carbon through abandoned farmland restoration and regenerative agriculture has numerous co-benefits. It mitigates CO_2 emissions from agriculture, provides food security, improves crop yields, reduces the need for costly synthetic soil inputs, improves wildlife and pollinator habitat, increases the soil's water storage capacity, decreases chemical run-off and algae blooms in rivers and lakes, reduces erosion and desertification, and protects rural jobs. Rebuilding soil by restoring degraded carbon-depleted agricultural lands with non-agricultural plantings and ecosystem restoration can have positive CO_2 emission reductions, biodiversity, wildlife habitat, watershed protection, and erosion and desertification reduction co-benefits; but the agriculture and food production benefits are lost.

2.1d Potential Adverse Impacts of Soil Restoration

Afforestation or ecosystem restoration of agricultural lands can impact food production and farm worker jobs. Since soil carbon sequestration benefits persist only if the land continues to be managed to restore and retain carbon, policies must be able to secure the application of best soil sequestration practices in perpetuity. Current agricultural policies and incentives tend to benefit large corporations and absentee landowners rather than the individuals most affected by management decisions. Regenerative agriculture applied holistically can substantially reduce or eliminate pesticide use, but individual practices like no-till agriculture that are poorly incorporated in the industrial mindset have depended on pesticides and other chemical inputs. Changing land use to maximize soil carbon could disrupt the livelihoods of those dependent on those lands. However, there may be offsetting gains in jobs from tourism, recreation and land management.

2.2 Policy-Soil Carbon Restoration and Sequestration

1. The Sierra Club strongly supports programs and policies to rebuild and retain soil carbon. Such programs should be implemented at the personal, local, corporate, Tribal, regional, state, federal and international levels, with the goal of restoring at least 4 parts per thousand soil carbon per year. All soil carbon programs and policies should be respectful of Indigenous people, human rights, and land stewards and follow the Jemez Principles. (See Equity and Justice Section in this document.)
2. Farmers and ranchers should be assisted and offered incentives to restore abandoned agricultural lands and implement regenerative agriculture practices that build up and maintain soil carbon levels, as well as, provide multiple co-benefits. Governments, NGOs, and universities should conduct and share research and education programs that provide agricultural operators with the information and tools necessary to adopt best practices that will rebuild and maintain carbon rich soils.
3. The Sierra Club favors implementing a variety of tax incentives, government leases of land for conservation practices, and other incentives to promote soil carbon. Such policies must be maintained over time so that the practices are continued. The Sierra Club also favors certification of agricultural products that are grown in ways that meet organic, environmental quality and soil carbon building standards, and encouraging

consumers and governments to buy those certified products as a way to create a market for climate smart farmers and ranchers.

4. Regenerative agricultural practices, afforestation, and ecosystem restoration should incorporate permanence into soil carbon sequestration strategies. Soil carbon accounting should be standardized so that improvements and permanence can be verified, with monitoring and reporting to ensure transparency on soil carbon levels and programs.
5. Agricultural subsidies (including crop insurance premiums) should be discontinued for farming practices that deplete soil carbon or lead to excessive soil erosion or desertification. Agricultural practices that deplete soil carbon and also significantly impact air and water quality or other commonly-held resources should be regulated to minimize those impacts.
6. Carbon-depleted public lands should be managed ecologically to rebuild and maintain soil carbon without disrupting natural ecosystems. Private agricultural and grazing interests that lease or otherwise use public lands should be required to conduct their operations in ways that rebuild and maintain soil carbon.
7. Private lands that support natural ecosystems should be managed ecologically to rebuild and maintain soil carbon without disrupting these ecosystems.
8. Soil carbon can also be increased by restoring degraded lands, wetlands, and forests to their natural ecosystems functions through enhanced mineralization or additions of biochar to soils. Also, protecting natural lands from destruction, including industrial extraction practices, and ensuring that vital nutrients and water are available will increase soil carbon. Those approaches are covered elsewhere in this policy.
9. The United States should use foreign aid, multilateral development banks, the United Nations, treaties and protocols, fair trade agreements, the Green Climate Fund, and other institutions and initiatives to promote non-coercive soil carbon restoration programs worldwide, while fully respecting native cultures and human rights.

Section 3- Forest Carbon Dioxide Removal

3.1 Background

Scientific studies are finding with increasing certainty that forests are degraded by climate disruption, including their functions of CDR and emissions reductions (U.S. Global Change Research Program, Fourth National Climate Assessment Ch. 6 (2018)).

Forests in the United States each year absorb nearly 900 million metric tons of CO_2, equal to more than 10% of annual U.S. carbon emissions, and store it in a form that can persist for years to centuries. There are many options for increasing the levels of CO_2 removal provided by forests (forest CDR), storing it as forest carbon, and reducing forest-related emissions. The major options are: 1) expanded forest protection; 2) restoration and proforestation (allowing areas of previously logged forests to mature and recover their ecological and carbon storage potential); 3) improved forest management that reduces emissions and increases forest carbon stores; and 4) reforestation and afforestation actions.

Forests capture (sequester) CO_2 through the natural process of photosynthesis, and store the carbon in trees and understory vegetation, surface litter, and forest soils. When properly designed and implemented, with monitoring for carbon benefits and ecological effects, forest CDR can be an effective tool in reducing a portion of climate change at the local, regional, and global levels.

In general, intact and healthy primary forests (i.e., those that have never been logged) store more carbon than do tree plantations and forests regrowing after logging or other disturbances. Trees can live hundreds and even thousands of years, yet only 15% of U.S. forests are older than 100 years. In the southern U.S., most forests are less than 40 years old due to the extent of short-rotation logging. Because older forests tend to sequester more carbon annually and contain far greater overall carbon stores, there is an opportunity to substantially increase carbon sequestration and storage by allowing U.S. forests to grow older, both through increased protection and improvements in forest management. Climate impacts, deforestation, and forest degradation caused by logging and other factors are reducing the ability of forest ecosystems to sequester carbon and decreasing carbon storage. Logging and associated road-building also degrade forest soils, leading to the loss of long-term carbon stocks and, in some cases, changing forest soils from net carbon sequestration to net emissions.

3.2 Policy-Forest Environmental Justice

There is a well-documented history of the adverse environmental justice impacts of logging, forest management, and wood products facilities. These include the exclusion of indigenous people and violation of their land rights, and direct impacts on local residents and communities through operations and pollution. For example, the majority of large plants processing wood pellets for export are located in the southeastern U.S. where low-income, African-American communities are disproportionately impacted by the forest clearcutting, logging trucks, and industrial facilities that produce pellets. (More than 25 million tons of wood pellets from over 600,000 acres of clearcut forests in the U.S. have so far been exported to Europe for biofuel under European climate policy.)

1. The expansion and restoration of forests--properly planned in cooperation with neighboring communities--can reduce the expanse and impacts of industrial operations like pellet production, and can increase access to open space and natural areas, with the associated benefits of that access and the ecosystem services that forests provide.
2. At the same time, there is a need for a just transition for the communities, families, and local businesses that have depended on a logging-based economy.

3.3 Proforestation-- Protecting and Maintaining Forest Carbon Storage

Proforestation is the practice of growing an existing forest intact toward its full ecological potential, protecting existing components, and fostering natural growth to increase carbon storage, structural complexity, and ecological functions. Intact, natural, and healthy forests provide ecosystem services, including biodiversity, food, and wood products, that are essential for the good quality of life and survival of local communities and global society.

Deforestation undermines important carbon sequestration functions of forests and releases stored carbon to the atmosphere. Deforestation is one of the largest sources of greenhouse gas emissions in the world, estimated at 5 billion metric tons emitted annually, or nearly 10% of annual global emissions. Due to logging, the amount of carbon sequestered by U.S. forests is estimated to be 35% less annually than it otherwise could be (see Great American Stand).

Logging operations degrade and reduce carbon storage at every level of forest structure--from the harvest of tree boles (tree trunks), to the destruction of understory vegetation, to the decomposition of roots and stumps, to the disturbance of forest soils through logging and road-building. The overall effect can shift forests from being net carbon sinks to net emitters for many decades. Protecting and maintaining forest ecosystems in their natural, functioning state will best preserve and maintain ecosystem services that we use and enjoy, as well as increase stored carbon pools.

Every forest type has specific ecological requirements for species mix and range, and is associated with unique biodiversity and ecosystem services that are vital to the quality of life of humans and animals in those regions.

3.4 Policy-Proforestation

1. Because native, intact, healthy forests are critical to maintaining functioning ecosystems and enhancing carbon sequestration and storage, primary forests must be protected and maintained. Previously logged forests should be managed for restoration and proforestation (allowing areas of previously logged forests to mature and recover their ecological and carbon storage potential). Removal of forest carbon from federal public lands through commercial logging should be ended. Policies and incentives should be enacted to encourage private forest landowners to maximize forest carbon storage and stewardship of functioning forest ecosystems. Funding for forestland acquisition into protected public ownership should be encouraged.
2. Federal, state, and local governments in the U.S. as well as other countries should adopt and enforce clear standards that protect forests and the carbon that those ecosystems sequester and store. Governments should adopt and enforce regionally based and biome-specific forest management plans that explicitly prioritize the preservation and enhancement of forest carbon stores (see Sierra Club Carbon Policy for Forests).
3. Forest management should increase carbon storage and enhance other environmental services and ecological values, and take into account regional and/or biome-specific requirements for sustaining those forests. Forest management should take into account current and future climate disruption, including the need for habitat connectivity and migration.
4. Forests should be restored, managed, and preserved to provide ecosystem services to the surrounding and remote communities. Managing forests to enhance forest carbon sequestration and storage must not harm vulnerable communities that rely on the forest for food or livelihood. Managing public lands for carbon should also promote access to and enjoyment of the forest. Such forests should be protected through policies that include meaningful public involvement in the administration of these

protections.

5. Public policies for the protection and management of forests should be developed through processes that are consistent with the Jemez Principles, respect Indigenous rights, include consultation with Indigenous and other impacted communities, and seek a just transition for timber-dependent workers and communities.

3.5 Reforestation and Afforestation

Reforestation is the cultivation of trees on land that had been cleared of forest, typically by clearcutting. In some cases, the land was converted to agricultural or other uses. Reforestation typically involves replanting tree seedlings.

Afforestation is the cultivation of trees on land that was not recently in forest land cover. This is most often sited on land in cultivation for annual agriculture crops.

Reforestation and afforestation are relatively low cost compared to many other methods of CDR. These methods can be deployed in all regions, in both urban and rural environments. Large-scale reforestation as a means of CDR and emissions reductions has the largest potential in the tropics and subtropics, where recent clearing has converted vast areas of forest to agriculture and rangelands. The carbon storage provided by reforestation and afforestation is dependent on that land remaining in forest cover over time. Subsequent loss of the forest through logging, clearing, or disturbance can release some or all of the stored carbon back into the atmosphere.

3.5a Potential Benefits of Reforestation and Afforestation

Reforestation or afforestation can offer substantial ecological benefits—forest health and resilience, wildlife habitat and connectivity. In addition to carbon sequestration and storage, healthy forest ecosystems also provide an array of ecosystem services in the form of water supply, air quality, recreation, the retention of storm runoff and snowmelt, and much more. Implemented with consideration of impacts to native ecosystems, reforestation is one of the most promising tools available for providing massive carbon benefits with minimal to no downsides.

3.5b Potential Adverse Impacts of Reforestation and Afforestation

Using non-native trees in reforestation and afforestation can result in poor habitat for native wildlife and can spread non-natives to surrounding natural forests. Planting and thinning operations can disturb soils and degrade habitat; these impacts are exacerbated when reforestation is coupled with salvage logging, which can diminish habitat and undermine natural regeneration. Afforestation of extant non-forest native ecosystems would diminish or destroy those native ecosystems and habitat. Afforestation on agricultural land can conflict with food production and the interests of the current users of the land. As the area of deployment increases, the risk of impacts and conflicts increases.

3.6 Policy-Afforestation and Reforestation

1. Reforestation of previously forested lands should focus on lands that have been cleared or degraded, should not undermine natural regeneration after natural disturbances, and should not involve salvage logging or the creation of tree plantations. Reforestation and afforestation should utilize appropriate native tree species that support and enhance the native local biodiversity.
2. Reforestation and afforestation efforts should be designed and implemented to provide ecosystem continuity and resilience, and wildlife habitat and connectivity, at the landscape scale. Reforestation and afforestation efforts should take into consideration biome specifications and climate change variations that would support continued beneficial biodiversity interactions and enhanced ecosystem services provided by healthy intact forest ecosystems.
   Non-native species and variations should be used only under the parameters of an explicit assisted migration project.
3. Reforestation and afforestation efforts should consider the ecosystem services and the needs of surrounding communities. Reforestation on productive agricultural land should consider impacts to food production, jobs, and access to food. These efforts should mitigate any negative impacts on vulnerable communities that rely on the affected lands for food or livelihood. Actions to promote the participation and consideration of vulnerable communities in reforestation and afforestation efforts and the support of these efforts through community engagement should be encouraged.
4. As the climate crisis results in deforestation, forest degradation, and reduced tree cover globally, the planting of trees in all appropriate areas, including urban centers, should be a priority locally, nationally, and globally. (See the Urban Forestry section below.) Local governments and other civic groups should adopt and support programs to plant and maintain trees in and around communities. Reforestation and afforestation in urban areas may put a lower priority on native trees and a higher priority on other values such as stormwater management, shade, wildlife, and fruit. The planting of exotic invasive species should be avoided.

3.7 Timber Management

Changes in forest management for timber production can increase the amount of carbon stored in the forest. For example, increasing the rotation length (i.e., harvest age) allows more years for trees to sequester and store carbon, and larger trees generally sequester more carbon per year than smaller trees. In addition, less intensive forest management practices such as reducing the size and proximity of clearcuts, increasing riparian buffers, increasing live tree retention, etc. can reduce the loss of stored forest carbon and increase carbon sequestration and storage potential. Extending the rotation age may require timber operators to deviate from harvest schedules that maximize revenues and may reduce total harvest volume over time.

Financial incentives can offset the costs for landowners and timber operators. Forest carbon incentives can encourage landowners to restore forests, keep land forested, and engage in better forest stewardship practices. In addition to payments based on tons of carbon stored in trees and soils, the incentives can also target areas where trees provide benefits such as for stormwater management, erosion and runoff control, endangered species, and hot urban areas. The forms of forest incentives include privately-traded offset credits for carbon emissions, credible third-party forest certification systems such as the Forest Stewardship Council (FSC), and government conservation payment programs (including through the U.S. Department of Agriculture and states). Effective forest carbon incentives require careful design, selection, accounting, monitoring, and evaluation.

Conservation easements can also provide financial incentives to encourage landowners to restore forests, keep land forested, and engage in sustainable forest stewardship practices. The Club supports conservation easements on private forest lands per the Sierra Club's *Carbon Policy for Forests, Wild Areas, and Other Lands*, 2009.

3.8 Policy-Timber Management

1. Financial incentives for increased forest carbon sequestration and storage must accurately account for the full carbon impacts of forest management activities, and should not diminish existing ecosystems and wildlife habitat.
2. Financial incentives for increased carbon sequestration and storage should never involve the conversion of diverse, native forests to tree plantations or tree monocultures, but may include extending harvesting rotations to increase carbon sequestration and habitat values on existing plantations.

3.9 Logging for Fire Management

Forest thinning and logging is often promoted as a method for reducing the carbon emissions from forest fires. Forest fire releases some portion of stored carbon. Disturbances like high-severity fire and insect outbreaks can result in tree mortality that can temporarily reduce carbon sequestration until the forest regrows. However, forest thinning is highly unlikely to reduce carbon emissions compared to forest fire because the fuels effects of thinning are temporary, and the carbon benefit would be realized only if a fire occurs in the thinned area in the short period of years before the fuels regrow. Furthermore, thinning operations reduce forest carbon stores and the resulting debris must eventually be released as carbon emissions. In the U.S., commercial logging results in far more carbon emissions than fire and bark beetle outbreaks combined. Moreover, increased logging and commercial thinning can often increase fire intensity by reducing the cooling shade of the forest canopy, creating hotter and drier conditions, creating kindling-like logging slash debris, spreading combustible invasive grasses, and reducing the buffering effect that trees have against the winds that drive flames.

3.10 Policy-Logging for Fire Management

1. Forest thinning for fire management should be planned and implemented with public safety as the overriding objective, and not as a CDR measure. Communities should use zoning and other measures that directly protect houses and communities from the threat of forest fire.
2. Fuels reduction projects cannot assume net climate benefit based on the assumption of

future fire. Accounting for the net carbon impacts of fuels reduction projects must include site-specific analyses that account for the carbon emissions associated with thinning and prescribed burning.

3.11 Urban Forestry

Although urban forestry can provide CDR, the rates and overall size of the reductions are probably small compared to the scale of rural and wildland forest programs. Nonetheless, planting trees and vegetation in urban areas can provide important benefits associated with climate resilience. This issue is discussed in more detail in Section 3.2h of Local Community Climate Resilience section of this document.

3.12 International Forests and Carbon

Tropical rainforests are among the most biologically diverse ecosystems on Earth and account for 80% of the world's documented species (World Wildlife Fund). Policies to reduce carbon emissions from deforestation and forest degradation in tropical countries can help to reduce losses of biodiversity and habitat. Furthermore, all countries experiencing heat waves, extreme storm events, wildfires, and other climate related changes, will experience forest degradation to some extent.

3.13 Policy-International Forests and Carbon Dioxide Removal

1. The U.S. and other countries should adopt and enforce clear standards to protect intact primary forests worldwide, respect Indigenous rights, and reduce deforestation and illegal logging.
2. Proforestation, reforestation and afforestation should be pursued aggressively in degraded forests and deforested lands worldwide, while respecting Indigenous rights, human rights, justice, biodiversity protection, and national sovereignty.
3. Wealthy countries, major polluters, and those industrialized countries that have contributed the most to historic and current global GHG emissions should provide financial resources to assist poorer and developing countries to protect, ecologically manage, and restore their forests and plant new forests.

Section 4-Wetlands, Coastal and Shallow Marine Habitats Carbon Dioxide Removal

4.1 Background

4.1a Wetlands Ecosystems and Carbon Sequestration

Wetlands are terrestrial ecosystems that are inundated by water either permanently or intermittently; they can be freshwater or saltwater; and they may be influenced by tides or they may be non-tidal. Depending on the types of plants, landscapes, soils and hydrology that make up the wetlands; these ecosystems are further characterized as swamps (which includes peatlands), marshes, bogs, and fens. They include mangrove forests, carr, pocosin, flood plains, mire, prairie potholes, and vernal pools. Wetlands of a similar category in different geographical areas with varying temperature and precipitation factors may function quite differently from each other. Therefore, it is important that these factors are considered in addressing the conservation and restoration of wetlands.

Most wetlands provide the following critical ecosystem services: water purification; long-term water storage and absorption during flooding; carbon and other nutrient processing and storage; shoreline stabilization; terrestrial and aquatic animals breeding and nursery habitats; increased plant, fish and other animal diversity; reduction in the impacts of harmful algal blooms (HABs); climate stabilization via carbon sequestration; and protection of marine coastal areas from flooding and subsequent erosion associated with extreme storm events such as hurricanes and torrential precipitation. Maintaining intact wetlands are a cost-effective and environmentally friendly alternative to addressing flooding compared to constructed barriers and conduits.

Wetlands can be both sources and sinks for carbon. Globally, they can store twice the organic carbon load as some cropland and sequester 20-25% of the world's organic soil carbon. Also on a global scale, some wetlands (i.e., vegetated wetlands and peatlands) sequester just as much CO_2 per unit area as do the most efficient tropical rain forests. Permafrost (frozen soils) is a particular wetlands category where carbon and methane can be stored for long periods of time. However, the melting of Arctic and Sub-Arctic permafrost due to the climate crisis can release this once-stored carbon and methane back into the atmosphere. These events are adding CO_2 and other heat-trapping greenhouse gases into the atmosphere, thereby increasing the climate crisis.

Currently, wetlands, in general, and wetland forests, specifically, are being destroyed at an alarming rate. Globally, the loss of natural wetlands since the 1700s until now is approaching 60%. Some of that destruction is due to human activities such as converting wetlands into farmlands, draining wetlands for development, harvesting wetland forests for wood products, draining peatlands for palm oil plantations, and harvesting grassy and/or shrubby wetlands for biomass fuel. Additionally, some wetlands are degraded by contaminated runoff (during heavy precipitation events) from concentrated animal feeding operations (CAFOs) or pollutant-housing dry sites such as coal ash sites and landfills.

4.2 Summary of Existing Wetlands Policy

Below is a brief summary of current wetlands policies codified and adopted by the Sierra Club Board of Directors in May 1987 (https://www.sierraclub.org/policy/wetlands).

4.2a <u>Policies associated with public involvement addressing wetlands:</u>

1. Extension of public incentives for the protection of wetlands;
2. Removal of public incentives for the degradation of wetlands; and
3. Acquisition of wetlands by public and private agencies and land trusts.

4.2b **Policies addressing wetlands management programs:**

1. Strict governmental oversight in the planning, management, and regulation of anthropogenic impacts on wetlands;
2. Such anthropogenic impacts should require an environmental assessment or environmental impact statement (EIS) and public review;
3. Pest control and water pollution into wetlands should be regulated;
4. Unauthorized dumping, alteration, or release of contaminants into wetlands must be discouraged; and
5. Public participation in the wetlands management process is encouraged.

4.3 Rivers, Lakes, Streams, and Ponds Carbon Sequestration

Rivers, lakes, streams, and ponds are often supported by surrounding wetlands that have their own CDR potential. Most of their CDR potential is located in the areas of significant plant productivity which is often near the shorelines, in the shallow water perimeters of the ecosystem, in the water column by algae, diatoms and other phytoplankton, and in the sediments. Even though surface freshwater systems seem to have a small footprint when assessing carbon stored and emitted by water when compared to the vast oceans, scientific evidence now suggests these systems may play an important role in the global carbon cycle. Inland streams and rivers move vast amounts of carbon from the land to the ocean, acting as carbon's busy transit system. They also play a disproportionately large role in the global carbon cycle through their high rates of carbon respiration and sequestration [Cole et al., 2007; Tranvik et al., 2009]. The soils and sediments of surface freshwater ecosystems collect dead plants, stems, branches, and tree trunks which store carbon as well. Rivers, lakes, streams, and ponds also play important roles in climate adaptation and CDR by providing the feedstock for the surrounding wetlands (through their watershed connectivity) to ensure those wetlands meet their optimal carbon sequestration and storage potential.

Surface freshwater ecosystems are warming at a higher rate than the atmosphere or oceans. The impacts of such warming on the global carbon cycle is uncertain. Warming and increased nonpoint source pollution from increasing human populations could potentially flip inland reservoirs from greenhouse gas sequestration to emissions.

The carbon sequestration potential associated with large rivers and lakes is being negatively impacted by the climate crisis. The Great Lakes region, which has a drainage basin of 295,710 square miles and includes the lakes themselves and their connecting waterways, is a vast area with significant potential for carbon sequestration. These freshwater bodies are under tremendous stress from the climate crisis. (More information is provided in the Freshwater Resources and Habitats and Coastal Resilience sections of this document.)

4.4 Policy-Wetlands, Rivers, Lakes, Streams, and Ponds Carbon Dioxide Removal

Below are specific policies addressing the restoration and protection of wetlands because of their role in addressing the climate crisis through their carbon sequestration potential.

1. The preservation, restoration, and conservation of intact wetland habitats should be a national priority because of their carbon sequestration potential, biodiversity enhancements, drinking water and general water purification potential, critical habitats, protection from harmful algal blooms, and other essential ecosystem services they provide. Landowners, governments, developers, and the public should be educated about the benefits of wetlands as natural solutions to the climate crisis. The U.S. should adopt a goal of restoring 60% of degraded wetlands and increasing overall wetlands acreage by 75% by 2050 to help the U.S. meet its Paris Agreement goals.
2. Since the climate crisis is causing the global surface freshwater ecosystems (including wetlands, rivers, lakes, streams, and ponds) to warm much faster than the atmosphere or oceans, it is imperative to support scientific studies determining what the impacts of this warming may be on the global carbon cycle. The role that rivers, lakes, streams, and ponds play in carbon sequestration should be better defined.
3. Peatlands protection and restoration should be a high priority for federal, state, and local governments to protect because of their carbon storage capacity and potential release of CO_2 and methane into the atmosphere when these sites are disturbed or degraded.
4. Where it has been determined for any specific project that the destruction of wetlands is unavoidable and that there is no other site available for that project, then full offset for the wetland loss at a minimum must be required.
5. To adequately restore degraded or destroyed wetlands, offset ratios for impacts to wetlands must account for both lost acreage and functions; as well as for the time period that such mitigation will take to fully replicate the wetlands' lost functions.
6. Freshwater monitoring data, including data collected by volunteer water quality monitoring programs, should include more indicators to help create more targeted data addressing the climate crisis.
7. Local and state governments associated with the Great Lakes region should develop a comprehensive strategy for addressing climate disruption in this region. That plan should include risk assessments associated with invasive species, acidity, "dead zones", warmer water temperature, harmful algal blooms (HABs), and pollution. More information is provided in the Freshwater Resources and Habitats section of this document.

4.5 Coastal Wetlands and Shallow Marine Habitats

Coastal and estuarine wetlands are predominantly tidal and brackish-water marshes and mangrove forests as well as adjacent non-tidal wetlands such as vernal pools/seasonal wetlands on the west coast and pocosins on the east coast. Other shallow water habitats include mudflats, beaches, flood plains, and in slightly deeper water, seagrass meadows and kelp forests.

Coastal wetlands and associated shallow water habitats are some of the most productive on Earth. Marsh vegetation grows quickly. Dying marsh vegetation in turn becomes detritus which provides food for the many fauna that live in mudflats, and seagrass and kelp bed soils. That fauna is the food base for much of our aquatic life. Marshes, seagrasses, and kelp forests provide breeding grounds and nursery habitat for over 70% of our commercial fisheries as well as many other species. Millions of shorebirds depend on the rich biota found in mudflats for their existence. Many other bird species, turtles, crabs, and snakes also depend upon the nutrients found in these shallow water habitats. These habitats are critical to the existence of many threatened or endangered species.

Tidal and non-tidal marshes play an important role in reducing flooding during high tides and storms. The marsh vegetation dissipates wave energy and reduces the height that waves can reach, providing significant help in reducing flood damage during storms and high tides. Beaches also provide the same benefit of reducing wave energy and flooding.

4.6 Coastal Wetlands and Shallow Marine Habitats Carbon Sequestration

Coastal wetlands, including seagrasses, tidal marshes and mangroves, also sequester significant amounts of carbon, particularly in their soils. Yet, when these wetlands are warmed or their soils disturbed, they release the three major heat-trapping GHGs (carbon dioxide, methane, and nitrous oxide) they had stored back into the atmosphere. Fast growing shallow water vegetation takes CO_2 from the air to help create new plant growth (a form of CDR). As the plants die, much of the dead material, now mostly carbon in some form, is kept in the tidal marsh soils and becomes material for new plants to grow on. As long as this new material is submerged, the carbon cannot be oxidized and will not be released as atmospheric CO_2. Layer upon layer of carbon is “sequestered” or trapped in these shallow water habitat soils and vegetation, and the amount can be very substantial. This carbon sequestering effect by coastal shallow water habitat vegetation is also called “Blue Carbon”. Mangroves, tidal marshes, and kelp beds are particularly effective at carbon sequestration. However, if these habitats are disturbed and exposed to the air, the carbon can be oxidized and there is a release of GHGs that had been stored in the shallow water habitats back into the atmosphere. As mentioned above, over 60% of historic wetlands have been destroyed by development and agriculture, thus reintroducing substantial amounts of carbon and other greenhouse gases into the atmosphere.

Kelp forests are being seriously degraded by the commercial harvesting of the kelp which is used for several purposes including the extraction of algin, which is a thickening, stabilizing, and gelling agent. Kelp forests are also being depleted as a result of the action of predators such as sea urchins for whom kelp provide a very attractive food source. Historically, sea urchin populations were controlled by sea otters. The slaughter of west coast sea otters in prior centuries, combined with ocean warming and other disruptions, has resulted in a dramatic expansion of the sea urchin population and a catastrophic reduction of kelp forests.

4.7 Policy-Coastal Wetlands and Shallow Marine Habitats Carbon Dioxide Removal

1. The conservation and restoration of marine coastal wetland areas (such as salt marshes, seagrasses, and mangrove forests) should be a national priority for their role in CO_2 sequestration and in protecting the coasts, shorelines, and nearby areas from flooding during extreme storms such as hurricanes and torrential precipitation.
2. Seagrass meadows and mangrove and kelp forests should be managed, protected, and restored to help preserve coastal wetlands and shallow water habitats for their carbon sequestration potential and numerous co-benefits. This could be accomplished by establishing Marine Protected Areas for these habitats, ensuring that their soils are also managed.
3. To increase their role in carbon sequestration, the restoration and development of new kelp forests and seagrass beds should be encouraged (where appropriate) including increased marine permaculture of kelp forests and seaweed and seagrass beds in shallow and deep oceans areas. Funding sources for these efforts should be developed. (See Ocean Carbon Dioxide Removal Policy.)
4. Science-based best management practices for the control of populations of nuisance animal species that destroy seagrasses and/or kelp forests should be developed and implemented. These practices would help ensure that seagrasses and/or kelp forests are not further degraded or destroyed, and their carbon sequestration potential and shoreline protection services are allowed to recover. Such practices should take into consideration all of the consequences of altering the food chain, and should only be adopted if they are proven not to have negative impacts. In order to save kelp forests, sound science should be used to determine any additional food chain impacts associated with introducing sea otters or enhancing their vitality to address the overpopulation of sea urchins that destroy kelp forests and diminish their role in carbon sequestration.

Section 5- Ocean Carbon Dioxide Removal

5.1 Background

Oceans comprise 71% of the Earth's surface and 97% of the Earth's waters. The global ocean is a continuous body of water that is divided into four main sections: the Pacific, Atlantic, Indian, and Arctic Oceans. This policy addresses impacts of the climate crisis on oceans associated with the contiguous U.S., Alaska, Hawaii, Puerto Rico and U.S. Territories: the Pacific Ocean, the Atlantic Ocean (including the Gulf of Mexico), and the Arctic Ocean north of Alaska. It is within these particular ocean waters the U.S. and its coastal states have various levels of authority to address the climate crisis.

5.2 Climate Crisis Impacts in Ocean Areas

Because they are so vast, oceans absorb approximately a quarter of humanity's CO_2 emissions from the atmosphere and over 90% of the heat from global warming. This absorption, which may benefit people in the short term, results in serious negative effects such as ocean acidification (decrease in ocean waters' pH) and increased temperature of the waters. These processes degrade and destroy marine ecosystems, including coral reefs and animal and plant diversity.

Oceans are natural heat sinks for a warming climate. Therefore, oceans directly reduce the atmospheric temperature; but paradoxically, this warming of oceans reduces their capacity to absorb CO_2. A warmer ocean results in the following impacts on its environment:

A. Sea level rise due to thermal expansion;
B. Sea level rise due to melting of glaciers and ice sheets;
C. Oxygen depletion resulting in "dead zones" in the ocean where aquatic animals and microorganisms cannot survive;
D. Increased temperature stratification;
E. Increased breakdown of calcium carbonate found in shellfish exoskeletons and animal egg shells releasing carbon into the waters; and
F. Increased harmful algal blooms (HABs), such as red tides.

The proliferation of "dead zones," particularly in the Gulf of Mexico waters, is increasing. Most often, such zones result from the increased incidents of HABs. In these zones, plants, fish, other aquatic animals, and beneficial microorganisms cannot survive. Also, the HABs can produce toxins that may negatively impact human and animal health upon exposure. These zones, which originally supported healthy fisheries and robust aquatic biodiversity, are now barren.

5.3 Ocean Habitats, Marine Organisms, and Their Role in Earth's Carbon Cycles

5.3a <u>Ocean Habitats</u>

Ocean environments are divided into pelagic environment (open ocean), euphotic zone (surface layer of the ocean that supports photosynthesis), and the benthic environment (ocean floor). Ocean habitats are numerous and varying depending on the geographic location. These habitats include large quantities and varieties of plant life, microorganisms, fish, and other aquatic animals. Some contain thermal vents associated with areas of active continental plate tectonics. Also, some ocean waters are cooler and support ice sheet formation and floating icebergs. For the purposes of this policy document, only habitats currently known to have significant carbon sequestration properties will be discussed. Such habitats include:

A. Coral reefs and shellfish beds which are located in the benthic environment;
B. Phytoplankton which is found in the euphotic zone;
C. Kelp forests which are usually found in the benthic environment spanning into the euphotic zones; and

D. Seaweed beds which are found in the benthic environment.

5.4 Ocean Temperature Stratification and "Dead Zones"

Oceans are stratified based on temperature. The warmer waters are near the ocean surface and the cooler waters are located in much lower ocean areas. Ocean upwelling is the influx and mixing of the cool, nutrient rich waters from the depths of the ocean with surface layers. Ocean upwelling is decreasing during the climate crisis because of increased areas of warmer waters. These larger warm waters increase ocean temperature stratification, hinder ocean upwelling currents, and support the proliferation of "dead zones." Dead zones are marine areas where there is no oxygen. Plants, phytoplankton, and aquatic animals cannot live in dead zones. The additional accumulation of dead plants and animals further depletes marine oxygen stores in surrounding areas, resulting in the growth of these zones.

5.5 Shellfish, Corals and Other Marine Animals

Shellfish, corals, and many other aquatic organisms extract carbon and oxygen from the aquatic environment and combine those molecules with calcium to form calcium carbonate. Calcium carbonate is used to form the shells, other outer hard body parts of organisms, and the eggs of animals. Therefore, these structures can remove carbon from the aquatic environment. When those animals die or molt and their exoskeleton shells or egg shells are buried in the benthic environment, this carbon is stored there. Only when that sediment is disrupted would the carbon be released back into the water column and potentially into the atmosphere.

Many marine animals consume aquatic plants (such as kelp and other seaweeds) and release nutrients into the ecosystem. These nutrients in turn provide food for phytoplankton, kelp forests, coral reefs, and other seaweeds proliferation, resulting in significant carbon sequestration and enhanced biodiversity. The dead plants not consumed often decay on the ocean floor and become embedded into the sediment. This process sequesters carbon for centuries in the form of dissolved carbon and carbonates. Therefore, this system is essential for the continued sequestration of ocean carbon and the overall vitaliy of ocean life.

5.6 Kelp Forests and Seaweed Beds

Marine kelp forests may be able to facilitate the storage of carbon in the oceans more permanently than terrestrial-based plant carbon sequestration can. Also, because carbon molecules have to break through the ocean waters' surface tension to get into the atmosphere, oceans provide an additional barrier for this carbon to be released into the atmosphere. The carbon in kelp biomass can readily be transformed into dissolved organic carbon and/or particulate organic carbon, both of which can last in ocean waters and sediment for a very long time. Kelp forests support ocean upwelling which is necessary for the health and vitality of the ocean environment. Therefore, these forests are good candidates for more research regarding farming them in both shallow and deep ocean waters. Likewise, seaweed beds located in ocean areas can sequester carbon, provide support for increased ocean biodiversity, and are essential for overall ocean health.

5.7 Phytoplankton

Phytoplankton are self-feeding, aquatic microorganisms, including cyanobacteria, diatoms, dinoflagellates, green algae, and coccolithophores. They thrive in aquatic areas that have an abundance of sunlight and nutrients such as nitrogen and phosphorus. They are mostly hard-shelled creatures whose spent bodies settle to the ocean floor and create limestone, sequestering CO_2. They grow well in waters less than 300 feet in depth, not too acidic, and cooler. Marine water phytoplankton remove CO_2 from the atmosphere through photosynthesis like terrestrial-based plants. Animals also eat these organisms, eventually die, and decompose on the ocean floor where their carbon becomes stored in the sediment for millions of years. Agricultural runoff or abundant marine fertilization from urban and industrial areas can result in HABs, such as red tides, and exposure of humans and animals to the toxins they produce. The proliferation of particular (non-harmful) phytoplankton in deep ocean waters and their role of carbon sequestration makes this species a good candidate for further research to improve its growth and increase its marine cover.

5.8 Options for Addressing Ocean Carbon Dioxide Removal

5.8a Maritime Jurisdictional Boundaries

In order to develop policies addressing deep ocean habitats, it is important to understand basic maritime jurisdictional boundaries. Internal waters (baseline to three nautical miles - nm) are where a coastal state has full sovereignty. In the territorial seas (baseline to 12 nm), a coastal state has partial sovereignty, including the waters, airspace above the waters, the seabed, and subsoil beneath the waters. However, foreign vessels have the right of innocent passage through these waters subject to the laws of the coastal states within the framework of Laws of the Sea Convention. The contiguous zone (territorial sea to 24 nm) is where coastal states have jurisdictional authority to manage the marine resources associated within these areas and foreign vessels have the right of innocent passage through the waters. Lastly, the Exclusive Economic Zone (EEZ) (baseline to 200 nm) extends further out into the marine deep waters and its below water resource management, harvesting, and research opportunities are governed by a coastal state. In the past, the Sierra Club adopted policies governing the activities within the marine environment associated with specific jurisdictional boundaries (See Policy on Sustainable Marine Fisheries).

5.8b Marine Protected Areas

Marine protected areas (MPAs) come in a variety of forms and are established and managed by many types of governmental entities. In 2019, there were 1,628 MPAs covering more than 3.2 million kilometers or 26% of U.S. waters. NOAA keeps a record of all MPAs and some data associated with the management of MPAs in its National MPA Center. That inventory can be found at https://marineprotectedareas.noaa.gov/dataanalysis/mpainventory/

Some MPAs include: marine sanctuaries, estuarine research preserves, ocean parks, and marine wildlife preserves. MPAs may be established to protect aquatic ecosystems, preserve cultural resources and archaeological sites, or sustain fisheries production. They vary in scope, aquatic locations, and types of habitats. For example, MPAs could be established in coastal and ocean areas, inter-tidal zones, estuaries, or the Great Lakes region. Depending on the governmental entity that established the MPA and the reason they decided an MPA designation was warranted, the MPA could be restrictive of certain activities while allowing others. Currently, there are numerous MPAs that support seaweed beds, kelp forests, and algae growth.

5.9 Marine Permaculture

Permaculture has been defined as a set of design principles centered around whole system thinking simulating the patterns and resilient features observed in natural ecosystems. In this document, marine permaculture refers to the management of ocean resources in a manner that is modeled from natural marine ecosystems and allows for the natural sustainability of those habitats. Marine permaculture may be a suitable option to address the climate crisis by simulating the natural marine environment for the growth of kelp forests, seaweed beds, or phytoplankton proliferation. However, there may be some limitations with these options.

5.9a Potential Benefits of Marine Permaculture

A. Since coastal states have significant jurisdiction within the boundary of their waters out to about 200 nm, there is ample opportunity for states and other entities to conduct research in particular suitable ocean waters for the managed proliferation of kelp forests and increased stimulation of growth of colonies of phytoplankton.
B. The leasing of marine areas is feasible and industrial entities routinely acquire the authority to conduct business (such as sea food processing and offshore oil exploration and drilling) or research in leased areas. Such areas could be leased for kelp beds/forest planting and maintenance as well as seaweed beds.
C. The maintenance of particular ocean resources such as specific phytoplankton, seaweed beds, and kelp forests may increase the ocean's capacity to continue to sequester carbon and the overall health of these waters.

5.9b Potential Adverse Impacts of Marine Permaculture

A. Poorly managed ocean farming could have similar consequences as have occurred on land: broad-scale, cumulative decimation of pre-existing wildlife and natural ecosystems.
B. The maritime jurisdictional boundaries may require additional permit requirements than usual agricultural production on leased land.
C. Intimate knowledge of the particular ocean dynamics within the potential maritime leased area is required. This knowledge is also important in identifying appropriate ocean areas for the growth of seaweed beds, kelp forests, coral reefs, and phytoplankton.
D. Regarding phytoplankton, the proliferation of some algae, diatoms and/or dinoflagellates can result in HABs that may negatively impact human and animal health upon exposure or ingestion.

E. Because the waters beyond the EEZ zone are under various international treaties addressing ocean dumping, only flag ships of the signatory nations are subject to such regulations. Since ocean fertilization is regulated via international ocean dumping treaties in waters beyond the EEZ, these waters may be more susceptible to unmanaged ocean fertilization. Nations could perform ocean fertilization without violating the treaties by allowing flag ships of non-signatory nations to perform the dumping of the marine fertilizer (i.e. iron dust) in the EEZ.

5.10 Ocean Fertilization

Ocean fertilization is the dumping of iron minerals into vast areas of the ocean stimulating phytoplankton growth resulting in algae blooms. These blooms can sequester significant amounts of CO_2 from the atmosphere. While ocean fertilization such as spreading iron minerals into the ocean could be pitched as benign augmented natural photosynthesis, it also poses unacceptable risks to the global commons. The blooms of ocean plant life from this fertilization could possibly wreak havoc with the food chain and ocean ecosystems. The waters involved are largely international and so again it poses major governance issues where one country might wish to radically change the ecosystem while other countries might object. The amount of ocean area required to be treated with the iron minerals in order for the stimulation to be effective for CDR is projected to be vast. Also, there is a critical balance of the amount of treatment required to be effective for CDR verses overstimulation of phytoplankton growth resulting in HABs or the proliferation of "dead zones."

5.11 Policy-Ocean Carbon Dioxide Removal

1. Governments of coastal states should encourage and support research on conditions of ocean waters to support efficient carbon sequestration, including factors such as temperature stratification, nutrient content, upwelling potential, and overall health of the various ocean areas and habitats (including coral reefs, shellfish, seaweed beds, kelp forests, and abundance of phytoplankton). The federal government should provide the necessary support for this information to be collected and disseminated.
2. In order to maintain and in some cases enhance their carbon sequestration potential during the climate crisis, kelp forests and seaweed beds should be restored and protected. Where appropriate, the planting of new seaweed beds and kelp forests using permaculture techniques should be encouraged.
3. Conditions supporting particular phytoplankton proliferation in appropriate marine areas during the climate crisis should be enhanced. For example, in areas where science has indicated that permaculture techniques to enhance the proliferation of phytoplankton are suitable, such techniques should be supported. Where additional research is required, particularly addressing potential HAB proliferation and other negative impacts on human and animal health (upon exposure or ingestion of the specific diatoms and/or dinoflagellates), such research should be conducted. All agencies (domestic and international) should support and guide these efforts. Where the findings of such research suggests that the enhancement of areas of the ocean that would support the proliferation of such species of diatoms and/or dinoflagellates which may negatively impact human and animal health, the Sierra Club's national policy on the Precautionary Principle, which states that "lack of full scientific certainty

shall not be used as a reason for postponing measures to prevent environmental degradation," should be enforced.

4. The establishment of MPAs to enhance ocean carbon sequestration during the climate crisis should be considered and supported by coastal states. There are many regions that have established MPAs for habitat protection associated with seaweed beds, kelp forests, algae proliferation, and other marine life. Additional restrictions for further protections of these habitats based on their carbon sequestration potential should be required.
5. Since ocean fertilization has many uncertainties associated with its application on the health of the marine environment and until those uncertainties have been addressed, the Sierra Club should implement the Precautionary Principle (which states that "lack of full scientific certainty shall not be used as a reason for postponing measures to prevent environmental degradation") when addressing ocean fertilization practices during the climate crisis.
6. Ocean fertilization is presently banned and we believe it should continue to be banned, as there are many other CDR options that do not pose such huge risks to the global commons.

Section 6- Technology-Based CDR Policy

Technology 1- Bioenergy with Carbon Capture and Storage (BECCS)

1.1 Background

Bioenergy with carbon capture and storage (BECCS) is the process of capturing CO_2 emissions from the generation of electricity from the combustion or pyrolysis (partial combustion) of biomass or biofuels, and storing that carbon in a form that keeps it out of the atmosphere in the long-term. The 2018 Intergovernmental Panel on Climate Change (IPCC) Special Report on Global Warming of 1.5°C advocates for expanded implementation of BECCS as a carbon dioxide removal measure, and many emissions scenarios rely heavily on BECCS to offset continued emissions from fossil fuels. However, there are only a handful of BECCS projects currently in operation.

Biomass energy can be generated from the combustion of any organic carbon source, but logging and mill residues, agricultural residues, and municipal waste are the most common feedstocks. The Sierra Club opposes relying on logging or the use of municipal waste to produce biomass energy (see Biomass Guidance and Energy Resources Policy. In BECCS, the CO_2 emissions from the combustion are captured at the smokestack, compressed, and injected into underground geologic formations for long-term storage. The most widely used method is to use the captured CO_2 in enhanced oil recovery (EOR), in which pressurized CO_2 is injected into oil-bearing formations to facilitate crude oil extraction, which we oppose. As with bioenergy more generally, the net carbon emissions differ by source and process, and a full and accurate carbon lifecycle accounting of the inputs and outputs is necessary to determine the climate impacts. Some potential feedstocks that are currently disposed of in landfills or open burning--such as municipal waste and agricultural residues--may be treated as waste that would otherwise result in greenhouse gas (GHG) emissions, as can logging and mill residues in some situations. Using these feedstocks for bioenergy production may reduce carbon emissions, assuming that there are no alternative end uses that have superior carbon outcomes, such as wood products or composting, and assuming that the biomass use does not increase the extent or intensity of forest fuel removal. Feedstocks like trees and other vegetation extracted through commercial logging and biomass harvest are often associated with substantial carbon emissions and the loss of forest carbon stores. Dedicated feedstocks that increase logging and displace forests or other wildlands can have substantial carbon emissions and reduce existing carbon stores.

1.1a **Potential Benefits of BECCS**

It is estimated that BECCS could theoretically provide CO_2 emissions reductions on the scale of 3.5–5.2 Gigatons of CO_2 per year worldwide, taking into account displacement of fossil fuel combustion. The geologic sequestration of carbon captured in BECCS is supposed to be virtually permanent. BECCS is less expensive and more ready for large-scale deployment than some technology-based CDR methods such as Direct Carbon Capture.

1.1b **Potential Adverse Impacts of BECCS**

Compared to afforestation and reforestation, BECCS offers few environmental co-benefits and is not ready for deployment at the same scale. It may also encourage unsustainable logging and forest degradation. BECCS relies heavily on financial incentives and subsidies that may divert funding from other CDR alternatives and renewable energy programs. Another downside to BECCS is that it can serve to delay the transition away from fossil fuel energy, either as a substitute fuel that fits into the existing fossil fuel production and distribution system, or as part of a public relations effort to protect fossil fuel companies from tighter climate regulation.

For BECCS projects based on agricultural feedstocks, there is a high probability that biomass production would displace food stocks, potentially exacerbating food insecurity. This would add pressure to convert remaining wildlife habitats into sources of game, farms, and grazing areas--further diminishing natural carbon sinks. Also, global biomass production at the scale of 3-5 Gt per year would likely involve unacceptable justice and equity impacts, such as the displacement of forest communities and the separation of populations from their lands or food sources. Depending on the particular feedstock, process, and storage, a BECCS project may be a net carbon source, rather than a sink.

All underground injection operations, including those used in geologic storage of CO_2, can cause serious disturbance to nearby residences and risk leaking toxic chemicals into the air or surface; they also risk causing oil and gas to leak to the surface or into underground drinking water aquifers and can induce seismic activity.

1.2 Policy-BECCS

The Sierra Club's position on BECCS is guarded, particularly projects involving forest-sourced woody biomass or crop feedstocks that displace food agriculture or natural ecosystems. Current Sierra Club policy on forest biomass states that bioenergy projects must incorporate the right technology, at the right scale, and in the right locations (see Sierra Club Guidelines for Activists Engaging in Proposals for Forest Biomass Energy Plants Sourcing Biomass from Public Lands).These criteria similarly apply to BECCS.

The Sierra Club supports research into promising BECCS technologies--including pyrolysis--that may be developed to scale. However, the Sierra Club opposes projects that involve the construction or continuation of facilities that exacerbate poor air quality conditions or result in hazardous waste in or near vulnerable communities.

As with bioenergy more generally, the carbon implications differ by feedstock source and site, and an accurate accounting of the full lifecycle carbon implications—including the carbon dynamics involved in the production of the feedstock—is necessary to determine the climate impacts.

1. BECCS projects must not use feedstocks derived from sources that involve the conversion of intact ecosystems or forest degradation.
2. BECCS projects must account for the full lifecycle emissions of their products, and must demonstrate that a project has a net negative carbon emissions, accounting for impacts to in-forest carbon stores and future sequestration, including impacts to sequestration and storage capacity due to nutrient removal and logging-caused soil damage.
3. BECCS projects must demonstrate that biomass feedstocks characterized as waste or residues—and where the energy costs of production are therefore assumed to be low or zero—would have been generated in the absence of the biomass project, and would have otherwise been burned or disposed in a landfill.
4. BECCS projects must not undermine efforts to direct feedstocks to alternative end uses that have superior ecosystem benefits and lower carbon profiles. BECCS projects should not utilize funds that would otherwise be used to support other more environmentally or socially beneficial CDR alternatives and renewable energy programs.
5. All industrial processes associated with BECCS projects must comply with the Sierra Club Environmental Justice Policy, and must control for air pollutants and toxic materials. (see Sierra Club Environmental Justice Policy, Adopted Board of Directors - September 18-19, 1993)
6. The Sierra Club opposes BECCS projects that involve enhanced oil recovery (where CO_2 is injected into oil-bearing formations to aid crude extraction), involve injection operations near communities, or are used to extend the life or financial viability of fossil fuel facilities.
7. Local zoning and permitting processes for BECCS projects should be supported, advocating for full consideration of the projects' environmental and community impacts.

Technology 2- Biochar

2.1 Background

Biochar is charcoal produced by heating biomass (organic matter) in conditions with low oxygen concentration (pyrolysis), then placing the charcoal on or in soils to create long term carbon storage, as well as to enhance soil fertility, biological growth, and moisture-holding abilities. Soil organic carbon content influences crop productivity and soil functions. Biochar is high in organic carbon and mass soil enrichment. Biochar has been shown to be effective at enhancing and restoring soil fertility. However, its role in reducing atmospheric greenhouse gas has not been well demonstrated beyond research settings.

Changing land use or soil management strategies can affect the ability of soils to sequester or release carbon. Traditionally, most agricultural and forest practices have resulted in decreasing the amount of carbon that soil can hold, and a release of existing soil carbon to the atmosphere. Research indicates that applying biochar can yield a wide range of potential net carbon sequestration rates. Typically, less than 1 Gt (Gigaton) of CO_2 equivalents (methane, nitrous oxide, etc.) in annual sequestration is feasible globally today--about 0.1 Gt in the U.S.--using biochar created from agricultural and logging waste material, without endangering food security, habitat or soil conservation. The potential net carbon benefit is two to five times greater if the biochar production is paired with bioenergy production as a BECCS project, with the energy generated in the pyrolysis process counted as avoided emissions from fossil fuel combustion.

2.1a <u>Potential Benefits of Biochar</u>

Managing soil carbon to prevent carbon loss and enhance future carbon sequestration can enhance ecosystem health and ecosystem services. Biochar can increase soil fertility and moisture-holding ability; can increase plant health; does not increase the use of land, water, or energy; and is relatively low-cost. Many of the herbicides and pesticides used in agriculture today can be trapped by the chemical and physical properties of biochar carbon amendments and immobilized in the soil for extended periods of time, and biochar can be effective at remediating other toxic materials and heavy metals. Biochar can theoretically remain stable in soils for 100 to 1,000 years.

2.1b <u>Potential Adverse Impacts of Biochar</u>

Redirecting organic waste to biochar production and away from alternative uses is not necessarily the best outcome with respect to carbon or other ecological and social benefits. Emissions from the pyrolysis process can reduce the climate benefits of biochar and increase air pollution. The permanence of biochar carbon sequestration is not guaranteed if soil moisture is reduced due to increased warming, agriculture practice changes, drought, or if warming reaches a level where soil respiration reverses. The carbon benefit of biochar is reduced if it is produced with agricultural waste that would otherwise have been left in the field, because some of that carbon would have naturally returned to the soil. Removing organic waste from agricultural fields can also reduce soil nutrients and the ability to conserve moisture, and drier soils increase respiration of carbon into the atmosphere. Growing dedicated crops or trees on agricultural lands for energy production or biochar may impact food production and land use. Removal of trees or branches from forests for biochar may decrease the forest's carbon sequestration and storage capacity by removing vital nutrients and compacting soil with ground-based logging machinery.

2.2 Policy-Biochar

The Sierra Club's position on biochar is guarded. The soil fertility benefits of biochar amendment are fairly well developed, but significant research is necessary to determine the net carbon benefits of biochar practices and the benefits of other uses for agricultural and logging waste. Further study is needed to determine the ecological impacts of application to natural ecosystems and the best practices for application.

2.2a Where biochar use could be beneficial

1. Biochar application must be done in established agricultural settings, not in intact and healthy ecosystems with intact soils.
2. Where biochar application is proposed, there should be thorough consideration of the environmental and community impacts.
3. Use of biochar in agricultural settings should ensure adherence to Sierra Club Environmental Justice Policy.

2.2b Biochar production methods

1. Unless biochar production directly incorporates carbon capture technology to recycle gaseous carbon generated in the pyrolysis process, the process is a net carbon emitter and cannot be considered a potential CDR measure. Biochar production must include the best available control technology and ensure that the process does not result in air pollution.
2. Biochar must contain no contaminants like heavy metals and antibiotics from human and animal waste.
3. The net carbon impacts of biochar must be determined by a full lifecycle accounting, and biochar should be considered only when it has greater carbon benefits than other available alternative uses for the organic feedstock.

2.2c Biochar Feedstocks

1. Natural forests must not be harvested for biochar feedstock; large, commercial trees should not be used for biochar feedstock.
2. The sourcing of biochar feedstock must not result in the depletion of nutrients from soils and natural ecosystems.
3. Biochar production must not use municipal solid waste as a feedstock (See Energy Resources Policy).

Technology 3- Direct Air Capture and Carbon Sequestration (DACCS)

3.1 Background

Atmospheric carbon dioxide removal (CDR) of up to 12.5 Gigatons per year (1,000 Gt by 2100) is needed to meet the Intergovernmental Panel on Climate Change (IPCC) 1.5 °C target and to also achieve net zero emissions by 2050. (IPCC 1.5°C, Chapter 2, figure 2.13.c) It is important to note that with the Sierra Club's target of 350 ppm CO_2 and 1°C by 2100, more CDR will be required. Numerous findings show that additional natural CDR of 2.75 to 10 Gt CO_2 per year is plausible when considering environmental justice issues, mostly with terrestrial mechanisms (IPCC.ch, Earth Systems, NAP.edu, Drawdown, Paris Climate Goals and Negative Emissions), leaving about 3 to 10 Gt needed CDR remaining from industrial or other means. Of the industrial CDR options, DACCS pilot projects look very promising and the projected costs are dropping substantially.

Air capture of carbon dioxide is not new. Cryogenics began separating air gases in the 1930s. The potash/lye process was used in submarines in World War II to keep our sailors safe from carbon dioxide poisoning. In the 1950s, one of the most abundant and important industrial chemical groups in the world, amines, were developed that are now at the forefront of capturing carbon dioxide from air.

Once CO_2 is removed from the atmosphere, it must be safely stored for at least 100 years, with the aim for permanent storage. This can be accomplished through high pressure underground injection in saline or depleted oil formations, in coal beds, or in other suitable geologic formations such as ultramafic and basaltic rocks. Or captured CO_2 can be stored above ground in the form of permanent mineralization (explained below) or converted into permanent materials used in manufacturing, industrial processes, or for permanent storage. Over 230 Mt of CO_2 has been safely injected underground since 1972. Further development and new research are expected to increase efficiency and scaling needed to address the gigatons of removal needed. Marine CO_2 sequestration is not considered here, but offers opportunity and further research is needed.

Carbon leakage from sequestration in underground formations that are not geologically suitable can plausibly create 25 Gt CO_2 of additional emissions throughout the twenty-first century. Net sequestration accounting is imperative.

Above ground mineralization consists of processes that allow above ground permanent stockpiling of stable carbonate minerals, or other stable carbon materials or compounds. Use and permanent sequestration of CO_2 in commercial and industrial products includes building materials where breakdown and degradation does not change the stable character of the vast majority of carbon stored.

Injection of CO_2 in oil fields for enhanced oil recovery (EOR) has been ongoing for decades with significant amounts of CO_2 stored. However, the Sierra Club opposes continued reliance on oil and gas as fuels, so we oppose subsidies and tax breaks for EOR even if it sequesters the CO_2. Existing uses of air captured CO_2 as industrial feedstocks include fertilizers, soda ash, concrete products, and carbonated beverages.

Sequestration is not a completely known science. In many areas it is well known, but nascent in others. Almost all sequestration knowledge is advancing very rapidly.

3.1a Potential Benefits of DACCS

The potential benefits of DACCS include very low land use for the process facilities themselves, moderate to low water use, few waste hazards, off the shelf components, widespread storage locations with high known capacity, the relative permanence of geologic sequestration compared with natural systems sequestration, and very high scaling capacity with what are today moderate costs that will very likely continue to fall with process enhancements and scaling.

3.1b Potential Adverse Impacts of DACCS

The most significant negative is the moral hazard, the risk that DACCS will give climate polluters free license to emit GHGs. DACCS technology comes with a relatively steep energy input requirement to run the equipment and costs are substantial. If the energy is supplied by fossil fuel, that reduces the CDR benefits and poses other land disturbance and pollution issues. If the energy is provided by renewable energy, that comes at a land disturbance cost and also increases the amount of renewable energy needed to be deployed. There are siting constraints given the need to place DACCS facilities close to geologic formations that can permanently sequester the CO_2. If they are not close by them, major pipeline infrastructure will be required. There is also the concern about potential leakage and liability associated with geologic sequestration. The high cost of CDR by this technology is an impediment, but costs appear to be dropping dramatically. Costs are down from $600 to $1,000 per ton CO_2 removed in 2011 to around $100 per ton in 2018 based on pilot projects.

3.2 Policy-DACCS

Direct Air Capture should only be considered in parallel with the most aggressive accepted decarbonization policy.

1. Any new or supplemental power required for a DACCS facility should only come from clean, renewable energy.
2. All DACCS must ensure adherence to Sierra Club Environmental Justice Policy.
3. Water requirements and energy generation requirements need strict evaluation to site facilities where water use and land needed for energy generation will not result in environmental justice issues or adverse environmental impacts.
4. Net sequestration must be proved and must include complete lifecycle energy use and greenhouse gas emissions.
5. Utilization as an industrial resource is appropriate if use meets the net sequestration test above.

6. Permanent sequestration should be defined as per California Low Carbon Fuel Standard (LCFS) of 100 years or more. Sequestration permanence certification should be required.
7. Above ground stockpiling of mineralized CO_2 should be done only with stable carbonate minerals or other materials that can be demonstrated stable for 100 years. Permanent sequestration products include carbon that is in the form of rocks or other low energy and stable material, such as concrete.
8. DACCS technologies are not new. Implementation of capture and sequestration at the megaton scale is needed to reduce costs and better understand sequestration strategies and risks.
9. The Sierra Club opposes DACCS projects that involve enhanced oil recovery (where CO_2 is injected into oil-bearing formations to aid crude extraction), involve injection operations near communities, or are used to extend the life or financial viability of fossil fuel facilities.

Technology 4- Enhanced Mineralization: Terrestrial and Marine

4.1 Background

Enhanced mineralization (or enhanced weatherization) involves accelerating the natural processes by which various minerals absorb CO_2 from the atmosphere. It involves mining, crushing, and spreading on land or in the oceans specific kinds of carbonate rocks and minerals, or injecting CO_2 into the ground. Enhanced mineralization generally remains at the very early stages of research and development, but the long-term potential for atmospheric CDR may be quite significant.

In surface land application, silicate rocks such as olivine or basalt would be used. The crushed rock reacts with the air to form carbonate minerals. The carbonates either remain stationary and become a part of terrestrial geology, or find their way into streams, rivers and oceans, eventually becoming calcium carbonate on the ocean floor. Carbon mineralization takes advantage of the fact that CO_2 reacts spontaneously with mineral-containing rocks, and it eventually becomes part of the rocks. Minerals such as calcium and magnesium bind with carbon in the air to form such rocks as calcite, magnesite, and dolomite. Some industrial strategies use heat to speed the chemical reaction that binds CO_2 permanently.

Underground injection has been happening with enhanced oil recovery (EOR) for generations. Though the Sierra Club does not support EOR, the technology is mature and can be used in saline aquifer injection where CO_2 chemical binds permanently with minerals.

Ocean alkalinization (liming) involves spreading crushed alkaline rocks, such as limestone, over the ocean where they would absorb CO_2. It may be possible to sequester hundreds of billions to trillions of tons of CO_2 without surpassing post-industrial average carbonate saturation states in the surface ocean. A 2015 expert assessment estimates that enhanced mineralization could be scaled up to capture 2–4 billion metric tons of CO_2 ($GtCO_2$) per year by 2050, with rates of more than 20 $GtCO_2$ per year theoretically possible by 2100, with another 1–27 $GtCO_2$ per year possible through ocean alkalinization. Estimates of the cumulative potential in this century range from 100 $GtCO_2$ to 367 $GtCO_2$, with even more possible through ocean alkalinization. Cost estimates vary widely, from less than $50 per ton of CO_2 sequestered to more than $200 per ton.

4.1a Potential Benefits of Enhanced Mineralization

In addition to the CDR being increased by the land application, minerals released in the process could also enhance soil fertility. Spreading powdered rocks on agricultural lands could reduce the demand for polluting fertilizers and increase productivity. It could also help neutralize acidic soils and provide protection against pests and diseases. The ocean application offers the added benefit of directly counteracting ocean acidification by increasing the pH of seawater, thereby helping address ocean and coral reef acidification.

4.1b Potential Adverse Impacts of Enhanced Mineralization

One problem is that at large scales the mining impacts are large, too. Sequestering 11 gigatons of CO_2, which is about 30 percent of fossil fuel emissions, would require 16 billion tons of rocks being mined, powdered and shipped per year, a bit more than twice the 2018 output of the coal industry. Mining, crushing, and shipping the rocks has very significant potential environmental and justice impacts. There is a potential for air and water pollution from toxic elements in the rock that are released. Ocean liming could change the biochemical cycles and release toxic minerals. These pose wildlife and environmental justice concerns.

4.2 Policy -Enhanced Mineralization

1. The Sierra Club supports continued research and development of enhanced mineralization for CDR in limited and carefully monitored terrestrial and marine applications.
2. Approval of large scale deployment should be on a case-by-case basis, looking at the local environmental and justice impacts of the mineral mining, crushing and transportation, and weighing those concerns against the benefits. Similarly, the impacts on the land and oceans where the minerals are applied need to be addressed.
3. Application of this technology should be restricted to developed, degraded and carbon depleted lands, particularly farmlands that already have a road structure. It should not be used to treat intact natural areas.
4. Potential air and water pollution from toxic elements in the rock should be monitored and mitigated or eliminated.

Topic III-Geoengineering Policy

Section 1- Introduction

1.1 Background

Geoengineering for the purposes of this policy refers to technological interventions in the global commons to reduce global warming. Included in this policy are Solar Radiation Management (SRM) and Large Scale Albedo Enhancement. Some literature treats all carbon dioxide removal (CDR) approaches as geoengineering. In this policy we categorize CDR separately from geoengineering. Geoengineering does not directly reduce atmospheric CO_2 concentrations, so it does not solve the underlying problem; it merely masks the impacts of high atmospheric greenhouse gas (GHG) levels temporarily and must be continually deployed in perpetuity, a costly and uncertain gamble.

Geoengineering is of particular concern because of its potential wide scale international impacts. A country or other entity seeking to protect itself from the climate crisis could potentially deploy a geoengineering technology that could have unforeseen negative consequences on another country, ocean currents, or entire ecosystems. For this reason, it is essential that international governance mechanisms with full representation by all nations be put in place before any geoengineering technologies are attempted in the global commons.

It is prudent to conduct research on geoengineering in case it is required as a desperate last resort emergency cooling strategy to head off climate catastrophe, but it is the Sierra Club's view that these technologies as currently understood have significant unknowns and are fraught with peril and potentially disastrous consequences. The Precautionary Principle (which states that "lack of full scientific certainty shall not be used as a reason for postponing measures to prevent environmental degradation") leads us to hold them in reserve rather than risk early experimental deployment.

1.2 Policy - Geoengineering (General)

1. Emergency cooling is the idea of using geoengineering solutions in the future as a last resort, to temporarily cool the planet if CDR efforts and emissions reductions have not averted dangerous temperature increases. The Sierra Club supports continued research into geoengineering regulated by international governance, which includes full representation of Indigenous communities and front line communities, in case emergency cooling is determined to be necessary by international consensus climate science.

Technology 1- Solar Radiation Management

Solar Radiation Management (SRM) is a type of geoengineering that reflects sunlight back into space to prevent or reduce global warming. (The National Academies of Science Engineering and Medicine published a thorough report on the topic http://dels.nas.edu/Report/Climate-Intervention-Reflecting-Sunlight-Cool/18988.) Generally, these strategies use reflective materials, aerosols, or cloud-creating condensation nuclei to create increased sunlight reflectivity. They are based on nascent science, are untried in real-world applications, and are highly controversial because of perceived and possible dramatic negative side effects. SRM proponents have suggested it could even be used to change ocean currents around Antarctica or restore monsoon rains.

Very little SRM research has been done, especially at the large scale. Most work has been done with modeling and volcanic eruptions studies. Studies of past major volcanic eruptions have demonstrated the temporary dramatic global cooling temperature effect of SRM, but also revealed its negative consequences.

1.1 Stratospheric Aerosol Injection

The basic SRM concept is to reflect incoming sunlight so as to reduce Earth's temperature. It can be done most efficiently in the stratosphere where one proposed technology is called Stratospheric Aerosol Injection (SAI). (Low altitude injection is considered much less effective than stratospheric or near stratospheric injection.) SAI can be done with sulfur additions in jet fuel burned in high altitude jet flight paths or a combination of the above with large tanks of materials to be sprayed or burned to create aerosols or aerosol precursors. SAI can also be deployed from mountain tops, or piped to high altitude tethered balloon platforms. The aerosols created would be of the class "bright aerosols", meaning they would reflect light, not absorb it like dark aerosols (ash). Two major forms of aerosol injection are suggested, sulfate and calcite (calcium carbonate). Stratospheric sulfate injection is what happens when volcanoes erupt sulfur into the stratosphere. Precipitation acidification is a perceived threat from SAI with sulfate, but that threat is unlikely because of the very low concentrations of sulfate needed in stratospheric cooling.

SRM could also involve deploying materials to reflect sunlight in space before it reaches the Earth. Diamond dust in space, or some bright reflective dust-like material, or large unfoldable reflectors have also been hypothesized. These are serious thought experiments, but far too undeveloped at this time to be evaluated.

1.1a Potential Benefits

SAI has projected low costs and can either be implemented with current jet industry transportation or modified jet trajectories closer to the stratosphere, or purpose specific air flight with modified planes flying at very high altitudes. SAI’s warming reduction could reduce natural CO_2 emissions caused by warming feedbacks (for example from melting permafrost) and reduce the need for greater energy use on a warmer planet to cool humans and processes. Using calcite for SAI encourages the formation of stratospheric ozone. These strategies could be implemented very quickly and have immediate effects. Because the aerosols only stay in the atmosphere for 2 to 4 years at the very most, their effects could also be "turned off" if found to be negative.

1.1b Potential Adverse Impacts

There are global, potentially substantial environmental justice issues with SAI, largely because of unknowns in implementation effects due to little research. One country could decide to deploy or cease deploying SAI to benefit itself while the negative consequences are borne by another country with no say in the matter. SAI with sulfur decreases stratospheric ozone. It is possible that SAI could negatively impact global weather patterns, leading to widespread disruption of monsoons, flooding, or drought with negative impacts on human communities, the food supply and natural ecosystems. In addition, when SAI is discontinued the global temperatures would rise abruptly, corresponding to existing greenhouse gas concentrations. The short-lived nature of SAI is also a negative aspect in that repeat and continuous applications are needed to sustain cooling.

1.2 Policy-Stratospheric Aerosol Injection

1. The potential negative widespread consequences of SAI are too risky and the Sierra Club opposes its deployment in the global commons at this time. Research and development of these technologies should be tightly controlled and within closed laboratories. The Sierra Club's national policy on the Precautionary Principle, which states that "lack of full scientific certainty shall not be used as a reason for postponing measures to prevent environmental degradation" should apply to SAI research and development in the open environment until it is proven to be safe.
2. There must be a democratic international governance structure put in place that fully represents all potentially impacted countries before any atmospheric testing or deployment of SAI is allowed.

Technology 2- Large-scale Albedo Enhancement On or Near the Earth's Surface

Large-scale albedo modification includes a variety of proposals to cool the Earth by increasing the albedo (solar reflectivity) of land, sea surfaces or clouds to reduce the absorption of solar energy. Like stratospheric- or space-based Solar Radiation Modification, these albedo proposals are geoengineering because they seek to reduce global warming through physical changes to the Earth rather than through drawing down greenhouse gases.

Large-scale albedo modification is a potentially huge problem. Small-scale albedo modification of the human built environment, such as painting or requiring that rooftops, roadways, parking lots, etc. be light- rather than dark-colored, is a positive public policy. White rooftops can reduce the temperature in urban areas, reduce air conditioning demand,

and save energy, thereby reducing emissions, but white roofs do little to influence global temperature increases. However, albedo modification at the scale necessary to influence global radiation levels has potentially huge negative impacts to the natural environment and global climate systems.

Cost estimates for large scale albedo modification range from very high for Arctic sea ice pumping and surface brightening with various materials, to relatively low for marine cloud brightening and condensation trail reduction. However, actual implementation costs are not yet well known because these ideas are still conceptual.

2.1 Examples of Recent Albedo Modification Proposals

2.1a Marine Cloud Brightening

Marine Cloud Brightening (MCB) involves adding iron salts, or other particles that act as condensation nuclei (the tiny particles around which clouds form), to low-lying marine clouds to make them whiter and increase their reflectivity. This can be done by spraying sea water into the near-surface marine atmosphere, or burning condensation nuclei generating additives in ship's fuel which is then discharged through its smokestack. While this technology might be relatively inexpensive compared with other geoengineering approaches, it carries the same risks of unpredictable weather impacts in and beyond the region of implementation. It also needs to be carried out continuously to maintain the cooling benefit.

MCB is also relatively low cost, fairly easy to deploy, poses fewer risks than SAI, and would not last very long if discontinued. MCB could also plausibly draw down some CO_2 through ocean fertility enhancement if the MCB uses iron salts. Because MCB strategies would be deployed at relatively low altitudes, the effects would tend to diminish before they travel far and therefore may raise fewer global environmental justice concerns than SAI. However, local negative impacts are possible. Iron salts could have other negative consequences related to fertilization of the marine environment. Depending on the size of the particles, there is a potential that marine cloud brightening could actually increase temperatures rather than reduce them, so carefully monitored research is needed before large scale deployment.

2.1b High Albedo Crops

High albedo crops involve replacing low albedo crop plants with plants with higher reflectivity. Switching from beans to corn (for example) on a small scale may not be significant, but changes in crop distributions and proportions at the scale necessary to affect global temperatures would have huge implications for the global food supply. Genetically engineering existing crop plants to create more reflective varieties carries all the concerns associated with other genetic engineering of our food supply--nutritional content of the plants, their photosynthetic capacity, soil impacts, and escape of genetic modifications. Converting non-agricultural land to high-albedo crops at a large scale raises concerns of land-use change, loss of natural systems and habitat, and expansion of industrial agriculture, with the associated problems of soil erosion and heavy use of agrochemicals.

2.1c Desert Covering

Desert covering is a scheme to cover a significant portion of the world's deserts with white, polyethylene film to reflect sunlight and lower surface temperatures. This film would destroy the underlying native desert ecosystem and habitat, and likely release CO_2 stored in plants and soils. Cooler desert temperatures could also bring unexpected changes to weather patterns in other regions.

2.1d Ice Covering

Ice covering, like desert covering, would involve a coating – perhaps a nanotech film or small silica beads – applied to polar ice to insulate rapidly melting snowpack and glaciers. There could be significant negative impacts to native species and the environmental impact of the covering material itself. There are also proposals to pump seawater up onto polar ice shelves or Arctic sea ice to increase albedo, create or thicken sea ice, and reduce the risk of polar amplification -- the phenomenon that any change in the net radiation balance tends to produce a larger change in temperature near the poles than the planetary average. Polar ice melting is a huge problem that is accelerating. Even though this option poses risks and would be expensive, if emergency cooling is needed, risks from geoengineering may be less than risks of unabated warming.

2.1e Mountain Top Painting

Mountain top painting is one of the most absurd large-scale albedo modifications proposed. In 2010, the World Bank awarded a small research grant to the winner of a "100 Ideas to Save the Planet" competition so that he could paint a Peruvian mountaintop white to simulate the lost glaciers and snowfields. Mountaintop rocks were painted with a lime, water and sand mixture and it did reduce the surface temperatures, as expected. But painting mountaintops at larger scales would negatively affect fragile mountain ecosystems, flora and fauna. It would also require a vast amount of paint, the production and transport of which has its own carbon footprint.

2.1f Snow Forest Clearance

Snow forest clearance is a proposal to clear the planet's remaining areas of boreal forest (largely in Russia and Canada) to remove the low albedo conifers and replace them with the high albedo of snow on open ground. Studies by the Yale School of Forestry, with partial funding from the U.S. Department of Energy, indicated at least local cooling effects. The creation of "white deserts" could destroy Subarctic ecosystem productivity, affecting the caribou, migrating birds and other fauna, as well as the plants and people that depend on them. Eliminating boreal forests would negatively affect the regulation of regional and local climates. Carbon contained in these forests would also be lost; as well as future carbon sequestration of the growing trees. Removed trees would need to be continually removed or the regrowth would eliminate the albedo effect.

2.2 Policy-Large-Scale Albedo Modification

1. As with SRM in the stratosphere, large-scale albedo modification is geoengineering and is opposed by the Sierra Club except for research into emergency cooling, where field-testing is closely constrained and includes international governance. While plausibly providing emergency cooling, such proposals and other similar ones generally do not address the underlying problems of eliminating carbon emissions and drawing down excess CO_2 emissions from the atmosphere. They include known and unknown risks of large adverse impacts on the natural environment, uncertainties associated with impacts to the hydrologic, carbon, and other biogeochemical cycles, and positive warming feedbacks. None should be allowed to proceed without first putting in place a robust global governance structure with all parties represented, including Indigenous people and frontline communities, so that the full costs and benefits can be weighed, so a single party or government does not deploy the technology unilaterally, and justice considerations can be addressed.

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