North Fork Forest Recovery Project

Carbon Effects Report

Prepared By:

Daniel Baldassare, PhD

Prepared For:

Sierra Institute for Community and Environment,

Plumas National Forest

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Contents

1.0 Overview

1.1 Introduction and Consistency with Relevant Laws, Regulations, and Policy

On January 9th, 2023, the Council on Environmental Quality (CEQ, 2023) published the *National Environmental Policy Act (NEPA) Guidance on Consideration of Greenhouse Gas (GHG) Emissions and Climate Change*. The CEQ guidance applies to Environmental Assessments (EA) and Environmental Impact Statements (EIS) scoped January 10, 2023 or later. It provides numerous recommendations to agencies, including that agencies: 1) consider the projected GHG emissions or reductions for proposed actions and their reasonable alternatives (Section IV); 2) use this information to assess potential climate change effects (Section V); 3) assess the potential future state of the affected environment in NEPA analyses (Section VI); and 4) consider the impacts of climate change on project actions and alternatives. For more information on incorporating climate change into NEPA Environmental Analysis, see Brandt and Schultz (2006).

The CEQ guidance recommends the use of high-quality, science-based, and accessible information and tools to guide these analyses. However, the guidance advises agencies to follow a rule of reason and the concept of proportionality in determining the appropriate depth of analysis. This guidance includes a recognition of the inherent complexities and uncertainties associated with analyzing projected biogenic carbon stocks and related fluxes for land and resource management actions under uncertain future climate conditions. To guide national forests and grasslands in interpreting the CEQ guidance, on December 13th, 2023, the US Forest Service (USFS) released *Forest Service Guidance for Project-Level Consideration on Climate Change and Greenhouse Gas.*

This project-scale NEPA carbon effects analysis focuses solely on biogenic carbon, hereafter ‘carbon.’ It incorporates qualitative and quantitative information on carbon stocks, fluxes, and drivers from the Plumas Forest unit-level Carbon White Paper (USDA Forest Service, 2024) and, when available, other resources, including peer-reviewed scientific literature, technical reports, and emissions quantification tools and frameworks. The Carbon White Paper uses Forest Inventory and Analysis (FIA) Program data to provide a nationally consistent assessment of baseline forest carbon stocks at the National Forest scale. The Carbon White Paper also provides a national forest-scale evaluation of the influences of disturbances and management activities from 1990-2011, using the Forest Carbon Management Framework (ForCaMF), and estimates of the long-term relative effects of disturbance and non-disturbance factors on carbon stock change and accumulation, using the Integrated Terrestrial Ecosystem Carbon (InTEC) model (USDA Forest Service, 2024).

1.2 Carbon Dynamics in Forest Ecosystems

Terrestrial ecosystems play an important role in the global carbon cycle. Through photosynthesis, plants sequester carbon dioxide from the atmosphere and store some of the carbon as biomass. Forest carbon stocks are highly dynamic, with carbon frequently transferring among pools such as from living to dead biomass and dead biomass to the soil or the atmosphere. The balance of carbon sequestration versus atmospheric emissions determines the size of the total forest carbon pool, which fluctuates over longer periods of time. Frequency of stand-replacing disturbance has a large effect on ecosystem carbon stocks and sequestration rates, with the most rapid uptake of carbon often occurring in young forest stands.

Carbon is also stored in harvested wood products (HWP) outside of the forest ecosystem. The percentage of harvested carbon stored as HWP varies regionally, depending on mill efficiencies, dominant types of HWP, and HWP markets. HWP carbon storage declines over time, as products reach their end-life. Some carbon continues to be stored in solid waste disposal sites (or landfills), where decomposition rates are generally slow. When wood fiber is used in place of materials that are more energy-intensive to produce, such as concrete and steel, this generates a substitution effect which can result in lower overall greenhouse gas emissions. Substitution potential does not include the CO_2eq stored in HWPs; rather, it only characterizes the reduced fossil fuel emissions associated with energy or product production.

The influence of forest management on atmospheric carbon exchange has gained attention in recent decades due to its potential to influence the exchange of carbon with the atmosphere, either by accumulating and storing carbon or releasing carbon emissions (i.e., carbon dioxide or CO_2). This exchange has implications for climate change as carbon dioxide is a greenhouse gas that regulates our climate. Climate change is a global phenomenon, because major greenhouse gases mix well throughout the planet's lower atmosphere. At present, within the United States, forested lands are a carbon sink, taking in (sequestering) and storing more carbon than they are emitting into the atmosphere (Domke et al., 2023). Forests, including woodlands, urban trees, and harvested wood products, are the largest terrestrial sink in the United States, offsetting more than 12.4 percent of total U.S. GHG emissions (Domke et al., 2023). In 2021 alone, forest land, HWP, woodlands, and urban trees in settlements collectively stored 785.0 teragrams (Tg; 1 Tg is equivalent to 1 million metric tonnes) of carbon dioxide equivalent (785.0 Tg of CO_2eq), bringing the total US forest and harvested wood carbon stock to 59,511 Tg CO_2eq. The "forest land remaining forest land" category (i.e., maintaining forest (or forested) land) was the largest net sink in the land sector, with an estimated annual uptake of 592.5 Tg CO_2eq in 2021 (Domke et al., 2023; EPA, 2023). Carbon stocks on the Plumas NF have increased from 128.24 Tg C in 2005 to 132.43 ±10.6 Tg C in 2023, a 3.3 percent increase in carbon stocks over this period. The net annual uptake of carbon is 0.23 Tg/year.

A complete assessment of forest carbon stocks and the factors that influence carbon trends (management activities, disturbances, and environmental factors), as well as underlying data and methodologies, for the Plumas NF is available in the project record in the Carbon White Paper (USDA Forest Service, 2024). The Carbon White Paper only includes a quantitative analysis of forest carbon (the majority of which is derived from FIA data) and does not include quantitative analysis of non-forested lands. This carbon effects analysis contains additional supporting information and references.

1.3 Carbon Dynamics in Non-Forested Ecosystems

Non-forested ecosystem types (such as rangelands) are an important source of long-term ecosystem carbon storage. Rangelands are dominated by grasses, forbs, and shrubs, and include vegetation types such as grasslands, prairies, shrublands, deserts, wetlands, and riparian zones. In rangelands, most carbon is stored underground (Paruelo et al., 2010; Terrer et al., 2021; White, 2000). In these systems, soil organic carbon (SOC) constitutes approximately 80-95 percent of total ecosystem carbon (Adams et al., 1990; Meyer, 2012; Ontl & Janowiak, 2017; Reeves et al., 2020). SOC is recalcitrant and well protected from natural disturbances (e.g., fire), making it generally resistant to change (Spangler, 2011). SOC is therefore considered to be relatively stable, especially when concentrated below the top 30 cm of the soil profile (Reeves et al., 2020). Shrublands have a greater percentage of SOC stored in the soil profile below 1 meter while grasslands usually have most SOC in the first meter of soil (Meyer 2012; USDA FS 2013). Combined with high ecosystem resilience to climatic changes, including rising temperature, drought, and fire, underground carbon pools in rangelands are generally unlikely to be emitted to the atmosphere (Booker et al., 2013; Dass et al., 2018; Paruelo et al., 2010; Terrer et al., 2021; White, 2000).

The net carbon balance in the soil is fundamentally determined by the balance between inputs (root and litter turnover) and outputs (decomposition) of soil organic matter (SOM) (Fynn et al., 2009). SOM content is dependent upon vegetation type, climate, soil type, parent materials, physiographic influences, and land use (Spaeth, 2020). Land management can increase or decrease soil carbon stocks, with sustainable management practices which increase SOM inputs or decrease loss from soil respiration potentially increasing soil carbon stocks (Spangler, 2011). These activities may include minimizing soil erosion, protecting soil aggregates, and promoting perennial vegetation retention and diversity (Tennigkeit & Wilkes, 2008). However, the impact of management practices can vary based on climatic characteristics, vegetation, and soil types, meaning sustainable approaches must be site-specific. Lastly, ecosystem changes can impact SOC storage in non-forested ecosystems. A shift from sagebrush shrublands to nonnative annual grasslands will eventually move carbon from deeper in the soil profile to the upper 20 cm (Qafoku, 2014). For example, an estimated 8 teragrams of carbon have been lost due to shrubland conversion to annual grasses, particularly cheatgrass (*Bromus tectorum*), in the Great Basin since 2006 (Meyer, 2012).

1.4 Purpose and Need of Project Related to Carbon Assessment

National forests and grasslands can play an important role in climate change mitigation. Balancing the numerous environment benefits, including carbon sequestration, provided by healthy ecosystems, is paramount to the Forest Service’s mission. The Forest Service principles of thoughtful carbon stewardship do not seek to maximize carbon at the expense of forest health, but rather, to assess carbon within the context of ecosystem integrity and climate adaptation.

As part of promoting balanced ecosystems on the Plumas NF, management objectives of the North Fork Forest Recovery Project include:

- Restoring forested areas burned by the Dixie Fire.
- Improving forest health and resilience to changes in environmental conditions.
- Reducing the risk from wildfire to human life and property by reducing fuels.
- Providing an economic benefit to local communities.
- Improving the overall recreation experience and safety of the recreational facilities through facilities improvements and access management.

These management objectives have been developed in response to past management and history of the Plumas NF. A policy of suppressing fire was initiated in 1905 with the establishment of the National Forest Reserve System (Taylor, 2000). This has resulted in high levels of fuel loading which, in conjunction with global warming driven increases in wildfire intensity, result in large-scale wildfires such as the Dixie Fire which in 2021 burned approximately 963,000 acres in total and 157,000 acres within the project area. The management actions described in the North Fork Forest Recovery Project assess carbon stocks alongside other ecosystem benefits. The anticipated impacts to carbon after the project has been fully implemented, over the lifetime of the project, include: an increase in carbon storage due to reforestation and improved resilience to carbon losses resulting from drought, insects, and fire. Carbon losses over short time frames may occur resulting from the following actions: tree harvesting and prescribed fire to reduce fuel loads, and tree harvesting and prescribed fire to create fire management features. Long-term carbon gains are expected due to reforestation and increased forest resilience to fire, insects, and drought, improving long-term storage of above-ground carbon. Compared to the no action alternative, project actions are predicted to: decrease short term carbon storage due to harvest and prescribed fire while increasing long-term carbon storage due to increased resilience. Overall, this project will result in an increase in carbon storage through reforestation of areas which experienced high-severity wildfire and may otherwise undergo type conversion, and improved forest resilience to fire, insects, and drought from thinning and fire management features.

1.5 Harvest

The Forest Service Handbook defines an issue as “a statement of cause and effect linking environmental effects to actions” (Forest Service Handbook 1909.15). The following issues pertaining to carbon emissions have been identified for detailed analysis:

Issue 1: Overstocked forests have decreased productivity and increased frequency and intensity of drought, insects, and high-severity wildfire, resulting in a decrease in stored carbon.

Issue 2: Type conversion following high-severity wildfire has the potential to reduce carbon sequestration in areas which have been severely impacted by the Dixie Fire in 2021.

Issue 3: The degraded state of the Dixie Fire footprint causes challenges for future carbon storage due to the potential for successive high-severity fires in early succession forests.

1.6 Analysis Assumptions

For the purposes of this analysis, the following assumptions apply:

1. The data described in the following effects analysis is based primarily on the unit-level forest carbon data available in the Carbon White Paper for the Plumas NF (USDA Forest Service, 2024).
2. Additional data on a finer scale are used if and when available to ensure the use of reliable data, resources, and models for this analysis.

2.0 Methodology

This section includes a description of the methods and data used in this analysis. The Carbon White Paper for the Plumas NF in the project record contains additional information on methodologies used to inform carbon data incorporated in the following analysis.

2.1 Harvest

The harvesting activities will remove roughly 168,000 CCF of roundwood from 164,395 acres (Table 1). North Fork Forest Recovery Project actions will be implemented over 20 years. For more details, see the Silviculture report.

We estimate project-level effects of harvest on carbon, which we compare to national forest unit-level carbon stocks and fluxes. The national forest unit is the smallest spatial scale for which we have nationally consistent and accurate carbon estimates.

Table 1. Estimates of roundwood (sawtimber, pulpwood, and fuelwood) volume removals (hundred cubic feet, CCF) and area (acres) for the proposed action.

Class	Proposed Action
Roundwood volume (CCF)	168,000
Area (acres)	164,395
CCF/acre	1.02

2.2 Project-Level Effects

Project-level carbon emissions associated with harvest are based on the Quantifying Greenhouse Gas Fluxes in Agriculture and Forestry: Methods for Entity-Scale Inventory (Murray et al., 2024) and the associated excel-based “level I” quantification workbook (tool) (Stockmann et al., 2024), published by the USDA. Estimates include total forest carbon transfers, HWP storage over time, net harvest atmospheric carbon emissions based on 100-year HWP storage (in use and in landfill), and maximum potential substitution benefits from substituting harvested wood products in the place of fossil fuel-based energy or other more energy-intensive products. In the tool, we entered total acreage estimates for harvested area and used the midpoint of the project duration (10 years) as the estimate of how long from now the harvest will occur. We used regional averages within the tool to estimate variables such as forest type, stand age, and regeneration origin due to the large uncertainty associated with forest conditions following the

Dixie Fire in 2021, which burned approximately 157,000 acres within the project area. Because the regional averages diverge from the conditions that exist in the project area following the Dixie Fire, which in 2021 released 37 million tonnes of CO_2 over the roughly 963,000 total acres burned (CARB, 2022), equivalent to more than 20% of the total transportation-related emissions in California in 2021 (CARB, 2023), the carbon emissions calculated from the project-level effects analysis may overestimate emissions. For harvested wood product life cycling, we used the default chi-squared option.

2.3 Prescribed Fire and/or Fuels Reduction

The prescribed fire and fuels reduction activities will be implemented over approximately 167,000 acres and 20 years. For more details on proposed activities, see Silviculture Report.

2.4 Restoration of Disturbed Ecosystems

The restoration of disturbed ecosystems will be implemented over approximately 167,000 acres and 20 years.

The proposed action targets the removal of Heterobasidion root disease (HRD). This disease is widespread throughout the Plumas NF and poses a significant threat to conifers. This project proposes borate stump treatments following variable density thinning to prevent the spread of HRD.

Approximately 81,190 forested acres within the project area experienced high-severity wildfire during the Dixie Fire in 2021. Restoration to these regions will consist of the removal of 70-80 percent of dead material, and the retention of the remaining standing dead trees to function as wildlife habitat and carbon storage, and to manage the soil moisture and provide microsites for planting. Removal of dead trees will occur through a combination of piling and burning, chipping, or some other economic use such as biomass for energy or heating, biofuels, distilled water, and biochar.

Planting will occur on roughly 5-10 percent of the area identified for reforestation. To manage brush competition for soil moisture for the first two years following planting, foliar application of herbicide will be utilized.

For more details, see the Silviculture Report. Our assessment of the carbon impacts of restoration activities draws on our Carbon White Paper as well as region- and ecosystem-specific scientific literature.

3.0 Analysis Boundaries: Expected Lifetime of the Project Action

Reforestation, forest thinning through harvesting and prescribed fire, and construction of fire management features are proposed within the Mt. Hough Ranger District. However, this specialist report considers the carbon stocks, fluxes, and drivers at Plumas NF unit level, which is the smallest spatial scale with nationally consistent and accurate estimates. Therefore, the spatial analysis area for direct and indirect carbon effects are the forested lands within the Plumas National Forest.

The proposed treatments will be implemented over 20 years, which is the temporal boundary for direct, indirect, and cumulative effects consideration.

4.0 Affected Environment

4.1 Forest Carbon Dynamics

Based on CCT analysis in the Carbon White Paper, forested area in the Plumas NF has decreased from 446,150 ha in 2005 to 422,413 ha in 2023, a net change of -23,738 ha. Carbon stocks on the Plumas NF have increased from 128.24 Tg C in 2005 to 132.43 ±10.6 Tg C in 2023, a 3.3 percent increase in carbon stocks over this period. The net annual uptake of carbon is 0.23 Tg/year. The trends observed in the Plumas NF result in its categorization as a high carbon density forest (USDA Forest Service, 2024). In the Plumas NF, CCT estimates that the largest carbon stocks are aboveground live and soil organic carbon, each storing 40 percent of total forest ecosystem carbon (USDA Forest Service, 2024). However, soil carbon stocks are likely larger than estimated, as CCT uses outdated FIA soil carbon and biomass equations. Soil carbon is typically one of the largest and more stable carbon pools within a forest (Domke et al., 2017; McKinley et al., 2011). The USDA FS Office of Sustainability and Climate - in partnership with Research & Development - is in the process of updating these stock and flux numbers.

4.2 Factors Influencing Forest Carbon

Historical land use impacts the carbon legacy of the Plumas NF, including pre-historically documented land uses, Native American land management practices, Euro-American settlement, and current land management and disturbances. The Maidu, Washoe and Paiute people called Feather River Country home for over 8,000 years. With European settlement came increased timber extraction, mining, grazing, and other impacts. The Dixie Fire in 2021 burned approximately 157,000 acres within the project area, releasing 37 million tonnes of CO_2 over the roughly 963,000 total acres burned (CARB, 2022), equivalent to more than 20% of the total transportation-related emissions in California (CARB, 2023). Past disturbance dynamics, forest regrowth and recovery, and forest aging have contributed to carbon trends.

Carbon sequestration and stocks vary with stand age, with younger to middle aged stands generally having high sequestration rates and low total carbon stocks, and older stands having lower sequestration but higher total carbon stocks (USDA Forest Service, 2024). In Plumas NF, most tree species peak in net primary productivity (NPP) between ages 30 and 80 years old before decreasing then stabilizing or continuing to decrease. Roughly 60 percent of the stands in the Plumas NF are middle-aged and older (greater than 80 years). There has been a sharp decline in new stand establishment in recent decades (Birdsey et al., 2019). If the Plumas NF continues this trajectory, stand-level growth will decline in the coming years, potentially causing the rate of carbon accumulation to decline. However, ecosystem carbon stocks may increase for decades, as dead organic matter and soil carbon continue to accumulate.

Disturbance and climate are also important drivers of carbon dynamics. In Plumas NF, fire was the largest disturbance driver of carbon stock change from 1990-2011 (USDA Forest Service, 2024), reducing carbon stocks by 7.1 percent compared to a scenario without disturbance.

Harvest was another key driver of carbon dynamics, reducing carbon stocks by 3.21 percent over the same period. Climatic changes have also affected carbon stocks in Plumas by increasing fire severity and the potential for disturbance by insects, disease, and drought. Forests have generally responded positively to the direct effects of nitrogen deposition and carbon dioxide fertilization. Overall, the carbon stock reduction caused by disturbances and climate conditions have been neutral and insignificant compared to the loss of forest carbon by fire and to a lesser degree harvest.

Management aimed at increasing ecosystem stability generally provides carbon benefits by promoting long-term ecosystem carbon stability. Appropriate management activities vary by forest type, region, and climate. In the Pacific Southwest, practices which promote carbon stability include forest thinning and prescribed fire for resilience to drought, wildfire, and insects.

4.3 Factors Influencing Rangeland Carbon

Annual fluctuations in productivity caused by yearly rainfall or other patterns influencing annual grasses impact rangeland carbon stocks less than the long-term, overall resilience and productivity of these systems (Spangler, 2011). Despite the relative stability of soil carbon, rangeland carbon stocks can fluctuate with variations in environmental conditions, species composition, disturbance, and management practices (EPA, 2023; Spangler, 2011). Present-day rangelands are highly vulnerable to human disturbance (i.e., introduced species, overgrazing, and land-use conversion to agriculture) and climate change (Noss & Scott, 1995). For example, there may be seasonal or growing season grazing utilization thresholds which promote maintenance of soil organic carbon, which can be influenced by precipitation patterns (Derner & Schuman, 2007). Additionally, the timing and rotational nature of grazing must be considered to accommodate regeneration of palatable species (Gadzia & Sayre, 2009).

Research suggests that the following management practices are important to maintain and/or increase carbon sequestration on rangelands (both in above ground biomass and in the form of SOC):

- Stabilizing and restoring degraded areas (e.g., seeding areas of low vegetation density with perennial plants).

- Improving/maintaining rangeland health through planned grazing management practices by matching timing, duration, frequency and intensity to ecological conditions and objectives.
- Facilitating grazing management and livestock distribution by developing structural rangeland improvements (e.g., fences, water facilities).
- Reducing shrub and/or tree encroachment based on site potential.
- Controlling invasive annual species.
- Improving/maintaining rangeland health using prescribed fire.
- Application of soil amendments such as biochar or fertilizer.
- Avoiding disturbance such as cultivation and land conversion.

4.4 Future State

The future carbon state of the project area in the absence of proposed activities will be impacted by climate change. Climate change will have significant impacts on forests through the next century, including changing establishment and composition (Chambers et al., 2015). Changing temperature, precipitation, and disturbance factors, including fire, insects, and disease, will increasingly stress forested ecosystems. A full summary of expected climatic changes to the Plumas is located within the Carbon White Paper (USDA Forest Service, 2024).

The Fifth National Climate Assessment (NCA5) represents the best available science for interpreting future climate impacts to the project area (Jay et al., 2023). While higher resolution projections exist for the project region from downscaled projections, these use older generation climate models which have been shown to be less reliable than the most recent generation of climate models over North America (Martel et al., 2022). Additionally, the NCA5 projections present downscaled information at the county level, which is appropriate for representing the effects in the project area. Rather than focusing on a range of emission scenarios, NCA5 presents county-level changes to critical climate variables at a range of global temperature levels as denoted by the change from pre-industrial temperature. An added advantage of this new method is that the smaller temperature increase levels can be used to investigate climate change impacts at present and in the next few decades despite temperatures in 2100 exceeding these lower temperature increase levels.

The four temperature increase levels used in NCA5 are 2.7 F, 3.6 F, 5.4 F, and 7.2 F. In 2023, global average temperature was 2.8 F above pre-industrial levels, significantly higher than the 2022 global average temperatures of 2.3 F in 2022 and 2.2 F in 2021 (Berkeley Earth, 2023). Over the last decade, global average temperature increase from the pre-industrial period was closer to 2.7 F than 3.6 F, indicating that the 2.7 F global mean temperature increase level in NAC5 likely represents the best estimate of climate impacts at present. Based on reliable, data driven projections from independent organizations such as the Climate Action Tracker, temperature by 2100 will likely be 3 F to 5 F warmer than pre-industrial temperature (Climate Action Tracker, 2023). However, much is unknown about future technology for mitigating and removing greenhouse gas emissions, international efforts to decrease emissions, and the sensitivity of the climate to greenhouse gases, leaving a wide range of plausible future temperatures and necessitating flexibility in climate adaptation planning. To analyze the impacts of climate on the project area, the 2.7 F level is used to represent the climate at present and over the coming decade, and the 3.6 F and 5.4 F levels represent the most likely climate by the late 21st century, with the 3.6 F warming level being more likely than the 5.4 F level. The 7.2 F level represents a worst-case scenario, which is less probable given current understanding of likely climate sensitivity and future emissions, but is still a plausible level of warming (IPCC, 2023; Climate Action Tracker, 2023).

The NCA5 projections of temperature and precipitation changes in Plumas County for the four global temperature change levels are presented in Table 2. Temperature increases in the project area are predicted to be slightly lower than global mean temperature increases, particularly at the lower global mean temperature increase levels. Precipitation is predicted to slightly increase at most global warming levels, with the largest increases at the higher global mean temperature increase levels. However, other research using the same global climate models has shown that there is substantial disagreement between models on whether precipitation will increase or decrease, with no robust changes in precipitation found near the project area (IPCC, 2023).

Table 2: Temperature and precipitation changes in the project area at four different global warming levels.

	Global Temperature Increase of 2.7 F	Global Temperature Increase of 3.6 F	Global Temperature Increase of 5.4 F	Global Temperature Increase of 7.2 F
Local Temperature Change	+2.0 F	+3.0 F	+5.0 F	+7.0 F
Change in Local Number of Days With Low Temperature Below 32 F	-19	-29	-52	-67
Local Precipitation Change	+1 %	0 %	+3 %	+6 %
Change in Local Extreme Precipitation (Top 1 % of Historical Events)	+4%	+1%	+23%	+26%

Despite the lack of robust precipitation changes near the project area, drought conditions are expected to get more frequent and more severe in the project area due to an increase in evaporation. The increase in evaporation with increasing temperature is known from theoretical arguments involving the Clausius-Clapeyron relation, observed changes from recent warming, and projections from global climate models (Novick et al., 2016; Albano et al., 2022; Fang et al., 2022). Barring an increase in precipitation in the project area beyond the range projected by recent climate projections (Jay et al., 2023), the increasing evaporation would increase drought frequency and intensity in the project area, necessitating changes to forest management. Despite the increasing potential for drought, the models suggest that extreme precipitation events will become roughly 25% more frequent at the two highest assessed warming levels.

Vapor pressure deficit is a meteorological variable which has been shown to be highly correlated with the annual area of burned forest area in the Southwest (Williams et al., 2015). Previous research suggests that global warming caused 68-88% of the observed increase in vapor pressure deficits in the Western United States from 1979-2020 and was responsible for roughly 50% of the record high vapor pressure deficits observed during the August Complex Fire in 2020 (Zhuang et al., 2021). As such, the projected rising temperature in the project area increase the potential for large wildfires resulting from large vapor pressure deficits, as well as the potential for extreme fire conditions such as those which occurred during the 2020 fire season in California (Safford et al., 2022).

In Plumas County, the number of days with a low temperature below 32 F is projected to decrease at the four global temperature increase levels described earlier (Table 2). The decrease in days with low temperature below freezing and the increase in average temperatures will result in a decrease in the percentage of precipitation deposited as snow further contributing to increasing drought conditions (Feng and Hu, 2007) and potentially an increase in the length of the fire season (Dong et al., 2022).

Taken together, the projected increase in aridity resulting from increasing temperature along with minimal changes in precipitation presents challenges for forest management. These changes present threats to forest resilience primarily from fire, drought, and insect related losses. As a result, aboveground carbon may decrease in sudden events such as fire, and over longer time periods as the result of increasing frequency and intensity of droughts and insect-related die offs (Anderegg et al., 2022). Additionally, type conversion from forested land to rangeland following high-severity wildfire is more likely to occur in a warmer climate due to the impact of aridity on reforestation, as well as fire frequency and intensity (Stevens-Rumann and Morgan, 2019). Climatic changes may have interactive effects with disturbance, further impacting carbon. For example, drought-stressed trees may also be more susceptible to insects and pathogens (Dukes et al., 2009), which can reduce carbon uptake (D'Amato et al., 2011; Kurz et al., 2008).

Changing disturbance is likely to impact future stand dynamics within Plumas NF. Damage from native insect species via climate-related changes in insect life-cycle attributes and reduced forest vigor may be one of the most prominent effects of a warming climate (Vose et al., 2018). Previous research suggests that higher rates of infestation may occur following wildfire, and that infestation is a significant factor in tree mortality immediately following fire (Kitchens et al., 2022). According to the Forest Health Advisory System, 320,149 acres of Plumas NF are susceptible to high level (>25 percent) of overall tree mortality, with 18 percent of the tree biomass threatened by forest pests (https://apps.fs.usda.gov/fhas). However, this data predates the Dixie Fire in 2021 which may have changed the susceptibility to forest pests.

Therefore, in the absense of the project, the affected environment will likely experience degradation due to fire, drought, and insects. The increases in aridity, length of the fire season, and potential for extreme fire weather conditions resulting from rising global temperature increases the likelihood of large-scale wildfires such as the Dixie Fire in 2021 (Heidari et al., 2021). These fires represent substantial greenhouse gas emissions, with the Dixie Fire emitting roughly 37 million tonnes of CO_2 over the entire burned area (CARB, 2022), equivalent to more than 20% of the total transportation-related emissions in California (CARB, 2023). In addition to the pressure from increasing aridity in a warming climate, portions of the project area which did not experience high-severity wildfire during the Dixie Fire remain overstocked. This is represented by an average stand density index of 65%, with a more detailed description in the Silviculture report. As a result, in the absence of the project, which aims to decrease the propensity for high-severity wildfire in the project area, substantial CO_2 emissions are anticipitated due to the likelihood of large and high-severity fire in the project area, and decreased carbon storage potential is likely due to type conversion in areas which experienced high-severity fire.

5.0 Direct, Indirect, and Cumulative Effects of the No-Action Alternative

In the no action alternative, the project area will continue to face an increased potential for losses due to fire, drought, and insects in a warming climate, as well as decreased potential for carbon storage due to limited forest restoration in areas which experienced high-severity wildfire. Rising temperature will increase aridity and could result in large potential losses from fire, drought, and insects. As mentioned in Section 4, the project area is likely to experience severe wildfires as occurred recently during the Dixie Fire in 2021. This fire burned 157,000 acres within the project area including approximately 81,190 forested acres which were subjected to high-severity fire. Therefore, while short-term carbon stocks are likely to continue to increase under a no-action scenario, there are long-term risks of drastically reduced carbon stocks, as a result of catastrophic wildfires. Therefore, the no action alternative could result in periodic large releases of CO_2, such as those which occurred during the Dixie Fire in 2021, and severely degraded conditions in the project area. The increases in local temperature will limit carbon accumulation due to drought and insect related pressures. A further decrease in the potential for carbon storage may occur due to limited natural forest regeneration resulting in type conversion to shrubs. Additionally, the increase in vapor pressure deficit in a warming climate may further decrease natural forest regeneration in burned areas, limiting carbon storage in the no action alternative (Stevens-Rumann and Morgan, 2019).

6.0 Direct, Indirect and Cumulative Effects of the Proposed Action

The proposed North Fork Forest Recovery Project includes prescribed fire, variable density thinning and fuel reduction through mechanical and hand thinning methods, hazard tree removal, reforestation, invasive species management through herbicide application, hydrological improvements, transportation improvements, and the construction of fire management features, all on approximately 167,000 acres of the Plumas NF. This scope and degree of change would affect a maximum of 15 percent of the 1,106,219 acres of forested land in the Plumas. The scale of greenhouse gas emissions from this project, which are around 500,000 tonnes of CO_2eq per year over the 20-year implementation period, are minimal compared to state level emissions over this time period. For comparison, the Scope 1 greenhouse gas emissions in Plumas County in 2005 were roughly 350,000 tonnes of CO_2eq (Sierra Business Council, 2012), and the statewide greenhouse gas emissions in 2021 were roughly 380 million tonnes of CO_2 (CARB, 2023). Therefore, the cumulative effects analysis will use the project area as the geographical boundaries. For temporal boundaries, recent large wildfires such as the Dixie Fire in 2021 resulted in 37 million tonnes of CO_2eq emissions (CARB, 2022), with a substantial portion of these emissions occurring within the project area, which represents more than 15% of the Dixie Fire footprint. These emissions far surpass potential emissions from the proposed project. As a result, the cumulative effects analysis will use the project timeline as the temporal boundaries. The boundaries for this analysis align with the 2023 guidance for Climate Change in USDA Forest Service National Environmental Policy Act Analyses.

The effect of the proposed action focuses on the aboveground living carbon pool, which comprises about 40 percent of the total ecosystem carbon stocks of the Plumas NF (USDA Forest Service, 2024). However, this data predates the Dixie Fire and may not accurately represent the current state of the forest.

6.1 Harvest

Under the no-action alternative, the forest stands in the project area will likely thin from disturbance, competition, and age, resulting in dead trees that decompose over time and release carbon. Under the proposed harvest project alternatives, wood and fiber removed from the forest will transfer to the wood products sector as various commodities which have different residence times as in-use products (Skog et al., 2014; Murray et al. Pending). Wood can also be used in place of other materials that emit more GHGs, such as concrete, steel, and plastic (Gustavsson et al., 2006; Lippke et al., 2011; McKinley et al., 2011), or burned to produce heat or electricity in place of fossil fuel combustion, which are considered substitution effects. Thus, managing forests with a harvested wood product component may result in lower net contribution of GHGs to the atmosphere than if the forest were not managed (Bergman et al., 2014; McKinley et al., 2011; Skog et al., 2014). The International Panel on Climate Change (IPCC) recognizes wood and fiber as a renewable resource providing lasting climate-related mitigation benefits that can increase over time with active management (IPCC, 2000; IPCC 2006).

As shown in the 2021 Dixie Fire, which burned 157,000 acres within the project area and released 37 million tonnes of CO_2 over the entire burned area, the combination of overly dense forests, abundant ladder fuels, and increasing aridity in a warming climate create the potential for large-scale wildfire resulting in loss of forest resources and CO_2 emissions. The removal of roughly 25% of forest material as measured by diameter at breast height in areas which did not experience high-severity fire during the Dixie Fire will reduce the potential for future high-severity fire. The removal of standing dead timber in roughly 81,000 acres which experienced high-severity wildfire during the Dixie Fire will also reduce the frequency and intensity of future wildfire and resulting carbon losses. Additionally, the targeted removal of ladder fuels will further decrease the likelihood and intensity of severe wildfire. In a warming and drying region, the reduction of fuel loads is even more necessary, as climate change will likely increase the frequency and intensity of high-severity fire. For more detail about proposed reforestation, thinning, and fire reduction see the Silviculture Report.

These benefits are balanced by a temporary decrease in aboveground carbon stocks. Based on our analysis, we expect that the project will remove 7,194,551 tonnes CO_2eq from the forest ecosystem (Table 3). However, this number is greater than the actual atmospheric emissions because of continued carbon storage in harvested wood products. Based on 100-year storage of HWP, the cumulative net harvest emissions are 5,649,235 tonnes CO_2eq (Table 3). These numbers assume that 25% of forest material will be removed in the 36,000 acres which are targeted for thinning, and that 75% of forest material in the form of standing dead trees will be removed in the 81,900 acres of forest which experienced high-severity fire. Because of the substantial and continuing changes to forest conditions which resulted from the Dixie Fire in 2021, detailed data does not exist for this analysis. Emissions from the proposed action are calculated using the Quantifying Greenhouse Gas Fluxes in Agriculture and Forestry: Methods for Entity-Scale Inventory (Murray et al., 2024) and the associated excel-based “level I” quantification workbook (tool) (Stockmann et al., 2024), published by the USDA. These methods allow for an estimate of emissions based on region, forest type group, age class, and other factors. However, the conditions present in the 81,900 acres, consisting primarily of standing dead timber and brush cover, are not represented by any of the available forest type groups. As a result, the emissions estimates from this analysis assume that rather than removing 75% of standing dead timber from an area that experienced high-severity wildfire in 2021, the project would instead consist of harvesting 75% of forested material from a forest with the typical conditions in the Pacific Southwest region, causing an overestimate of lost carbon storage. Another issue exists for estimating the change in carbon storage from thinning of overstocked stands over 36,000 acres, where the tool calculates the emissions from a typical Sierran Mixed Conifer forest, which may differ substantially from the actual area. Overall, the analysis presented here likely overestimates the resulting emissions due to issues with the calculation of the carbon storage losses which result from the removal of 75% of standing dead timber in 81,190 acres.

Table 3: Estimates of carbon transfers and maximum substitution potential based on analysis using the Entity Guidelines tool.

Project-level biogenic Carbon transfers (tonnes CO2eq)	TOTAL
Total harvest transfer	7,194,551
Carbon storage, HWP in use/in landfill, year 100	-1,545,316
Cumulative net harvest emissions, project timeline	5,649,235
Maximum substitution potential	
Products	-2,648,737
Bioenergy from fuelwood	-783,427
Total	-3,432,163

The proposed action has a maximum substitution potential of 3,432,163 tonnes CO_2eq (Table 3). Although these values are close in magnitude to the total biogenic CO_2eq emissions, we do not add maximum substitution potential (which is negative as it represents atmospheric carbon avoided emission) with harvest-related carbon emissions for two key reasons. First, potential substitution impacts occur outside the system boundaries of the IPCC estimation protocols for forest carbon flux (ecosystem and HWP). Secondly, there is uncertainty about the true amount of displacement or substitution occurring. Factors such as additionality (quantifying the actual change in carbon emissions occurring as a result of proposed activities) and leakage (the potential for fossil fuel use to be shifted outside of the system boundary as a result of the substitution) must be included for full accounting and are not factored into our estimates. It is likely that the analysis presented here overestimates the amount of wood product which will be utilized due to the overabundance of harvested material following the Dixie Fire, and economic challenges for local mills. Thus, these estimates indicate the upper bounds of the potential for the HWP sector to offset carbon flux related to harvest. The social cost of greenhouse gases is calculated using this estimate, producing a wide range of values (Table 4).

Table 4: Social cost of greenhouse gases following different parameters. Here, “average” indicates that the value is the mean of a range of estimates, while “95th percentile” denotes that the value is roughly two standard deviations from the mean and represents an upper end estimate. The 2.5%, 3%, and 5% indicate the discount rate applied, which determines the amount to which future damages are discounted. Values are input into the FS SC-GHG calculator with the carbon estimates from Table 3 equally divided into the period from 2024-2044.

	Average, 5%	Average, 3%	Average 2.5%	95th Percentile, 3%
Estimated SC-CO_2 for all CO_2 emissions, 2020$)	$76,235,628	$280,261,592	$420,665,310	$851,365,685

For Federal agencies, the best currently available estimates of the SC-GHG are the interim estimates of the social cost of carbon dioxide (SC-CO2), methane (SC-CH4), and nitrous oxide (SC-N2O) developed by the Interagency Working Group (IWG) on the SC-GHG. Select estimates are published in the Technical Support Document (IWG, 2021) and the complete set of annual estimates are available on the Office of Management and Budget’s website. These IWG estimates in the 2021 Technical Support Document are referenced by CEQ’s GHG Guidance. The IWG’s SC-GHG estimates are based on complex models describing how GHG emissions affect global temperature, sea level rise, and other biophysical processes; how these changes affect society through agricultural, health, or other effects; and monetary estimates of the market and nonmarket values of these effects. One key parameter in the models is the discount rate, which is used to estimate the present value of the stream of future damages associated with emissions in a particular year. A higher discount rate assumes that future benefits or costs, potentially accruing to future generations, are more heavily discounted (i.e., valued less) than benefits or costs occurring in the present (i.e., future benefits or costs are a less significant factor in present-day decisions). The current set of interim estimates of SC-GHG have been developed using three different annual discount rates: 2.5%, 3%, and 5% (IWG, 2021).

As expected with such a complex model as, there are multiple sources of uncertainty inherent in the SC-GHG estimates. Some sources of uncertainty relate to physical effects of GHG emissions, human behavior, future population growth and economic changes, and potential adaptation (IWG, 2021). To better understand and communicate the quantifiable uncertainty, the IWG method generates several thousand iterations of estimates of the social cost for a specific gas, emitted in a specific year, with a specific discount rate, where each iteration is based on different assumptions about variables or modeling parameters describing how (i) climate changes in response to GHG concentrations, (ii) resources and production change in response to climate, and (iii) projected changes in/responses of human populations and production capacity over time. These estimates create a range of frequency distributions based on the different iteration values for key climate and economic model parameters that are uncertain. The shape and characteristics of that frequency distribution demonstrate the magnitude of uncertainty relative to the average or expected outcome, allowing us to describe the probability of experiencing lower or higher levels of impacts. Because the carbon stock decrease is likely overestimated due to the use of regional averages which do not represent current forest conditions, the social cost of carbon estimates are likely unrealistically high.

Previous research has shown that there is substantial variation in natural forest regeneration following wildfire in the Western United States (Stevens-Rumann and Morgan, 2019). A decade after the Storrie Fire burned 55,000 acres near the project area in 2000, Crotteau et al. (2013) found that reforestation varied by burn severity, with the lowest rates of regeneration in the high-severity burn patches. It is difficult to determine the extent to which natural reforestation will occur following the Dixie Fire, which burned 157,000 acres in the project area, including 81,190 acres which burned at high severity.

To analyze the potential carbon storage from reforestation, the Quantifying Greenhouse Gas Fluxes in Agriculture and Forestry: Methods for Entity-Scale Inventory (Murray et al., 2024) and the associated excel-based “level I” quantification workbook (tool) (Stockmann et al., 2024), published by the USDA are used. For the no action alternative, natural reforestation over 81,190 acres is calculated from this tool assuming an unknown forest type group, which likely results in an overestimate considering the limited potential for natural reforestation in this area. For more information on natural reforestation in the project area see the Silviculture Report. For the proposed action, a similar analysis is conducted using the same tool, but assuming 73,190 acres of natural reforestation and 8,000 acres of planted reforestation. The analysis suggests that the proposed action results in roughly 300,000 tonnes of CO_2eq of additional carbon storage from reforestation compared to the no action alternative (Table 5).

Table 5: Cumulative additional carbon storage from natural regeneration and planted reforestation in the proposed action and no action alternative.

	No Action Total	Proposed Action Total
Carbon Storage From Reforestation (t CO2eq)	9,468,813	9,765,593

Combining the harvest emissions (Table 3) with the carbon storage from natural regeneration and planted reforestation in the proposed action (Table 5), it is estimated that the proposed action will result in roughly 4 million tonnes CO_2eq of additional carbon storage. This is less than the roughly 9 million tonnes of added carbon storage in the no action alternative, which has no associated harvest emissions. However, these analyses do not account for important factors such as the potential for limited regeneration rates and type conversion following wildfire, the decrease in aboveground carbon in the project area following the Dixie Fire, or differences in future wildfire patterns and carbon losses following the proposed action and no action alternative.

6.2 Fire Regime Management via Prescribed Fire and/or Fuels Reduction

Carbon emissions associated with prescribed fires come mainly from combustion of duff, litter, and small-sized dead wood which would otherwise decay and release carbon even in the absence of fire. The project's prescribed fire treatments will primarily affect understory and forest floor carbon pools. Together, these pools comprise about 9.4 percent of the forest-wide ecosystem carbon stocks. However, we cannot use unit-level averages to estimate project-level potential carbon impacts from prescribed fire due to spatial and temporal heterogeneity in the distribution of fuels and variability in prescribed fire fuels consumption. About 39.6 percent of the ecosystem carbon is in mineral soils, a very stable and long-lived carbon pool (McKinley et al., 2011; USDA Forest Service 2015; Domke et al. 2017) that is generally not impacted by fire (Nave et al., 2011).

Past management of fire in the project area has likely created intensified fire conditions. For example, the exclusion of fire in the Plumas NF increased the intensity of the Dixie Fire in 2021 (Taylor et al., 2022). This study also found that areas which had been mechanically thinned experienced less severe fire, while areas which had previously experienced high-severity wildfire were more likely to burn at high severity during the Dixie Fire (Taylor et al., 2022). In the absence of actions to reduce stand density and fuel loads, the project area may be more at risk from severe wildfire under the no action alternative. These high-severity fires have the potential to cause large amounts of CO_2 emissions, for example the 37 million tonnes of CO_2 released over the roughly 963,000 total acres burned during the Dixie Fire (CARB, 2022), equivalent to more than 20% of the total transportation-related emissions in California (CARB, 2023). Additionally, the potential for type conversion following severe and repeated wildfire threatens long term changes to forest composition (Nemens et al., 2022). This may result in decreases in ecosystem services, such as climate regulation through CO_2 storage, recreation, habitat, and water quality. By reducing the threat of severe and repeated wildfire, the project would create more advantageous conditions to support forest resiliency and carbon stability, thereby promoting carbon stewardship.

Prescribed fires tend to target surface and ladder fuels and are typically less severe than wildfires (Agee & Skinner, 2005; Hunter & Robles, 2020) since they are conducted only when weather conditions are optimal and fuel moisture is high enough to keep combustion and spread within predetermined limits. Thus, prescribed fire typically results in limited overstory tree mortality and limited combustion of available fuel (Carter & Darwin Foster, 2004; Hurteau & North, 2008; Waldrop & Goodrick, 2012). This produces lower GHG emissions than if the same area burned in a high-severity wildfire (Wiedinmyer & Hurteau, 2010). A large portion of emissions associated with prescribed fire is from duff, litter, and dead wood, which comprise carbon pools that decay quickly over time and release carbon to the atmosphere. Prescribed fire will occur through a variety of methods, including jackpot burning, pile burning, and understory burning, reducing the potential for emissions resulting from high-severity wildfire.

For the Plumas NF, total carbon losses from 1990 to 2011 due to fire are equivalent to about 2 percent of non-soil carbon stocks. The methods used to quantify the effects of fire on carbon stocks do not differentiate between prescribed fire and wildfire. Between 2011 and now, multiple large wildfires have occurred in the region. The Chips Fire in 2012 burned 75,431 acres, including approximately 1,475 acres of the project area. The Camp Fire in 2018 burned over 150,000 acres, killed more than 80 people, and destroyed more than 18,000 structures. The Dixie Fire in 2021 burned approximately 963,000 acres, including 157,000 acres within the project area. Overall, wildfire has occurred over far more acres than prescribed fire in the project area, as less than 1,000 acres of prescribed fire have occurred in the Plumas NF between 1995 and 2023. Considering the decrease in fire severity in the Dixie Fire footprint from mechanical thinning shown in Taylor et al. (2022), we anticipate the proposed action will cause a decrease in large high-severity wildfires in the project area, allowing for improved sequestration of CO_2.

6.3 Restoration via Prescribed Fire or Harvest

Some tree species and forest communities within the Pacific Southwest Region are well adapted to fire and in some cases may depend on it for survival and regeneration. Between 1990 and 2011, total carbon losses from fire were roughly 2 percent of non-soil carbon stocks. The Chips Fire burned 75,431 acres, including approximately 1,475 acres of the project area. This was dwarfed by the Dixie Fire in 2021, which burned approximately 963,000 acres, including 157,000 acres within the project area. Approximately 28,000 acres in the project area are currently at or above 60 percent of the maximum stand density. By decreasing stand density and reducing vegetative competition for light and water, as well as decreasing the likelihood of high-severity wildfire, the proposed prescribed fire after harvest would improve resilience and promote growth and carbon sequestration. This would support forest resilience in a changing climate and reduce long-term GHG emissions. For more details on current and proposed future conditions, see the Silviculture Report.

6.4 Rangeland Management, Improvements, and/or Permitted Livestock Grazing

Historically, rangelands were subject to naturally occurring disturbances, such as low-intensity wildfires (Zouhar, 2021) and ungulate grazing. Present-day rangelands are highly vulnerable to human disturbance (i.e., introduced species, overgrazing, and land-use conversion to agriculture) and climate change (Noss & Scott, 1995). Therefore, sustainable management practices must be site-specific.

When managed properly, grazing can provide ecosystem services, such as fuel load reduction of rangelands, potentially decreasing probability of catastrophic wildfire and increasing carbon sequestration opportunities. Proper grazing management alone has been estimated to increase soil carbon storage on USA rangelands from 0.1 to 0.3 Mg carbon per ha per year (Schuman et al., 2002). Management approaches should be selected and designed in a manner that is relevant to the landscape needs and associated ecological potential to ensure realistic outcomes may be achieved and the actions are balanced with the other uses and resource needs of an area. Grazing will be utilized to reduce fuel loads and create fire management features while producing additional economic benefits. Grazing combined with thinning has been shown in modeling studies to reduce the severity of wildfire (Donovan et al., 2022). The reduction of wildfire severity will likely reduce carbon emissions, improve ecosystem resilience, and increase carbon stocks.

6.5 Restoration of Disturbed Ecosystems

Habitat restoration, including reforestation, can result in long term increases to carbon stocks in forest ecosystems. Both natural regeneration and tree planting can assist in post-disturbance recovery of forest ecosystems (USDA Forest Service, 2022). The Forest Service has internal directives and guidance related to management activities for maintaining, regenerating, and restoring forest cover, including reforestation. Managed reforestation following disturbance events can enhance carbon ecosystem functions by increasing woody biomass and sequestration rates, with immediate and long-term carbon benefits. Where agricultural lands are converted to forest via reforestation, carbon sequestration in topsoil increases significantly (Nave et al., 2019).

In the United States, reforested lands occupy more than 500,000 km^2. Within a century, these lands are projected to sequester 1,300-2,100 Tg carbon (Nave et al., 2018). In addition to carbon sequestration benefits, reforestation can provide additional wildlife habitat, forest wood products, and opportunities for recreation (Nave et al., 2019).

The distribution of plant species is largely determined by climate, with research showing that plant distribution is expected to change in response to a changing climate (Hill & Field, 2021). Therefore, it is important to understand how species ranges may expand or contract under a changing climate. Species and seed origin in restoration or reforestation projects should be selected to adapt forests to near-term and potential future climatic conditions (USDA Forest Service, 2022). To that end, seed selection for the proposed action was based on the anticipated increase in temperature and aridity in this region.

6.6 Invasive Species Removal

Invasive species are a major threat to the health, sustainability, and productivity of native ecosystems (Poland et al., 2021). Impacts from invasive species in terrestrial ecosystems include alterations to species abundance and distribution, fire regimes, belowground biotic and abiotic processes, and availability of resources to native species. Invasive plants also impact primary productivity and nutrient cycling and frequently accelerate carbon cycling. Invasive plant species effects on ecosystem carbon stem from traits of the invading and resident species as well as environmental conditions (Poland et al., 2021).

Therefore, our proposed management activities of herbicide application for the removal of invasive species may increase carbon sequestration by reducing invasive species coverage and allowing for more effective reforestation. Carbon benefits resulting from restoration will vary by location and project. Furthermore, critical ecosystem services beyond carbon sequestration are typically achieved by restoring ecosystems. Those may include improvement of functional water catchments and delivery of clean water, food production, critical wildlife habitat protection, and biodiversity enhancement (Delgado et al., 2011; Sanderson et al., 2013; Schuman et al., 2002). In the long-term, increased ecosystem resilience and health as a result of project actions are likely to increase stability of ecosystem carbon under changing climates and disturbance regimes.

6.7 Fossil Fuel Emissions Associated with Project Implementation

The following are sources of fossil fuel emissions associated with project implementation: road construction, transportation emissions associated with hand thinning, mechanical thinning, and prescribed fire, and emissions from the operation of equipment. The emissions resulting from the proposed actions are dependent on the forest conditions which determine which treatments will be applied. Due to uncertainty around forest conditions fossil fuel emissions from implementation are not calculated.

6.8 Cumulative Effects of the Proposed Action

Annual and recurring management which could contribute to cumulative impacts to carbon include the proposed project as well as past and reasonably foreseeable projects within the spatial and temporal boundaries described in Section 3.0. Effects from other projects within the proposed action area could include future fuel treatments, timber harvest, and other treatments affecting biogenic carbon.

Section 4 contains an overview of the key past drivers of carbon trends to the present. These include a gradual increase in carbon storage in the Plumas NF between 2005 and 2023 as indicated by the Carbon White Paper, and a large reduction in carbon storage in 2021 as a result of the Dixie Fire. This pattern indicates the risk to carbon storage in this region, where large amounts of carbon storage can be released in a single event, necessitating management to prevent large-scale losses resulting from wildfire. These threats will increase as temperature, aridity, and the potential for severe fire conditions increase in coming decades as the planet warms.

The proposed project will decrease carbon stocks through the removal of standing dead trees and thinning of overly dense forest. However, long-term carbon storage is likely to be increased due to the reduction of the frequency and intensity of large-scale fires such as the Dixie Fire in 2021. The reforestation in the proposed action will also result in increased long-term carbon storage, as in the absence of reforestation it is likely that some areas which experienced high-severity wildfire will undergo type conversion to non-forested vegetation, limiting carbon storage.

Within the temporal and spatial cumulative effects boundaries, carbon losses are anticipated due to drought, insects, and fire. Additionally, transportation will continue to release CO_2 within the project area through the consumption of fossil fuels. While the project aims to decrease the likelihood and severity of carbon losses due to drought, insects and fire, it remains possible that losses will occur despite the proposed actions, or that losses will occur before resilience can be improved through the proposed actions. Within the temporal boundaries the region will continue to warm, challenging carbon storage due to the anticipated increase in aridity.

In 2021, the largest source of forest sector emissions in the United States was from the conversion of forest land to non-forest, with estimated losses of 144.4 MMT CO_2eq (Domke et al., 2023; EPA, 2023). The conversion of forest to non-forest, primarily driven by high-severity fire, is a major management challenge in the Southwest (Guiterman et al., 2022). The proposed activities in the North Fork Forest Recovery Project will not result in the loss of forest land from the Plumas NF. In fact, forest health and long-term stability is enhanced by thinning and removal of fuels including standing dead trees from burned areas, as well as reforestation of some areas which experienced high-severity wildfire. Without implementation of the proposed actions, it is possible that the forest area could experience a land cover type conversion (e.g., forest to rangeland) as a result of rapidly changing climate conditions. Some assessments suggest that the effects of climate change in some United States forests may cause shifts in forest composition and productivity or prevent forests from fully recovering after severe disturbance (Anderson-Teixeira et al., 2013), thus impeding their ability to take up and store atmospheric CO_2 and retain other ecosystem functions and services.

The proposed actions are consistent with options proposed by the IPCC for minimizing the impacts of climate change on forests, thus meeting objectives for both adapting to climate change and mitigating GHG emissions (McKinley et al., 2011). They are also consistent with many existing carbon management strategies (Kaarakka et al., 2021; Ontl et al., 2020). These considerations are increasingly important as wildfire, drought, insects and disease, and combinations of disturbance types can reduce ecosystem carbon storage and alter ecosystem functions (D’Amato et al., 2011; Millar et al., 2007). Short term decreases in carbon stocks are anticipated from the proposed action due to the removal of standing dead trees, forest thinning, and burning of forest floor material. However, long term carbon storage is expected to increase due to improved resilience to fire, insects, and drought as well as reforestation decreasing the likelihood of type conversion. The reduction in severe fire has particularly large potential for long term carbon storage considering the Dixie Fire which occurred in the project area in 2021 released 37 million tonnes of CO_2 (CARB, 2022).

7.0 Conclusion

The proposed action is likely to result in short term decreases in carbon stocks, and long-term increases in carbon storage due to improved resilience to drought, insects, and fire as well as reforestation. The vast majority of the project area burned in the Dixie Fire in 2021, which released 37 million tonnes of CO_2 over the entire burned area. Anticipated increases in aridity and fire severity necessitate improvements to forest resilience, which this project aims to achieve by reducing density, removing fuels, and through targeted reforestation. By improving resilience and recovery, this project will likely increase long term carbon storage and decrease the likelihood of large-scale high-severity wildfire.

In summary, this proposed action is consistent with internationally recognized climate change adaptation and mitigation practices, as well as desired conditions within the Plumas NF Land and Resource Management Plan.

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