people would trigger more vehicle travel on local roads, increasing exhaust and dust emissions in the area. Future proposed actions on the forest would be evaluated to determine if, when added to non-forest sources, they would exacerbate attainment or increase haze and decrease visibility in both the local airshed and in Class I areas.

- Industrial sources of air pollutants near the forest include power plants, factories, and other facilities that release pollutants from a single point. Air emissions from each of these are regulated under permits by the state and local environmental agencies. Therefore, if new significant sources of this kind are proposed, the increment of criteria pollutants, greenhouse gases, and hazardous substances would be reviewed by regulators. Mitigation and monitoring would be required to ensure continued attainment of the National Ambient Air Quality Standards.
- Emissions for oil and gas development on the forest is not a significant issue at current levels and is controlled by current best management practices, standards and guidelines, lease and contractual requirements, and state and Federal law. If development significantly increases, the increment of criteria pollutants, greenhouse gases, and hazardous substances would need to be reviewed by the forest and regulators. Mitigation and monitoring may need to be required to ensure continued attainment of the National Ambient Air Quality Standards.
- Planned and unplanned fire ignitions may produce smoke, from which primary, secondary, and hazardous pollutants are released to the atmosphere. Planned ignitions are applied under the direction of a Federal, state, or local land management agency after consideration of variables such as weather, acreage to be treated, type and condition of fuels, and duration, among other factors. Authorization for planned ignitions by the State of New Mexico is based, in part, on consideration of the potential for cumulative effects from smoke and other activities planned during a concurrent timeframe. Therefore, the potential for significant cumulative effects from planned ignitions is largely avoided or, in some cases, mitigated by adherence to the Smoke Management Program in the state implementation plan.
- The occurrence and extent of wildfires are not predictable, and when uncharacteristic fires occur, their high intensity may result in temporary violations of the National Ambient Air Quality Standards in the affected airshed(s). The effects of wildfires are not considered additive with planned forest activities because they are unplanned events.

Conclusion

Under each alternative, the potential for significant air quality impact could occur, due to wildland fire. Alternatives 2, 3, 4 and 5 are improvements over the current plan in that added direction is included in all four that would improve the management of air quality on the forest in terms of impacts from wildland fire and monitoring of critical loads. Alternatives 2, 3, 4 and 5 have potential direct emissions that are 11 to 20 times more than the current plan, depending on the alternative. The potential indirect effects from CO_2 emissions through carbon sequestration could reduce CO_2 emissions when compared to the current plan. While highly uncertain, the potential reduction in CO_2 emissions from management activities between alternatives is proportional to the acres treated. As a result, while all would be improvements to the current plan, the greatest potential is in alternative 4. Alternatives 2, 3, and 5 are equivalent. There are significant uncertainties between all alternatives in terms of the effects on air quality including CO_2 emissions due to the unknowns such as climate and the amount of wildland fire that may occur.

Carbon

Forests are dynamic systems that naturally undergo ebbs and flows in carbon storage and emissions as trees and other vegetation establish and grow, die with age or disturbances, and re-establish and regrow. Through photosynthesis, growing plants remove CO_2 from the atmosphere and store it in forest biomass, such as in plant stems, branches, foliage, and roots. Forests are generally most productive when they are young to middle age, then productivity peaks and declines or stabilizes as the forest canopy closes and as the stand experiences increased respiration and mortality of older trees (He et al. 2012; Pregitzer and Euskirchen 2004). Some of this organic material is eventually stored in forest soils through biotic and abiotic processes (Ryan et al. 2010). Carbon can also be transferred and stored outside of the forest ecosystem in the form of wood products, further influencing the amount of carbon entering the atmosphere (Gustavsson et al. 2006; Skog et al. 2014). Many management activities initially remove carbon from the forest ecosystem, but they can also result in long-term maintenance or increases in forest carbon uptake and storage by improving forest health and resilience to various types of stressors (McKinley et al. 2011).

Description of Affected Environment

The carbon legacy of the Carson NF is tied to the history of Euro-American settlement, land management, and disturbances. The national forest accumulated carbon rapidly from the early 1900s through the 1970s because of regrowth following disturbances and heightened productivity of young to middle-aged forests (30 to 60 years old). Stand establishment declined between 1970 and 2010, because of drought and older stands reaching slower growth stages in the 1970s, causing the rate of carbon accumulation to decline by the mid-1980s. From 1990 to 2011, fire has been the main disturbance affecting carbon stocks, causing a 2 percent decline in forested area (Dugan et al. 2020).

Forests on the Carson NF have increased carbon stocks from 56.4±8.2 teragrams of carbon (Tg C) in 1990 to 56.9±7.3 Tg C in 2013, just a 0.9 percent increase in carbon stocks over this period (Dugan et al. 2020)[15]. The stability in carbon storage is related to the age of trees on the Carson NF. Most stands are middle-aged and older (over 80 years old) and there has been a decline in new stand establishment in recent decades (Birdsey et al. 2019).

According to satellite imagery, fire (wildfire and prescribed) was the dominant disturbance type on the Carson NF from 1990 to 2011. The area burned was relatively small, affecting on average just 0.09 percent of the Carson NF's forested area annually (about 470 hectare (ha) per year). Corresponding carbon losses from the forest ecosystem associated with fire have also been relatively small, with non-soil losses from 1990 to 2011 totaling 0.4 Mg C per ha or about 0.5 percent of non-soil carbon stocks (Birdsey et al. 2019). Given that Carson NF contains about 513,688 ha total, non-soil carbon losses from fire have been about 9,785 Mg C per year (0.0098 Tg C yr-1) (Dugan et al. 2020).

Insects affected on average 0.02 percent of forested area annually (about 115 ha) on the Carson NF from 1990 to 2011. Overall, insect disturbance detected over this 21-year period resulted in the loss of approximately 0.14 Mg C per ha (0.2 percent) of non-soil carbon. This is equivalent to an estimated loss of about 0.0034 Tg C per year, an extremely small fraction of the total carbon stocks on the Carson NF (Dugan et al. 2020).

Timber harvest also affected an average of 0.02 percent of forested areas annually (about 85 ha) from 1990 to 2011. Timber harvest resulted in the loss of approximately 0.05 Mg C per ha (0.1 percent) of non-soil carbon. This is equivalent to an estimated loss of about .0012 Tg C per year, an extremely small fraction of the total carbon stocks on the Carson NF (Birdsey et al. 2019). These estimates do not account for continued storage of harvested carbon in wood products or the effect of substitution. Recent declines in timber harvesting have slowed the rate of carbon accumulation in the product sector (Dugan et al. 2020).

Warmer temperatures and lack of precipitation have stressed forests, causing a negative impact on carbon accumulation since the 1990s. Conversely, increased atmospheric CO_2 and nitrogen deposition have

[15] See environmental impact statement appendix C for a complete description of the modeling process.

potentially enhanced growth rates and helped to counteract ecosystem carbon losses from disturbance, aging, and climate (Dugan et al. 2020).

Environmental Consequences for Carbon

Methodology and Analysis

The carbon assessment draws largely from two recent U.S. Forest Service reports: the Baseline Report (USDA FS 2015a) and the Disturbance Report (Birdsey et al. in press). These reports provide assessments of forest ecosystem and harvested wood product carbon stocks and flux, and the factors that have influenced carbon dynamics. The Resource Planning Act assessment (USDA Forest Service 2016) and a regional vulnerability assessment (USDA FS 2010c, 2014a) also provide information on potential future carbon conditions. These reports incorporate advances in data and analytical methods and collectively represent the best and most relevant scientific information available for the Carson NF.

Potential carbon effects are discussed qualitatively, with supporting estimates where possible by drawing on the quantitative analysis of the impacts of past management activities on forest carbon stocks and fluxes, as well as through future-looking analysis where available (Dugan et al. 2020).

This analysis considers the following:

- The potential impacts of climate change on the Carson NF as indicated by consideration of changes in climate (e.g., temperature and precipitation patterns) and the effects of climate change impacts on ecological, social, and economic resources; and
- The potential effects of management actions on climate change as indicated by consideration of changes in carbon sequestration and storage arising from natural and management driven processes.

Indicators

- Carbon pools (carbon stocks), carbon uptake, and CO_2 emissions
- Natural and human-caused influences on carbon stocks, uptake, and emissions

Assumptions

Carbon dioxide emissions are projected to increase through 2100 under even the most conservative emission scenarios (IPCC 2014). Several models project greater increases in forest productivity when the CO_2 fertilization effect is included in modeling (Aber et al. 1995; Ollinger et al. 2008; Pan et al. 2009; Zhang et al. 2012). However, the effect of increasing levels of atmospheric CO_2 on forest productivity is transient and can be limited by the availability of nitrogen and other nutrients (Norby et al. 2010). Productivity increases under elevated CO_2 could be offset by losses from climate-related stress or disturbance.

Given the complex interactions among forest ecosystem processes, disturbance regimes, climate, and nutrients, it is difficult to project how forests and carbon trends will respond to novel future conditions. The effects of future conditions on forest carbon dynamics may change over time. As climate change persists for several decades, critical thresholds may be exceeded, causing unanticipated responses to some variables like increasing temperature and CO_2 concentrations. The effects of changing conditions will almost certainly vary by species and forest type. Some factors may enhance forest growth and carbon uptake, whereas others may hinder the ability of forests to act as a carbon sink, potentially causing various influences to offset each other. Thus, it will be important for forest managers to continue to monitor forest responses to these changes and potentially alter management activities to better enable forests to better adapt to future conditions.

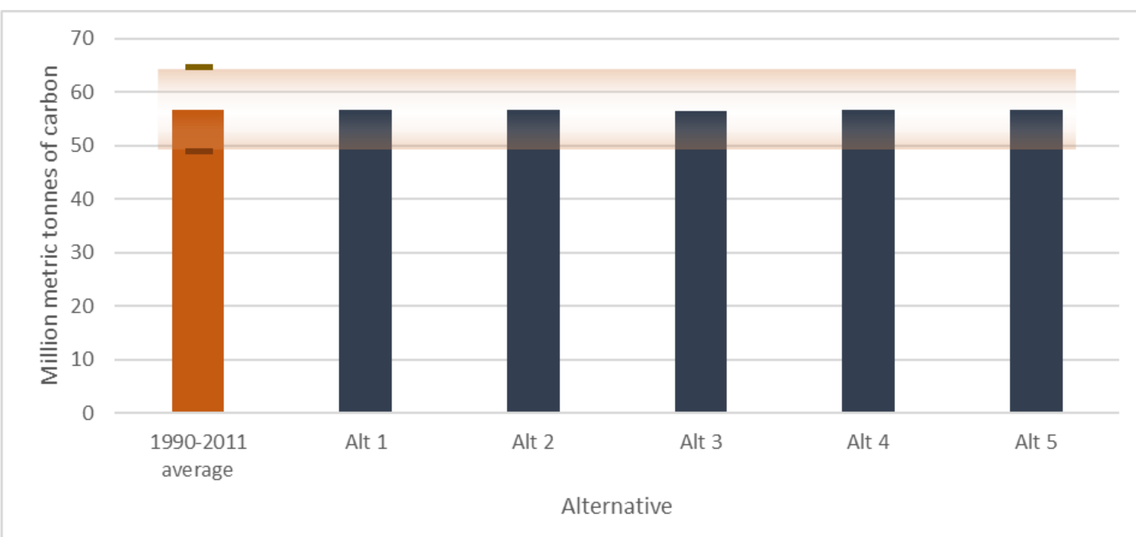
Environmental Consequences for Carbon Common to All Alternatives

All action alternatives provide the same desired conditions for terrestrial ecosystems, and the standards and guidelines that help achieve or maintain those conditions. These proposed activities will help maintain critical ecosystem functions into the future, in part by balancing the maintenance of carbon stocks and rates of carbon uptake.

All the proposed management activities would initially directly reduce carbon stocks on the forest, though minimally. This initial effect would be mitigated or even reversed with time, reducing the potential for negative indirect and cumulative effects. These short-term losses and emissions are small relative to both the total carbon stocks on the forest and national and global emissions. Further, the proposed activities would generally maintain and improve forest health and supply wood for forest products, thus having positive indirect effects on carbon storage. The Carson NF will continue to be managed to maintain forests as forests and to maintain the many ecosystem services and co-benefits that forests provide, including carbon uptake and storage.

Environmental Consequences for Carbon – Alternative 1

Under alternative 1, timber harvest and fire disturbance would remain similar to recent trends and would result in a similar pattern of carbon storage and flux as described in the Affected Environment section above. Recent levels of timber harvest have increased since the 1990 through 2011 reference period. In recent years, timber harvests have averaged 1,349 acres per year, or about 6.5 times the annual amount during the reference period. Assuming that, the annual carbon impact also increases up to 6.5 times above reference period levels, harvest treatments under alternative 1 may result in a maximum removal of about 7,817 Mg/ha of carbon per year (0.0078 Tg C) from aboveground pools. Levels of disturbance from fire and insects have been similar to the reference period since 2011, and their effects would be similar to those described for the reference period. With little mechanical treatment or prescribed fire, the recent decline in new stand establishment is likely to continue. As forest stands continue to age toward middle-aged to older more will reach slower growth stages in coming years, potentially causing the rate of carbon accumulation to decline.



Dark bars around the 1990 to 2011 average and shading represent the 95 percent confidence interval for recent total carbon stocks (Dugan et al. 2020).

Figure 19. **Lost potential storage of carbon because of disturbance on the Carson NF by alternative, compared to average carbon stocks between 1990 and 2011**

Environmental Consequences for Carbon – Alternatives 2 and 5

Alternatives 2 and 5 include the same objectives for acres of mechanical and fire treatment, thus they are projected to have similar effects on carbon. Compared to alternative 1, alternatives 2 and 5 would impact more area based on objectives for treatment in frequent fire forest types (FW-MCD-O-1, FW-MCD-O-2, FW-PPF-O-1, and FW-PPF-O-2).

The maximum treatment area for harvests and thinning under alternatives 2 and 5 would be approximately 4,000 acres per year, or about 0.2 percent of total forested area on the Carson NF. This is an increase of about three times the annual harvest area compared to alternative 1, and nineteen times harvest levels in 1990 to 2011. Assuming that the annual carbon impact also increases up to nineteen times above past levels, harvest treatments under alternatives 2 and 5 may result in a maximum removal of about 23,295 Mg per ha of carbon per year (0.0233 Tg C) from aboveground pools (Dugan et al. 2020).

Alternatives 2 and 5 also include a twelve-fold increase (compared to the reference period) in prescribed burning and wildfires managed for resource benefit (up to 13,500 acres annually). If that level of prescribed burning is achieved, it would result in a potential loss of about 113,779 Mg C annually (0.1138 Tg C), based on the historical analysis (Dugan et al. 2020). However, the historical period included wildfires, which generally burn at higher severities and result in greater carbon losses than prescribed burns. By reducing hazardous fuels, additional prescribed burning may indirectly reduce the risk of more severe wildfires and the resulting higher carbon losses in the future (Agee and Skinner 2005; Wiedinmyer and Hurteau 2010).

Considering the maximum area treated with harvesting and prescribed fire, the amount of carbon that might be removed is small relative to the approximately 56.9 million metric tonnes (Tg) of carbon stored in the forest ecosystem of Carson NF. With maximum intensification, potential management actions would affect up to 1.2 percent of the forested area and approximately 0.1405 Tg C annually. The actions under alternative 2 or 5 would not significantly, adversely, or permanently affect forest carbon storage, but would rather achieve a more resilient forest condition that would improve the ability of the Carson NF to maintain carbon stocks and enhance carbon uptake (Dugan et al. 2020).

The total annual lost carbon storage potential would be slightly greater than under alternative 1, though still small compared to the total carbon stocks on the forest and within the uncertainty for measurement of total forest carbon stocks (figure 19). Lost storage potential is likely to be offset by an increased rate of carbon accumulation due to younger forest establishment following disturbance.

Environmental Consequences for Carbon – Alternative 3

The maximum treatment area for harvests and thinning under alternative 3 would be approximately 10,400 acres per year, or about 0.7 percent of total forested area on the Carson NF. This is an increase of about 2.5 times the annual harvest area compared with alternative 2. Assuming that the annual carbon impact also increases two and a half times above alternative 2, harvest treatments under alternative 3 may result in a maximum removal of about 60,568 Mg/ha of carbon per year (0.0606 Tg C) from aboveground pools (Dugan et al. 2020).

Alternative 3 includes the same acreage (up to 13,500 acres annually) of prescribed and wildfire managed for resource benefit as alternative 2, which is 11.5 times the amount under alternative 1. If maximum levels of prescribed burning are achieved, this would result in a potential loss of about 113,779 Mg C of carbon annually (0.1138 Tg C), as estimated from the historical analysis (Dugan et al. 2020). However, the historical period included wildfires which generally burn at higher severities and result in greater carbon losses than prescribed burns. By reducing hazardous fuels, additional prescribed burning up to maximum levels described in Tier 2 may indirectly reduce the risk of more severe wildfires and greater carbon losses in the future (Agee and Skinner 2005; Wiedinmyer and Hurteau 2010).

Considering the maximum area treated with harvesting and prescribed fire, the amount of carbon that might be removed is small relative to the approximately 56.9 million metric tons (Tg) of carbon stored in the forest ecosystem of Carson NF. With maximum intensification, potential management actions would affect up to 1.6 percent of the forested area and 0.1777 Tg C annually. The alternative 3 actions would not significantly, adversely, or permanently affect forest carbon storage, but would rather achieve a more resilient forest condition that would improve the ability of the Carson NF to maintain carbon stocks and enhance carbon uptake (Dugan et al. 2020).

The total annual lost carbon storage potential would be slightly greater than under alternative 2, though still small compared to the total carbon stocks on the forest and within the uncertainty for measurement of total forest carbon stocks (figure 19). Lost storage potential is likely to be offset by an increased rate of carbon accumulation due to younger forest establishment following disturbance.

Environmental Consequences for Carbon – Alternative 4

The maximum treatment area for harvests and thinning under alternative 4 would be approximately 930 acres per year, a negligible percentage of total forested area on the Carson NF in terms of carbon flux. This is a decrease of more than four times the annual harvest area compared to alternatives 2. Compared to alternative 1, harvests under alternative 4 decrease removal of carbon by about a third, assuming that the annual carbon impact increases proportionally. Mechanical treatment and removal under alternative 4 would result in a maximum potential removal of about 5,416 Mg/ha of carbon per year (0.0054 Tg C) from aboveground pools (Dugan et al. 2020).

Alternative 4 includes a 15-fold increase in the level of prescribed burning and fires managed for resource benefits (compared to the reference period) of up to 17,760 acres annually. If maximum levels of prescribed burning are achieved, this would result in a potential loss of about 149,683 Mg of carbon annually (0.1497 Tg C), as estimated from the historical analysis (Dugan et al. 2020). However, the historical period included wildfires, which generally burn at higher severities and result in greater carbon losses than prescribed burns. By reducing hazardous fuels, additional prescribed burning up to the maximum levels described in alternative 4 may indirectly reduce the risk of more severe wildfires and greater carbon losses in the future (Agee and Skinner 2005; Wiedinmyer and Hurteau 2010).

Considering the maximum area treated with harvesting and prescribed fire, the amount of carbon that might be removed is small relative to the approximately 56.9 million metric tonnes (Tg) of carbon stored in the forest ecosystem of Carson NF. With maximum intensification, potential management actions would affect up to 1.25 percent of the forested area and about 0.1585 Tg of carbon annually. The alternative 4 actions would not significantly, adversely, or permanently affect forest carbon storage, but would rather achieve a more resilient forest condition that would improve the ability of the Carson NF to maintain carbon stocks and enhance carbon uptake (Dugan et al. 2020).

The total annual lost carbon storage potential would be slightly greater than under alternative 2, though still small compared to the total carbon stocks on the forest and within the uncertainty for measurement of total forest carbon stocks (figure 19). Lost storage potential is likely to be offset by an increased rate of carbon accumulation due to younger forest establishment following disturbance.

Federally Recognized Tribes

Description of Affected Environment

The Carson shares a common boundary with the Jicarilla Apache Nation, Picuris Pueblo, Southern Ute Mountain Tribe, and Taos Pueblo, and is in proximity to several other tribal communities.

reports (emissions tracking also applies to wildfires greater than 100 acres that are fully suppressed) (20.2.65 New Mexico Administrative Code, Smoke Management).

Concern Statement 165 **Greenhouse Gas Emissions**

The Assessment did not provide emissions data and analysis for the Carson NF. Instead, the Assessment relied on a study for the Apache-Sitgreaves NF in Eastern Arizona and Western New Mexico as a "surrogate solution for emissions assessment" on the Carson NF. While this study is instructive, its conclusions may not be fully applicable to the Carson, and we urge the Carson NF to undertake Carson-specific greenhouse gas emissions research to better inform management decisions on the Carson NF. The Apache-Sitgreaves study examined "the long-term (100 years difference in carbon stocks and carbon emissions between treated [for fire prevention] and untreated forest ecosystems." The study found that carbon storage is higher in untreated areas, but treated areas have lower emissions related to wildfires.

Associated Comment Letters: 4911

Response

An analysis of carbon loss and sequestration by alternative based on Carson-specific data has been added to the FEIS (Chapter 3, Carbon). The full description of the carbon modeling process can be found in appendix C of the FEIS.

Climate Change and Carbon - CCC

Concern Statement 166 **Carbon Sequestration**

The plan should describe the value of carbon sequestration in designated and management areas and in each type of forest ecosystem (vegetation, soils, wetlands).

Associated Comment Letter: 4911

Response

Carbon sequestration is identified as an ecosystem service in the introduction to chapter 2 in the final Plan. Carbon sequestration is also discussed in the introduction to the Soil Resources and Air Resources sections in the final Plan. FW-VEG-DC-3 directs management to maintain ecosystem functions including carbon sequestration. The Plan does not assign value to any ecosystem service. It does not discuss carbon sequestration under management areas or designated areas because it is not the designation itself that sequesters carbon, but rather the resources (vegetation, soils) within the area that sequester carbon.

Concern Statement 167 **Carbon Sequestration Alternative**

The Forest Service has a carbon sequestration alternative that was not made public and which the Forest Service is not receiving comment on because it was rejected. Keeping this alternative out of the EIS and not revealing it violates the spirit and letter of NEPA's public information requirements, the requirement that the action be noticed for public comment and comment by other agencies, and the requirement that the EIS provide sufficient information to the decision-maker to choose among alternatives.

Associated Comment Letter: 154

Response

Forest Service directives for environmental impact statements state that the EIS rigorously explore and objectively evaluate all reasonable alternatives and briefly discuss the reasons for having eliminated other alternatives from detailed study (FSH 1909.15 Chapter 20 Section 23.3 5(a)).

An alternative that manages forest lands for carbon sequestration to offset greenhouse gas emissions was included as an Alternative Considered but Eliminated from Detailed Study in the draft and final environmental impact statements. This alternative was not included in detailed study within the FEIS analysis because management to maximize carbon sequestration over other ecosystem services is not a goal of the plan nor is it included in the purpose and need for revising the forest plan (FEIS, Purpose and Need section). The revision topics identified in the purpose and need for change include: Terrestrial Ecosystem and Habitat, Watersheds and Water, and Multiple Use and Human Influences. The final Forest Plan addresses the needs of changing climate patterns with a focus on restoration by managing for functional ecosystems over time to provide ecosystem services including carbon storage (Chapter 2 Forestwide Plan Components, Ecological Sustainability and Diversity of Plant and Animal Communities Introduction). The following plan components address carbon storage: FW-VEG-DC 3; Management Approach for All Vegetation Communities-11. FW-FAC-DC 2 addresses Forest facilities, setting a desired condition that these are energy-efficient and that renewable energy sources are used for power.

The Carson NF had extensive public engagement throughout the planning process, from assessment through the 90-day public comment period (FEIS, Public Involvement Section). We held monthly open houses beginning in 2016 to allow the public to speak with and ask questions of Carson personnel on the many documents being developed as part of the draft plan and draft EIS. The Carson NF has accepted all comments received from the public.

Concern Statement 168 **Carbon Sequestration by Alternative**

The Forest needs to evaluate the differences between alternatives regarding the current carbon sequestration and the carbon emissions and determine which one provides for more carbon sequestration and reducing carbon emissions. The Draft Environmental Impact Statement, Environmental Consequences for Air Resources - Alternative 2 Restoration to Provide Diverse Ecosystem Services, page 264. The following statement: "Alternative 2 would restore approximately 11 times more acres annually than the current plan, which would result in greater potential for carbon sequestration over the life of the plan." is not complete and requires revision. Please provide the study citation (author, title, date, publisher) that demonstrates that the Carson National Forest Restoration (i.e. reduction in Forest densities), through a reduction in the number of trees, results in an increase in carbon sequestration over the life of the Land Management Plan

Associated Comment Letter: 160

Response

While the Carson NF recognizes the vital role that forested lands play in carbon sequestration, the final Plan manages for overall ecosystem function, which implies inherent levels of carbon sequestration and greenhouse gas emissions. The analysis of carbon sequestration has been expanded in the FEIS (Chapter 3, Environmental Consequences for Carbon) and documentation of the modeling process has been added to appendix C.

A citation has been included in the FEIS to support the statement that forest restoration can lower risk for greater carbon stock losses and emissions in the future (Wiedinmyer and Hurteau 2010).

Concern Statement 169 **Carbon Sequestration**

Manage forests to serve as vast carbon sinks. The Forest Plan should acknowledge and optimize the climate value of national forests and maximize long-term carbon storage on public lands. Given that the adverse impacts of climate change on the forest are caused by excessive carbon emissions into the atmosphere, and that carbon sequestration can offset these emissions and hence reduce this cause, it follows that maximizing carbon sequestration promotes the overall ecosystem function over the long-term.

Associated Comment Letters: 154, 4911, 5347

Response

The value of the Carson NF for carbon sequestration is noted in several places in the final Plan including FW-VEG-DC-3 and the Soil Resources section introduction. An alternative to manage forest lands for carbon sequestration to offset greenhouse gas emissions was considered but eliminated for detailed study (FEIS, chapter 2). While the Carson NF recognizes the vital role that forested lands play in carbon sequestration the final plan manages for overall ecosystem function which implies inherent levels of carbon sequestration and greenhouse gas emissions.

> The basic approach involves managing C through managing the health and productivity of the Nation's forests. The approach focuses on managing risks to the health, productivity, and ability of the resource to provide the goods and services called for in management plans. Management actions have C outcomes and those are considered among the benefits being managed. Forest systems are dynamic and emit and capture C regardless of human intervention. The Forest Service C strategy is embedded in a larger adaptation strategy for managing the resource that considers multiple impacts of natural and anthropogenic stressors (Birdsey et al. 2019, p. 15).

We disagree that managing to maximize carbon sequestration promotes ecosystem function and management to maximize carbon sequestration over other ecosystem services is not a primary management focus in the plan. Janowiak et al. (2017) briefly summarize how land management planning incorporates carbon sequestration, "The long-term capacity of forest ecosystems to capture and store carbon depends in large part on their health, productivity, resilience, and adaptive capacity."

> Land management in a dynamic system considers cumulative effects across time, factoring in risk, severity, scale, and likely outcome of disturbances. For example, storing carbon in overly dense forests increases the risk of losing the carbon through fire and decomposition of fire-killed trees following large wildfires (M. D. Hurteau and Brooks 2011). Dense stands are less vigorous and more susceptible to insect attack (Oliver and Larson 1996). Land management programs that restore forests to healthy and productive conditions will help ensure the long-term maintenance and transformation of forest carbon stocks (Janowiak et al. 2014).

Concern Statement 170 **Carbon Sequestration, Wilderness**

The EIS should analyze the impacts of each alternative to the carbon cycle. If the Carson considered and quantified the carbon sequestration and carbon storage capabilities of wilderness it may have developed and chosen an alternative with greater recommended wilderness. Instead, it rejected the two alternatives with the greatest wilderness, without apparent consideration of these factors. The Forest Service should be conducting an explicit cost-benefit analysis to ensure that there are in fact net economic benefits when the impacts of not avoiding carbon emissions are taken into account.

Associated Comment Letter: 154

Response

The Carson NF has quantified carbon flux under each alternative (FEIS, appendix C). Carbon stocks on the Carson NF have increased from 56.4±8.2 teragrams of carbon (Tg C) in 1990 to 56.9±7.3 Tg C in 2013, a 0.9 percent increase. All of the alternatives would initially directly reduce carbon stocks on the forest, though minimally. However, this initial effect would be mitigated or even reversed with time, reducing the potential for negative indirect and cumulative effects. As shown in figure 1, all action alternatives have a greater potential for carbon loss per year from disturbance (tree removal, insects, disease, and fire). Carbon loss from disturbance would be offset to varying degrees by increased net primary productivity and carbon sequestration from young tree establishment following disturbance (figure 2). The success of tree establishment is related to overall ecosystem integrity that would vary by alternative. But replacing old trees (generally greater than 50 years in age on the Carson NF) with younger more productive trees increases the rate of carbon sequestration, and most stands on the Carson are more than 50 years old (figure 3).

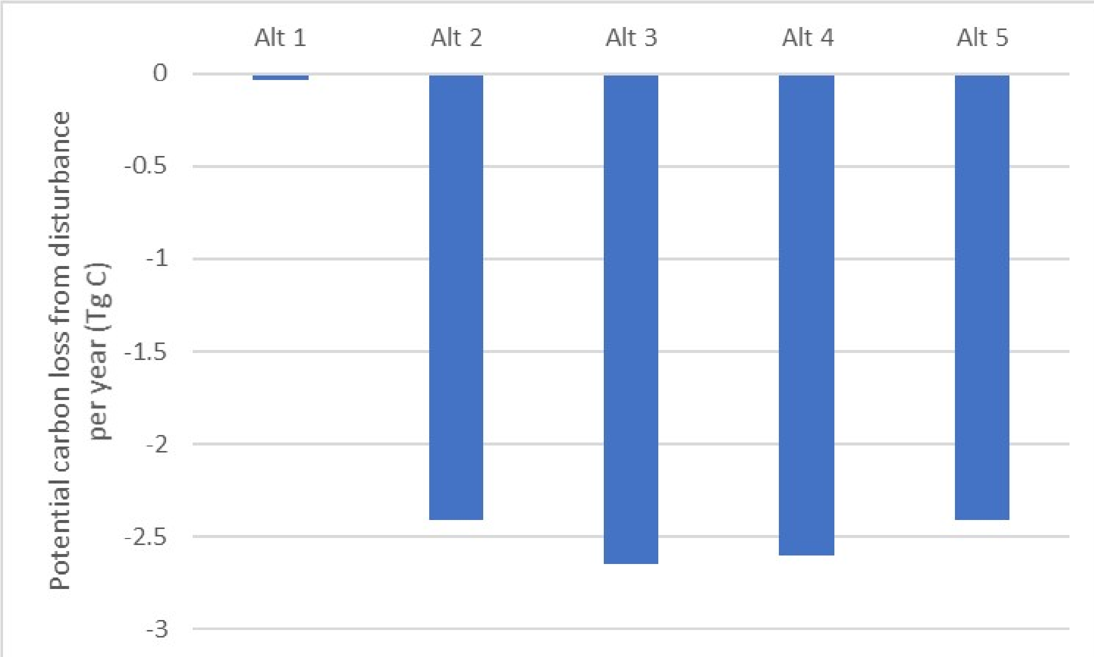


Figure 1. Potential carbon loss from disturbance per year by alternative

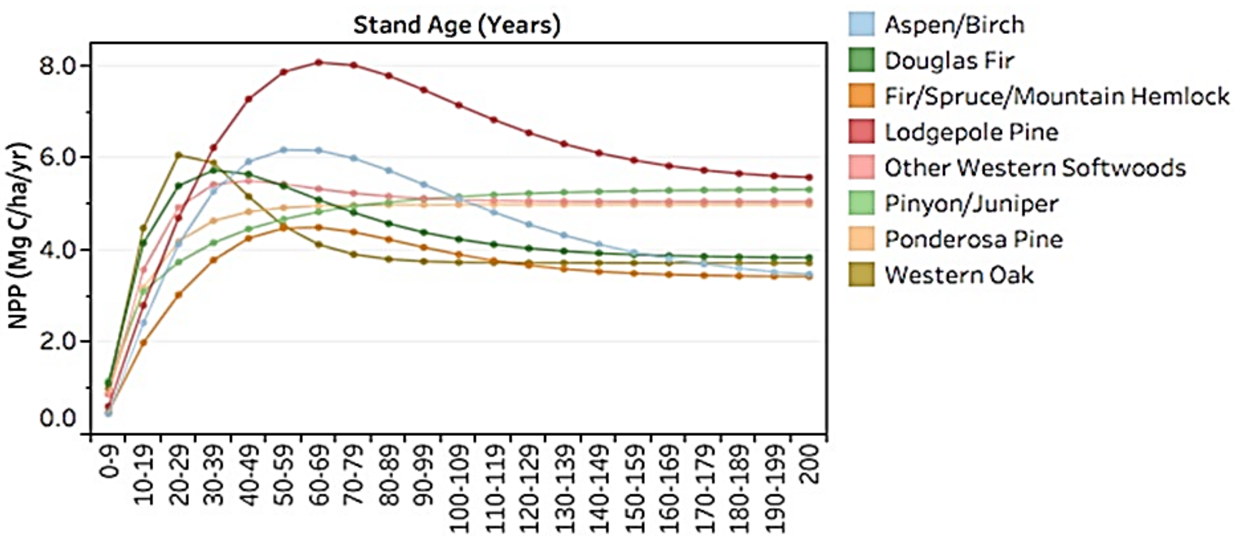


Figure 2. Net Primary Productivity-stand age curves by forest type group in Carson National Forest. Derived from forest inventory data and He et al. 2012.

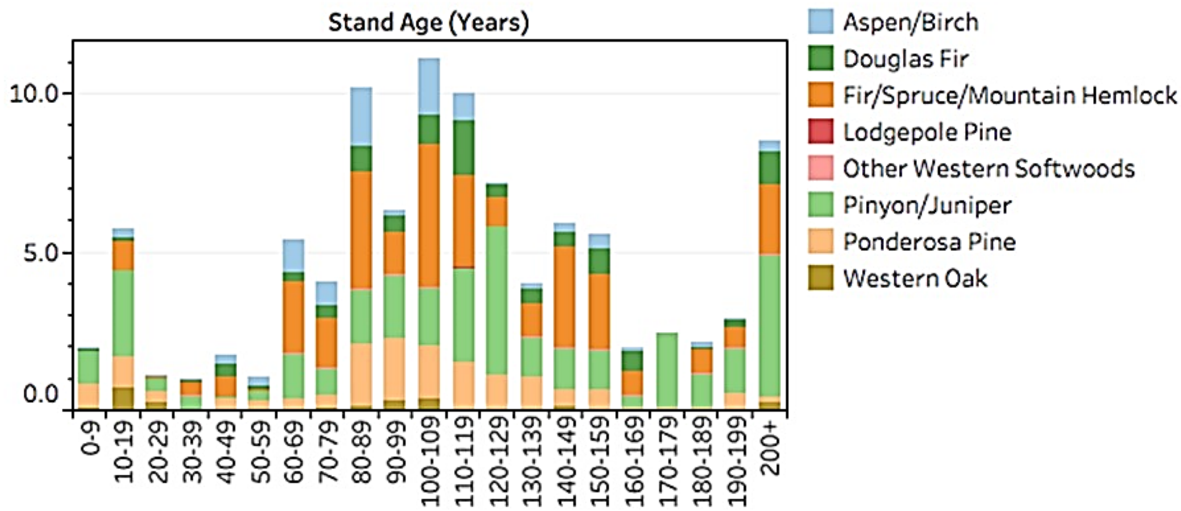


Figure 3. Stand age distribution in 2011 by forest type group in Carson National Forest. Derived from forest inventory data.

In a global atmospheric CO_2 context, even the maximum potential management levels described by the plan alternatives would have a negligible impact on national and global emissions and on forest carbon stocks. When impacts on carbon emissions (and carbon stocks) are small, a quantitative analysis of carbon effects is not warranted and thus is not meaningful for a reasoned choice among plan alternatives (USDA FS 2009b). Although advances in research have helped to account for and document the relationship between greenhouse gas emissions and global climate change, it remains difficult to reliably simulate observed temperature changes and distinguish between natural or human causes at smaller than continental scales (IPCC 2007).

Even more challenging is the ability to quantify future carbon consequences of management alternatives due to potential variability in future conditions and the unpredictable nature of disturbances (Ryan et al. 2010). The dominant disturbance influence on carbon flux on the Carson NF between 1990 and 2011 was wildfire with some contribution from insect-induced mortality (Birdsey et al. 2019). Across southwestern national forests, other factors such as climate variability, atmospheric CO_2, and nitrogen deposition were significant drivers of carbon stock fluctuations (Birdsey et al. 2019). The result of these sorts of variable influences is a very low signal-to-noise ratio: small differences in carbon impacts among management alternatives, coupled with high uncertainty in carbon stock estimates, make the detection of statistically meaningful differences among alternatives highly unlikely.

Carbon storage capabilities of wilderness, recommended wilderness, and non-wilderness were not considerations in the wilderness recommendation process. The wilderness recommendation process followed 2012 Planning Rule direction (FSH 1909.12 chapter 70). The record of decision details the considerations used to make final wilderness recommendations.

Concern Statement 171 **Carbon Sequestration, Thinning and Logging**

Facilitate carbon-rich ecosystems by increasing the number of trees. The assumption that mechanical thinning and treatment will avoid the carbon emissions associated with more frequent high severity fires, see DEIS at 261, is flawed. Eliminate mechanical thinning because it causes a net loss of forest carbon storage and a net increase in carbon emissions. Thinning and logging can increase fire intensity rather than reduce it (Bradley et al. 2016). Because timber production releases carbon in the harvest process, reduces the carbon storage capacity of the forest and reduces its potential for carbon sequestration, it adds carbon to the atmosphere and is not compatible with the objective of sustaining a healthy forest ecosystem.

Associated Comment Letters: 154, 5008, 5361, 5673

Response

We stand by the supposition that thinning and prescribed fire increase carbon sequestration over longer time frames and have added supporting documentation to the assumptions section of Environmental Consequences for Air Resources (FEIS, Chapter 3). While mechanical thinning does result in a short-term loss of forest carbon emissions, over the long term (several decades to one century), forest restoration results in more total ecosystem carbon and lower wildfire emissions than a no-harvest scenario (Hurteau 2017; McCauley et al. 2019). Carbon "losses caused by thinning and burning treatments are out-weighed by the [carbon] gains from decreased tree mortality rates and increased sequestration" (Hurteau et al. 2016).

Bradley, Hanson and DellaSala (2016, p. 7) did show a negative correlation between protection status (PAD-US, USGS 2012) and fire severity; however, the observed correlation does not indicate, as the paper concludes, that burn severity is higher in areas with "more intense management" (p. 7). The comment incorrectly links national forest lands where more intensive management is allowed (non-wilderness and non-inventoried roadless areas, Gap Analysis Program protection class 1 and 2) to areas where thinning and logging are occurring. In fact, Bradley, Hanson, and DellaSala (2016, p. 9) conclude, "due to the coarseness of the management intensity variables that we used (i.e., GAP status), we cannot rule out whether low intensities of management decreased the occurrence of high-severity fire in some circumstances. However, the relationship between forest density/fuel, mechanical fuel treatment, and fire severity is complex."

More protective management, such a wilderness or inventoried roadless areas, often reflect a historical pattern of lower human use. That is, the same lack of access that makes areas good candidates for more protective designations has also discouraged past human use and management that have contributed to the current departed forest conditions and fire regimes in other places. A large body of evidence indicates that thinning of frequent-fire forests from which fire has historically been excluded is effective at reducing uncharacteristic fire effects (Evans 2018).

Concern Statement 172 **Climate Resiliency Potential**

Protect places that have high climate resiliency potential, like headwater streams, wetlands, and the Valle Vidal. This is crucial for preparing our landscape for the stresses of climate change.

Associated Comment Letter: 236

Response

The final Plan has incorporated climate change into the management of resources and has pinpointed desired conditions and objectives that increase the ecological resiliency of the Carson to predicted changes in climate. Stream function and resiliency is described in the FW-WSW-RMZ-STM section and wetland function and resiliency is described in the FW-WSW-RMZ and FW-WSW-RMZ-WR sections. The Valle Vidal is managed according to forest wide plan components with additional direction provided in the MA-VVMA section.

The final Plan addresses climate-related stressors through strategies that are responsive to an uncertain and changing climate (Chapter 1, Plan Concepts). Complex interactions will occur among species as they migrate and adapt in response to changing environmental conditions. Future management will benefit by being adaptive, innovative, and flexible as species associations and environmental stressors without historical equivalent emerge (Millar et al. 2007). Management that reduces stressors that are well understood will produce ecosystems with better baseline resiliency and more adaptive capacity to continue to function in the face of other, more uncertain stressors (Hanberry et al. 2015). Strategies for management that take climate uncertainty into consideration are integrated throughout the plan (FEIS, Chapter 3, Assumptions Common to All Resources, Management Implications of Projected Future Climate).

Concern Statement 173 **Climate Change Impacts**

Reference conditions should be adjusted to account for climate change impacts.

Associated Comment Letter: 4911

Response

Reference conditions represent the characteristic natural range of variability prior to European settlement and under the current climatic period (final Plan, glossary). The glossary definitions in the final Plan and FEIS have been edited to clarify that reference conditions can be used to inform desired conditions but may have to be refined considering factors such as climate change.

The final Plan has incorporated climate change into the management of resources and has pinpointed desired conditions and objectives that increase the ecological resiliency of the Carson to predicted changes in climate. For example, vegetation management practices in the final Plan can reduce drought stress and the risk of uncharacteristic fire, both of which are consequences of changing temperature and precipitation regimes combined with uncharacteristically dense and fuel-laden forests. Management practices are also designed to allow for the flexibility to address changing conditions over time.

The implications of climate change for both society and natural resources are profound and complex, as are the challenges of integrating adaptation and mitigation responses. A successful approach will be based on thorough assessments and well-tailored policies, engaging a full range of stakeholders across the landscape in activities for adaptation, mitigation, and education (USDA FS 2010a). The uncertainty that accompanies a changing climate creates challenges for natural resource management and dependent communities (Gowda et al. 2018; Hand et al. 2018; Jantarasami et al. 2018). Broad scientific ecological knowledge is based on observations of natural process and interaction under past and current climatic conditions. Complex interactions will occur among species as they migrate and adapt in response to changing environmental conditions. Future management will benefit by being adaptive, innovative, and flexible as species associations and environmental stressors without historical equivalent emerge (Millar et al. 2007).

Management that reduces stressors that are well understood will produce ecosystems with better baseline resiliency and more adaptive capacity to continue to function in the face of other, more uncertain stressors (Hanberry et al. 2015). Strategies for management that take climate uncertainty into consideration are integrated throughout the plan (FEIS, Chapter 3, Assumptions Common to All Resources, Management Implications of Projected Future Climate).

Concern Statement 174 **Climate Change Impacts**

There is insufficient analysis of the impacts of management decisions on the environment in light of the compounding impacts of climate change.

Associated Comment Letter: 4994

Response

Management implications of projected future climate are summarized at the beginning of chapter 3 of the FEIS (Assumptions Common to All Resources). The FEIS also includes discussion of the impacts of climate change in the Environmental Consequences for Vegetation; Fuels and Wildland Fire; High Elevation Forests; Frequent Fire Forests; Woodlands; Soil Resources; Watersheds and Water; Wildlife, Fish, and Plants; Sustainable Rangelands and Livestock Grazing; Recreation; Scenery; Transportation and Forest Access; Wilderness; the Jicarilla Natural Gas Management Area; Socio-Economics; and Environmental Justice (chapter 3).

The implications of climate change for both society and natural resources are profound and complex, as are the challenges of integrating adaptation and mitigation responses. There is significant uncertainty that accompanies a changing climate and complex interactions will occur among species as they migrate and adapt in response to changing environmental conditions. Accordingly, the final Plan is designed to be adaptive, innovative, and flexible to respond to unforeseen challenges as species associations and environmental stressors without historical equivalent emerge (FEIS, Chapter 3, Assumptions Common to All Alternatives, Management Implications of Projected Future Climate Change).

Concern Statement 175 **Climate Change Impacts**

The plan needs to take into account the ongoing and future impacts of a changing climate.

Associated Comment Letters: 1218, 1826, 4847, 4857, 4911, 5673

Response

The final Plan has incorporated climate change into the management of resources and has pinpointed desired conditions and objectives that increase the ecological resiliency of the Carson to predicted changes in climate. For example, vegetation management practices in the final Plan can reduce drought stress and the risk of uncharacteristic fire, both of which are consequences of changing temperature and precipitation regimes combined with uncharacteristically dense and fuel-laden forests. Management practices are also designed to allow for the flexibility to address changing conditions over time.

The implications of climate change for both society and natural resources are profound and complex, as are the challenges of integrating adaptation and mitigation responses. A successful approach will be based on thorough assessments and well-tailored policies, engaging a full range of stakeholders across the landscape in activities for adaptation, mitigation, and education (USDA FS 2010a). The uncertainty that accompanies a changing climate creates challenges for natural resource management and communities dependent on forest resources (Gowda et al. 2018; Hand et al. 2018; Jantarasami et al. 2018). Broad scientific ecological knowledge is based on observations of natural process and interaction under past and current climatic conditions. Complex interactions will occur among species as they migrate and adapt in response to changing environmental conditions. Future management will benefit by being adaptive, innovative, and flexible as species associations and environmental stressors without historical equivalent emerge (Millar et al. 2007).

Management that reduces stressors that are well understood will produce ecosystems with better baseline resiliency and more adaptive capacity to continue to function in the face of other, more uncertain stressors (Hanberry et al. 2015). Strategies for management that take climate uncertainty into consideration are integrated throughout the plan (FEIS, Chapter 3, Assumptions Common to All Resources, Management Implications of Projected Future Climate).

Concern Statement 176 **Climate Change Section**

There is no comprehensive section concerning climate change in either the draft plan or DEIS. The piecemeal approach to the issue of climate change makes it difficult to get a good sense of how the Carson is planning to address climate change and how climate change is likely to impact the forest. It also makes it hard to determine what gaps exist in the Carson's climate-related management direction and environmental analysis. Include a section on climate change in the draft plan that describes climate change impacts on the forest, explain how the Carson plans to address climate change (including climate mitigation, adaptation, and resilience), and cross-references all plan components that concern climate change. The Carson should also include a comprehensive section on climate change in the final EIS. The analysis should describe current and expected climate impacts in the Carson and explain how the various alternatives would address climate change.

Associated Comment Letters: 154, 4856, 4911, 4951, 4994, 5574

Response

Projected climate change impacts on the Carson NF are described in the Assessment (pp. 275–279); the final Plan itself does not describe impacts. The FEIS is organized by resource; projected climate change is discussed throughout the analysis in terms of its impact on individual resources. The FEIS also summarizes management implications of projected future climate at the beginning of chapter 3 (Assumptions Common to All Resources).

The implications of climate change for both society and natural resources are profound and complex, as are the challenges of integrating adaptation and mitigation responses. There is no single approach that will successfully address climate change across the Carson NF and its multiple resources. Future management will benefit by being adaptive, innovative, and flexible as species associations and environmental stressors without historical equivalent emerge (Millar et al. 2007). Changing climate is identified as a foundational plan concept that "sets the tone for the plan throughout" and is "important to consider during implementation" (final Plan, Chapter 1, Plan Concepts). Strategies for management that take climate uncertainty into consideration are integrated throughout the plan (FEIS, Chapter 3, Assumptions Common to All Resources, Management Implications of Projected Future Climate). Management that reduces stressors that are well understood will produce ecosystems with better baseline resiliency and more adaptive capacity to continue to function in the face of other, more uncertain stressors (Hanberry et al. 2015). Desired conditions throughout the plan reduce stressors to improve resiliency increase adaptive capacity. The final Plan does include management approaches that describe possible strategies that may be useful under future climatic conditions such as, Management Approaches for All Vegetation Communities-2, -8, and -11, and Management Approach for Transportation and Forest Access-5.

Concern Statement 177 **Climate Change, Other Stressors**

It does not appear the Forest Service considered factors related to climate change and other stressors in developing this Plan as required by the 2012 Planning Rule. Responsible officials must identify and evaluate a baseline assessment of carbon stocks, as a part of the assessment phase. Climate change must be taken into account when the responsible official is developing plan components for ecological sustainability. When providing for ecosystem services and multiple uses, the responsible official is required to consider climate change. Measurable changes to the plan area related to climate change and other stressors affecting the plan area must be monitored.

Associated Comment Letters: 154, 4994

Response

A baseline assessment of carbon stocks was conducted during the assessment phase and is documented on pages 284–297 of the Assessment. Climate change was considered during the development of plan components for ecological sustainability, ecosystem services, and multiple uses. Changing climate is identified as a foundational plan concept that "sets the tone for the plan throughout" and is "important to consider during implementation" (final Plan, Chapter 1, Plan Concepts). Monitoring topic VI measures changes to the plan area related to climate change and other stressors. An additional question has been added to annually monitor seasonal temperature and precipitation trends (Final Plan, Chapter 4).

Concern Statement 178 **Monitoring, Drought**

Drought should be an added indicator to Monitoring Topic VI: Measurable Changes Related to Climate and Other Stressors.

Associated Comment Letter: 3228

Response

Drought has been added to the list of stressors in Table 14, Monitoring Topic VI: Measurable Changes Related to Climate and Other Stressors.