1.1 Carbon and Greenhouse gas emissions

Forests play an important role in the global carbon cycle by sequestering carbon from the atmosphere and storing it in biomass and soil. Forestry has gained attention in recent decades because of its potential to influence the exchange of carbon with the atmosphere, either by increasing storage or releasing carbon emissions. Forests can take up and store atmospheric carbon through photosynthesis and release carbon through mortality, plant respiration, microbial decay, fire, and use of wood fiber. Forests can store carbon in soils and plant material as well as in harvested wood products that store carbon outside of the forest ecosystem. In addition, wood fiber can be used to substitute for products that are more energy-intensive to produce, such as concrete and steel, creating a substitution effect which can result in lower overall greenhouse gas emissions.

A complete and quantitative assessment of forest carbon stocks and the factors that have influenced carbon trends (management activities, disturbances, and environmental factors) for the Hoosier National Forest is available in the project record (Dugan et al. 2019). This carbon assessment contains additional supporting information as well as references for this proposed action.

1.1.1 Affected Environment

The carbon legacy of the Hoosier National Forest is tied to the history of Euro-American settlement, land management, and disturbances. As the first region to be widely settled in the United States, eastern forests have had a long history of intensive harvesting and conversion of forests to agriculture. Historical disturbance dynamics, forest regrowth and recovery, and forest aging have been most responsible in driving carbon accumulation trends since the mid-20th century. Forests are still recovering from historic management activities. Estimates indicate that the forested area on the Hoosier National Forest have increased from 1990 to 2013. Forests in the Hoosier National Forest are maintaining a carbon sink. Forest carbon stocks have increased by about 34 percent between 1990 and 2013 (USDA Forest Service, 2015), and negative impacts on carbon stocks caused by disturbances and climate conditions have been modest and exceeded by forest growth. However, over half of the stands on the Hoosier are middle-aged and older (greater than 80 years) and there has been a sharp decline in new stand establishment in recent decades (Birdsey et al., in press). If the Forest continues on this aging trajectory, more stands will reach a slower growth stage in coming years and decades, potentially causing the rate carbon accumulation to decline and the Forest may eventually transition to a steady state or to a carbon source.

According to satellite imagery, timber harvests has been the dominant disturbance type on the Hoosier National Forest from 1990 to 2011, although harvesting has typically affected less than 0.1 percent of the forested area annually (Birdsey et al., in press). During this period, only about 0.6 percent of the forested area experienced some level of harvest treatments. However during this period, timber harvesting declined substantially relative to the previous decades (USDA Forest Service, 2015). Carbon losses from the forest ecosystem associated with harvests have been relatively small compared to the total amount of carbon stored in the forest, with losses from 1990 to 2011 equivalent to about 0.09 percent of non-soil carbon stocks (Birdsey et al., in press). These estimates may represent an upper bound, because they do not account for continued storage of harvested carbon in wood products or the effect of product substitution.

According to satellite imagery, fire has been a minor disturbance type on the Hoosier National Forest from 1990 to 2011 although the forests records show more burning was done than could be detected from the air. During this period, less than 0.1 percent of the forested area experienced some level of fires including prescribed fires and wildfires. Fires were only detected in 2010. However, some prescribed fires that burned only along the forest floor may have gone undetected because they did not cause a change in canopy cover. Carbon losses from the forest ecosystem associated with fires have been relatively small compared to the total amount of carbon stored in the forest, with losses from 1990 to 2011 less than about 0.01 percent of non-soil carbon stocks (Birdsey et al. in press).

1.1.2 Direct, Indirect and Cumulative Effects of Alternative A

The proposed Houston South project includes both timber harvesting and prescribed burning treatments that would be conducted on approximately 23,363 acres, 9,833 acres of which is on private land. This scope and degree of change would be minor, affecting seven percent of the approximately 204,000 acres of forested land in the Hoosier National Forest. The effect of the proposed timber harvest focuses on aboveground carbon stocks that is stored in live woody vegetation and comprises about 45 percent of the totally ecosystem carbon stocks on the Hoosier National Forest. The effect of the proposed prescribed fire focuses the understory and forest floor, which together comprise about nine percent of the Forest-wide ecosystem carbon stocks (USDA Forest Service 2015). About 33 percent or more 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). The majority of the treatments will not remove 100 percent of the trees so not all of the 45 percent of the above ground carbon stock would leave the site.

Mineral soil is an important consideration for long-term carbon storage capacity in soils in most ecosystems. Timber harvesting generally results in a negligible amount of carbon loss from the mineral soils typically found in the United States, particularly when operations are designed in a way that minimizes soil disturbance (Nave et al. 2010, McKinley et al. 2011). Although timber harvest and prescribed fire can also affect the carbon stored in the understory and forest floor organic layer consisting of debris in various stages of decomposition, the carbon loss would be negligible given it is not stable or long-lived and would be replaced with months to a few years.

Climate change is a global phenomenon, because major greenhouse gasses (GHGs)[1] mix well throughout the planet's lower atmosphere (IPCC 2013). Considering emissions of GHGs in 2010 was estimated at 13,336 ± 1,227 teragrams[2] carbon globally (IPCC 2014) and 1,881 teragrams carbon nationally (US EPA, 2015), the Houston South project makes an extremely small contribution to overall emissions. Because local GHGs emissions mix readily into the global pool of GHGs, it is difficult and highly uncertain to ascertain the indirect effects of emissions from single or multiple projects of this size on global climate. Relative to the amount of carbon stored and sequestered by the Hoosier National Forest, this proposed action's direct and indirect contribution to GHGs and climate change are minor. In addition, because the direct and indirect effects would be negligible, the proposed action's contribution to cumulative effects on global GHGs and climate change would also be negligible. Lastly, carbon emissions during the implementation of the proposed action would have only a temporary influence on atmospheric carbon

[1] Major greenhouse gases released as a result of human activity include carbon dioxide (CO_2), methane, nitrous oxide, hydrofluorocarbons, and perfluorocarbons.

[2] This report uses carbon mass, not carbon dioxide (CO2) mass, because carbon is a standard unit and can easily be converted to any other unit. To convert carbon mass to CO2 mass, multiply by 3.67 to account for the mass of the oxygen (O2).

concentrations, because carbon will be removed from the atmosphere with time as the forest regrows, further minimizing or mitigating any potential cumulative effects.

From 2000 to 2009, forestry and other land uses contributed 12 percent of the human-caused global CO_2 emissions[3]. The forestry sector's contribution to GHG emissions has declined over the last decade (IPCC 2014, Smith et al. 2014, FAOSTAT 2013). The largest source of GHG emissions in the forestry sector globally is deforestation (e.g., conversion of forest land to agricultural or developed landscapes) (Pan et al. 2011, Houghton et al. 2012, IPCC 2014). However, forest land in the United States has had a net increase since the year 2000, and this trend is expected to continue for at least another decade (Wear et al. 2013, USDA Forest Service 2016).

The proposed activities in the Houston South project are not considered a major source of GHG emissions. Forested land will not be converted into a developed or agricultural condition or otherwise result in the loss of forested area. In fact, forest stands are being retained and harvested and prescribed burned to maintain a vigorous condition that promotes tree growth and productivity, reduces insect and disease levels and supports sustainable ecosystems, thus contributing to long-term carbon uptake and storage.

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 carbon[4] and retain other ecosystem functions and services. Climate change is likely already increasing the frequency and extent of droughts, fires, and insect outbreaks, which can influence forest carbon cycling (Kurz et al. 2009, Allen et al. 2010, Joyce et al. 2014). In fact, reducing stand density, one of the goals of the Houston South project, is consistent with adaptation practices to increase resilience of forests to climate-related environmental changes (Joyce et al. 2014). This project is 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).

Forest management activities such as harvests and prescribed burns have characteristics similar to disturbances that reduce stand density and promote regrowth through thinning and removal, making stands and carbon stores more resilient to environmental change (McKinley et al. 2011). The relatively small quantity of carbon released to the atmosphere and the short-term nature of the effect of the proposed actions on the forest ecosystem are justified, given the overall change in condition increases the resistance to insects, disease, wildfire, age related declines in productivity, or a combination of factors that can reduce carbon storage and alter ecosystem functions (Millar et al. 2007, D'Amato et al. 2011). Furthermore, any initial carbon emissions from this proposed action will be balanced and possibly eliminated as the stand recovers and regenerates, because the remaining trees and newly established trees typically have higher rates of growth and carbon storage (Hurteau and North 2009, Dwyer et al. 2010, McKinley et al. 2011).

The wood and fiber removed from the forest in this proposed action will be transferred to the wood products sector for a variety of uses, each of which has different effects on carbon (Skog et al. 2014). Carbon can be stored in wood products for a variable length of time, depending on the commodity

[3] Fluxes from forestry and other land use (FOLU) activities are dominated by CO_2 emissions. Non-CO_2 greenhouse gas emissions from FOLU are small and mostly due to peat degradation releasing methane and were not included in this estimate.

[4] The term "carbon" is used in this context to refer to carbon dioxide.

produced. It can also be burned to produce heat or electrical energy, or converted to liquid transportation fuels and chemicals that would otherwise come from fossil fuels. In addition, a substitution effect occurs when wood products are used in place of other products that emit more GHGs in manufacturing, such as concrete and steel (Gustavasson et al. 2006, Lippke et al. 2011, McKinley et al. 2011). In fact, removing carbon from forests for human use can result in a lower net contribution of GHGs to the atmosphere than if the forest were not managed (McKinley et al. 2011, Bergman et al. 2014, Skog et al. 2014). The IPCC recognizes wood and fiber as a renewable resource that can provide lasting climate-related mitigation benefits that can increase over time with active management (IPCC 2000). Furthermore, by reducing stand density and restoring historic composition, structure, and function, the proposed action may also reduce the risk of more severe disturbances, such as insect and disease outbreak and wildfires, which may result in lower forest carbon stocks and greater GHG emissions. Please see Swaim, 2019 for more information on stand densities.

Some tree species and forest communities within eastern U.S. are well adapted to fire and in some cases may depend on it for survival and regeneration. Historical fire suppression has allowed some fire-dependent forests in the eastern U.S. to become unnaturally dense and altered species composition and structure (Olson 1996, Nowacki and Abrams 2008). Carbon emissions associated with prescribed fires from duff, litter, and dead wood which comprise carbon pools that would otherwise decay quickly over time, releasing carbon to the atmosphere, even in the absence of fire. By reducing vegetative competition in the understory, the proposed prescribed burning following harvest would help establish oak habitat and increase the ability of harvested areas to regenerate more quickly. This would help to support forest health in a changing climate and reducing GHG emissions over the long-term.

In summary, this proposed project affects a relatively small amount of forest land and carbon on the Hoosier National Forest and, in the near-term, might contribute an extremely small quantity of GHG emissions relative to national and global emissions. This project will not convert forest land to other non-forest uses, thus allowing any carbon initially emitted from the proposed project to have a temporary influence on atmospheric GHG concentrations, because carbon will be removed from the atmosphere over time as the forest regrows.

Furthermore, the proposed project will transfer carbon in the harvested wood to the product sector, where it may be stored for up to several decades and substitute for more emission intensive materials or fuels. This proposed action is consistent with internationally recognized climate change adaptation and mitigation practices.

1.1.3 References

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