AMERICAN FOREST RESOURCE COUNCIL

VIA Email: comments-northern-kootenai-three-rivers@fs.fed.us

August 10, 2018

Kristen Kaiser, District Ranger
Three Rivers Ranger District
12858 US Highway 2
Troy, Montana 59935

Dear Kristen:

On behalf of the American Forest Resource Council (AFRC) and its members, thank you for the opportunity to comment on the Black Ram Project.

AFRC is a regional trade association whose purpose is to advocate for sustained yield timber harvests on public timberlands throughout the West to enhance forest health and resistance to fire, insects, and disease. We do this by promoting active management to attain productive public forests, protect adjoining private forests, and assure community stability. We work to improve federal and state laws, regulations, policies and decisions regarding access to and management of public forest lands and protection of all forest lands. Many of our members have their operations in communities within and adjacent to the Kootenai National Forest and management on these lands ultimately dictates not only the viability of their businesses, but also the economic health of the communities themselves.

The project area is located north and west of Troy, Montana and encompasses 95,412 acres, of which 91,647 acres are National Forest Service (NFS) lands. Proposed activities are on NFS lands only. The project area includes 23,846 acres of NFS lands in the Wildland Urban Interface (WUI). Additionally, 8,133 acres are in West Fork Yaak Inventoried Roadless Area (IRA) and 10,731 acres in the Northwest Peaks IRA, both of which are located along the northwest border of the project area. The focus of the Black Ram project is to manage the forest stands in the project area to maintain or improve their resilience to disturbances such as drought, insect and diseases outbreaks, and wildfires.

AFRC supports the Purpose and Needs for this project which includes:

1. Provide forest products that contribute to the sustainable supply of timber products from National Forest System Lands.
2. Reduce the potential for high intensity wildfire while promoting desirable fire behavior characteristics and fuel conditions in the Wildland Urban Interface and other areas with values at risk.

3. Maintain or improve watershed conditions in order to provide water quantity, water quality, stream channel conditions, and native aquatic species habitat that support ecological functions and beneficial uses.
4. Improve big game winter range conditions and promote forage opportunities.
5. Maintain and improve the recreation opportunities in the project area.

While AFRC supports the Purpose and Needs for this project we offer the following comments which we believe will improve the project.

1. The project area contains 91,647 acres of National Forest lands of which 18,964 acres are in Inventoried Roadless Areas (IRA). Assuming no commercial harvests will be done in the IRAs this leaves a land base of 72,683 acres that could be available for commercial harvest and management. At this point the Forest is only planning to treat 4,100 acres mechanically which equates to only 5.6% of the land base. This low number of acres is a BIG concern for AFRC for many reasons, not the least that 23,846 acres are in the WUI and very susceptible to large wildfires like the Forest in 2017.

   AFRC does not believe the Forest can accomplish the Purpose and Needs for this project by only mechanically treating 5.6% of the land base. Specifically, the needs to contribute to the sustainable supply of timber products from National Forest lands, and the reduction of potential for high intensity wildfire while promoting desirable fire behavior characteristics and fuel conditions in the WUI and other areas with values at risk will not be met!

   Additionally, the project's focus is to maintain and improve forest landscape resiliency by providing for tree species, stocking levels, and landscape patterns that better resist insects, disease, and stand-replacing wildfire(s).
   Goals specific to the Black Ram project include:

   - Promote early seral tree species including western larch, ponderosa pine, and western white pine
   - Maintain or improve old growth character within existing old growth
   - Encourage fire's ecological function on the landscape
   - Improve resilience and resistance to insects, disease and
   - Design size of treatments to be consistent with the patch size and pattern of the respective biophysical setting
   - Diversify successional stages

   Again, AFRC does not believe the Forest can meet the purpose and need by only treating 5.6% of the land base.

   AFRC requests the Forest complete a thorough stand exam of the project area to establish what treatments each stand needs to get them into an improved forest health condition. From this information, AFRC would like the Forest to complete a maximum mechanical treatment alternative that would bring all stands into an improved forest health condition and would provide a maximum timber harvest alternative to satisfy the Purpose and Need.

2. In looking at the project map, it appears that a lot more work could be done in and around the WUI areas. AFRC suggests that the Forest review all of the forest health work outlined by the stand exams needed in these WUI areas, particularly with reference as to the fire intensity from the 2017 wildfires and make sure that adjacent properties and structures are protected.

3. Further, AFRC would like to remind the Forest that the National Forests in Montana are very important for providing the raw materials that sawmills within the state need to operate since so much of the Forests are owned by the Forest Service. Currently, Montana's forest products industry is one of the largest components of manufacturing in the state and employs roughly 7,700 workers earning about $335 million annually. The majority of the industry is centered in western Montana where the project is located. The timber products provided by the Forest Service are crucial to the health of our membership and the counties and communities where they are present. Without the raw material sold by the Forest Service these mills would be unable to produce the amount of wood products that the citizens of this country demand. Without this material, our members would also be unable to run their mills at capacities that keep their employees working, which is crucial to the health of the communities that they operate in. These benefits can only be realized if the Forest Service sells their timber products through sales that are economically viable. This viability is tied to both the volume and type of timber products sold and the manner in which these products are permitted to be delivered from the forest to the mills.

4. Another Purpose and Need is to maintain or improve watershed conditions in order to provide water quantity, water quality, stream channel conditions, and native aquatic species habitat that support ecological functions and beneficial uses. A number of streams and drainages are present in the planning area and AFRC strongly encourages the Forest to enter into the riparian areas to remove some of the fuel loading and cover. Recent large wildfires have shown that some of the most severe burns and resource damage have occurred in the riparian areas where the fuel loads are the highest. Creating openings in the riparian areas also allows more sunlight to enter which can enhance other vegetation and insect production for a variety of species that depend on them for food.

   Work in Riparian Reserves to control stocking and acquire vegetation characteristics are needed to obtain Aquatic Conservation Strategy objectives. Such work would be appropriate for this project. It has been documented by many that most of the wood that naturally recruits to streams comes from within the first 65 feet of the stream channel (Murphy and Koski, 1989; McDade et al. 1990. Johnson et al. 2011). If this is where the LWD is coming from then thinning in this region would likely accelerate its creation. We encourage the Forest to design riparian thinning treatments on this project in ways that foster positive changes to large wood supplies that would result in measurable changes. One way to accomplish this is to reduce the no-cut buffers. It has also been documented that vegetated buffers that are greater than 33 feet in width have been shown to be effective at trapping and storing sediment (Rashin et al. 2006). Partial cutting down to one or two conifers from intermittent and perennial stream channels would accelerate the recruitment of LWD with minimal impacts to sedimentation and stream temperature. We would like the Forest Service to consider these trade-offs closely in the planning for this project to improve riparian conditions on the maximum amount of these reserves.

We would also like the Forest to consider including some of the following pieces of scientific research into their analysis. Controversy surrounding any type of thinning in riparian reserves has surfaced, and we think the following information would be useful in justifying the kinds of beneficial treatments the Forest implements.

Stream temperature
Janisch, Jack E, Wondzell, Steven M., Ehinger, William J. 2012. Headwater stream temperature: Interpreting response after logging, with and without riparian buffers, Washington, USA. *Forest Ecology and Management*, 270, 302-313.

Key points of the Janisch paper include:
- The amount of canopy cover retained in the riparian buffer was not a strong explanatory variable to stream temperature.
- Very small headwater streams may be fundamentally different than many larger streams because factors other than shade from the overstory tree canopy can have sufficient influence on stream temperature.

Riparian reserve gaps
Warren, Dana R., Keeton, William S., Bechtold, Heather A., Rosi-Marshall, Emma J. 2013. Comparing streambed light availability and canopy cover in streams with old-growth versus early-mature riparian forests in western Oregon. *Aquatic Sciences* 75:547-558.

Key points of the Warren paper include:
- Canopy gaps were particularly important in creating variable light within and between reaches.
- Reaches with complex old growth riparian forests had frequent canopy gaps which led to greater stream light availability compared to adjacent reaches with simpler second-growth riparian forests.

(1) Small Functional Wood
Nearly all wood that falls into stream channels has the capacity to influence habitat and aquatic communities (Dolloff and Warren, 2003). Therefore, smaller woody material that enters stream channels is important to overall channel function because it can store sediment and organic material, contribute nutrients, and provide temporary pool habitat and slow-water refugia. It is important to note, however, that pools formed by smaller wood generally are not as deep or complex as those formed by large wood. In addition, small wood does not persist for long periods of time because it deteriorates quickly and is more likely to be flushed from the system (Naiman *et al*., 2002, Keim *et al*., 2002).

(2) In smaller streams adjacent to previously harvested stands, field surveys (McEnroe, 2010) indicated that relatively large amounts of existing (in-stream) and potential (standing) small functional wood are present. Field surveys also indicate that the vast majority of the down wood in these areas originated from within 50 feet of the stream channel. This is consistent with findings by Minor (1997), who found that in second-growth coniferous riparian forests, 70-84 percent of the total in-stream wood was recruited from within 15 meters (49 feet) of the channel. In addition, McDade *et al*. (1990) and Welty *et al*. (2002) found that 80 percent and 90 percent, respectively, of the wood loading occurred within 20 meters (66 feet) of the stream channel in coniferous forests.

5. AFRC supports the harvest of 548 acres in the old growth areas using intermediate harvests techniques. AFRC also supports using regeneration harvest techniques including shelterwood, seed trees, and clearcuts to create openings larger than 40 acres in size to address forest health and wildlife issues.

6. AFRC supports the construction of 4.5 miles of new roads to access some of the units. We also support putting 34 miles of roads into storage, which could be used in the future. AFRC does not support the decommissioning of roads using the Level 5 technique which is completely eliminating the roadbed by restoring natural condition and slopes with culverts removed.

7. AFRC suggests looking more at the use of DxP for any commercial harvests. We believe that better results can be achieved in a much more efficient, and cost effective manner by utilization of basal area thinning. Many forests are now using DXP almost exclusively including the Colville National Forest.

8. AFRC further suggests that in those areas being treated for fire resiliency and enhancement of large and old tree development, commercial thinnings be conducted that will significantly reduce the basal area in the stands and crown closure. Since this project area will probably not be entered for at least another two decades or more, the stands should be thinned to a spacing that will provide for maximum growth and forest health for that time period.

9. AFRC suggests using tractor skidding on slopes over 35% to more efficiently capture the economic value of the timber and to provide more revenues back to the Forest for other resource improvements. The nearby Colville National Forest is testing skidding on slopes up to 45%. Additionally, many acres have been bypassed in the past because of concern about damage to soil from compaction, erosion and other issues. Today's new high tech logging equipment has a very light footprint and damage to the soil resource is minimal.

10. The Forest is planning to perform prescribed fire on 7% of the project area or 7,500 acres. AFRC suggests that the Forest plan to allow salvage of burnt dead trees that occur in these prescribed fires should the burns get out of control. Often the Forest is expecting some mortality from the burns which is acceptable, however, prescribed fire areas that

get out of control and burn hotter killing more trees should have some option for immediate salvage.

11. Carbon sequestration as it relates to climate change is a topic that often gets broadly analyzed in NEPA documents. The analysis that the Forest Service will likely be conducting through the ensuing environmental analysis will discuss forest health benefits, effects on carbon sequestration and storage potential and meeting the purpose and need all within the context of an economically viable timber sale. We would like the Kootenai National Forest to review the following summary of information and incorporate this into its environmental analysis. AFRC believes this will help educate the public about and disclose localized effects to the forested landscape regarding carbon sequestration, carbon storage, and climate change as a whole.

Background

The Black Ram consists of Type of Treatments including Variable Density Thinning, Regeneration, etc.) which may affect the treated stands ability to resist, respond, or be resilient to climate change in the project area. The direct, indirect, and cumulative effects of carbon sequestration and storage and its relationship to climate change in regard to this project must be viewed at much larger scales than the general project area because the scientific literature regarding these, only support analysis on larger scales. There is a large body of literature on management strategies that have the greatest carbon sequestration benefit. In general, actively managing the forest will produce a positive net increase in carbon sequestration thus a positive benefit to reducing anthropogenic effects on climate change (IPCC, 2007). AFRC urges you to analyze the type of treatments being proposed and determine through the literature how they will affect carbon sequestration potential through time.

As defined by the USFS in the Climate Change Glossary,

> "Climate change refers to a statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period (typically decades or longer). Climate change may be due to natural internal processes or external forces, or to persistent anthropogenic changes in the composition of the atmosphere or in land use" (USFS, n.d.).

The United States Environmental Protection Agency (EPA) estimated that national greenhouse gas emissions were 6.87 billion metric tons CO_2-eq/yr in 2015 (EPA, 2016). With increased concentrations of greenhouse gasses, more heat is retained leading to an increase in the earth's average surface temperature e.g. global warming (USFS, 2010). In total, 91.262 billion metric tons of carbon is stored in the managed US forests as of 2016. In 2016, the US sequestered 216 million metric tons of carbon in its forests (Woodall et. al, 2015). According to the EPA (2016), 11% of the US CO_2 emissions were sequestered in forests and associated wood products in 2014. National Forest System lands only represents 13% of all forest sequestration in the US.

Strategies

There are two main strategies for addressing climate change: adaptation and mitigation.

“The International Panel on Climate Change (IPCC) (http://www.ipcc.ch/) defines *adaptation* as an initiative to reduce the vulnerability of natural or human systems to expected climate change effects.” (USDA, 2011).

Adaptation strategies include the following:

1. Building *resistance* to climate-related stressors such as drought, wildfire, insects, and disease.
2. Increasing ecosystem *resilience* by minimizing the severity of climate change impacts, reducing the vulnerability and/or increasing the adaptive capacity of ecosystem elements.
3. Facilitating large-scale ecological *transitions* in response to changing environmental conditions.” (USDA, 2011)

According to the Office of Sustainability and Climate Change, “Forest ecosystems capable of adapting to changing conditions will sequester carbon and store it more securely over the long term, while also furnishing woody materials to help reduce fossil fuel use (Office of Sustainability and Climate Change, 2016). Therefore, adaptation can be enhanced through active forest management activities which improve the health and vigor of the forest ecosystem. By enhancing the vigor and growth of the forest, the forest as a carbon sink, can also be vitalized.

“The IPCC defines *mitigation* as an intervention to reduce the emissions or enhance the storage of greenhouse gases. Mitigation is predicated on adaptation: the long-term capability of ecosystems to capture and store carbon depends in large part on their ability to adapt to a rapidly changing climate” (USDA, 2011).

Mitigation strategies include the following:

1. Promoting the uptake of atmospheric carbon by forests and the storage of carbon in soils, vegetation, long-lived wood products, and recycled wood materials.
2. Indirectly reducing greenhouse gas emissions (for example, through the use of carbon-neutral bioenergy to offset fossil fuel emissions and substituting wood for more fossil fuel-intensive building products)
3. Diminishing greenhouse gas emissions (for example, through the cooling effects of urban forests, which reduce the need for fossil fuels to run air conditioners) or through more prudent consumption in facilities, fleet, and other operations.

This is why active management is vitally necessary. The world is at a time where deliberate action needs to be taken for the future of humankind. Through meaningful and well-developed forest practices, increased adaptation and mitigation can occur. “An actively managed forest landscape that provides a large amount of sustainable biomass yield while at the same time maintaining large standing forest carbon stocks, provides greater climate benefits in the long run compared to unmanaged forests” (Lundmark et al. 2016). Which is tied back to Nabuurs and Masera 2007 and Lundmark et al. 2014. “Several studies have shown the importance of a sustained or increased yield in actively managed forest to increase the climate benefit (Canadell and Raupach 2008; Malmsheimer et al. 2008; Poudel et al. 2012; Lundmark et al. 2014; Sieva¨nen et al. 2014) … In order to make additional climate benefits compared with today, the most efficient strategy … is to increase growth and yield and to maximize the substitution benefits" (Lundmark et al. 2016).

Carbon Sequestration

Regeneration and Patches

When a forest stand is harvested, the stored carbon removed is transferred into other pools. It could go into the carbon sequestration of harvested wood products (HWP pool), into the soil organic carbon (SOC pool) or released into the atmosphere due to decomposition or slash burning. The small portion that is released into the atmosphere is captured again through increased photosynthesis of the remaining or new stand in a short period of time. Davis et al. (2009) suggested that just after 55 years, carbon sequestration was similar in harvested as un-harvested forests. Not only can forests have equal sequestration over the long term, but it is suggested that the recovery of the ecosystem can be extremely elastic as well. Amiro et al. (2010) discovered that, "A clear GPP[1] recovery occurred within about the first 20 years following a stand replacing harvest." AFRC acknowledges the fact that there is a reduction in the short term in net primary production (NPP[2]) following a harvest. However, when a long-term (>40years) scale is used, harvesting older trees or thinning overstocked stands will always increase positive climate change benefits because of long term storage of carbon in furniture, houses, etc., the substitution effect and increased CO_2 sequestration due to increased photosynthesis.

Some may argue that maintaining canopy cover or a continuous forest will best allow for trees to remain as secure carbon storage on the landscape while thinning underneath can provide the wood the timber industry needs, but "[t]he long-term annual average carbon stock change in living trees is close to zero for a continuous cover forest while an annual net increase occurs on production forests where clear-cuts are utilized." (Lundmark et al. 2016). This shows how forests that grow in a patchy environment will always have higher increment growth with greater carbon sequestration potential than continuously thinned stands.

Old Trees

Yu et al. (2017) in their paper titles "Influence of site index on the relationship between forest net primary productivity and stand age" found the following:

- "Similar to previous studies, our results also show that forest NPP[2] increases quickly at young ages, reaches the maximum value at middle age (10±40 years old), and then decreases to a relative stable level at old ages. However, we additionally found that forests under better site conditions have faster growth rates in young ages and steeper declines after reaching the maximum."

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[1] (Gross primary production (GPP) is the total amount of carbon dioxide "fixed" by land plants per unit time through the photosynthetic reduction of CO_2 into organic compounds."

[2] Net primary production (NPP) of plant structural biomass in stems, leaves, and fruit, labile carbohydrates such as sugars and starch, and, to a much lesser extent, volatile organic compounds used in plant defense and signaling.

- "NPP increases rapidly before reaching its maximum and thereafter decreases to a relatively steady state. At younger ages, carbon is mostly accumulated in stems, branches and coarse roots so the total NPP is dominated by living biomass increments. The decline of NPP with age is mainly caused by the decreasing rate of living biomass increment. At older ages, NPP-age curves are dominated by leaf and fine-root turnovers since carbon allocations to these two components are larger than the other parts."
- "Coniferous forest NPP decreases substantially after reaching to its maximum value."
- "Studies indicated that NPP in old forests generally decreased to about half or one-third of its maximum value."
- "The decrease of NPP at old ages is mainly due to the declining carbon allocation to wood components, in addition to increased autotrophic respiration for sapwood maintenance, decreased photosynthesis efficiency and declining N-availability to trees (Ryan et al. 1997). In addition to these factors affecting the performance of individual trees, changes in forest structure, such as self-thinning and wind damage, would also negatively impact forest NPP at old ages (Smith et al. 2001). For old age forests, leaf and fine root turnovers take a large part of photosynthetic productions (DesRochers et al. 2001). Accurate estimates of leaf and fine root turnovers and carbon allocation ratio of new fine roots to new leaves are of importance to NPP calculation." (Yu et al., 2017).

Harvested Wood Products (HWP)

The utility that forest products provide humans in their day to day lives is paramount. Products connected to the forest are used every day by everyone. "If forested ecosystems are to be managed with carbon sequestration in mind, then wood product market fluctuations must be considered in addition to ecosystem responses to harvest" (Davis et al., 2009). Often when carbon pools are brought up, the HWP pool is left out or misrepresented. The fact is that humans use wood products that do not decompose quickly; in fact, "only 30% of the carbon from paper and 0–3% of the carbon from wood are ever emitted as landfill gas. The remaining carbon … remains in the landfill indefinitely. Some of this carbon may be removed during leachate treatment, but a large portion is permanently sequestered where its impact on global warming is negligible. The placement of forest products in landfills serves as a significant carbon sink, and its importance in the global carbon balance should not be overlooked" (Micales & Skog, 1997). Carbon is stored securely in HWP of all kinds. The potential of any given acre to store carbon is exponentially increased when active management occurs on that piece of land because of harvesting and storing wood in the HWP pool, the substitution effect, and replanting after final harvest. When carbon is stored in houses, furniture, fences, light poles and other products, the wood is not only storing carbon, but serving a tangible benefit as well. Many of these products will outlive the tree/s they came from due to insects, disease, or fires that would have otherwise killed the tree, released the stored carbon and had its carbon legacy taken away. The homes, dresser, rocking chair, or local bar all get to live on.

Substitution

One of the most frequently disregard factors concerning the harvest of trees as it relates to CO_2 sequestration or emissions is the carbon footprint of the materials that will be used as substitutes if these trees are not utilized to build homes, make furniture or any of the myriad of products produced from wood fiber. These commonly include concrete, steel, and plastics. The use of "forest products led to a significant reduction in atmospheric carbon by displacing more fossil fuel-intensive products in housing construction. The result has important policy implications since any incentive to manage forest lands to produce a greater amount of forest products would likely increase the share of lands positively contributing to a reduction of carbon dioxide in the atmosphere." (Perez-Garcia et al. 2005).

The Consortium for Research on Renewable Industrial Materials (CORRIM; www.corrim.org), a not for profit university lead research group of 16 research institutions, developed a research plan in 1998 to study the complete environmental performance of wood. Since its inception in 1996, CORRIM has developed comprehensive environmental performance information on wood building materials consistent with International Organization for Standardization (ISO) standards for life-cycle inventory (LCI) and lifecycle assessment (LCA) research. They summarize their research to date in the following fact sheet.

In summary, any analysis of the effects of timber harvest on CO_2 emissions or sequestration must be made using a long term, life cycle approach incorporating long term storage of currently sequestered carbon, net primary production of forest stands, and the net increase of CO_2 emissions associated with the use of substitute materials. Much research has been done on these subjects which supports the position that managing forests using regeneration timelines related to NPP will result in greater net carbon sequestration than non-management approaches. Research also supports positive potential climate change effects of thinning to promote increased growth and vigor. All of the silvicultural tools need to be used to maximize the positive benefits trees and forests provide for the world. To find more information about Oregon's forest benefits you can view a report by the Oregon Forest and Industries Council (OFIC) here. OFIC does a wonderful job at explaining just how wonderful an environment Oregon is to grow trees and the fantastic carbon sequestration power they have here.

Thank you for the opportunity to provide pre-scoping comments on the Black Ram Project. I look forward to following the implementation of this project as it moves forward.

Sincerely,

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Amiro, B. D., et al. (2010), Ecosystem carbon dioxide fluxes after disturbance in forests of North America, *J. Geophys. Res.*, *115*, G00K02, doi:10.1029/2010JG001390

Climate Change Advisor's Office. USDA Forest Service. 2014. Baseline Estimates of Carbon Stocks in Forests and Harvested Wood Products for National Forest System, Units; Eastern Region. 42 p. Whitepaper.

DesRochers A, Lieffers VJ. Root biomass of regenerating aspen (Populus tremuloides) stands of different densities in Alberta. Canadian Journal of Forest Research. 2001;31(6): 1012–1018

Nabuurs, G.J., O. Masera, K. Andrasko, P. Benitez-Ponce, R. Boer, M. Dutschke, E. Elsiddig, J. Ford-Robertson, P. Frumhoff, T. Karjalainen, O. Krankina, W.A. Kurz, M. Matsumoto, W. Oyhantcabal, N.H. Ravindranath, M.J. Sanz Sanchez, X. Zhang. (2007): Forestry. In Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [B. Metz, O.R. Davidson, P.R. Bosch, R. Dave, L.A. Meyer (eds)], Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

IPCC. 2014. Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. Geneva, Switzerland: IPCC

Lundmark, T., Bergh, J., Nordin, A. et al. Ambio (2016) 45(Suppl 2): 203. https://doi.org/10.1007/s13280-015-0756-3

Micales, J., & Skog, K. (1997). The decomposition of forest products in landfills. *International Biodeterioration & Biodegradation, 39*(2-3), 145-158. doi:10.1016/s0964-8305(97)83389-6

Office of Sustainability and Climate Change. USDA Forest Service. 2016. Assessment of the Influence of Disturbance, Management Activities, and Environmental Factors on Carbon Stocks; Eastern Region. 90p. Draft.

Perez-Garcia, J, Lippke, B., Comnick, K, & Manriquez, C. Wood and Fiber Science, 37 Corrim Special Issue, 2005, pp. 140 – 148

Ryan M, Binkley D, Fownes JH. Age-related decline in forest productivity: pattern and process. Advances in ecological research. 1997;27:213–62.

Sarah C. Davis, Amy E. Hessl, Carrie J. Scott, Mary Beth Adams, Richard B. Thomas, Forest carbon sequestration changes in response to timber harvest, Forest Ecology and Management, Volume 258, Issue 9, 2009, Pages 2101-2109, ISSN 0378-1127, doi.org/10.1016/j.foreco.2009.08.009.

Smith FK, Long JN. Age-related decline in forest growth: an emergent property. Forest Ecology and Management. 2001;144: 175–181.

Woodall, C., Coulston, J., Domke, G., Walters, B., Wear, D., Smith, J., Andersen, H., Clough, B., Cohen, W., Griffith, D., Hagen, S., Hanou, I., Nichols, M., Perry, C., Russell, M., Westfall, J., Wilson, B. The U.S. Forest Carbon Accounting Framework: Stocks and Stock Change, 1990-2016. 2015. Gen. Tech. Rep. NRS-154. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 49 p.

United Stated Department of Agriculture. 2011. National Roadmap for responding to Climate Change. p.18. PDF

United States Forest Service. 2010. U.S. Forest Service - Climate Change Emphasis Area. *U.S. Forest Service - Climate Change Emphasis Area*. USDA Forest Service. Web. <https://www.fs.fed.us/climatechange/climate.shtml>.

United States Forest Service. 2015. Forest Inventory and Analysis National Program. Forest Inventory and Analysis National Program - Forest Carbon. USDA Forest Service. Web. <https://www.fia.fs.fed.us/forestcarbon/index.php>.

United States Forest Service. n.d. glossary. USDA Forest Service. PDF. <https://www.fs.fed.us/climatechange/documents/glossary.pdf>.

Yu Y, Chen JM, Yang X, Fan W, Li M, He L (2017) Influence of site index on the relationship between forest net primary productivity and stand age. PLoS ONE 12(5): e0177084. https://doi.org/10.1371/journal.pone.0177084