Forest Management in an Era of Climate Change

Purpose: This document reports the best available scientific findings and management strategies related to forest carbon sequestration and storage in the APSAF Region. This information is intended to guide development of public policy for forest management in this region. Forests are central to our history, identity and way of life. These forests provide important products and contribute greatly to local and state economies. Our forests also provide critical ecosystem services including water quality, biodiversity, carbon sequestration and storage, recreation, and critical contributions to human health and well-being, while providing solace and sense of place. Climate change, coupled with land use history and increasing human population, has heightened the need to responsibly manage these forests for multiple uses including sequestration and storage of atmospheric carbon.

Scope: This statement outlines the ways in which a spectrum of forest stewardship strategies contribute to climate change mitigation and adaptation, provide services and products for society, and sustain resilient forests for future generations.

Position

It is the position of the Appalachian Society of American Foresters (APSAF) that active forest management, grounded in science, is essential to maintain and promote resiliency and ecosystem services. Such management:

1) Promotes carbon sequestration and storage (Evans and Perschel 2009, McGarvey et al. 2015);

2) Provides additional ecosystem services including air and water pollution mitigation (Cardinale et al. 2012);

3) Provides locally sourced and sustainable wood products that substitute for more carbon intensive materials (e.g., wood instead of concrete, biomass fuels instead of fossil fuels) (Rudell et al. 2007);

4) Reduces forest fragmentation, mismanagement, and conversion to non-forest land uses both locally and globally; and

5) Improves biodiversity and the capacity of ecosystems to withstand and adapt to the impacts of climate change.

A Position of the Appalachian Chapter of the Society of American Foresters

Issue

The issue of forests and carbon is complex and increasingly important. Carbon uptake (i.e., sequestration) occurs in growing forests, the most rapid sequestration generally occurs in early stand development, but sometimes continues at high rates through late-successional stages, particularly in structurally complex forest systems (Bormann and Likens 1979, Keeton et al. 2007, Keeton et al. 2011). Carbon storage occurs in the above and belowground biomass of forested systems and in long-lasting wood products, such as lumber.

The concept of "proforestation" means to "grow existing forests intact to their ecological potential" (Moomaw et al. 2019). This concept excludes performing active management activities. This has been proposed in conjunction with reforestation (replanting trees in areas that previously had tree cover) and afforestation (planting trees in areas that did not previously have tree cover) as strategies to increase carbon sequestration. While proforestation can contribute positively to ecosystem services and carbon storage, this strategy disregards the benefits of active forest management and essentially reduces the overall amount of carbon that could be sequestered (i.e., captured and removed from atmospheric CO_2) in a given land area, where active forest management strategies are employed.

Wood products store carbon and help to offset the need for extraction and production of non renewable, carbon-intensive materials such as concrete, steel, and petroleum-based plastics. The recent increase in mass timber usage for construction is especially positive for long-term carbon storage (Harte 2017). Locally and regionally produced wood products sourced from well regulated forests have a relatively smaller carbon footprint due to lower transportation requirements (Ashton et al. 2012).

Forest management (which includes timber harvesting) is consistent with goals of promoting long-term carbon sequestration and storage. Management practices continue to adapt as we gain a better understanding of the relationships between forestry and atmospheric carbon. Reducing harvest frequency and favoring high levels of structural retention, for example, can sequester up to 57% more carbon (Nunery and Keeton 2010). Reforestation also increases carbon sequestration (Rhemtulla et al. 2009, Nave et al. 2019). In urban areas this would also improve quality of life through other ecosystem services (Nowak and Greenfield 2008, Guan et al. 2017). Managing forests for a variety of values and uses on a long-term timescale using peer-reviewed forest science and a holistic understanding of the forest systems ensures that forests continue to capture and store carbon, maintain ecosystem functions and services, offer the sustainable supply of wood for consumption, and decrease global deforestation and fossil fuel use. While reserve based management is appropriate in some places, sustainable timber harvesting in most forests best serves human needs in the long term. Meeting these objectives will require a full suite of conservation strategies working together, including both sustainable harvesting and reserve based management (Foster et al. 2017).

Background

The Importance of Forests

Nearly 50% of the land in the southeastern U.S. is covered in forests and in the APSAF states of Virginia, North Carolina, South Carolina, between 61 and 80% of the land is forested (Oswalt et al. 2019). Forests are an integral component to our history, identity, and way of life, and our future is dependent upon creating and maintaining healthy forests. Forests contribute to myriad ecosystem benefits, including clean air and water, and provide habitat for a diverse array of flora and fauna. Forests are critical to our economy and livelihood and help maintain a sense of personal well-being – which is even more critical now as we continue to endure a global pandemic. Forestry and forest-based manufacturing industries are a particularly vital economic engine in rural counties. In 2017, the southern forest products industry contributed about $308 billion of U.S. South regional economic output, supporting over 1.3 million full- and part-time jobs with $76.9 billion in payroll (E. McConnell, Personal Communication).

Forest Disturbance and the Need for Resilience

Disturbances play an important role in structuring the forested landscape and are vital for functions including regeneration. Disturbances range in type, size, frequency, and intensity (Turner et al. 1998, Lorimer and White 2003). Variation in post-disturbance abundance and spatial arrangement of live and dead trees impacts species composition and carbon storage dynamics (Franklin et al. 2002, Seymour et al. 2002, Birdsey et al. 2019). While the most common natural disturbances are wind and ice storms, fire, invasive insects and fungal diseases also play a role (Hurteau et al. 2011, Guo et al. 2019, Potter et al. 2019). Anthropogenic disturbance (e.g., harvesting and silvicultural activities) is also an influential driver of forest condition and response to decades of active forest management is one of the largest factors shaping current forest conditions (Duveneck et al. 2017).

Climate change is altering ecosystem disturbance regimes (Evans and Perschel 2009). Changes vary seasonally and include increases to average temperatures, heavy precipitation events, drought, and decreases in snowfall (Janowiak et al. 2018). Forest composition and condition models show varying responses to changes in climate and natural disturbance regimes (Tang and Beckage 2010, Rustad et al. 2012). The impacts may happen at such a rate that the recovery of the forest ecosystem cannot keep pace (Liang et al. 2018), or cause substantial loss of species richness and diversity (Iverson and Prasad, 2001). At the same time, the landscape is facing loss of forests through conversion to other land uses (Kittredge 2009, Olofsson et al. 2016).

Resiliency – a forest's capacity to recover function after a disturbance – is critically important for sustaining forest ecosystems in this era of rapidly changing climatic conditions. Resiliency

enables the forest to maintain, restore or enhance ecosystem services, including carbon sequestration and storage, following disturbances. Informed forest management and protection of forestland from development or other land use conversion provides the opportunity to maintain or improve resiliency by retaining connectivity, increasing complexity and maintaining or enhancing diversity across forested landscapes (Catanzaro and D'Amato 2019).

Forest Carbon

Forested ecosystems provide a valuable ecosystem service by storing and sequestering carbon, thus reducing atmospheric CO_2. Temperate forest ecosystems have been widely acknowledged as a carbon sink (Ashton et al. 2012). In the U.S., terrestrial forests offset about 16% of annual U.S. CO_2 emissions (Hoover and Riddle 2020) through the sequestration of carbon from the atmosphere through the process of photosynthesis in trees and forest vegetation. Carbon is stored in various pools including live and dead aboveground biomass, belowground biomass, woody material and leaf litter, and soil (Fahey et al. 2005, Catanzaro and D'Amato 2019). Amounts of sequestered and stored carbon are dynamic, constantly fluxing between and within pools as forests and land-use change over time. Decades of research illuminate the variety of factors driving forest carbon sequestration and storage dynamics. Stand age is strongly predictive of aboveground biomass along with other variables such as ecoregion and composition, accounting for 25-33% of variability (Keeton et al. 2011). Disturbance, both natural and anthropogenic, is also a driving factor of carbon sequestration and storage dynamics (Birdsey et al. 1997, Duveneck et al. 2017). Because of these factors, reports of carbon sequestration and storage vary widely (Barford et al. 2001, Hadley and Schedlbauer 2002, Fahey et al. 2005, Keeton et al. 2011).

The carbon stored in wood products adds to the complexity of carbon accounting. Hardwood flooring, dimension lumber, mass timber, and plywood are forms of stored carbon and should be accounted for as such. Further, the use of these products avoids carbon emissions from the extraction and production of more carbon-intensive materials such as vinyl, carpet, concrete, and steel (Oliver et al. 2014). Wood utilization and technology continue to improve the production of wood products and increase associated carbon storage (Tollefson 2017). Cross-laminated timber (CLT) is capable of replacing concrete for multi-story buildings (Robertson et al. 2012). A life cycle assessment of the four-story John W. Olver building at the University of Massachusetts found that the use of CLT and other wood products instead of concrete and steel reduced the building's global warming potential by 13% (Gu and Bergman 2018). Substituting wood for steel and concrete in new buildings world-wide would reduce global CO_2 emissions by 14 to 31%

(Oliver et al. 2014) and interest in this technology is rising (Struck 2019).

Sequestration in the forest and carbon emission offsets associated with wood products from sustainable forest management are critical components of carbon management. Research

continues to increase our understanding and must guide forest practitioners to improving the capacity of this vital resource.

Sustainable Forest Management and Timber Harvesting

Sustainable forest management is a "dynamic and evolving concept, which aims to maintain and enhance the economic, social and environmental values of all types of forests, for the benefit of present and future generations" (FAO 2020). APSAF strongly supports the practice of sustainable forest management that includes both limited reserves and responsible harvesting as the best way to ensure that forests continue to provide a wide array of benefits. FAO lists the following climate change mitigation and adaptation actions for forests:

1) Carbon sequestration enhancement by silvicultural practices, which include site preparation activities, prescribed fire, and various tree harvesting activities;
2) Carbon stock conservation by preventing deforestation, implementing reduced impact logging, and pest control;
3) Substitution of wood products for steel, concrete, aluminum, and plastic; and
4) Reducing the vulnerability and strengthening the adaptive capacity of trees and forests.

Sustainable forest management can accelerate development of complex structure in forests (Keeton 2006), making it possible for early successional canopies to support the complex functioning and biodiversity seen in late-successional or old-growth forests (Donato et al. 2012). Reducing harvesting frequency (Curtis 1997), increasing rotation lengths (Harmon and Marks 2002, Ryan et al. 2010), and encouraging post-harvest structural complexity (Keeton 2006, Franklin et al. 2007, Swanson and Chapin 2009, Puettmann et al. 2009) have been found to increase stand-level carbon storage. Maintaining adequate stocking of large trees (Stephenson et al. 2014), while also allocating growing space for younger trees can promote higher rates of stand-level carbon storage and sequestration (D'Amato et al. 2011). These practices can also strengthen forest resiliency. Each parcel's unique species composition, forest structure, and landscape position must be evaluated to determine its vulnerability to disturbance and its role in benefiting present and future generations.

There is opportunity to maximize both the carbon sequestration and carbon storage benefits provided by forests, and maximizing these benefits often requires active management. Sustainable forest management considers many different tree and site characteristics to determine the most suitable actions to meet the goals of forest management. The effects of certain management prescriptions on carbon sequestration and storage, for example, are

dependent on stand age characteristics. Reducing harvest frequency more effectively increases carbon sequestration in uneven-aged stands than in even-aged stands (Nunery and Keeton 2010). Retaining such biological legacies as large old trees also promotes diversity by sustaining many organisms and critical ecosystem functions, such as soil stabilization, nutrient retention and recycling, and resilience to disturbance (Franklin et al. 2007, Hanson et al. 2012). Generally, silvicultural treatments that maintain a large proportion of mature trees maintain or increase aboveground carbon storage (D'Amato et al. 2011).

Sustainable forest management that includes harvesting reduces the volume of dead wood that will release carbon due to decay (Hoover and Stout 2007). The carbon in durable wood products such as plywood, framing, flooring and furniture is stored much longer than the carbon in dead trees (Russell et al. 2014). Durable wood products are more carbon-efficient than alternative products, in addition to storing sequestered carbon that would otherwise be released back to the atmosphere through decay. In addition to the benefit from the carbon stored in durable wood products, there is less carbon released from harvesting and manufacturing wood products than from mining non-renewable resources and manufacturing products from them (Bergman et al. 2014). Many studies have documented that one of the key carbon sequestration benefits of active forest management is the substitution of products made from wood for those made from steel, aluminum, or concrete (Oliver et al. 2014, Woodbury and Wightman 2017).

A resilient forested landscape consists of a variety of forest conditions. Sustainable harvesting in actively managed forests and conservation management to protect old forests each result in the storage of significant amounts of carbon. Minimally disturbed forests provide critical habitat for some species and are invaluable for scientific research. Forest management that includes harvesting can proactively and intentionally create or enhance habitat for the myriad vertebrate and invertebrate species that depend on young forests or forests with heterogeneous structure (DeGraaf and Rudis 1986, DeGraaf et al. 2005). Sustainable forest management that includes harvesting yields additional benefits for useful, renewable products, reduced carbon emissions, and important aspects of resilience that preservation does not.

Resilient, vigorous, functional and diverse forests are critical for continuing our way of life. The disturbance regime that our forests experience has changed due to the loss of some species (including apex predators), the introduction of others (especially invasive species), and a changing climate. Sustainable forest management maintains and enhances ecosystem function and resiliency so that the forest resource continues to meet societal needs. Water quality, soil integrity, carbon capture, diverse wildlife habitat, forest products, recreational opportunities, and aesthetic beauty can be maintained or increased. We have the opportunity and the responsibility to be a part of the solution by maintaining the ability to sustainably manage where suitable and for the greater good.

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