Climate Change

Climate change is and will continue to be one of the most critical factors affecting Wisconsin's forests. Adapting Wisconsin's forests to climate change will be critical. Forests are a natural way for carbon mitigation and Wisconsin has a high potential for both mitigation and adaptation actions due to its larger forested areas.

Climate change refers to the observable and predictable changes in the Earth system processes that affect Earth's climate due the relationships among greenhouse gas emissions and atmospheric concentrations of these gases. Greenhouse gases cause an imbalance of heat trapped by the atmosphere compared to an equilibrium state (Melillo, Richmond, & Yohe, 2014). Some activities, either natural or human-related, emit greenhouse gases while other processes remove these gases from the atmosphere. Currently the rate of emissions is higher and faster than the rate of removals. Processes or activities that emit greenhouse gases are called "sources" while processes that remove them from the atmosphere are called "sinks". Some examples of sources are burning of fossil fuels, crop production, livestock production, and grasslands, while examples of sinks are forests, urban trees, and wetlands.

ASSESSMENT

CLIMATE CHANGE & WISCONSIN'S FORESTS

One of the most common and known greenhouse gases is carbon dioxide (CO_2), which is removed from the atmosphere by natural processes at a rate that is roughly half of the current rate of emissions from human activities. Therefore, mitigation efforts that only stabilize global emissions will not reduce atmospheric concentrations of carbon dioxide but will only limit their rate of increase.

In the U.S., sources of carbon have been relatively stable over the last two decades, while sinks have been more variable. Studies have shown that there is a large land-use carbon sink in the United States(Birdsey, Pregitzer, & Lucier, 2006; Pacala et al., 2007; USDA, 2011). Many publications attribute this sink to forest re-growth, and the sink is projected to decline as a result of forest aging (Pan et al., 2011; Williams, Collatz, Masek, & Goward, 2012; Zhang et al., 2012; Zheng, Heath, Ducey, & Smith, 2011) and factors like drought, fire and insect infestations reducing the carbon sink of these regions. The amount of fossil fuel CO2 emissions in the U.S. over the past two decades taken up annually by U.S. land sinks is between 7% to 24%, with a best estimate of about 16% (Melillo et al., 2014; U.S. Environmental Protection Agency, 2019). Forests make up the largest portion of the U.S. carbon sinks, annually offsetting about 11 percent of the total greenhouse gas emissions in the U.S. (McNulty et al., 2018; U.S. Environmental Protection Agency, 2019).

Forests provide a unique opportunity to address climate change because they can both prevent and reduce emissions of greenhouse gases while simultaneously providing essential social, environmental, and economic benefits. Trends suggest significant emissions from forest clearing forest clearing in the early 1900s followed by a sustained period of net uptake from forest regrowth over the last 70 years. There is uncertainty as to how our environment will ultimately be affected by climate change, but the role of forests is undeniable. However, changes in climate are expected to impact the function, health, and productivity of forests, particularly in northern latitudes (Muller, Nagel, & Palik, 2019), and forest managers face many challenges associated with the uncertainty of how forests will respond to environmental changes. Strategies and actions to increase carbon storage in forests have been identified and can accessed through the Climate Change Response Framework website (Northern Institute of Applied Climate Science, 2020; Ontl et al., 2020).

Wisconsin's climate is changing, and forests will respond to these changes in a variety of ways. The Wisconsin Initiative on Climate Change Impacts (WICCI), an expert panel of forest researchers and managers, compiled information on climate change in their "Wisconsin's Changing Climate: Impacts and Adaptation" report (WICCI, 2011). Additionally, a collaborative assessment from the Nelson Institute for Environmental Studies, University of Wisconsin-Madison and the Wisconsin Department of Natural Resources was completed, "Climate Wisconsin 2050 – Scenarios of a State of Change: Forestry" (Handler, 2016). Also available is a technical report compiled by the USDA "Forest Ecosystem Vulnerability Assessment and Synthesis for Northern Wisconsin and Western Upper Michigan" (Janowiak et al., 2014). The highlights from these reports are:

- Temperatures have already warmed by about 2° F in Wisconsin and winters have warmed about twice as much as other seasons. Temperatures are projected to increase 3 to 9° F over the next century.
- Warmer temperatures have an impact on snowfall, snowpack, frozen ground, growing season length, drought stress, earlier springs, and possibly other unforeseeable changes. This has implications for forestry activities that require frozen ground to avoid negative impacts to soils, water, or impacts to sensitive species.
- Currently, Wisconsin already receives about 2 inches more annual precipitation than in the earlier 1900s and the projection is to continue to increase by another 1 to 3 inches by the end of the century. Most of the increases will be concentrated in spring and winter and from heavier rainfall events, which have impacts on soil moisture, depth of snowpack, frozen ground duration, flooding, and surface runoff.
- Wisconsin's growing season has already increased by almost two weeks over the past 70 years and this trend is expected to continue by 14 to 49 days by the end of the century. A longer growing season has both advantages and disadvantages depending on the species and if the trees acquire the additional water and nutrients needed. Earlier warm temperatures will lead to trees breaking dormancy sooner, creating a greater risk for frost damage. Due to these changes, some forest types could have their ranges expand or contract. Central Hardwoods may expand their range, although it is uncertain how this forest type will be affected by much wetter or much drier conditions. Boreal species are at risk due to warmer winter temperatures and possible late summer droughts. Jack pine could be resil-

ient because it's adapted to extremely dry sandy sites and not so dependent on climate. Conifer lowlands are vulnerable due to sensitivity to changes in water tables and snow cover. Urban forests can respond well if cities replant with species suited to warmer temperatures.
- White-tailed deer are expected to benefit from warmer winters and reduced snow depth, which can result in greater impacts on forests across Wisconsin. Heavy browsing of some species that are anticipated to gain suitable habitat with warmer temperatures, such as sugar maple, white oak, and northern red oak, can limit their actual ability to increase on the landscape. While other species that are not browsed so heavily, such as ironwood and black cherry or invasive species, like buckthorn or Japanese barberry, can be favored.
- Young forests may be vulnerable due to stress and mortality from changing temperature and precipitation patterns, which may result in lower natural regeneration.
- Stress will increase from forest pests, diseases, and non-native species.
- Habitat suitability will be altered for many species.
- Wildfires are expected to increase in both frequency and intensity and therefore burn more acres, particularly in boreal and temperate conifer forests. However, more wildfire could be beneficial for some forest types, such as jack pine and other fire-dependent systems.

MITIGATION & ADAPTATION

When discussing climate change, two terms are often discussed: mitigation and adaptation. Mitigation refers to actions that are aimed at reducing carbon dioxide and other heat-trapping gases emissions. Adaptation requires identifying and preparing for changes that are likely to occur due to raising temperatures.

Lage-scale adaptation can be a complex and costly process that crosses both spatial and temporal scales and purposes (Wang, Zhao, & Wang, 2018), but some adaptation practices may be simpler and less costly (Northern Institute of Applied Climate Science, 2020). Even though the estimated cost to address adaptation in the United States alone could reach tens of billions per year (Sussman et al., 2014), when weighing the risks of climate change, adaptation can still effectively reduce the risk imposed by climate change despite perceived difficulties (Fankhauser, 2017). 10 basic strategies have been described by NIACS (Swanston et al., 2016) and include:

- Sustain fundamental ecological functions.
- Maintain or improve the ability of forests to resist pests and pathogens.
- Reduce the risk and long-term impacts of severe disturbances.
- Maintain or create refugia.
- Maintain and enhance species and structural diversity.
- Increase ecosystem redundancy across the landscape.
- Promote landscape connectivity.
- Maintain and enhance genetic diversity.
- Facilitate community adjustments through species transitions.
- Realign ecosystems after disturbance.

In sum, adaptation is important, relevant, challenging, and public policy is highly important in promoting healthy adaptation (Fankhauser, 2017; Wang et al., 2018).

As described above, forests are a great warehouse of carbon and can be used as one of several mitigation tools. Tree biomass is approximately 50 percent carbon, based on dry weight. This mass of carbon has become an important part of forest resource reporting in recent years primarily because forests sequester carbon from the atmospheric greenhouse gas carbon dioxide, which is linked to global climate change. Among terrestrial ecosystems, forests contain the largest reserves of sequestered carbon. Forests with more biomass (typically older forests that are fully stocked and have larger trees) store more carbon than forests with less biomass. Regional and national greenhouse gas reporting forums include forest carbon stocks because increases in forest carbon stock represent quantifiable partial offsets to other greenhouse gas emissions. Lumber and engineered wood products are important product pools and their use displaces the consumption of more fossil-fuel intensive products.

In Wisconsin, soil organic carbon accounts for an estimated 64 percent of forest carbon and live trees account for 24 percent of forest carbon stocks (Figure 14). Fourteen percent of live tree carbon is in the wood and bark of the bole of trees at least 5 inches in diameter. Deforestation and land use change causes rapid loss of carbon contained in forested soils. It may take decades to restore those carbon stocks as deforested areas are reforested. We can aid mitigation efforts by using forest biomass as a feedstock for bioenergy, substituting for an equivalent amount of fossil fuel energy, and avoiding the associated emissions (Keith, Lindenmayer, Macintosh, & Mackey, 2015).

The carbon pools discussed here include living plant biomass (live trees ≥1-inch d.b.h. and understory vegetation), dead wood and litter (standing dead trees, down dead wood, and forest floor litter – i.e., non-living plant material), and soil organic matter exclusive of coarse roots and estimated to a depth of 1 meter. Carbon estimates, by ecosystem pool, are based on sampling and modeling. For additional information on current approaches to determining forest carbon stocks see the "Inventory of U.S. Greenhouse Gas Emissions and Sinks – 1990-2017" report (United States Environmental Protection Agency, 2019).

Active management can lessen the impacts of climate change. According to the United Nations Intergovernmental Panel on Climate Change (IPCC), the most cost-effective mitigation options in forestry are afforestation, sustainable forest management and reducing deforestation (IPCC, 2014). Similarly, the Second State of the Carbon Cycle report suggests that key opportunities in carbon management include avoiding deforestation, promoting afforestation and harvest removals directed towards clean energy solutions (Domke et al., 2018); and the Northern Institute of Applied Climate Science has identified important strategies for forest carbon management including: maintaining or increasing forested cover, ecological function, forest resiliency, carbon stocks, sequestration capacity; prioritizing management; and reducing carbon losses from natural disturbances (Northern Institute of Applied Climate Science, 2020; Ontl et al., 2020). Resources currently available to aid forest managers in adaptation best practices include:

- The Wisconsin Initiative on Climate Change Impacts: https://www.wicci.wisc.edu/publications.php
- Forest Adaptation Resources: Climate Change Tools and Approaches for Land Managers, 2nd edition (Swanston et al., 2016).
- USDA Forest Service Climate Change Resource Center: https://www.fs.usda.gov/ccrc/
- Climate Change Response Framework: https://forestadaptation.org
- Forest-Climate working group: https://www.americanforests.org/our-work/forest-policy/fcwg/

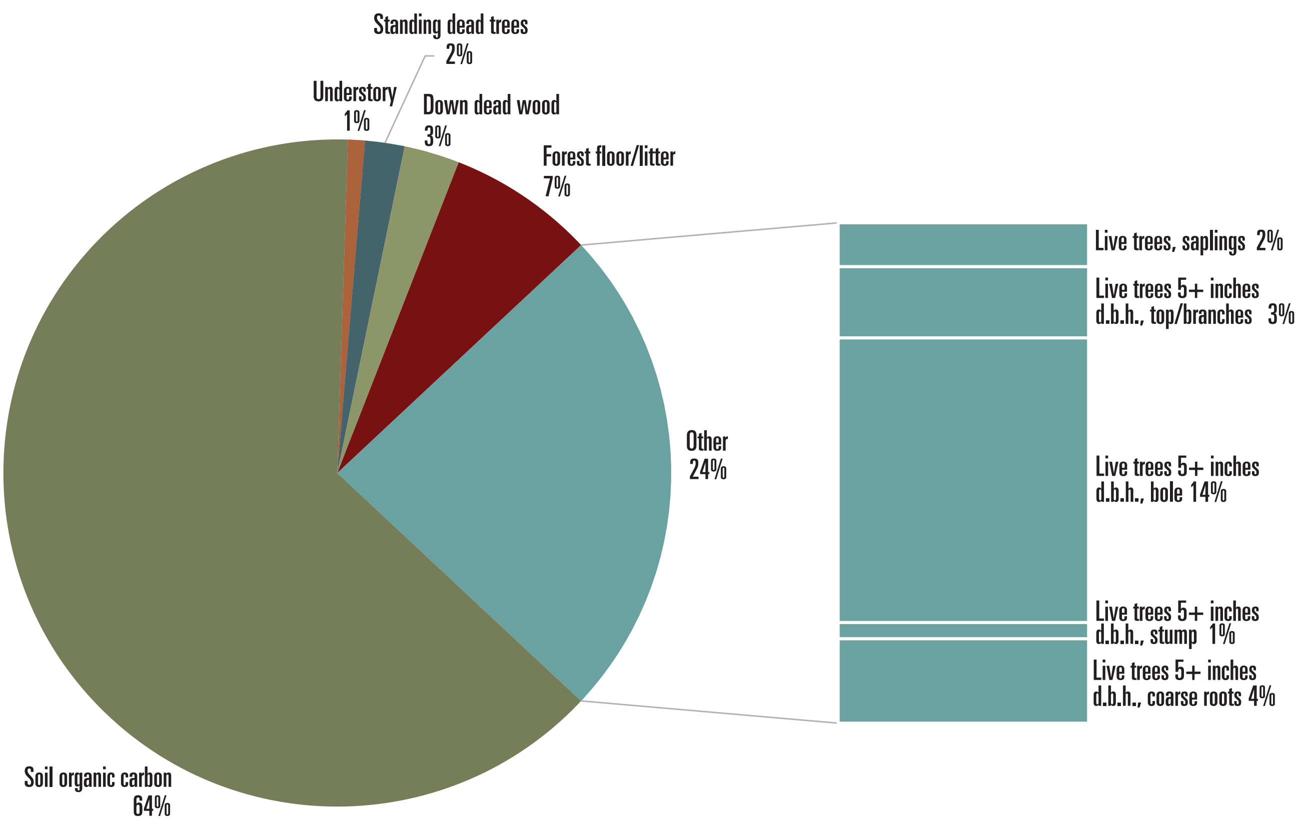

Figure 14: Percentage of forest carbon stocks within each forest ecosystem component, Wisconsin, 2017. Source: U.S. Forest Service, 2017

Climate Change: CONDITIONS & TRENDS

- Forest pests and diseases may be more damaging in stressed forests. Current natural pests could expand their range and new pests and/or pathogens may enter Wisconsin in the future. [2]
- Invasive species will disproportionally benefit from warmer and wetter conditions because of their naturally more aggressive ability to colonize and exploit changed or disturbed areas. [2]
- Increased frequency and severity of catastrophic events may result in increased damage to forests, altered forest soils, loss of forest productivity and changes in forest composition. [2]
- Forested land cover can help mitigate the effects of climate change by providing soil protection, diminishing rain impact and runoff, by holding more water in the ground and by sequestering carbon. [1, 3]
- Climate change may result in the need to adapt current management strategies. [1, 2, 3]
- Forest management goals and outcomes may become less predictable and forestry investments may be riskier. [2]
- With an expected decrease in frozen ground duration, certain forest management activities could become more limited. [2]
- In cases where forest simplification has occurred, these forests may be less resilient to the effects of climate change. [2]
- Adaptation can provide our forests the best chance for success considering the plausible future risks. [1, 3]
- Long-term increases in forest area and growing-stock volume in Wisconsin have allowed forest carbon storage to increase. [1, 3]
- An important factor in maintaining and increasing carbon stocks is maintaining current forests as forests, and maintaining a balanced distribution of forest types, ages and size classes. Older forests systems with large trees generally store more carbon than younger forests and should be well represented on the landscape. [1, 3]
- The largest losses of carbon occur when forested land is converted to other land uses. [1, 3]
- Active forest management, including the use of durable wood products, can increase the amount of greenhouse gas emissions that are offset from our forests and lessen this impacts of climate change, creating win-win scenarios with multiple benefits. [1, 3]
- There is a growing opportunity for Wisconsin's forests to capture carbon on voluntary or direct sale markets. [1, 3]

PRIORITY ISSUE

Climate change priority issue is described in the Priority Landscapes and Issues portion of the plan.

GOALS AND STRATEGIES

Goals and strategies are captured in subject areas throughout the plan. Many goals highlighted in one section of this document are pertinent to other sections. A list of all goals and strategies, including other goals related to Climate Change, is included in the Summary of Goals and Strategies section.

GOAL J: FORESTS ARE RESILIENT AND ADAPTABLE TO FUTURE CONDITIONS.

Strategies

1. Manage forests so that there is a diversity of species, age, and size classes to maintain healthy productive forests to be more resilient.
2. Identify and fill knowledge gaps in climate change research.
3. Maintain current forested areas and avoid land use conversion, particularly of unique, sensitive, and at-risk communities to increase diversity and resilience under a changing climate.
4. Promote landscape connectivity for more resilient and adapted ecosystems, by reducing fragmentation and creating corridors through reforestation, afforestation, or restoration.
5. Plan for and respond to severe disturbances to reduce risk and long-term impacts of increasing and more intense hazards.
6. Plan for and respond to shorter periods of frozen ground.
7. Reduce the impacts of current biological stressors and monitor the spread of insects and diseases that are not yet found in Wisconsin but can due to a more favorable changing climate.
8. Develop and support training opportunities for forest managers and landowners on managing their forests for resiliency.
9. Increase management capacity by encouraging partnerships at different levels, from federal to local stakeholders.
10. Promote public awareness and education on climate change related issues.
11. Use best available science and research on climate change adaptation strategies to guide forest management.
12. Identify, conserve, and manage diverse forest genetic resources that are adaptable for future climatic conditions and maintain forest productivity and health.

GOAL K: CARBON STORAGE IN FORESTS AND FOREST PRODUCTS IS INCREASED.

Strategies

1. Reduce the rate of conversion of forestland to alternative land uses to allow for long-term carbon storage.
2. Encourage reforestation and afforestation to enhance, protect, and connect larger tracts of forested land in appropriate locations consistent with ecological landscapes.
3. Increase Wisconsin's forested area to increase total stored carbon in the state.
4. Develop silvicultural guidance to maximize carbon sink capacity while maintaining productivity in working forests through diversifying age classes, stocking levels, and rotation ages.
5. Expand value-added products industry to create long-lasting carbon sequestration materials.
6. Increase use and marketing of forest products, including mass timber buildings.
7. Quantify carbon budgets of forest management practices, including prescribed fire, to optimize carbon storage and other forest management objectives, while still providing sustainable forest products.
8. Expand access to markets for forest carbon offsets to provide new income streams to forest owners and incentivize carbon storage in working forests.