



Missouri Forestry Supplement
*Southeastern Forests &
Climate Change PLT Secondary Module*
June 2017



Forests and Climate Change Supplement

Missouri and the Midwest

Introduction to Supplement

This publication is a Missouri-specific supplement to the 2015, Second Edition *Southeastern Forests and Climate Change* Project Learning Tree Secondary Module, published by the University of Florida and the American Forest Foundation. The Secondary PLT Module has many video and technology pieces that make it unique and useful for classroom teachers, as well as activities to teach about climate change. The University of Florida received grant funding to produce and distribute the Climate Change guides, and while they are perfect for the Southeastern region of the US, several surrounding states found that by altering a few activities, the guide would be useful for us too. Kentucky PLT put together a sheet to identify which activities could use new information and these activities were slightly altered here: Activities 2-8, and Activity 12.

Dedicated Missouri foresters provided research information and Missouri-specific forestry information. For each activity altered, background material for Missouri is included, along with anything else needed to do the activity. All other materials are found within the *Southeastern Forests and Climate Change* Secondary Module.

Acknowledgements

Missouri PLT worked with our partner organization, the Missouri Society of American Foresters, to find foresters willing to work on this supplement, and we are grateful for the following professional foresters who volunteered their time and expertise for this project:

Cody Bailey, Missouri Department of Conservation

Frances Main, Missouri Department of Conservation

Hank Stelzer, University of Missouri Extension

The Society of American Foresters was founded when a group of seven foresters got together at the organization's first meeting in November 1900. That meeting was held in the old Agriculture Department building in Washington, D.C., and saw the founding of an organization dedicated to professional forest conservation throughout the United States. The Missouri Society of American Foresters was founded in 1929.

Missouri Forests Introduction

- The forests we enjoy today are very different from the forests of 100 years ago in Missouri. Our state was in the midst of a logging boom in 1900. The pine forests of the Ozarks attracted lumbermen from the eastern United States, and from about 1880 until 1920 Missouri was one of the leading lumber-producing states in the nation. Huge sawmills produced building lumber, shingles, molding and railroad ties for a growing nation.
- At the turn of the last century, Missouri was a leading timber-producing state. The peak of Missouri's timber production was in 1909. By 1910, nearly all of the pine had been

Forests and Climate Change Supplement

Missouri and the Midwest

cut. And by 1920 the boom was over; there were no more trees left to cut the Ozarks. That's when work began in earnest to help regenerate Missouri's forests.

- In 1933, President Franklin D. Roosevelt created the Civilian Conservation Corps. The CCC was formed to provide much-needed employment to young men and to aid in the conservation of the United States' natural resources. The program enrolled some 520,000 men in the United States at its peak, and approximately half of those were assigned to forestry projects. Nationwide, the CCC developed more than 800 state parks, planted 3 billion trees, built 3,100 lookout towers and fought thousands of acres of wildfires.
- Missouri voters approved a state constitutional amendment creating the Conservation Commission in 1936. This new agency included a Forestry Division; an innovative idea at the time.
- All across Missouri and the United States, forests were generally logged and abandoned in the early part of this century. This practice continued until the 1920s, when forest conservation became widely practiced. Now, an average of 1.9 billion tree seedlings are planted in the U.S., translating into six seedlings for every tree cut. Five million trees were planted in Missouri alone at the George O. White State Forest Nursery in Licking. This includes 70 different species of trees, shrubs and prairie forbs. Each summer and fall the nursery collects or buys tens of thousands of pounds of seeds to grow all these species. Last year, for example, about 5,000 bushels of walnuts, 15,000 pounds of white oak acorns, 8,000 pounds of hazelnuts and 600 pounds of plum seed were needed just to establish seedlings for these four species.
- Today, the state of Missouri boasts more than 14 million acres of forestland. It ranks seventh out of the 20 northeastern states in the amount of forested acreage. Only New York, Michigan, Maine, Pennsylvania, Minnesota and Wisconsin have more forest land. Of those 14 million acres, private landowners own 85 percent. Only 15 percent is government-owned: 12 percent is owned by the federal government, mostly in the Mark Twain National Forest, and 3 percent is owned by the state of Missouri and local governments.
- Annual growth of forests far exceeds the amount harvested, ensuring ample forests for future generations. Harvesting and processing trees into wood products gives thousands of people jobs and contributes about \$3 billion each year to Missouri's economy. Wood industries provide countless people with the materials necessary to build homes, furniture and other items necessary to our daily lives. Approximately one-third of Missouri is covered by forestland, featuring some of the finest oak, walnut, pine and red cedar trees anywhere.

Forests and Climate Change Supplement

Missouri and the Midwest

Activity 2: Clearing the Air

Students will learn about the scientific evidence supporting climate change and will use this information to evaluate and improve conclusions that people may draw about climate change. Students will participate in a role-play to negotiate solutions.

Background Information:

- A noticeable increase in average temperatures in the Midwest has been observed.
 - The largest increase in temperature has been measured in winter, extending the growing season by more than one week.
 - Heavy downpours are twice as frequent as they were a century ago.
 - Increased survival rates of ticks and mosquitoes (West Nile increase)
 - The Great Lakes contain 20% of planet's available fresh water
 - Projected levels to fall between 1 and 2 feet by the end of the century, decreased ability for large vessels to travel
 - Precipitation is projected to increase in winter and spring, and the become more intense throughout the year
 - Overall, lower water levels in the summer could create problems for river traffic, and native fish populations
 - Livestock production is expected to become more costly as higher temperatures stress livestock, decreasing productivity and increasing costs associated with the needed ventilation and cooling equipment
- Population of more than 61 million people (about 20% of the national total) and generated a regional gross domestic product of more than \$2.6 trillion (about 19% of the national total)
 - 1895-2012 is equal to an increase of 1.5°F
 - Between 1950 and 2010, the average temperature increased twice as quickly, and between 1980 and 2010, it increased three times as quickly as it did from 1900 to 2010
 - Projections for regionally averaged temperature increased by the middle of the century (2046-2065) relative to 1979-2000 are approximately 3.8°F for a scenario with substantial emissions reductions (B1) and 4.9°F with continued growth in global emissions (A2). The projections for the end of the century (2081-2100) are approximately 5.6°F for the lower emissions scenario and 8.5°F for the higher emissions scenario
 - Region accounts for about 65% of U.S. corn and soybean production, mostly from non-irrigated lands.
 - The Midwest growing season lengthened by almost two weeks since 1950, due in large part to earlier occurrence of the last spring freeze

Resources:

- <http://nca2014.globalchange.gov/report/regions/midwest> (USGCRP, 2009)

Forests and Climate Change Supplement

Missouri and the Midwest

Activity 3: Atlas of Change

Students will use various resources to explore the effects of climate change on the future distributions of suitable habitats for forest types, tree species, and bird species. Students will learn how modeling is used to project climate change impacts.

Background Information:

- Forests are Missouri's greatest renewable resource. If managed wisely, a healthy forest will keep producing quality trees for years to come, creating tremendous economic, environmental and social benefits.
- Most of Missouri's recreation and tourism industry is centered in forested regions of our state.
- Healthy forests protect hillsides from erosion, filter the air, soften the extremes of weather and beautify urban areas. They also keep unwanted runoff out of our streams. At the same time, forests represent a diverse resource of plants, animals, birds and other life forms.
- Wildlife species such as whitetail deer, wild turkeys and wood ducks were almost extinct at the turn of the century. Wildlife conservation and habitat enhancement has resulted in flourishing populations of these and other species we now take almost for granted. Today, foresters are working with other conservation professionals to improve habitats and ensure survival of other wildlife species.
- Missouri forests evolved with native insects and diseases, and have developed defenses against them. Pests from other countries are a much more serious threat to our forests. The gypsy moth is expected to reach the state early in the 21st century. Oaks are one of the moth's favorite foods, and the gypsy moth's effect on our oak forests could be devastating. As global commerce continues to grow, we must guard against other harmful pests being introduced.
- Livestock grazing in woodland areas is a serious detriment to tree regeneration and wildlife habitat. Usually only undesirable tree species remain because they are unpalatable to the livestock grazing on them. Sharp hooves damage tree root systems and remove the protective leaf litter on the ground, resulting in accelerated soil erosion.
- Careful cutting of trees is a large part of effective forest management and creates a greater diversity of plant and animal life in our forests. Missouri is home to at least 730 species of wildlife, many of which live in our forests and are sustained through the careful management of tree growth in those forests.

Forests and Climate Change Supplement

Missouri and the Midwest

- Fire prevention and control has been a top priority for foresters in Missouri since the founding of the Society of American Foresters in 1900. At least three-fourths of the land outside state parks burned over twice each year as recently as the 1920s and 1930s. Today, less than one-tenth of 1 percent of Missouri forestland is burned.
- Although forest fires are still a major threat to Missouri's forests, fire management today is the best it's ever been. Lookout towers, once common sights throughout the heavily forested areas of the Ozarks, are disappearing because they are no longer needed. Fires today are much fewer and farther between, and the acreage lost is a tiny fraction of the total protected area. Less than one-tenth of one percent of Missouri's forests burn each year, and 99 percent of those fires are preventable. Most are accidental and are caused by carelessness like burning trash, leaves or other debris on a windy day, carelessly tossed cigarettes, children playing with matches, or improperly extinguished campfires.
- While most forest fires in Missouri are accidents and are preventable, a full 40% of forest fires that burn every year are deliberately set. Arson accounts for at least one out of every three forest fires every year. To report arsonists, the Conservation Department has set up a toll-free hotline, Operation Forest Arson at 1-800-392-1111.
- Responsible forest management is the key to a healthy forest. As part of an effective management program, sometimes cuts are needed to help regenerate parts of the forest. Also consideration for wildlife and aesthetic value is key when deciding when and what cuts need to be made.
- Some wood products are now being labeled "green". This means that those wood products come from a forest that is sustainably managed. In other words, those products come from a forest that is aggressively promoting new growth and forest regeneration, while at the same time offering mature trees to be used for quality wood products.
- There are more than 1,000 Certified Tree Farmers in Missouri who own almost a half-million acres of forest. Six of them recently have been named recipients of the Centennial Stewardship Farm Award for contributing to Missouri's natural resources for 100 years or more.
- In Missouri, experts from the Conservation Department are available to help landowners make the right decisions about stewardship of their property. These professionals include foresters, wildlife and fisheries biologists, soil scientists and Extension specialists, and they are all available to help free of charge.
- Healthy forests remove about 1.8 pounds of carbon dioxide and release 1.3 pounds of oxygen into the air for each pound of wood produced. One acre of trees can remove 13

Forests and Climate Change Supplement

Missouri and the Midwest

tons of dust and gases from the air every year. This means trees actually help clean the air we breathe, helping us live healthier lives.

- Water in tree-lined streams is, on average, 10 degrees cooler than non-forested streams. A healthy stream depends on a healthy forest growing on its banks, and tree-lined riverbanks significantly lessen the impact of flooding.
- A few well-placed trees around a house can reduce winter heating bills anywhere from 10 to 50 percent. Likewise, strategically placed shade trees can reduce air conditioning and cooling costs in summer time by 10 to 50 percent. Tree-shaded streets, homes and parking lots are noticeably cooler in summer than their non-shaded counterparts.
- The average life of a tree in a heavily used city park is 25 to 30 years. By contrast, the average life span of a tree in a remote rural forest is 100 to 150 years.
- Each year the average American uses the equivalent of one large tree about 100 feet tall and 18 inches in diameter for his or her wood and paper needs. All parts of three are used to make wood and paper products.
- One cord of air-dried oak firewood weighs more than 4,000 pounds. That one cord of wood can be used to produce 250 copies of the typical Sunday New York Times, or 2,700 copies of the average 36-page daily paper.
- An average 2,000 square-foot, single-family home can contain up to 13,000 board of lumber and up to 9,500 square feet of panel products. This includes products ranging from structural beams and roof supports to the sheathing, trim and paneling. Home building and remodeling are the largest single use of lumber and wood products, accounting for about two-thirds of domestic consumption.

Resources:

All About Birds: The Cornell Lab of Ornithology

www.allaboutbirds.org

The Audubon Society of Missouri State University

<http://mobirds.org>

Bird I.D. sent through Cornell

Dendrology at Virginia Tech (vTree)

<http://dendro.cnre.vt.edu/dendrology/factsheets.cfm>

Forests and Climate Change Supplement

Missouri and the Midwest

Tree dichotomous Guide

<https://www.arboday.org/trees/whatTree/whatTree.cfm?ItemID=E6A>

4-H Forest Resources, Florida Forest Ecology

<http://www.sfrc.ufl.edu/extension/4h/trees/index.html>

Missouri Botanical Garden

Native trees for Missouri landscapes

<http://www.missouribotanicalgarden.org/gardens-gardening/your-garden/help-for-the-home-gardener/advice-tips-resources/visual-guides/native-trees-for-missouri.aspx>

Climate Change Tree Atlas (A Spatial Database of 134 Tree Species of the Eastern USA)

<http://www.nrs.fs.fed.us/atlas/tree/>

Southern Forest of the Future

Forest Service Southern Forest Futures Project

<http://www.nrs.fs.fed.us/futures/>

Forests and Climate Change Supplement

Missouri and the Midwest

Activity 4: The Changing Forests

Students will learn about research that is assisting forest managers monitor and respond to climate change using new tools and management techniques. Students will learn how climate change affects a forest ecosystem

Background Information:

- Found air and soil temperatures were strongly correlated within ecological land types
- Species diversity of ground flora was negatively correlated with temperature
 - Higher temperatures may be harmful to some ground flora

- High temperature is generally related to poor and dry soils
- The combined effects of climate change, land-use change, and increasing numbers of invasive species are the primary threats to Midwest natural ecosystems
- Migration to accommodate changed habitat is expected to be slow for many Midwest species, due to relatively flat topography, high latitudes, and fragmented habitats including the Great Lakes barrier. To reach areas that are 1.8°F cooler, species in mountainous terrains need to shift 550 feet higher in altitude (which can be achieved in only a few miles), whereas species in flat terrain like the Midwest must move as much as 90 miles north to reach a similarly cooler habitat.

Resources:

- Xu et al. 1997
- <http://nca2014.globalchange.gov/report/regions/midwest>

Forests and Climate Change Supplement

Missouri and the Midwest

Activity 6: Mapping Seed Sources

Students will use growth data from loblolly pine forests to identify genetically different populations and project where trees with certain characteristics are likely to thrive. Students will learn the value of maintaining genetic diversity within a population as climate becomes more uncertain and variable.

Background Information:

While the focus species in this module is a southern pine (loblolly), for the time being, a teacher can use this module “as is”. I say this for three main reasons:

- The wide geographic range of the species highlights the natural genetic diversity scientists are able to explore and select individuals that may be more adaptable to hotter and drier climates in the future. The authors do an especially nice job of using drought tolerance in both the background information and in the activity.
- Due to (1) its commercial importance as a timber tree and (2) the amount of genetic research that has gone into this species, this species has the most extensive database.
- While not native to Missouri, one can find planted loblolly along the Missouri-Arkansas line. This was unheard of 40 years ago. I know because my first job out of college was working for a paper company in Morrilton, AR. We never planted loblolly north of the Arkansas River because it just could not take the cold winters. Now, my colleagues with that company routinely plant loblolly in norther Arkansas. Quite a change in only 40 years. Yes, the species is still susceptible to ice and snow (due to the species long needles ability to catch the frozen precip). But, still one does see it around. A sign of things to come? Perhaps.

Forests and Climate Change Supplement

Missouri and the Midwest

Activity 7: Carbon on the Move

Students will imagine themselves as a carbon atom and take part in a simulation that allows them to cycle through biological and physical systems. Students will learn how the carbon cycle is “in balance” and how releasing carbon stored in fossil fuels affects other carbon pools.

Changes for the Station Cards (pg. 134) to better reflect Missouri.

Atmosphere
1. You continue to circulate through the atmosphere. Stay at Atmosphere.
2. You continue to circulate through the atmosphere. Stay at Atmosphere.
3. In a forest, an oak leaf absorbs and uses carbon dioxide during photosynthesis. Go to Forest.
4. In a forest, an oak leaf absorbs and uses carbon dioxide during photosynthesis. Go to Forest.
5. Through your river, you dissolve into the waters of the Gulf of Mexico. Go to Surface Ocean.
6. Through your river, you dissolve into the waters of the Gulf of Mexico. Go to Surface Ocean.

Forest
1. Through respiration, a tree uses your sugar molecule for energy. Go to Atmosphere.
2. The acorn where you have been stored is eaten by a whitetail deer. Go to Animals.
3. You become sequestered in a tree’s trunk. After several years, your tree gets cut down. Go to Wood Products.
4. You become sequestered in a tree’s trunk. After several years, your tree gets cut down. Go to Wood Products.
5. You become sequestered in a tree root, which dies and decays. Go to Soil Carbon.
6. A fire moves through the forest and burns the tree where you have been stored. Go to Atmosphere.

Revised “Atmosphere” and “Forest” Station Cards.

Forests and Climate Change Supplement

Missouri and the Midwest

Activity 8: Counting Carbon

Students will measure trees nearby and calculate the amount of carbon stored in individual trees. Students will compare the carbon sequestration potential for land-use types and to the amount of carbon released by human activities.

Background Information:

This module can be taught basically “as is” with the following modifications:

- We have FOUR basic landscapes in Missouri: (1) forestland, (2) cropland, (3) range/pastureland, and (4) urban forests. The Missouri data one needs for the “Carbon in Different Landscapes” activity are as follows:
 - Population: 6,083,672
 - Forestland: 15,408,700
 - Cropland: 12,259,000
 - Rangeland: 10,310,000
 - Urban Area: 1,186,000
 - Rangeland acreage is what ERS calls Rangeland PLUS Cropland used as pasture

- Carbon sequestration rates mentioned in the Background text and in the table on page 157 can be used as is; namely (units are tons/ha/yr):
 - Forestland 1.90
 - Cropland 0.10
 - Pasture/Rangeland 0.07
 - Urban Forest 0.80
 - BONUS. One might find the following website, Forest Carbon Estimation <http://www.fia.fs.fed.us/forestcarbon/index.php> an interesting site.

- The Green Weight equations need to be updated as follows:
 - In Missouri, our equations are a bit more specific because they are based on species and NOT diameter. We can do this because:
 - (1) Forest scientists at the University of Missouri conducted a biomass study in Southeastern Missouri whereby they actually weighed ENTIRE trees, by species
 - And (2) since three out of every four trees in Missouri will either be an oak or a hickory (hence the forest types classification of ‘oak-hickory’), we developed the following equations:
 - For oaks in the “red oak” group (e.g. northern red, Shumard, black, scarlet, shingle, pin)
 - $GW = \exp[-2.17 + 2.14 \cdot \ln(\text{dbh}) + 0.35 \cdot \ln(\text{ht})]$
 - GW = the total aboveground biomass (kg)
 - *exp* = exponential function
 - dbh = diameter breast height (cm)
 - ht = height of tree (m)

Forests and Climate Change Supplement

Missouri and the Midwest

- \ln = natural logarithm
- For oaks in the “white oak” group (e.g. white, burr, swamp white, chinkapin, post)
 - $GW = \exp[-3.03 + 1.72*\ln(\text{dbh}) + 1.21*\ln(\text{ht})]$
- For any “hickory” (including pecan and black walnut)
 - $GW = \exp[-5.19 + 2.65*\ln(\text{dbh}) + 0.82*\ln(\text{ht})]$
- Note: These equations will OVERESTIMATE GW slightly because they were developed using merchantable height, which is something less than total tree height. But, to keep things simple, we are taking some liberty here.

Resources:

- U.S. Census Bureau, 2015
- USFS Forest Inventory and Analysis Database, 2016
- USDA Economic Research Service, 2007

Forests and Climate Change Supplement

Missouri and the Midwest

Activity 12: The Carbon Puzzle

Students will assess a series of facts to understand how to manage plantation forests to maximize the removal of atmospheric carbon.

Background Information:

- Although global forest currently capture and store more carbon each year than they emit, the ability of forests to act as large, global carbon absorbers (“sinks”) may be reduced by projected increased disturbances from insect outbreaks, forest fire, and drought, leading to increases in tree mortality and carbon emissions. Some regions may even shift from being a carbon sink to being an atmospheric carbon dioxide source, though large uncertainties exist, such as whether projected disturbances to forests will be chronic or episodic. Midwest forests are more resilient to forest carbon losses than most western forests because of relatively high moisture availability, greater nitrogen deposition (which tends to act as a fertilizer), and lower wildfire risk.

Resources:

<http://nca2014.globalchange.gov/report/regions/midwest>

National Climate Assessment 2014 Midwest:

<http://nca2014.globalchange.gov/highlights/regions/midwest>

Climate Change in the Midwest: A Synthesis Report for the National Climate Assessment:

<http://www.cakex.org/virtual-library/climate-change-midwest-synthesis-report-national-climate-assessment>

Temperature and its Variability in Oak Forests in the Southeastern Missouri Ozarks:

<http://mofep.mdc.mo.gov/Pubs/XuEtAL1997.pdf>

Woody Biomass for Energy in Missouri:

<http://extension.missouri.edu/p/g5153>

Greenhouse Gas Emissions from Forestry Operations: A Life Cycle Assessment:

http://www.lanecounty.org/Departments/PW/LMD/LandUse/Documents/Lane%20County%20Land%20Use%20Task%20Force/Jim%20Just_Greenhouse%20Gas%20Emissions%20from%20Forestry%20Operations.pdf

Missouri’s Forests 2008:

http://www.nrs.fs.fed.us/pubs/rb/rb_nrs54.pdf

Missouri’s Forest Resource Assessment and Strategy:

https://mdc.mo.gov/sites/default/files/resources/2010/08/9437_6407.pdf

Carbon Storage and Accumulation in United States Forest Ecosystems:

Forests and Climate Change Supplement

Missouri and the Midwest

http://www.nrs.fs.fed.us/pubs/gtr/gtr_wo059.pdf

Data from 1800s Can Help Researchers, Forest Managers Maintain Healthy Forest Ecosystems Today:

<http://munews.missouri.edu/news-releases/2016/0323-data-from-1800s-can-help-researchers-forest-managers-maintain-healthy-forest-ecosystems-today/>

MOFEP papers: <http://mofep.mdc.mo.gov/ListPublications.asp>

Guyette RP, Rabeni C. – 1995 – Climate response among the rings of fish and trees., *Oecologia*, Vol. 104, pp 272-279

Stambaugh, M.C. and R.P. Guyette – 2004 – Long-term growth and climate response of shortleaf pine at the Missouri Ozark Forest Ecosystem Project, Proceedings of the 14th Central Hardwood Forest Conference, USDA Forest Service GTR-NE-316, Vol. , pp 448-458

Xu, M.; Chen, J.; Brookshir, B. – 1997 – Temperature and its variability in oak forests in the southeastern Missouri Ozaarks <http://mofep.mdc.mo.gov/Pubs?XuEtAL1997.pdf>, Climate Research, Vol. 8(9), pp 209-223

Xu, M.; Chen, J.; Qi, Y. – 2002 – Growing-season temperature and soil moisture along a 10 km transect across a forested landscape, Climate Research, Vol. 22, pp 57-72