

The Impact of Climate on the growth of *Celtis occidentalis*:
A Dendrochronological Investigation

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Abstract

Dendrochronology was used to understand how hackberry trees (*Celtis occidentalis*) growing in the Litzsinger Road Ecology Center have responded to climatic events throughout their lives. An increment borer was used to obtain 10 tree cores from 8 hackberry trees. The cores were analyzed for significantly narrow or wide rings. The same 17 narrow rings and one wide ring were found on half or more of the cores and were represented on a master chronology which was compared to climatological data to develop possible explanations for the ring sizes in each of the years.

Introduction

Dendrochronology is the field of study that uses annual rings in trees to learn about the history of the land they have been growing in. Only trees that grow in temperate climates can be used for dendrochronology because of their physiological response to the seasons (Speer, 1). During the growing season, spring and summer, the trees are able to photosynthesize and create sugars and hormones in their leaves. These products are transported down the tree toward the roots while being used by the tree's meristems to grow outward and upward. Throughout the growing season the cells in the wood vary in size depending on the amount of substances they are transporting. In the beginning of the growing season the tree produces new leaves which don't yet have a waxy coating to prevent water from escaping (Mauseth, 191). To compensate for this the tree produces large cells (earlywood) to transport water to the leaves so they can fully develop (Mauseth, 191). Once they are developed the cells can get smaller and transport less water for leaf maintenance (latewood). This shift in cell size throughout the season is visible in the wood and is most notable at the end of the growing season when the cells stop being produced, become small, and appear to be darker. This area is followed by the next year's growth when the cells grow large again to accommodate the new leaves. There is a distinct line between the growing seasons which is used to designate one annual tree ring (Figure 1).

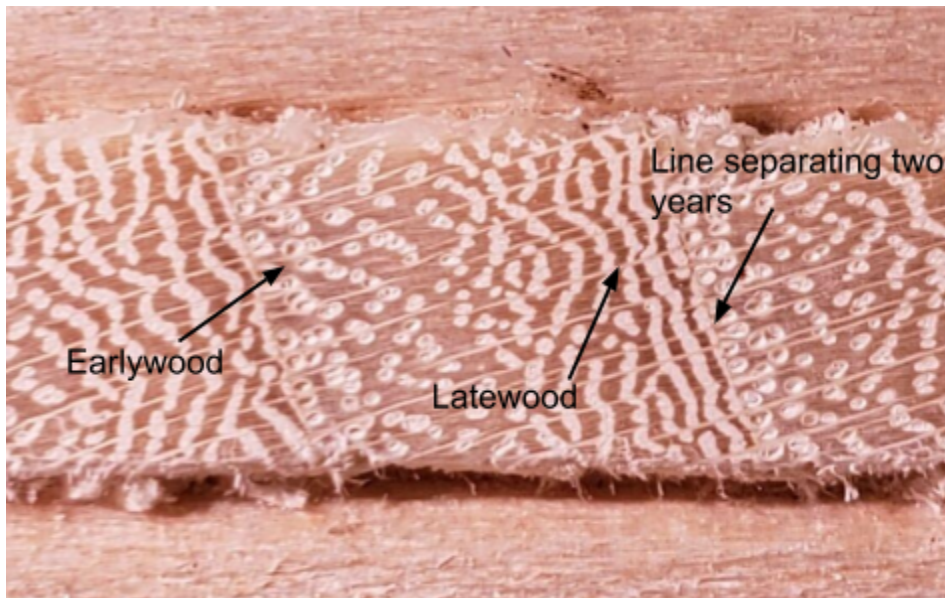


Figure 1. A picture of a tree core in a mount. The smooth wood on the top and bottom of the image is the mount and the textured wood in the middle of the image is the tree core. Earlywood on left, latewood in middle, line of annual separation on right. Photo credit: Lauren McDaniel

Dendrochronologists use an increment borer to analyze the rings in a tree without cutting it down (Figure 5). An increment borer is a hollow tube that is drilled by hand into the trunk of a tree. What results is a tree core: a long, thin cylinder of wood containing every one of its rings.

Trees rely on various abiotic resources to live and can only grow as much as the most limited resource allows (Speer, 15). This limitation causes annual rings to be different widths depending on the environmental conditions during a given year. These variable widths can be

used to reconstruct a climate history by comparing them to known climatic data and observing patterns that can be extrapolated further into the past. The smallest rings in each tree core can be matched up to assign an actual calendar year to every ring being studied. A tree core with rings of variable widths is considered to be “sensitive”, whereas a tree core with rings that are all about the same width is considered to be “complacent” (Speer, 4). While doing a dendrochronological study the investigator is looking for a signal. The signal is the information in the tree cores that is pertinent to the study being done (Speer, 10). The focus of this study was on climate related signals.

Study Area

This study was performed at the Litzsinger Road Ecology Center in Ladue, Missouri. Deer Creek runs through the 34 acre lot making the woodlands mesic to wet and prone to flooding during heavy rains. The winters in the area have reached lows of -20°F and the summers have reached temperatures as high as 115°F (National Weather Service).

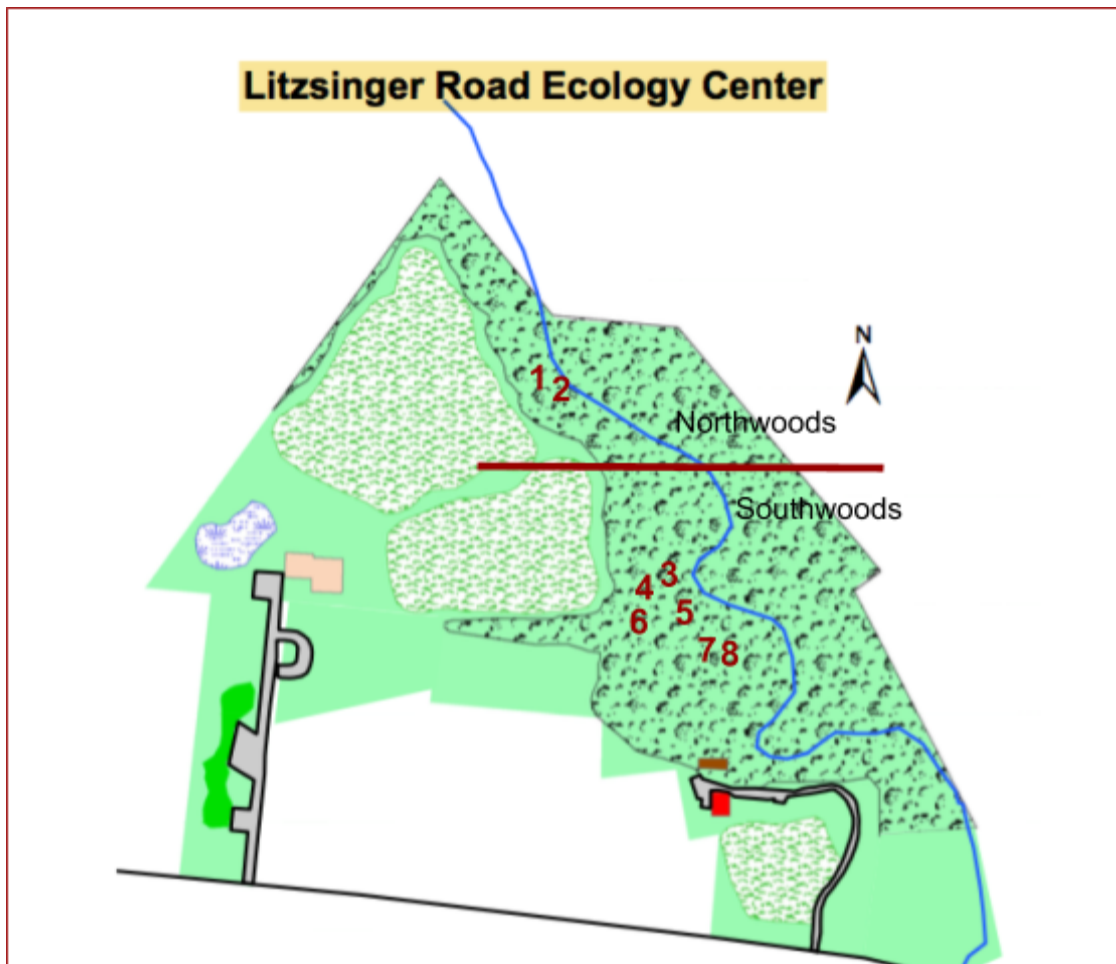


Figure 2. A map of the study area and the approximate locations of the trees from which samples were taken. Photo credit: LREC staff

Tree of Study

Celtis occidentalis (hackberry) trees were used in this study because of their fast growth (USDA). They are most common along rivers and streams in wet bottomlands, but they can grow under most conditions and are drought tolerant because of their deep roots (USDA). Due to the species preference for moist conditions it was assumed that they would be sensitive to water changes and might yield information related to the water levels or annual precipitation. *Celtis occidentalis* grows ring-porous wood, which means it has large cells at the beginning of the growing season which shrink as the year progresses. Hackberry has a Crossdating Index of 1, which means that these trees are useful when crossdating between trees of the same species, but may not be useful for crossdating in a stand of multiple species (Speer, 261).



Figure 3. The bark of *Celtis occidentalis*.
Photo credit: Lauren McDaniel



Figure 4. The leaves of *Celtis occidentalis*.
Photo credit: Iowa State University

Methods

The book *Fundamentals of Tree-Ring Research* by James H. Speer was used as a guide book for this project. It provided a history of dendrochronology, its various uses, and detailed instructions on how to do a dendrochronological research project. Another book used was *An Introduction to Tree-Ring Dating* by Marvin A. Stokes and Terah L. Smiley. This book was used sparingly because it contained a lot of the same information as *Fundamentals of Tree-Ring Research*, except with a more in-depth look at dendroarchaeology, which was not the focus of this study. A textbook called *Botany: An Introduction to Plant Biology* by James D. Mauseth was used to gain more in depth information about tree physiology.

An increment borer was borrowed from the Missouri Department of Conservation Community Forestry Department. 10 tree core samples were taken from 8 trees over the course of July 17th, 19th and 20th during the tree's latewood formation. The samples were taken approximately 1 meter from the ground. After a tree core was extracted it was placed inside a plastic straw to prevent it from breaking. Every straw was labeled with the tree number, sample number, location of the tree, side of the tree the core was taken from, and the date it was taken. The straws were placed in a paper towel tube covered in duct tape so all of the straws could be carried at once. After a sample was taken from a tree a piece of yellow flagging tape was tied around it and numbered. Trees 1 and 2 in the Northwoods each had two cores extracted, and trees 3-8 in the Southwoods each had one core extracted (Figure 2). Trees near the creek were chosen because the land near the creek experiences more flooding and disturbance than the trees upland and had the potential to yield more sensitive rings.

When a core was brought back from the field it was placed, still in its straw, onto a piece of fluted wooden door trim that was cut into 10.25 inch pieces. None of the cores obtained were badly twisted. The cores were all allowed to dry for 3-5 days then glued into the fluted trim which served as a core mount. Multiple large books and bricks were placed on top of them to prevent them from bending. Once the glue was dry the cores were sanded using a randomized hand sander with 80 grit sandpaper, then by hand using 120 grit, then with the sander using 220 grit and by hand again using 320 grit and 400 grit sandpaper. The cores were sanded until they were flush with the trim, removing about half of their diameter. The cores were polished using wool roving and were then ready for analysis.

In order to perform analysis the cores were converted into skeleton plots. A piece of 2mm grid paper was cut into strips that were 15 boxes high and 135 boxes long. Within the top five boxes the tree identifier was written, "CLOC", which is the standard species code for *Celtis occidentalis*, followed by the sample number of the core the plot would represent. The label below that was the researcher's first initial and last name, and below that was the date the plot was created. An upside down flag was drawn on the rightmost line to represent the year the core was taken. Each line to the left of that represented one year and the earliest year was designated with another flag (Figure 6). One core was analyzed at a time under a microscope at 6.7x magnification. The rings that were notably smaller than the surrounding rings on each side were represented as a line on the skeleton plot drawn from the bottom up. The smaller the ring was the longer the line on the plot was to signify its importance as a signal. Extremely wide rings were also noted on the skeleton plot by writing a "B" on the corresponding line.

A master plot was created by drawing lines from the top down on grid paper for every line that occurred on 50% or more of the other plots. The result was a representation of the years in which tree growth was most noticeably affected. These years were compared to public climate data from the National Weather Service to see if any of these dates matched up with a year of extreme average annual rainfall, temperature, or snowfall.



Figure 5. The tools used for this project from left to right: wooden skewers, straws in a paper towel tube, wool roving, gloves, increment borer, water soluble glue, permanent marker, sandpaper, wooden fluted trim to mount the cores.

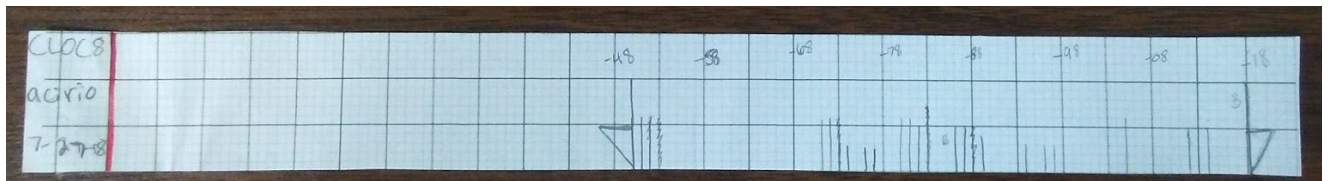


Figure 6. A skeleton plot made during the study.

Results

The black boxes on the graph in Figure 7 represent the 18 lines that made it on the master chronology. These were the years which corresponded to a ring that was very narrow, or in the case of 1985, very wide on half or more of the tree cores obtained. Because these signals were found in so many of the cores it is likely that they are the result of a climatic event which all the trees were subject to. The years which were represented on the master chronology were 2012, 2008, 1996, 1995, 1994, 1993, 1988, 1987, 1986, 1985 (B), 1983, 1982, 1981, 1980, 1972, 1971, 1963, and 1960. The National Weather Service termed rainfall “precipitation,” which is how it appears in Figure 7, therefore precipitation does not include snowfall.

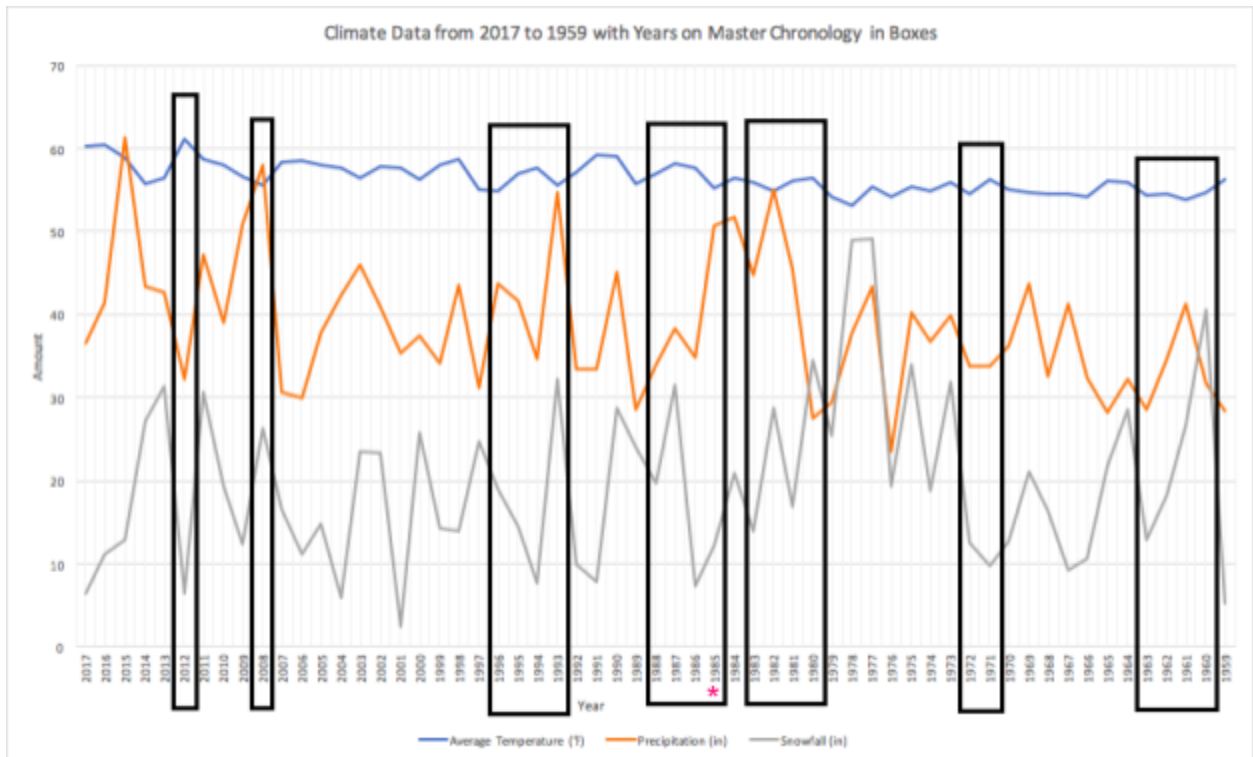


Figure 7. The three lines represent climate data from 2017 to 1959. The unit for each line is listed in the legend. The black boxes are surrounding the dates which made it onto the master chronology. There is an asterisk on 1985 to denote that it was a year with predominately wide rings. Rainfall is denoted as precipitation as it was termed in the data used, however precipitation data does not include snowfall which is a separate line on the graph.

Discussion

The ring corresponding to 2012, which was the hottest year on record, was very small in almost all of the samples. It is possible that this year yielded a signal because extreme heat can inhibit tree growth by increasing water loss through the leaves, and in the case of 2012 the heat was accompanied by little precipitation which would have accentuated water loss and prevented the trees from producing growth hormones.

There was also a strong signal for the year 2008 which corresponds to a year with a lot of precipitation. High amounts of precipitation can limit tree growth because when soil gets inundated with water oxygen can be restricted from entering the roots. Floods have the same effect on tree growth.

The mid 90's yielded multiple signals in a row. The 4 signals in the 90's occur after a year of heavy precipitation in 1993 which could have damaged the trees. Damage and stress that occurs to a tree one year can affect the tree's ability to grow in the years following. If a tree loses leaves or branches, its ability to photosynthesize will be impeded for the rest of its growing season and potentially the following growing seasons. That occurrence would result in multiple small rings in a row.

The signals that occurred in the 1980's begin with the second lowest amount of precipitation in the time of study. If a tree doesn't get enough water during its growing season it cannot make sufficient sugars and hormones which can affect growth. 1981 also had a narrow ring which could be a result of stress or damage from the previous dry year. The year 1982 had a significant amount of rainfall which could cause damage to the tree by either restricting its oxygen uptake or causing leaves or branches to become detached. This damage could cause lasting growth restriction and could provide an explanation for the narrow ring in 1983 as well. 1984 and 1985 both show years with a more moderate amount of rainfall than 1982 which could have led to no signal for 1984 and a growth spurt in 1985. The signals in 1986-88 could be due to the relatively little rain that fell those years, along with the average temperature which was the highest it had been up to that point.

1971 and 1972 both yielded a signal and were relatively dry years. When a tree doesn't get enough water it can't properly photosynthesize. This would cause the tree to grow less in these two years than the years around it.

The early 1960's had four signals in a row which could be explained by the high amount of snow that fell in 1960. If the trees were subject to cold snowy weather they could have acquired frost damage or limb loss which would have caused growth suppression in the following years. This growth suppression could have been accentuated by a decrease in rainfall each subsequent year.

There are some possible sources of error that could affect the accuracy of the data. If a tree experiences harsh growing conditions one year it can result in part of the tree not receiving the hormones necessary to grow (Speer, 47). If a sample is taken from the area that didn't grow, then the ring will be missing. A tree can also form false rings if the limiting environmental factor temporarily ceases during the growing season. This can cause a tree to stop growing and start up again when the environment returns to normal giving the appearance of 2 rings in one year (Speer, 47). If either of these events took place, the dating of a core could have been off by a

year or more. It is possible that the many consecutive signals throughout the 1980's were a result of this. For instance, if many trees had false or missing rings in the location from which the sample was taken it would have made the signals appear to be shifted forward or backward one year. If that happened to enough trees, it would seem like there were narrow rings multiple years in a row, rather than multiple trees having a narrow ring in the same year.

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