Tree Health and Productivity in the Context of Global Climate Change:

Incorporating Eastern White Pine (*Pinus strobus*) Into an Existing Dendrochronology Database

The UNIVERSITY of VERMONT

FOREST SERVICE U S DEPARTMENT OF AGRICULTURE

Project Participants

Student Researchers:

Jonathan Constabel, KJ Darling, Ingrid Evans, Ethan Goss, Molly Heuss, Jack Kilbride, Jake King, Helena Murray, Doran Zimmerman

Faculty Advisor:

Shelly Rayback, Geology Department, University of Vermont

Project Partner:

Paul Schaberg, U.S. Forest Service, Northern Research Station

Overview

Service Learning courses provide students with an opportunity to apply the knowledge and skills learned in-class in a hands-on professional working environment.

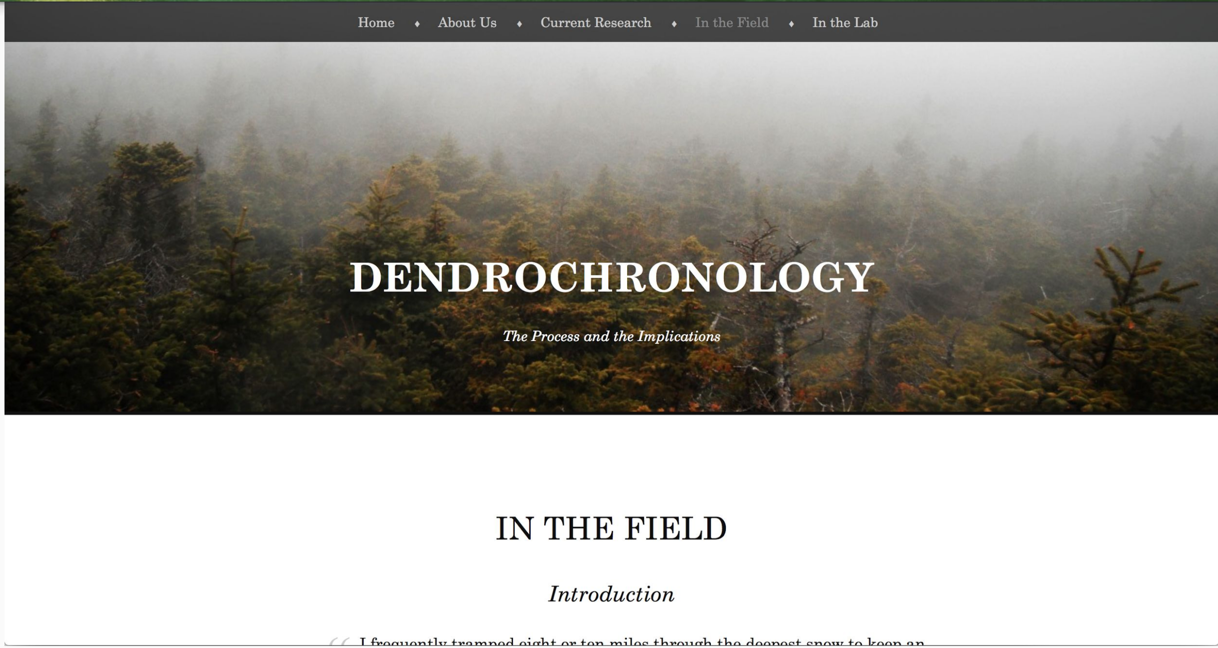
Students enrolled in Dendrochronology (GEOG 244) were approached by the U.S. Forest Service to assist in the collection and analysis of data on Eastern white pine and contribute to a pre-existing dendrochronology database.

Project Objectives

1. To help the forest service by adding more Eastern white pine to the dendrochronology database
2. To begin assessing the correlation between Eastern white pine growth and climate
3. To apply our knowledge gained in class to a real-world project
4. To improve our communication and abilities to contribute positively to a group research project

Deliverables

1. Formal Report
2. Website



http://blog.uvm.edu/jpconsta-dendrochronology/in-the-field/

Introduction

- Dendrochronology database- USFS and UVM Geography
  - Needs more white pines!
- Engel et al (2016) found that red spruce (*Picea rubens)* is rebounding. Why?
  - Acid deposition?
  - Climate change/ longer growing season?
- White pine can help answer this!
  - Temperate conifer that is not known to respond to acid deposition

Introduction

Eastern white pine:

- Temperate conifer- grows from Newfoundland down to Georgia
- is somewhat of a generalist and can subsist under a variety of conditions
    a. "competes best on well drained sandy soils of low to medium site quality" (1)
- can live up to 450 years old, commonly found at 200 years old in undisturbed stands
- Non-porous: rings are easy to see

1. Burns, Russell M., and Barbara H. Honkala, tech. coords. 1990. *Silvics of North America: 1. Conifers; 2. Hardwoods*. Agriculture Handbook 654. U.S. Department of Agriculture, Forest Service, Washington, DC. vol.2, 877 p.

Introduction

Eastern white pine:

- Temperate conifer- grows from Newfoundland down to Georgia
- is somewhat of a generalist and can subsist under a variety of conditions
    a. "competes best on well drained sandy soils of low to medium site quality" (1)
- can live up to 450 years old, commonly found at 200 years old in undisturbed stands
- Non-porous: rings are easy to see

1. Burns, Russell M., and Barbara H. Honkala, tech. coords. 1990. *Silvics of North America: 1. Conifers; 2. Hardwoods*. Agriculture Handbook 654. U.S. Department of Agriculture, Forest Service, Washington, DC. vol.2, 877 p.

Methods: Site Selection

Centennial Woods Natural Area

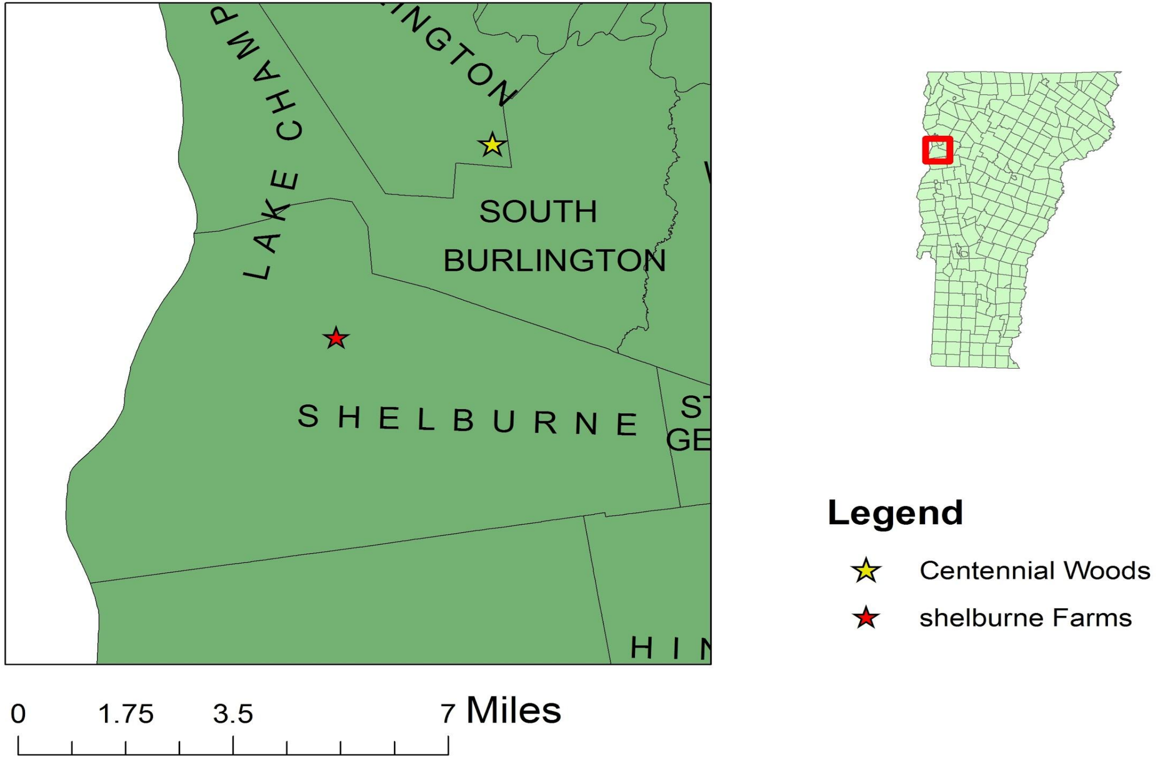
- Burlington, VT
- Owned by UVM
- Recreational trails throughout property
- Stand: hemlock (*Tsuga canadensis*) & white pine dominated
    - ~30% slope with northwest aspect

Methods: Site Selection

Shelburne Farms

- Shelburne, VT
- Working farm, land preserve and historical landmark
- 5 white pine stands around the Farm Barn (centrally located on the property)
- Cored from woods' edges and open areas

Methods: Site Selection

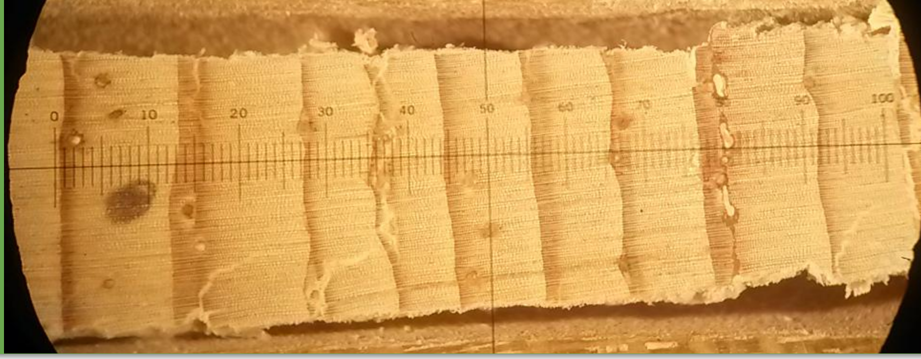


Methods: Data Collection & Analysis

In the Field

- Two increment cores per tree
- Diameter at Breast Height
- Labels (date, core #, collector, species)

Methods: Data Collection & Analysis



In the classroom & Spear Street Lab

- Mount and sand cores
- Count rings
- List method
- Measure ring widths with Measure J2X
- Cross-date with COFECHA
- Calculate basal area increment
- Compare RWI and BAI to climate data

Initial Results - Data Summary

	Centennial Woods	Shelburne Farms
Total # Cores	39	35
Total Rings Counted and Measured	4,157	3,327
Date Range of Chronology	1877-2015	1904-2015
Total Years Covered	139	112
Mean Chronology Length (Years)	106.6	95

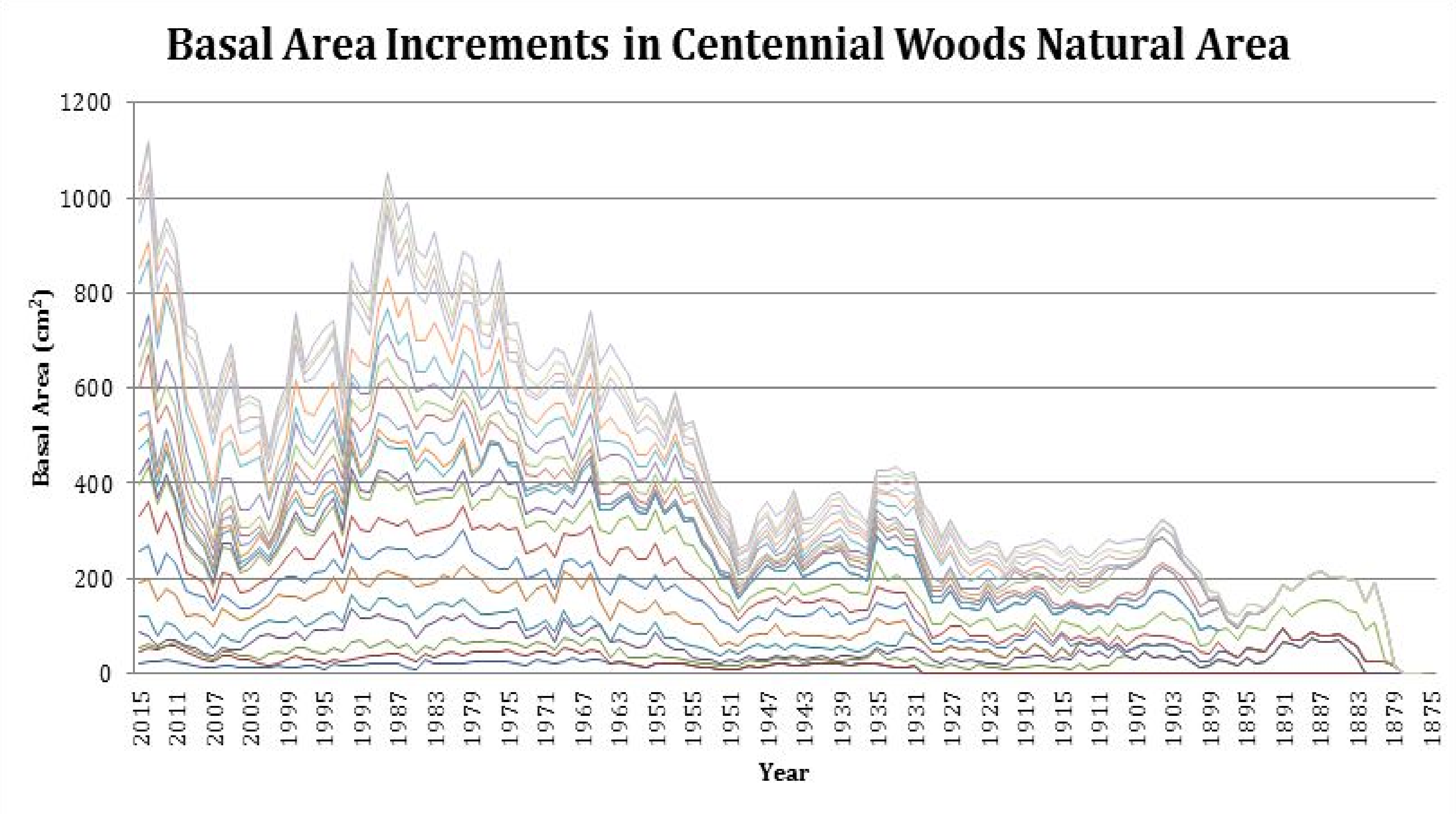
Initial Results - COFECHA

	Centennial Woods	Shelburne Farms
Series Intercorrelation	0.415	0.549
Average Mean Sensitivity	0.261	0.218

- SI: The lowest values for trees that can still be reliably cross-dated are around 0.400.
  - Most chronologies have values between 0.550 and 0.750.

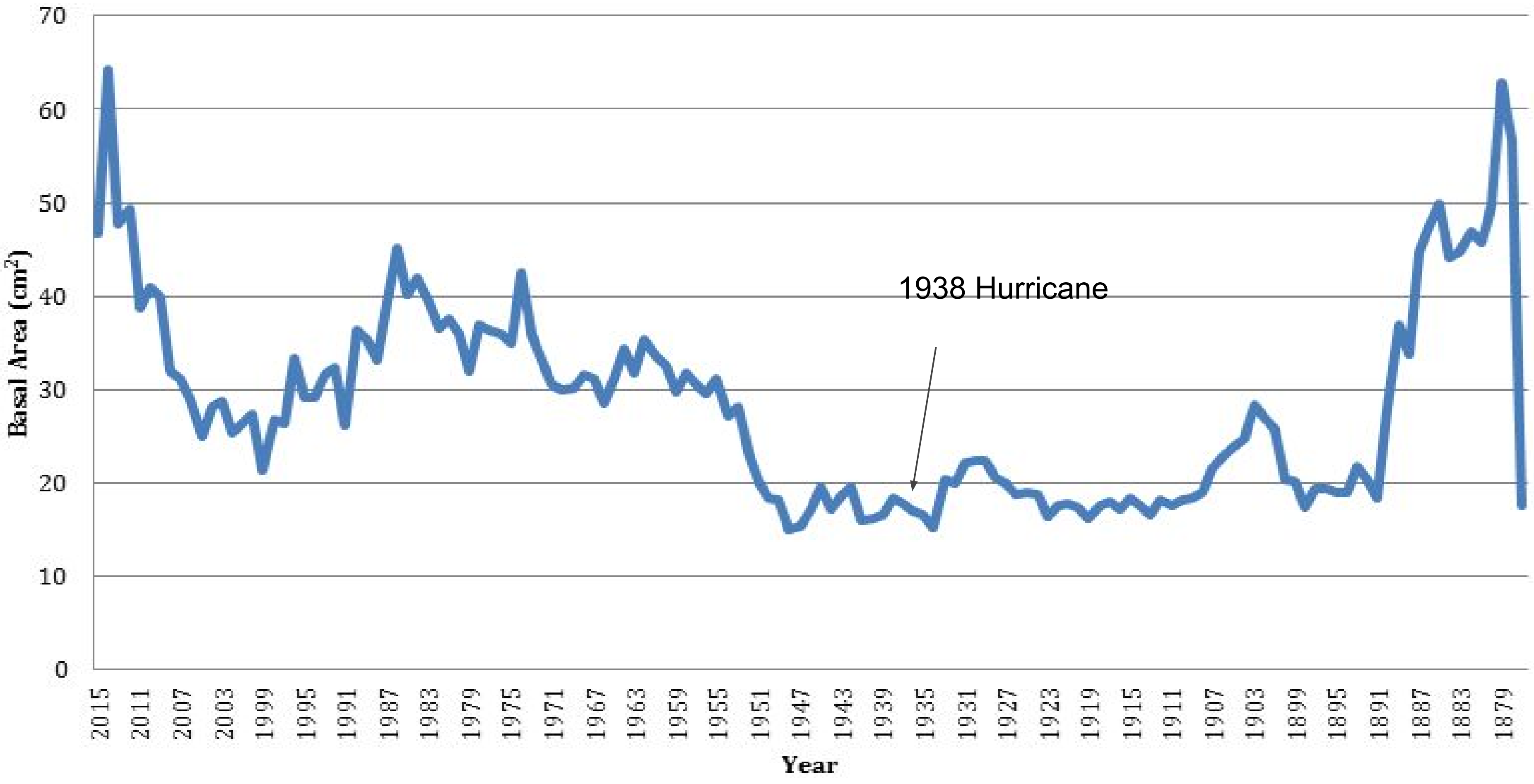
- AMS: Relative change in ring-width from one year to the next
  - Varies from around 0.650 (for very drought-sensitive conifers) to 0.150 for the most complacent trees.

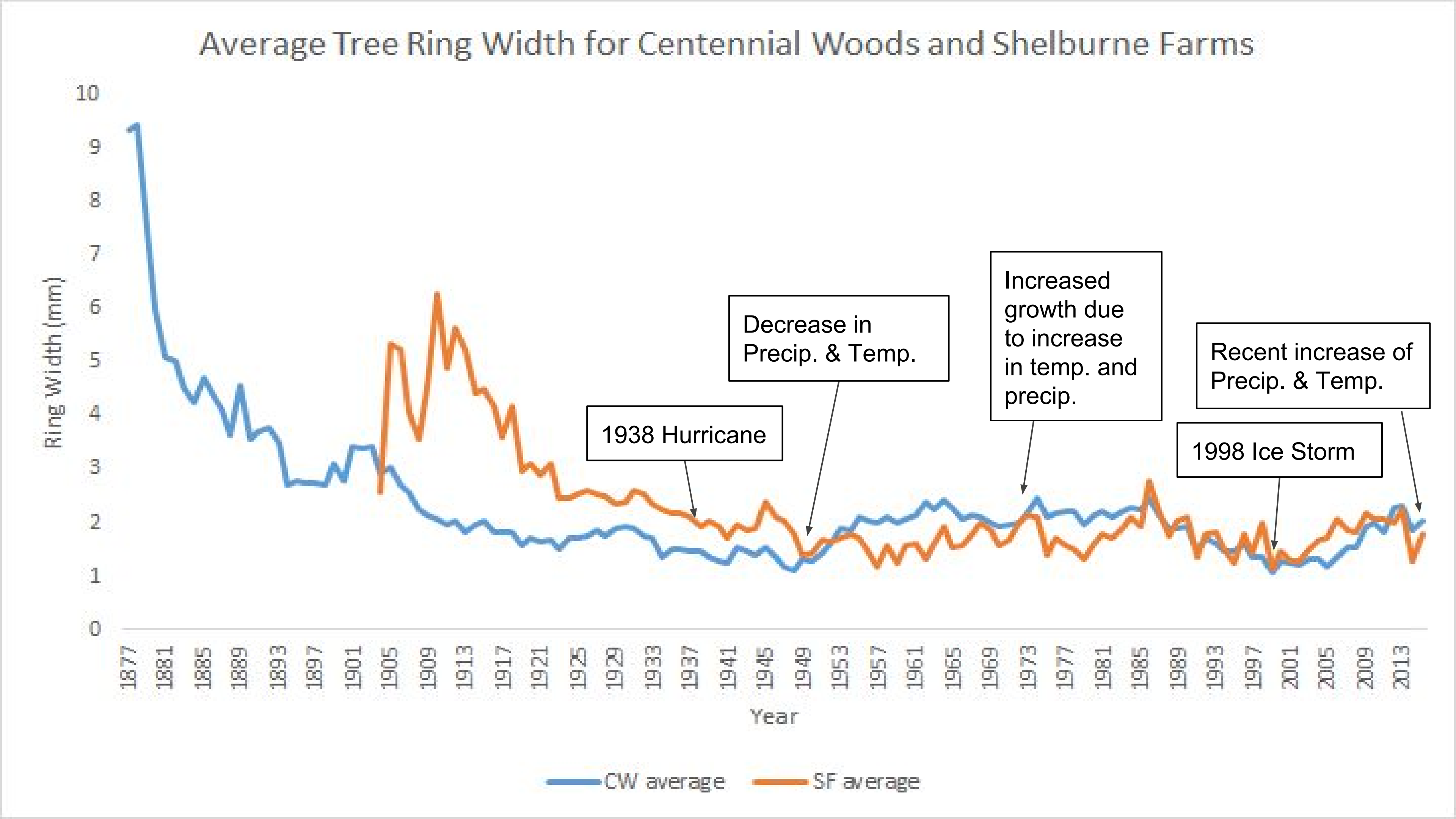
(NOAA, 2008)



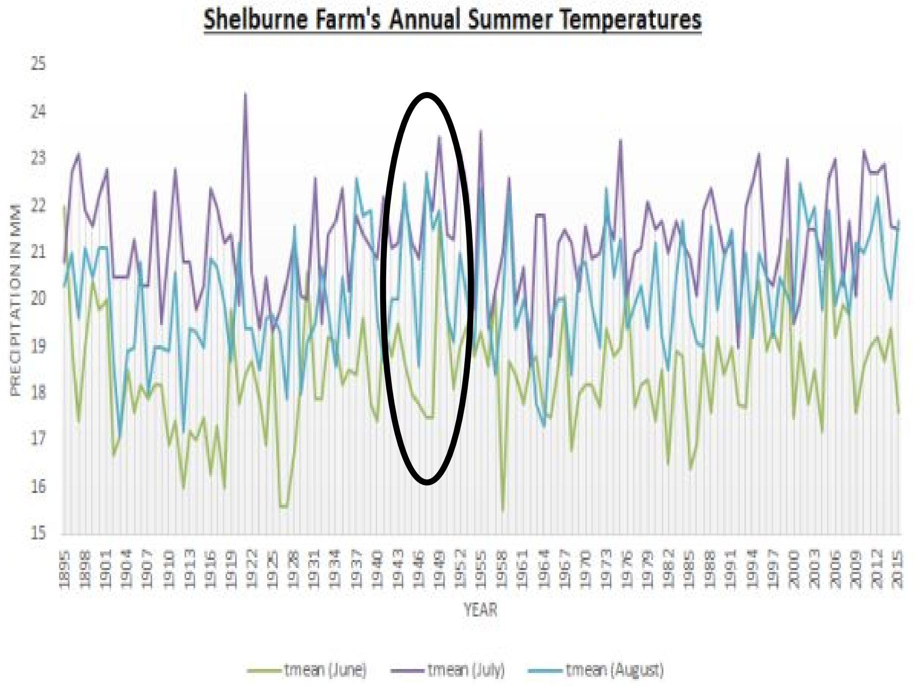
Basal Area Increments in Centennial Woods Natural Area
Basal Area (cm2)
0
200
400
600
800
1000
1200
2015
2011
2007
2003
1999
1995
1991
1987
1983
1979
1975
1971
1967
1963
1959
1955
1951
1947
1943
1939
1935
1931
1927
1923
1919
1915
1911
1907
1903
1899
1895
1891
1887
1883
1879
1875
Year

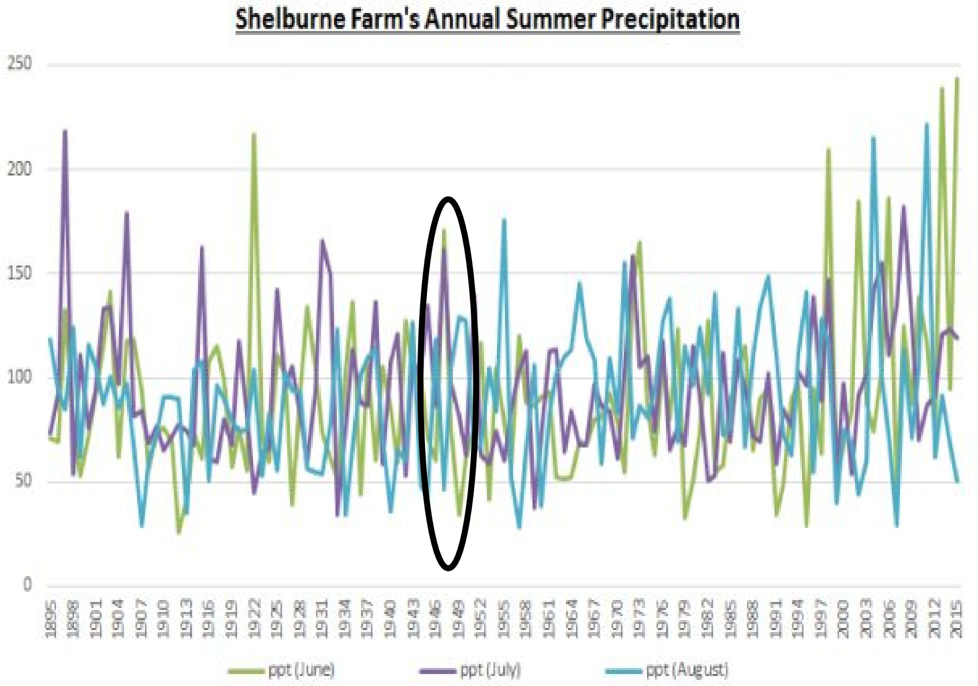
Average BAI of Centennial Woods



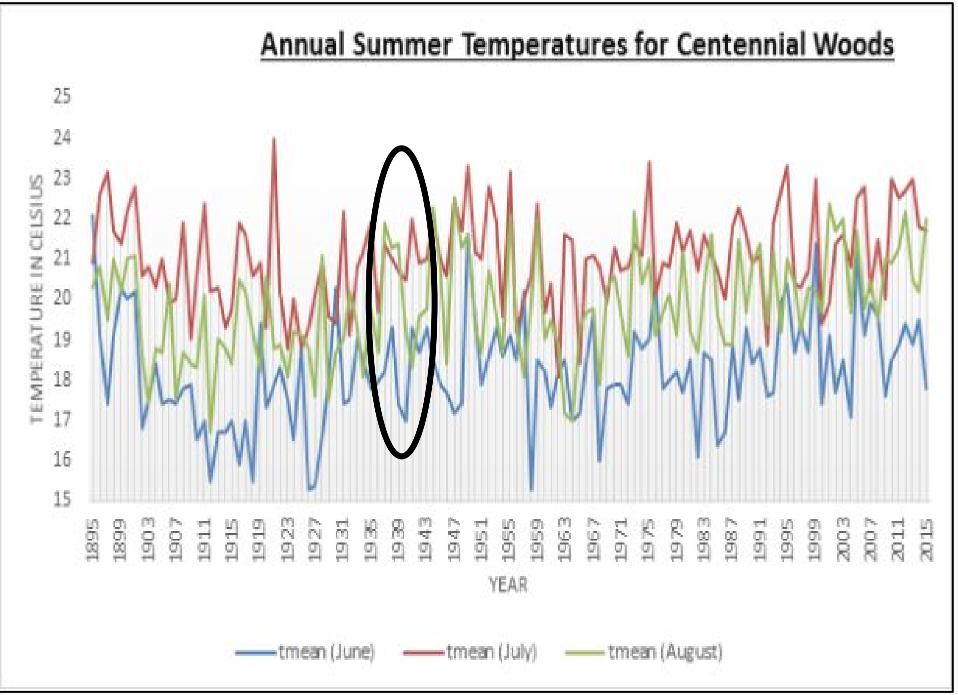

Average Tree Ring Width for Centennial Woods and Shelburne Farms
Ring Width (mm)
10
9
8
7
6
5
4
3
2
1
0
1877
1881
1885
1889
1893
1897
1901
1905
1909
1913
1917
1921
1925
1929
1933
1937
1941
1945
1949
1953
1957
1961
1965
1969
1973
1977
1981
1985
1989
1993
1997
2001
2005
2009
2013
Year
1938 Hurricane
Decrease in Precip. & Temp.
Increased growth due to increase in temp. and precip.
Recent increase of Precip. & Temp.
1998 Ice Storm
CW average
SF average

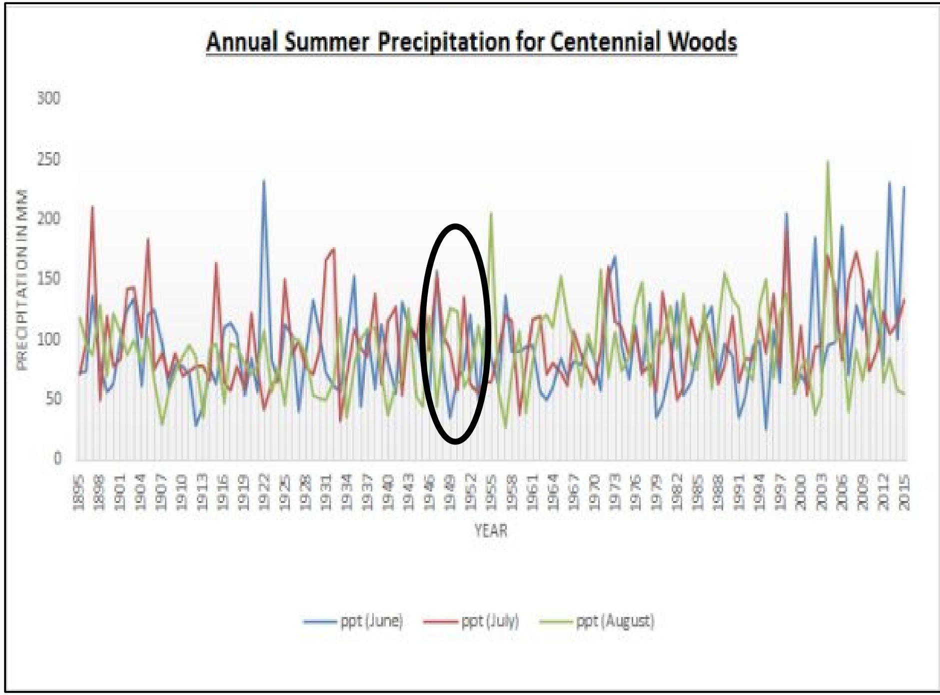
Decrease in Forest Productivity 1945-1950

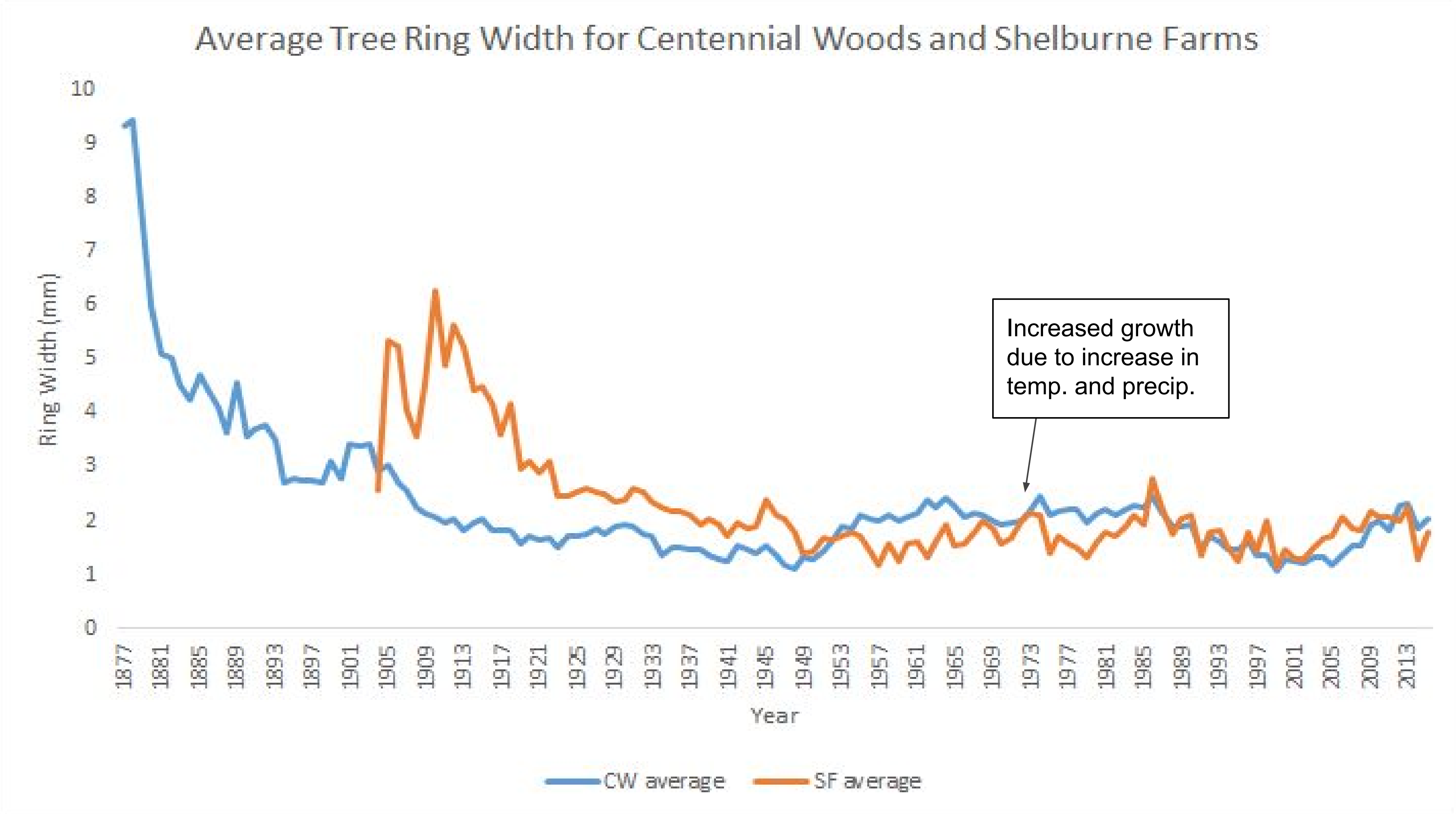




Decrease in Forest Productivity 1945-1950 Cont.

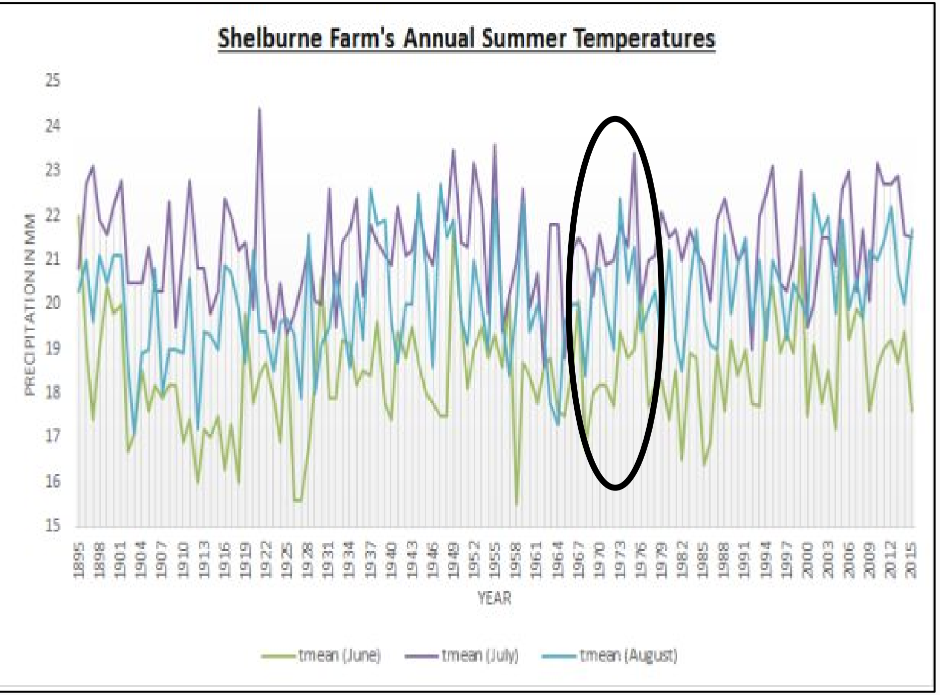


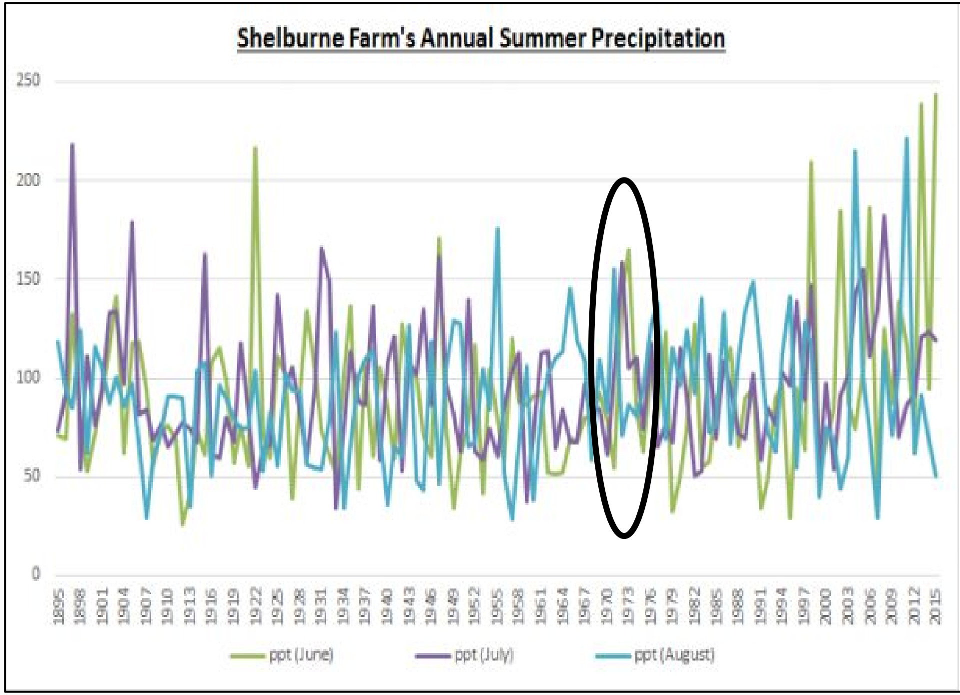




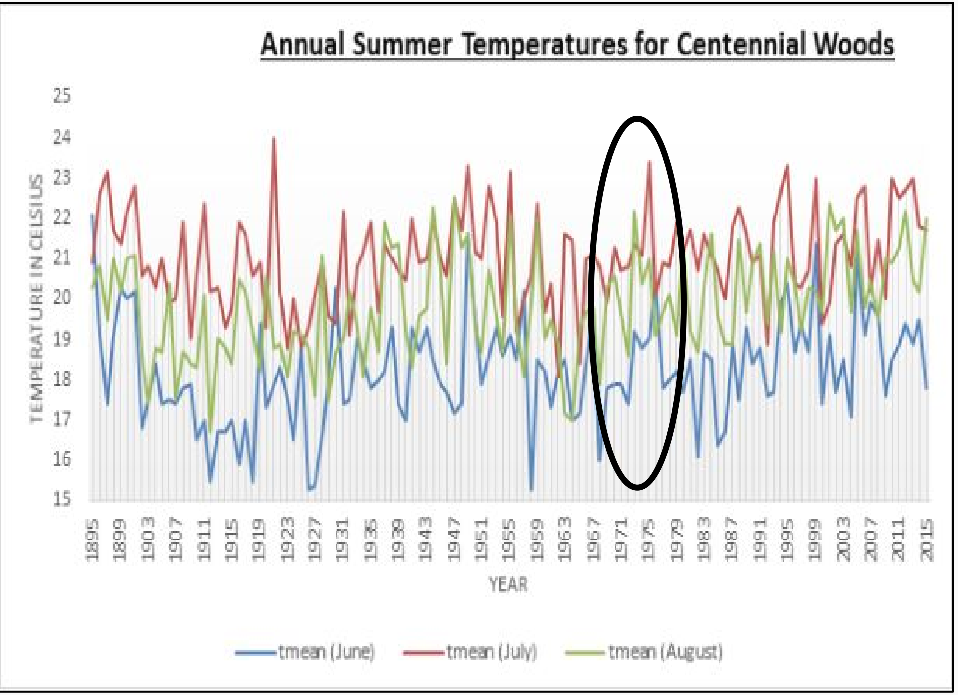
Average Tree Ring Width for Centennial Woods and Shelburne Farms
Ring Width (mm)
10
9
8
7
6
5
4
3
2
1
0
1877
1881
1885
1889
1893
1897
1901
1905
1909
1913
1917
1921
1925
1929
1933
1937
1941
1945
1949
1953
1957
1961
1965
1969
1973
1977
1981
1985
1989
1993
1997
2001
2005
2009
2013
Year
Increased growth due to increase in temp. and precip.
CW average
SF average

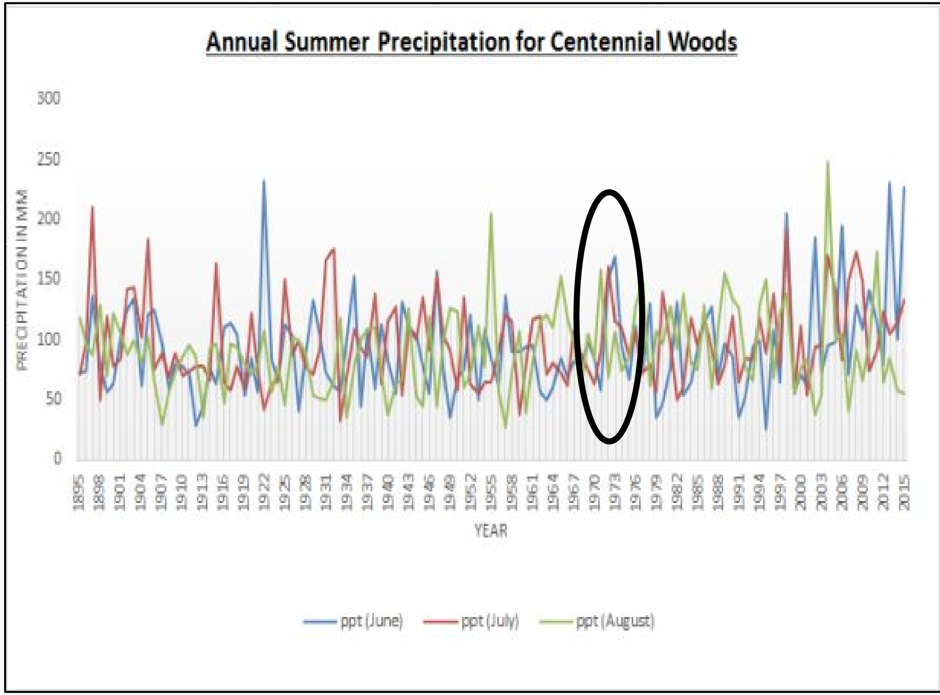
Increase in Forest Productivity During Early 1970s

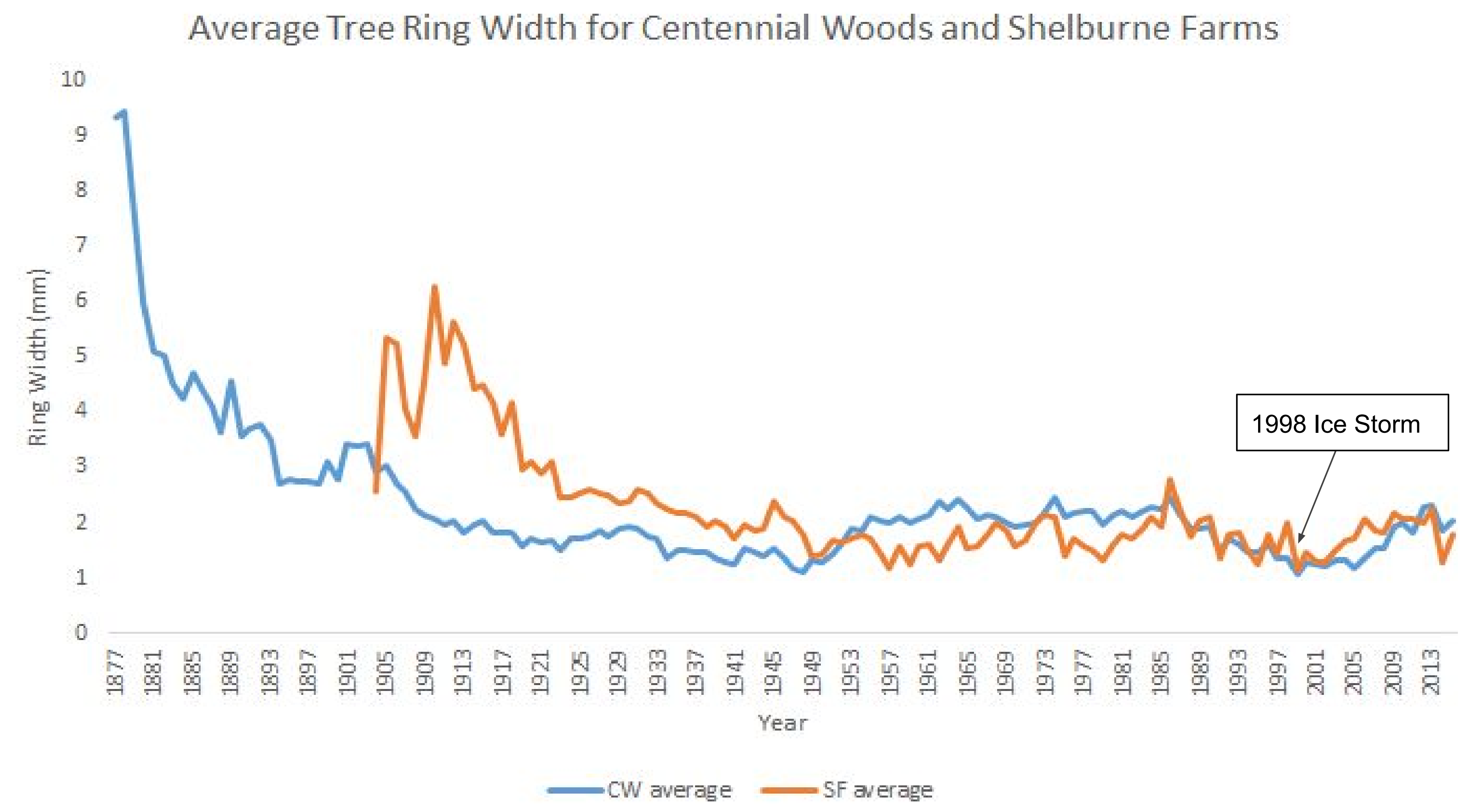




Increase in Forest Productivity During Early 1970s Cont.







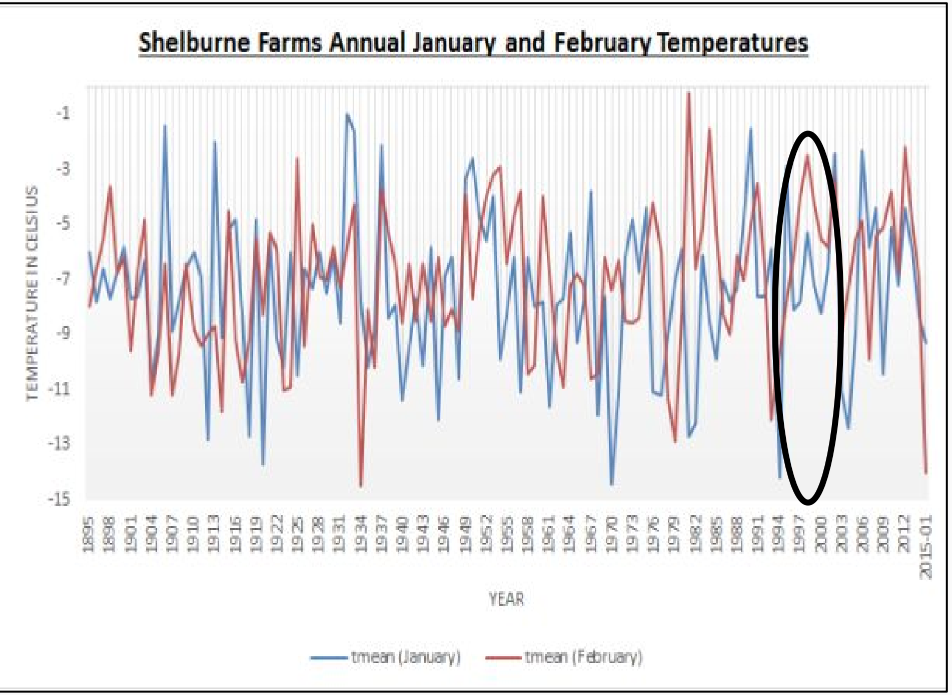
Average Tree Ring Width for Centennial Woods and Shelburne Farms
Ring Width (mm)
0
1
2
3
4
5
6
7
8
9
10
Year
1877
1881
1885
1889
1893
1897
1901
1905
1909
1913
1917
1921
1925
1929
1933
1937
1941
1945
1949
1953
1957
1961
1965
1969
1973
1977
1981
1985
1989
1993
1997
2001
2005
2009
2013
1998 Ice Storm
CW average
SF average

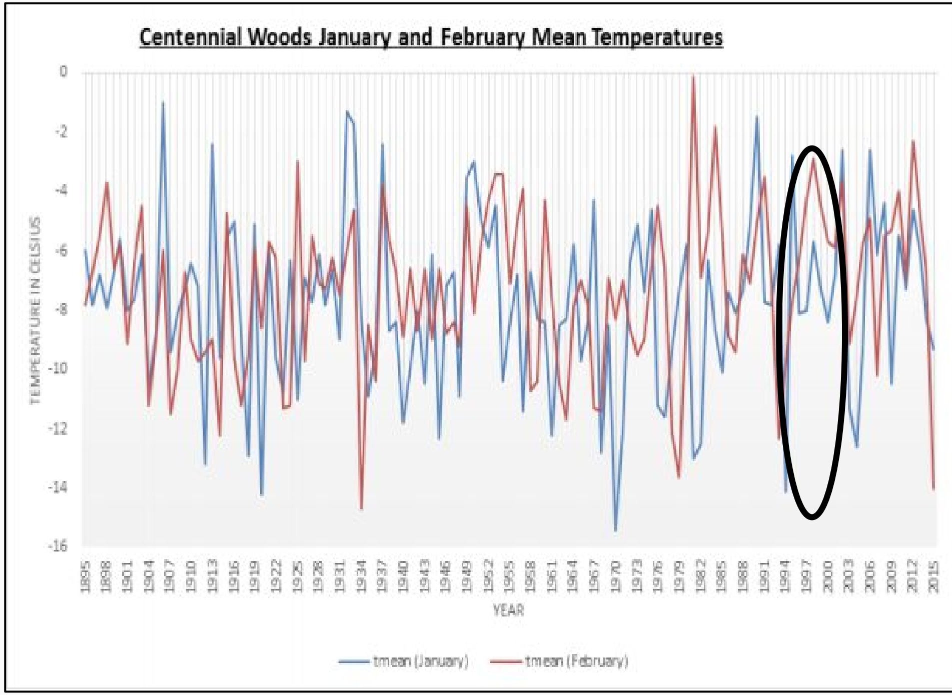
1998 New England Ice Storm

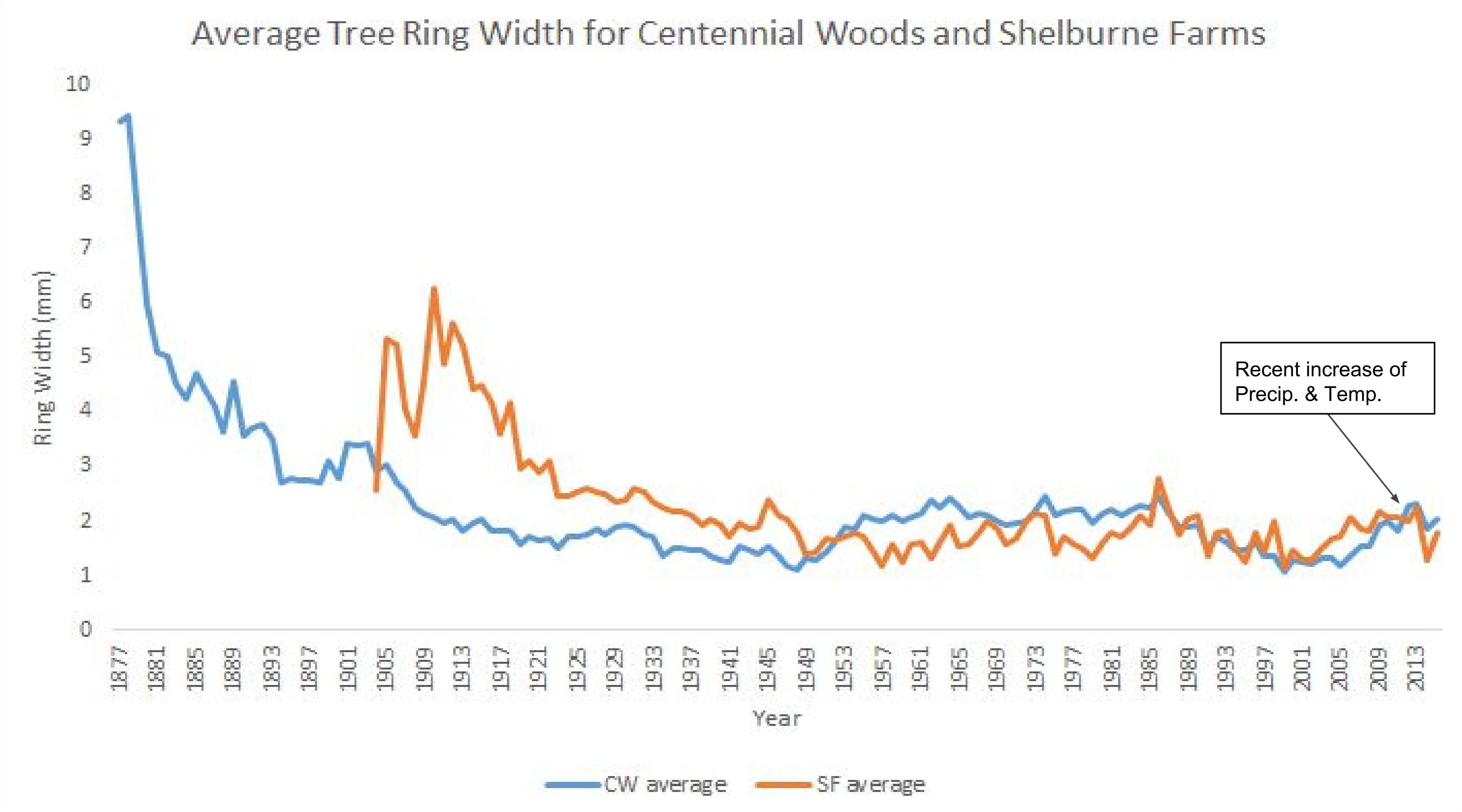
- Comparing tree ring width and basal area increment time series to historical climate data
- Indication of a major disturbance event in both Centennial Woods and Shelburne Farms occurring in 1998.
- Potential explanation: 1998 ice storm that caused damage across the the New England Region[1]

[1]Halman, Joshua M., Paul G. Schaberg, Gary J. Hawley, and Christopher F. Hansen. 2011. “Potential Role of Soil Calcium in Recovery of Paper Birch Following Ice Storm Injury in Vermont, USA.” *Forest Ecology and Management* 261 (9): 1539–45. doi:10.1016/j.foreco.2011.01.045.

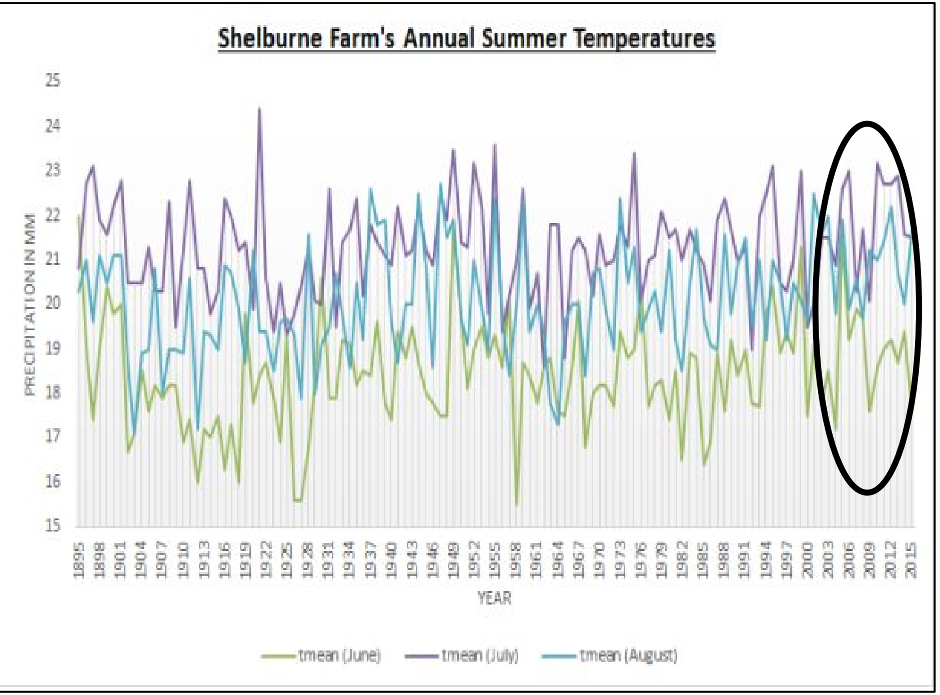
1998 New England Ice Storm Cont.

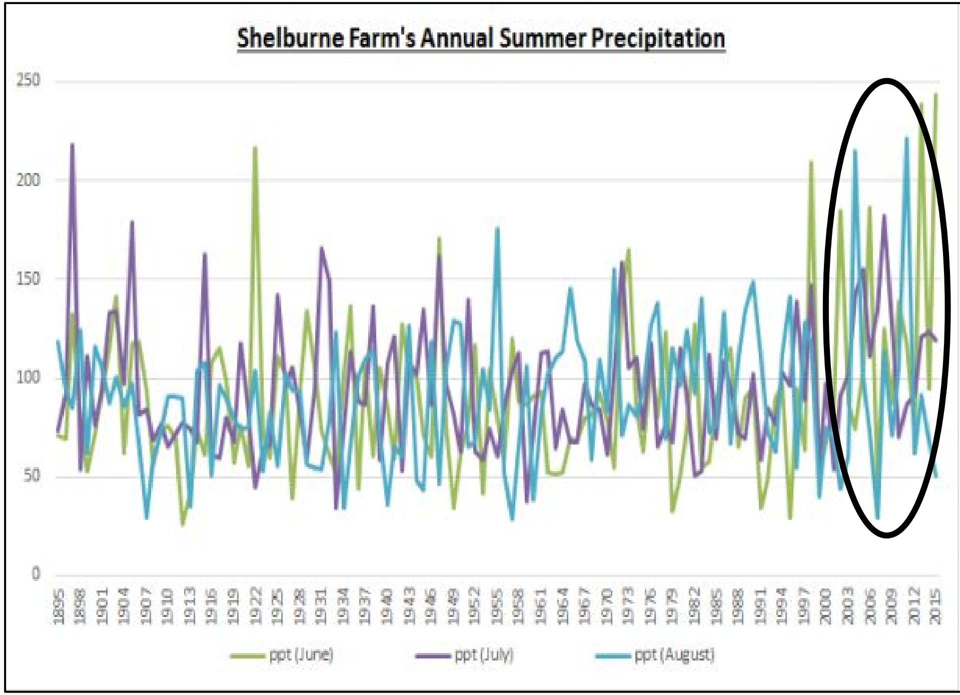




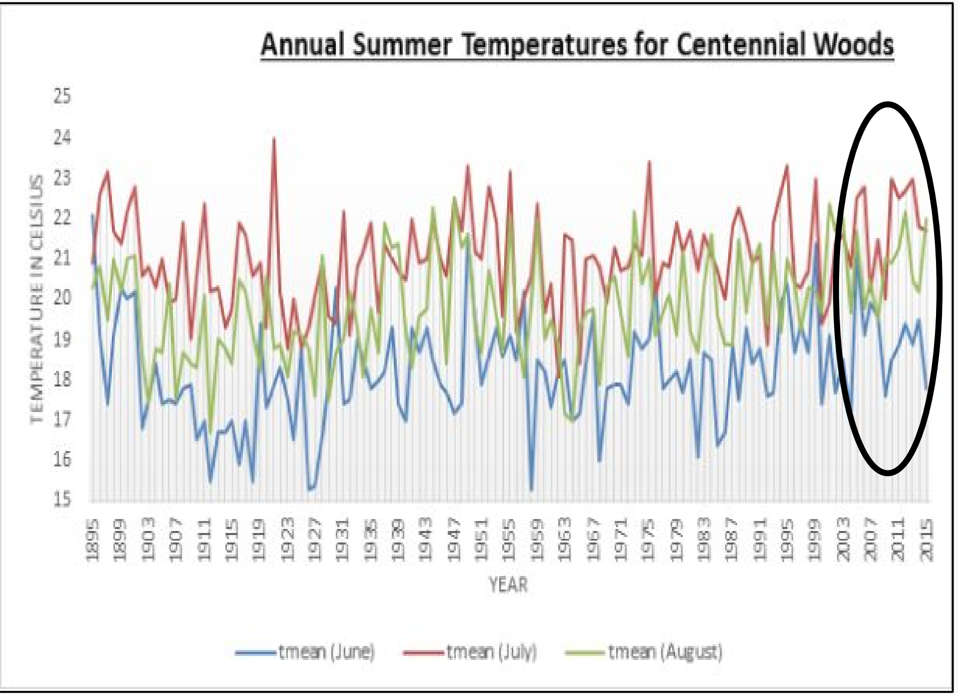

Average Tree Ring Width for Centennial Woods and Shelburne Farms
Ring Width (mm)
Year
Recent increase of Precip. & Temp.
CW average
SF average

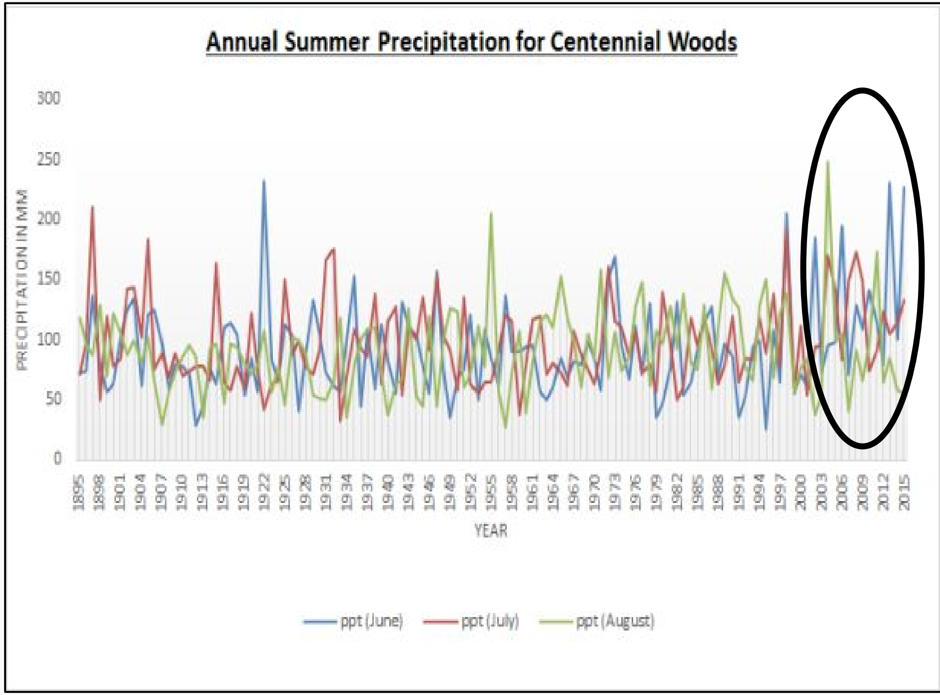
Increase in Forest Productivity During the 2000s

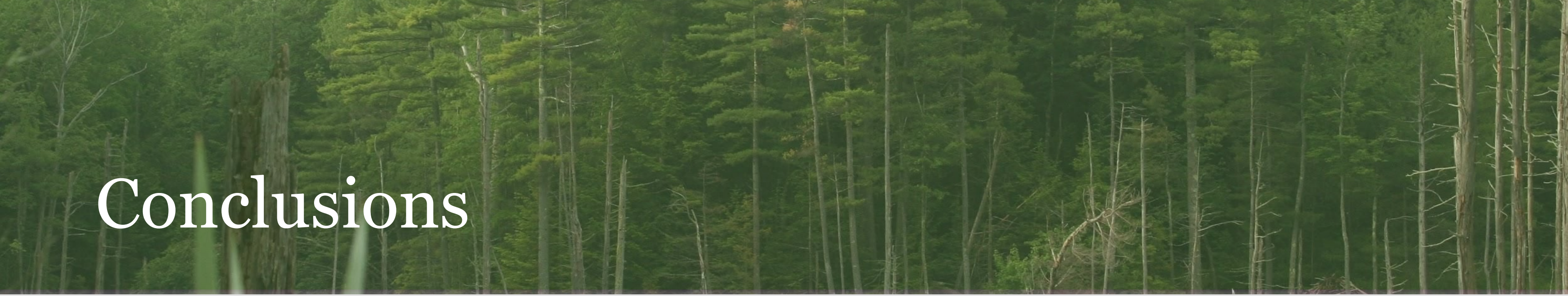




Increase in Forest Productivity During the 2000s







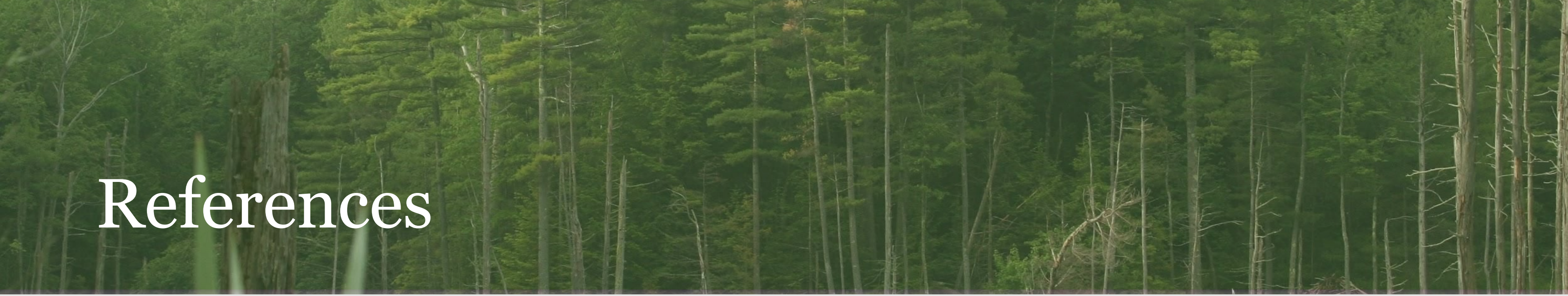
Conclusions

- successfully cored, prepared, measured, and crossdated two white pine chronologies
- counted and measured > 7,500 rings, identified possible correlations of ring width indices to climatic data and disturbance events
- growth trends possibly correlated in both sites with the disturbance events and changes in temperature and precipitation
- further statistical analyses ongoing to confirm results and identify additional correlations between tree growth and environmental parameters
- some evidence for recent increase in white pine growth in BAI and RWI, could support hypothesis that red spruce rebound is related to climatic trends

Acknowledgments

Our sincere thanks for support and guidance from:

- ★ Shelly Rayback & the UVM Geography Department
- ★ Paul Schaberg & the U.S. Forest Service
- ★ Shelburne Farms
- ★ UVM CUPS



References

Benjamin J. Engel, Paul G. Schaberg, Gary J. Hawley, Shelly A. Rayback, Jennifer Pontius, Alexandra M. Kosiba, and Eric K. Miller. 2016. “Assessing Relationships between Red Spruce Radial Growth and Pollution Critical Load Exceedance Values.” *Forest Ecology and Management*, Special Section: Forests, Roots and Soil Carbon, 359 (January): 83–91. doi:10.1016/j.foreco.2015.09.029.

Grissino-Mayer, H. (2008, August 20). Guide to COFECHA output. Retrieved December 5, 2015, from https://www.ncdc.noaa.gov/paleo/treering/cofecha/userguide.html#intercorrelation

Henri D. Grissino-Mayer. 2001. “Evaluating Crossdating Accuracy: A Manual and Tutorial for the Computer Program COFECHA.” *Tree-Ring Research*. http://arizona.openrepository.com/arizona/handle/10150/251654.

James H. Speer. 2010. *Fundamentals of Tree-Ring Research*. Tucson, Ariz: Univ. of Arizona Press.

Lindsey Rustad, John Campbell, Jeffrey S. Dukes, Thomas Huntington, Kathy Fallon Lambert, Jacqueline Mohan, and Nicholas Rodenhouse. 2012. “Changing Climate, Changing Forests: The Impacts of Climate Change on Forests of the Northeastern United States and Eastern Canada.” http://www.nrs.fs.fed.us/pubs/41165.

Maine Department of Conservation. 2008. *Forest Trees of Maine*. Augusta, Me.: Maine Forest Service.

Marvin A. Stokes, and Terah L. Smiley. 1996. *An Introduction to Tree-Ring Dating*. Tucson: University of Arizona Press.

National Climatic Data Center. 2015. “Drought: A Paleo Perspective.” https://www.ncdc.noaa.gov/paleo/drought/drght_temporal.html.

R. B. Myneni, J. Dong, C. J. Tucker, R. K. Kaufmann, P. E. Kauppi, J. Liski, L. Zhou, V. Alexeyev, and M. K. Hughes. 2001. “A Large Carbon Sink in the Woody Biomass of Northern Forests.” *Proceedings of the National Academy of Sciences* 98 (26): 14784–89. doi:10.1073/pnas.261555198.

University of Vermont. 2012. “Background : Vermont Climate : Vermont State Climate Office ARSCO.” http://www.uvm.edu/~vtstclim/?Page=climate_vermont.html&SM=vtclimsub.html.

Wendel, and Clay Smith. 1985. “Pinus Strobus L.” http://www.na.fs.fed.us/pubs/silvics_manual/Volume_1/pinus/strobus.htm.