Assessing the drivers of the 'spring dip' in foliar moisture content and their potential impact on forest fire behavior

W. Matt Jolly[1] , John Hintz[2], Rachael Kropp[1], Elliott Conrad[1], Jim Barnier[2]

[1]USFS, RMRS, Fire Sciences Laboratory, Missoula, MT

[2]Wisconsin DNR

Lakes States Fire Sciences Consortium
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Objective

- Determine the main drivers of the ‘Spring Dip’ in Jack Pine and Red Pine fuel moistures
- Assess their impact on potential fire behavior
- Develop tools that can be used by managers to assess the onset and timing of the dip spatially

Spring Dip

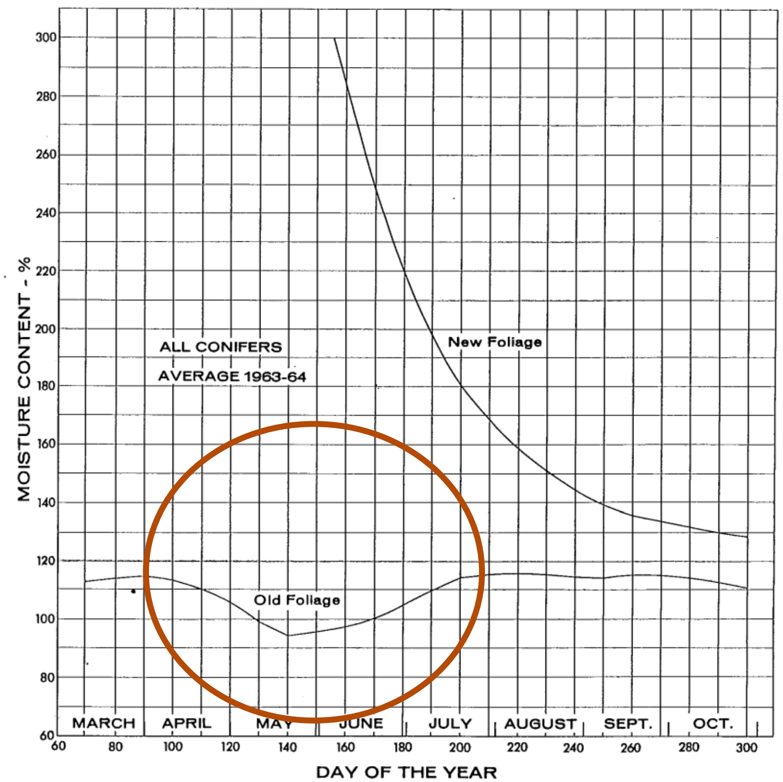

Figure 1. Foliar moisture trend of the five conifers together, averaged for 1963 and 1964.

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CANADA
DEPARTMENT OF FORESTRY AND RURAL DEVELOPMENT

SEASONAL VARIATION IN MOISTURE CONTENT OF EASTERN CANADIAN TREE FOLIAGE AND THE POSSIBLE EFFECT ON CROWN FIRES

by
C. E. Van Wagner

Extrait en français

FORESTRY BRANCH
DEPARTMENTAL PUBLICATION No. 1204
1967

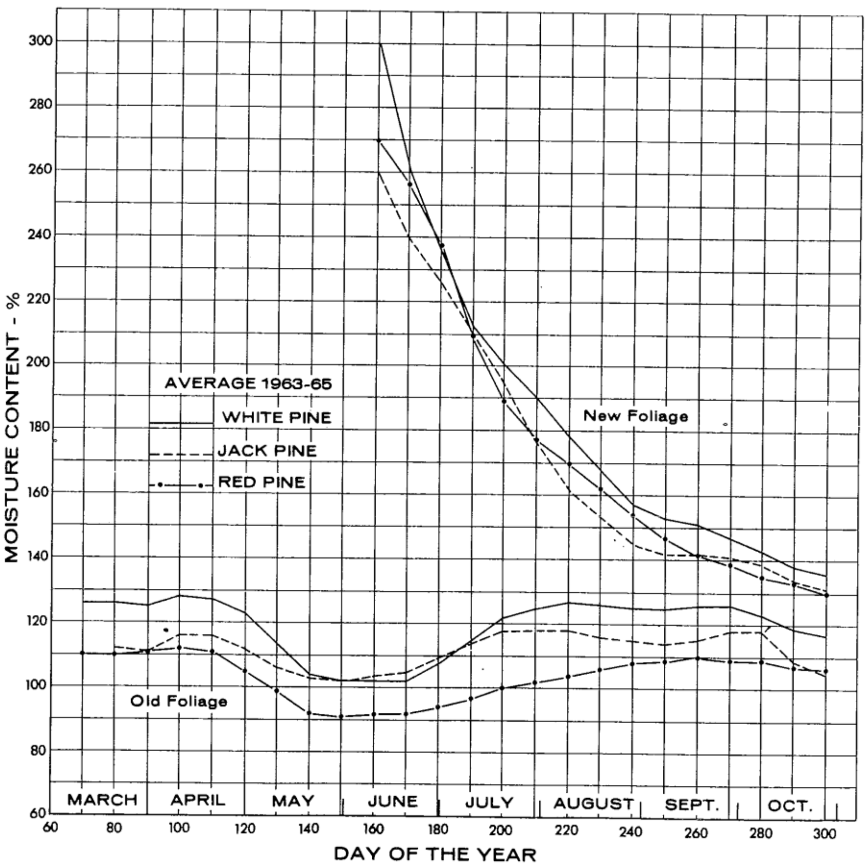


Figure 3. Trends of foliar moisture in white pine, jack pine and red pine, averaged for the years 1963 to 1965.

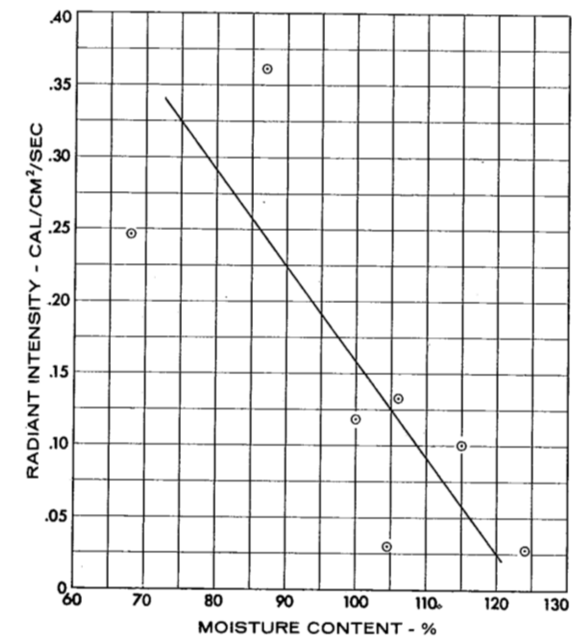


Figure 5. Effect of foliar moisture content on maximum radiant intensity 3 feet from burning 5-foot white spruce trees.

What is Foliar Moisture Content?

- Amount of water in the fuel expressed as percentage of the fuels dry weight

Live Foliar Moisture Content = (Water Weight / Dry Weight) * 100

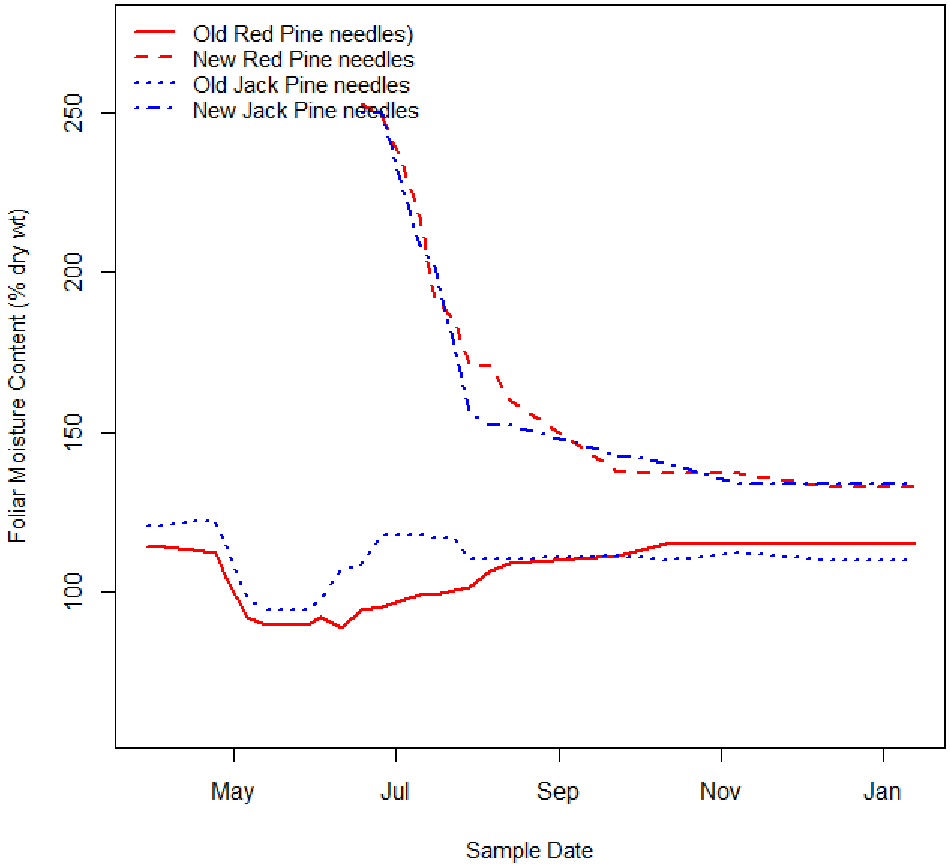
- LFMC can change by either changes the amount of water in the fuel or the amount of dry weight in the fuel.
- LFMC of 100% indicates that you have the same amount of water and dry mass of fuel

What we did

- Sampled Jack Pine and Red Pine starting before the “Dip” and continuing through summer
  - Generally weekly throughout the period
- Quantified important characteristics of the fuel:
  - Foliar Moisture Content
  - Relative Water Content
  - Density
  - Heat Content
  - Chemistry
  - Ignitability
- Here’s what we found:

Results

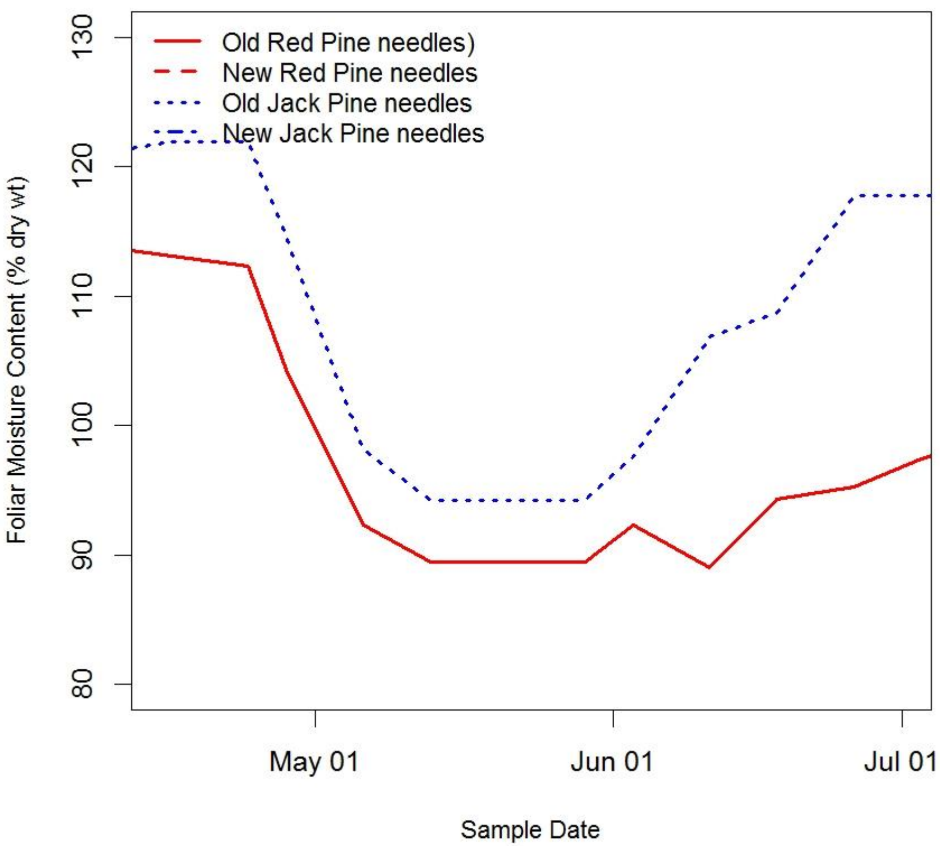
LFMC Seasonal Variations



	Jack Pine	Red Pine
New Needles	184% (30%)	176% (37%)
Old Needles	110% (8%)	104% (10%)

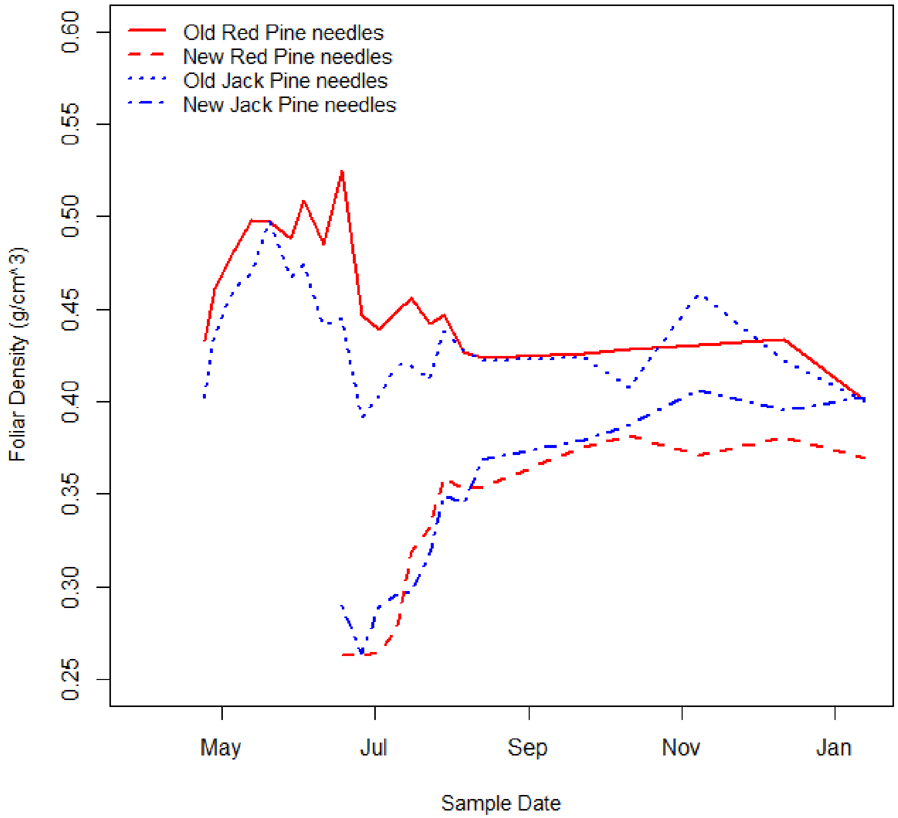
These variations
Are driven by the
Plants green-up cycle

Old Needles During Spring



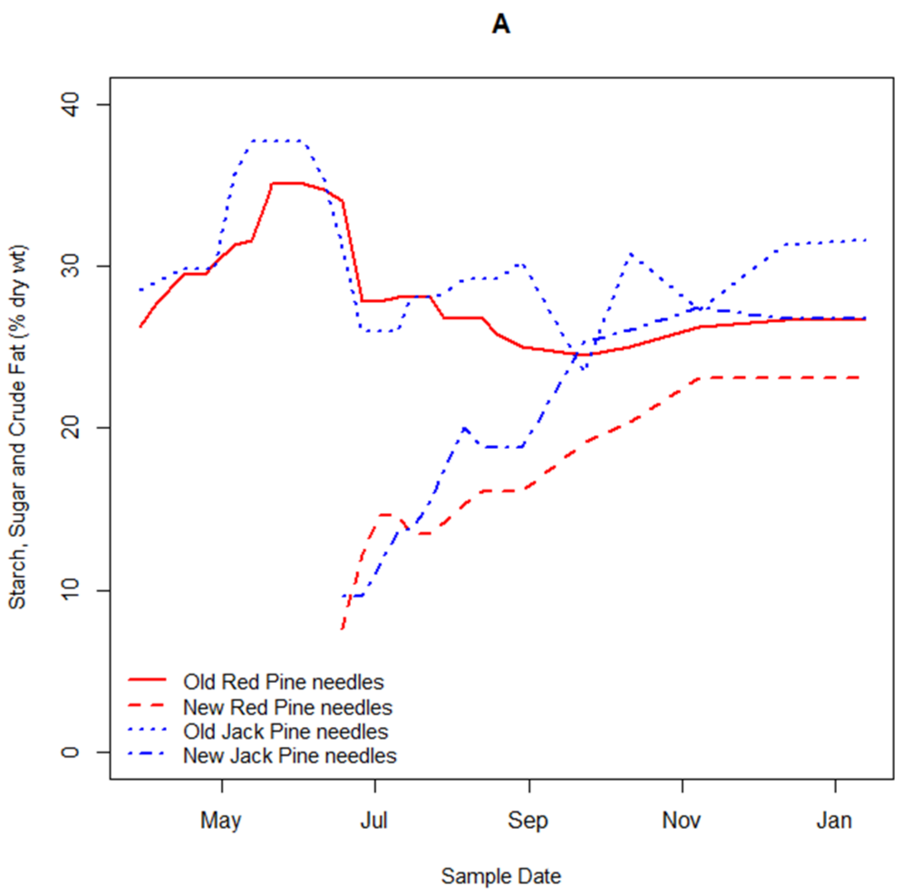
- Dip is more pronounced in Jack Pine but Red Pine has lower minimum moisture content
- Minimums:
- Jack Pine 96.6%
- Red Pine 86.0%

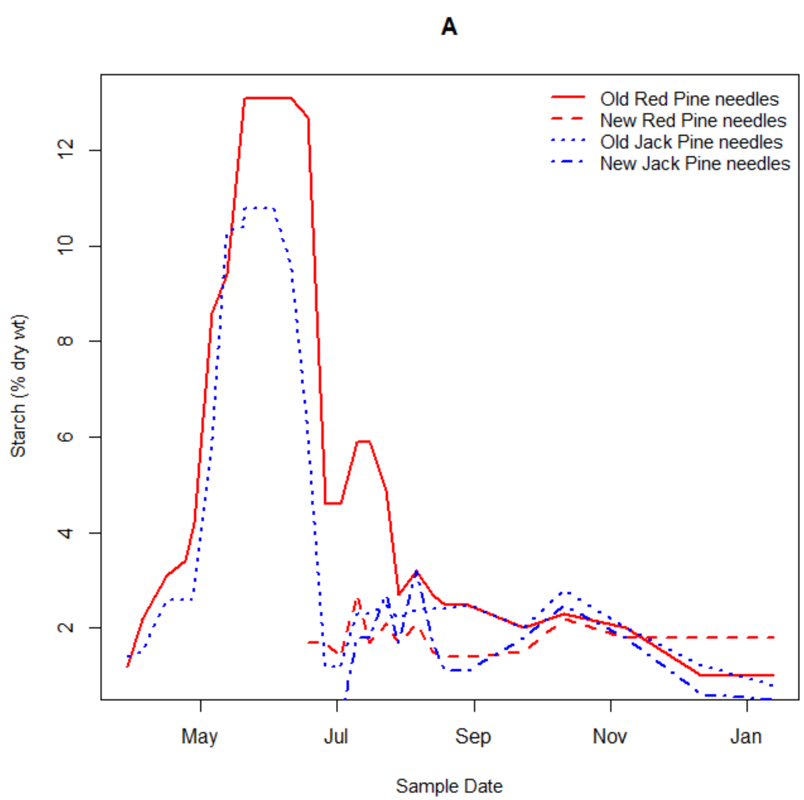
Density



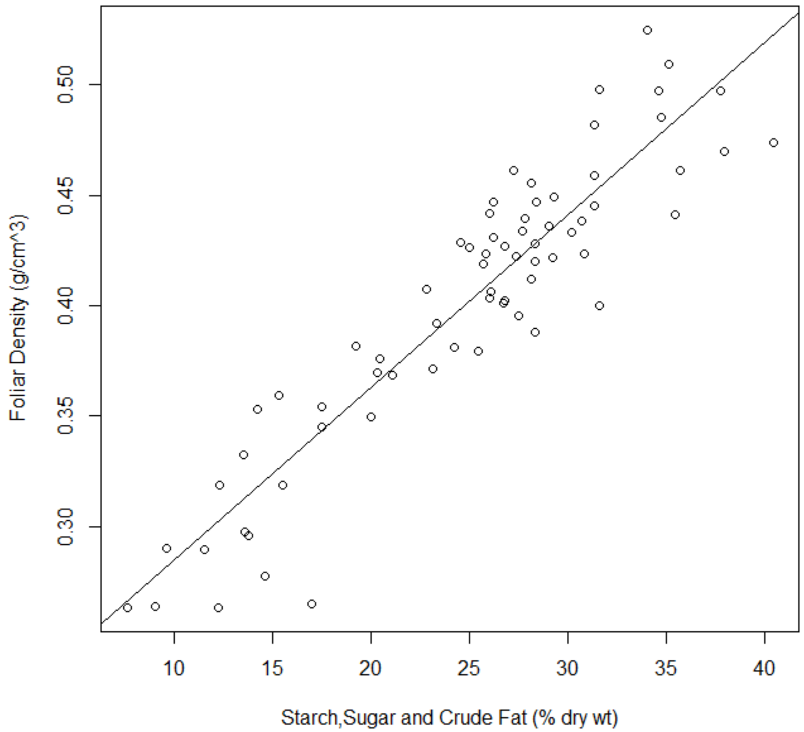
Old Red Pine needles
New Red Pine needles
Old Jack Pine needles
New Jack Pine needles
Foliar Density (g/cm^3)
0.25
0.30
0.35
0.40
0.45
0.50
0.55
0.60
May
Jul
Sep
Nov
Jan
Sample Date

Seasonal variations in starch, sugar and crude fat

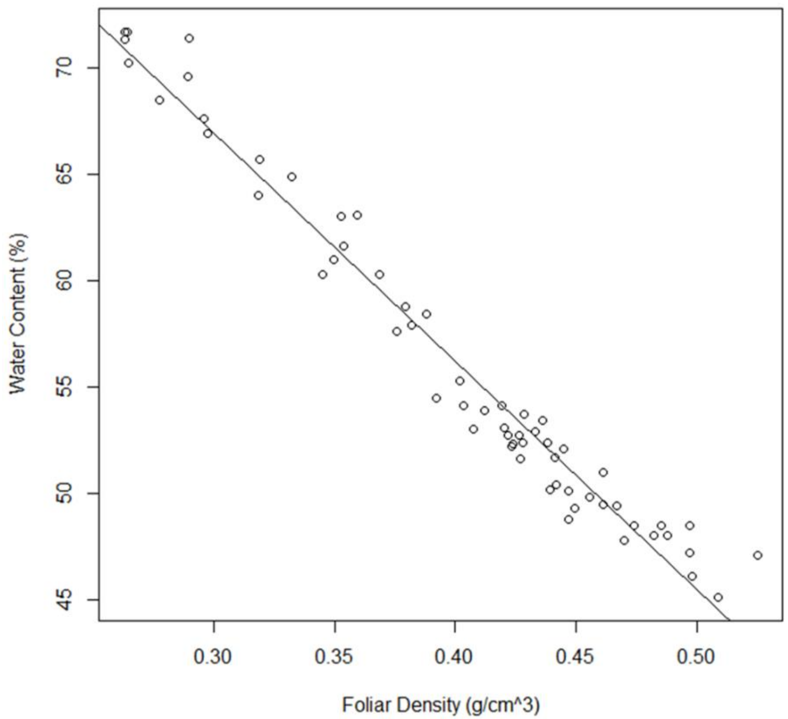




- Very strong seasonal variations noted in needle starch content
- 10-fold increase in needle starches during the spring dip



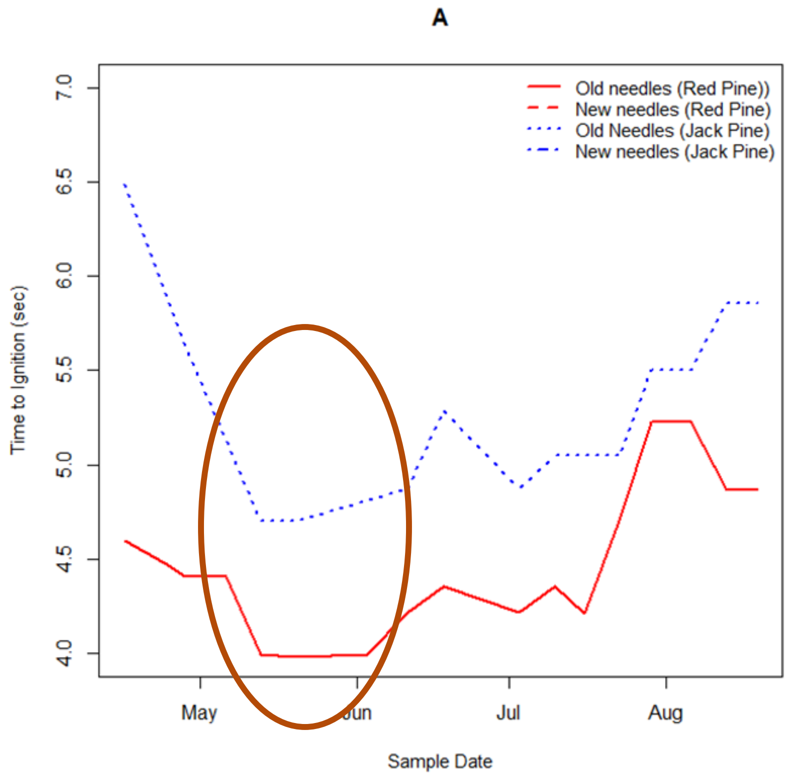
- Needle chemical composition drives the changes foliar density
  - Amount of starch, sugar and crude fat explain 85% of the variation in foliar density



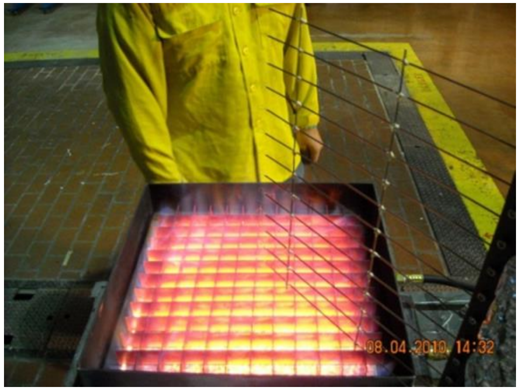
- Foliar Density explains 97% of the variation in foliar water (moisture) content

Time to Ignition

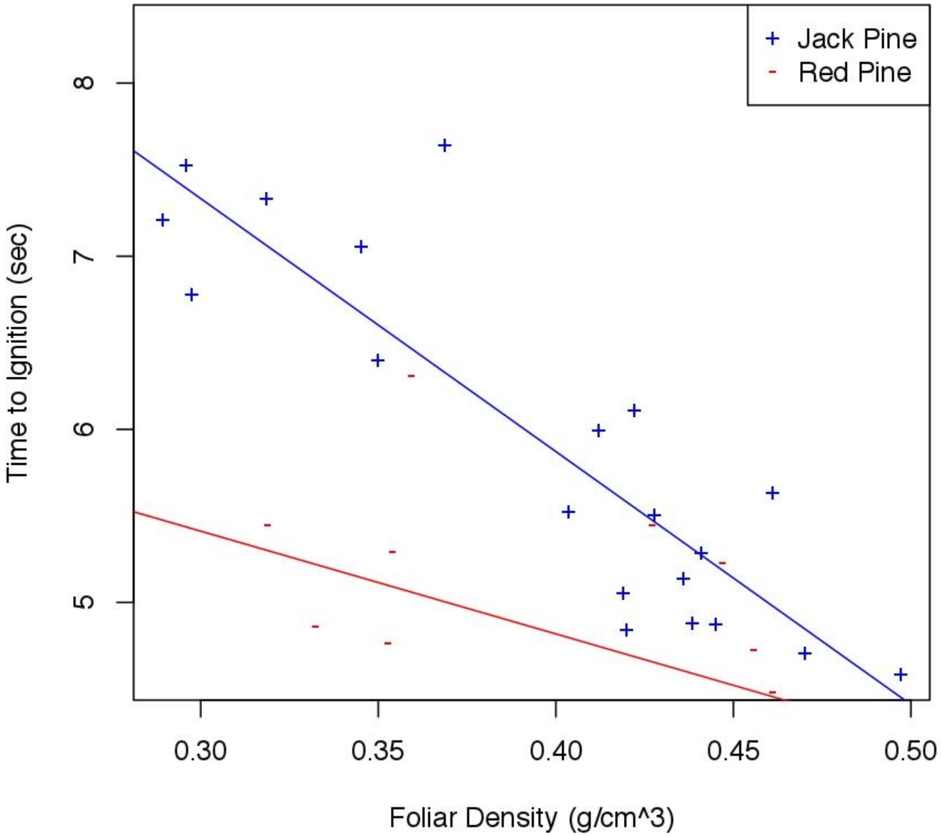
Rapid-heating



- Highest flammability observed during late May for both species



Inverse relationship between foliar density and flammability

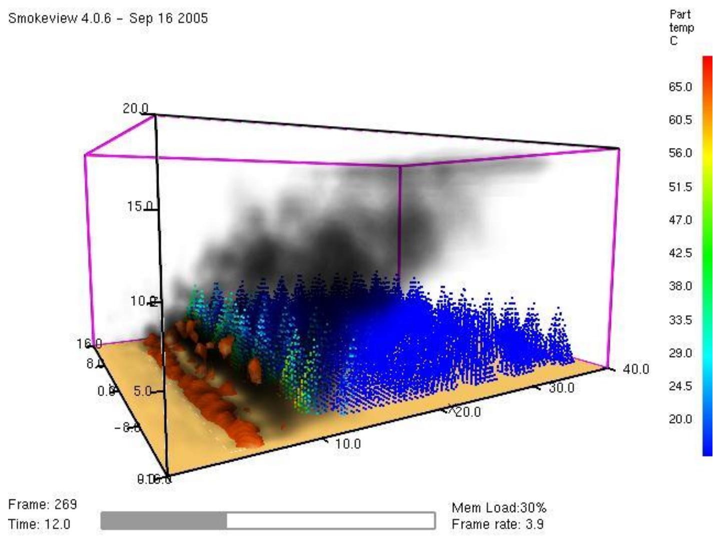


- Increasing Density, decreases Time to Ignition (Increases Flammability)
- More pronounced seasonal changes in Jack Pine but faster overall ignition in Red Pine

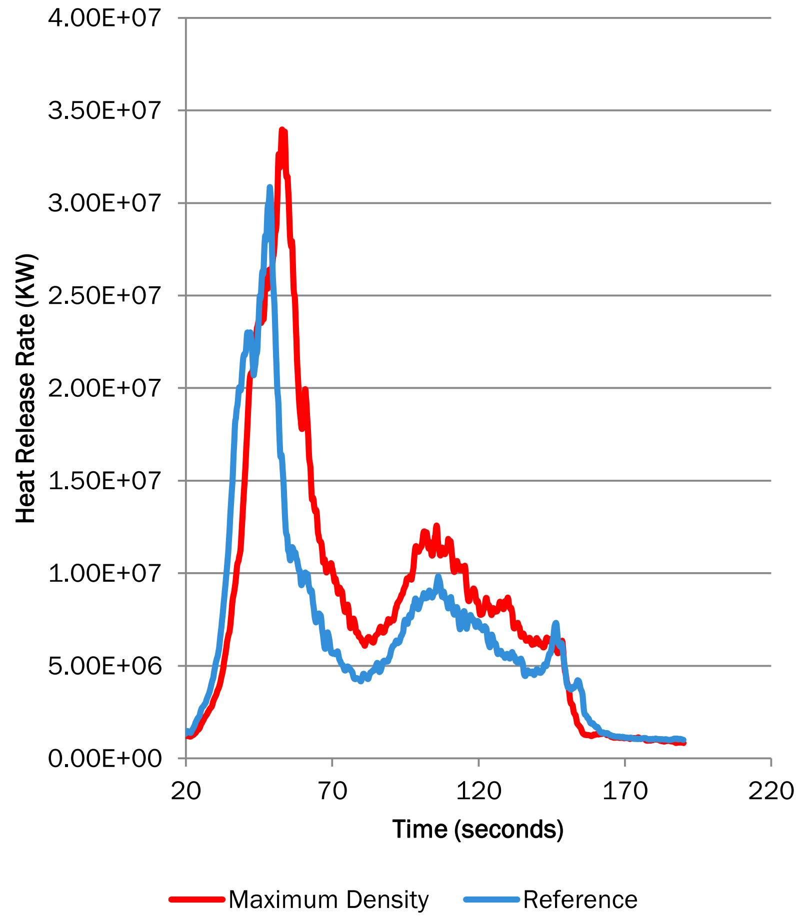
Simulating these differences

Fire Behavior Simulations

- We used the Wildand-Urban Interface Fire Dynamics Simulator to determine the implications of these findings on potential fire behavior
- These results are preliminary



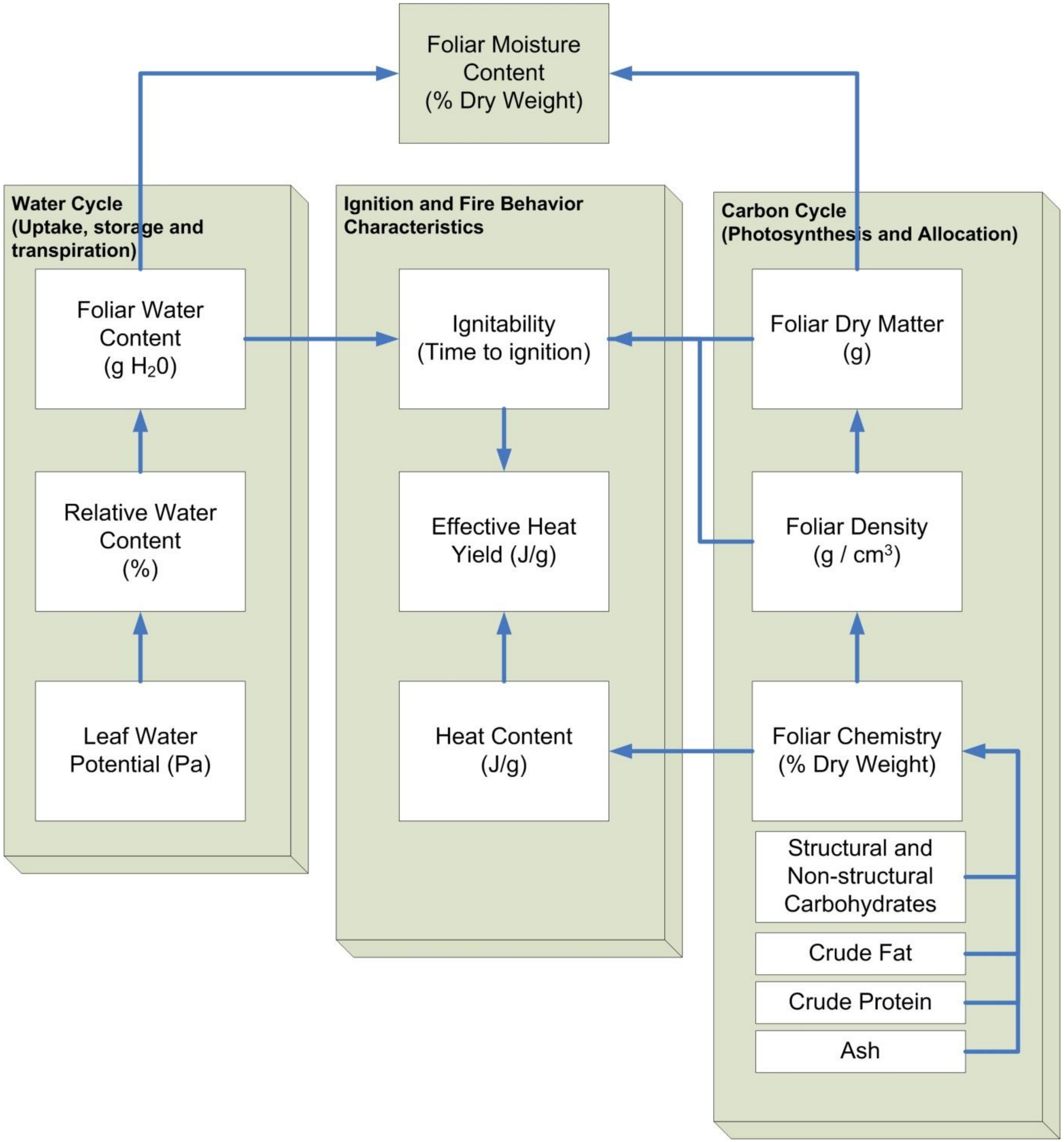
WFDS Simulation Results



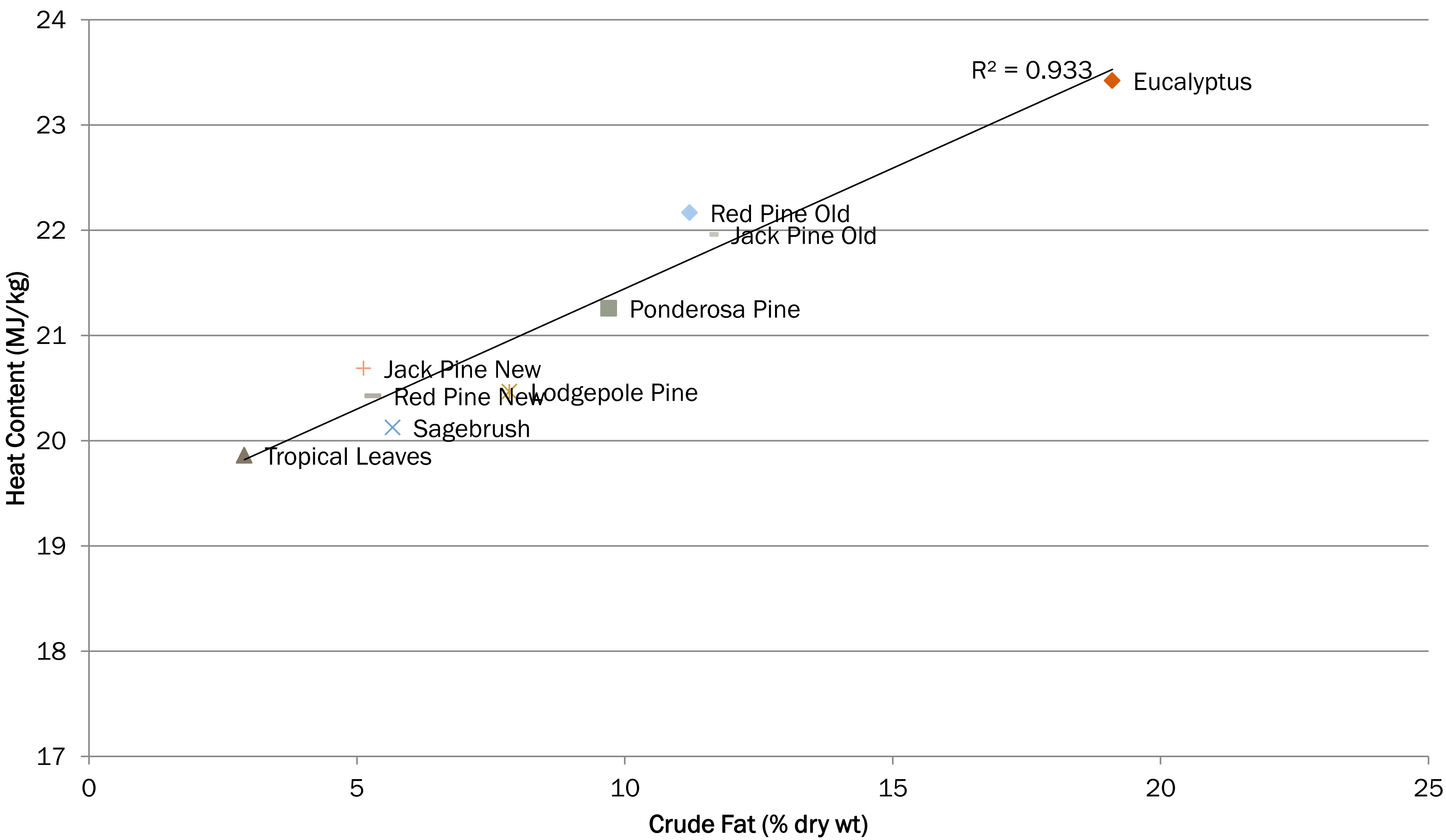
- Higher peak heat release rate and a long peak heat release duration during the ‘spring dip’ period

Putting it together

- Foliar moisture content follows previously documented trends: “Spring Dip”
- Dip was driven by a change in foliar density, not a change in water content
- Density changes were most correlated to changes in sugar, starch and crude fat
  - Primarily influenced by a 10-fold increase in starch
- If total fuel volume stays constant, there is more available foliar fuel during the dip period
- Flammability tests follow the same trends



Foliar Moisture Content (% Dry Weight)
Water Cycle (Uptake, storage and transpiration)
Foliar Water Content (g H_20)
Relative Water Content (%)
Leaf Water Potential (Pa)
Ignition and Fire Behavior Characteristics
Ignitability (Time to ignition)
Effective Heat Yield (J/g)
Heat Content (J/g)
Carbon Cycle (Photosynthesis and Allocation)
Foliar Dry Matter (g)
Foliar Density (g / cm^3)
Foliar Chemistry (% Dry Weight)
Structural and Non-structural Carbohydrates
Crude Fat
Crude Protein
Ash



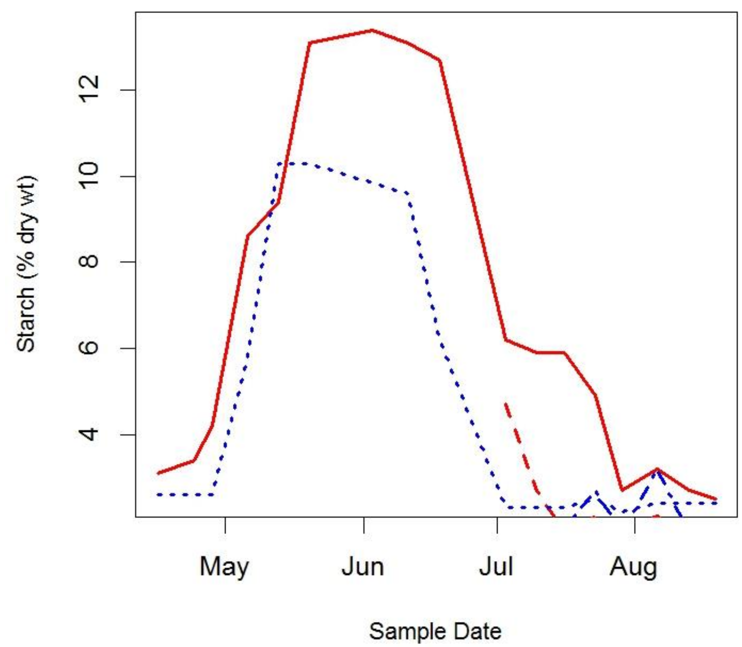
24
23
22
21
20
19
18
17
Heat Content (MJ/kg)
0
5
10
15
20
25
Crude Fat (% dry wt)
R² = 0.933
Eucalyptus
Red Pine Old
Jack Pine Old
Ponderosa Pine
Jack Pine New
Red Pine New
Lodgepole Pine
Sagebrush
Tropical Leaves

Example: Germann Road Fire

Germann Road Fire

Samples Taken After the Fire

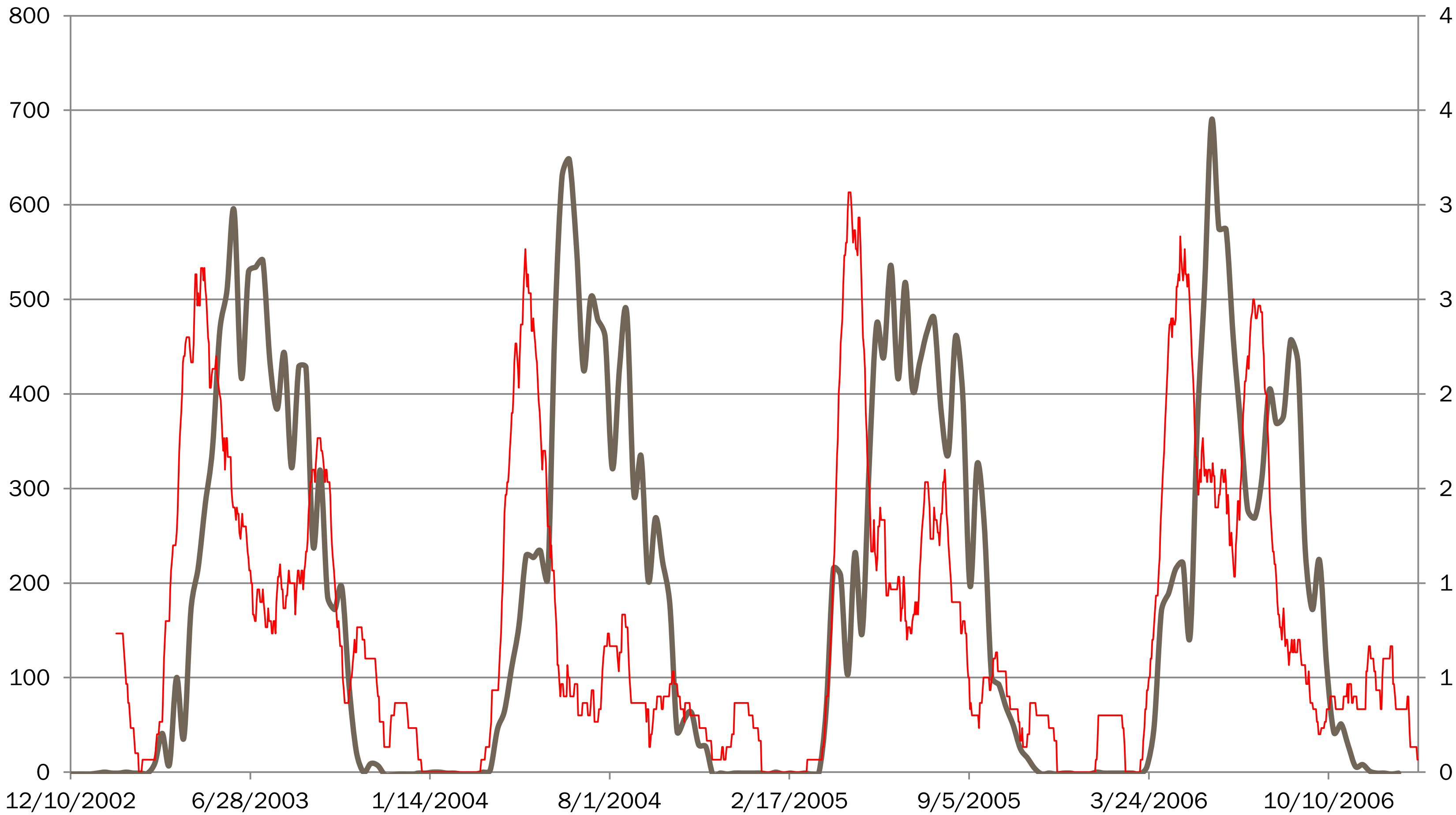
	Red Pine	Jack Pine
Foliar Moisture Content	90.0%	93.1%
Starch Content	12.9%	10.8%



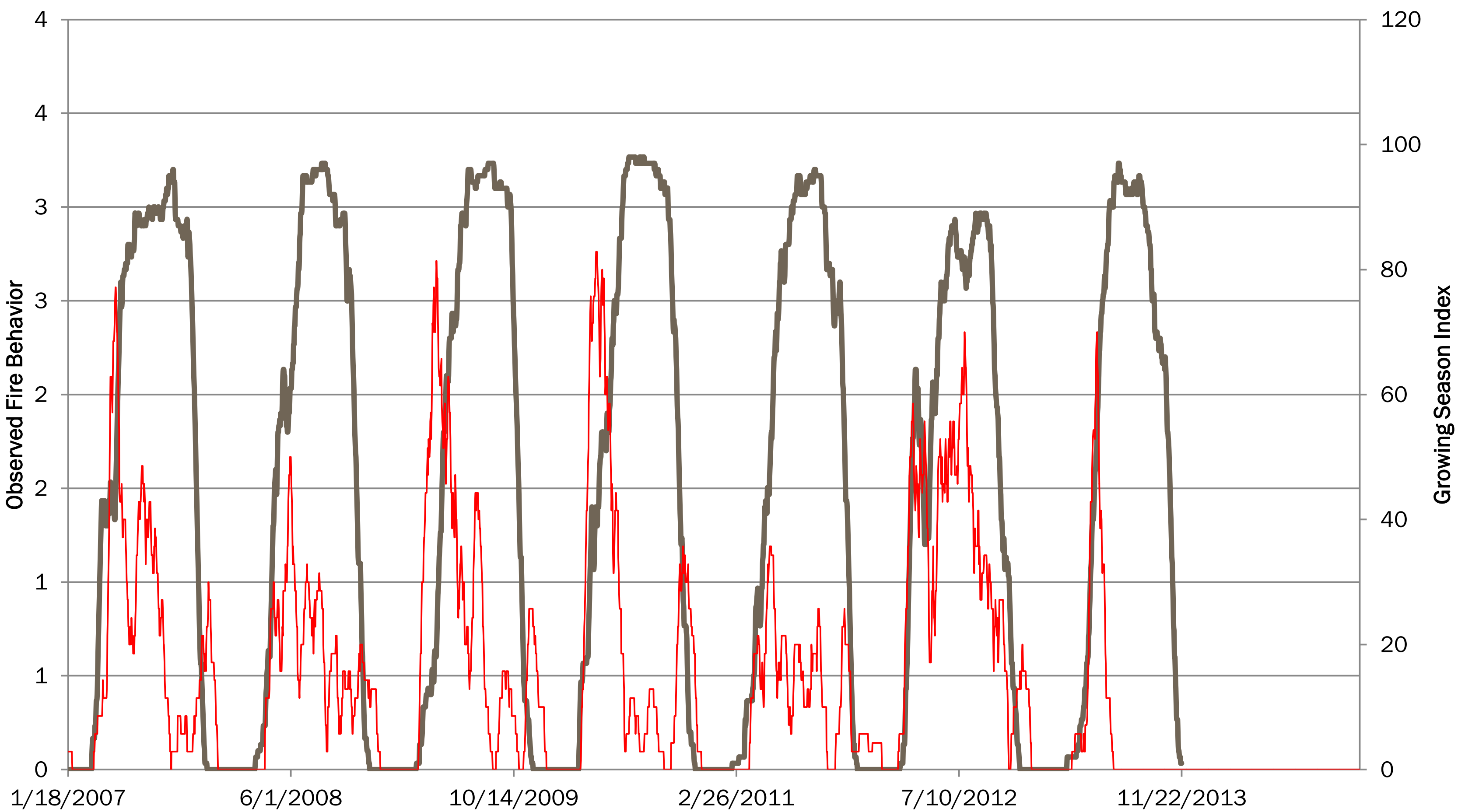
The Dip is mainly driven by photosynthesis

- Accumulations of starch are primarily due to the onset of springtime photosynthesis, prior to new needle emergence

Fire behavior versus MODIS Gross Primary Production



Fire behavior versus Growing Season Index (Live Fuel Index)



Seasonal Variation in Dip Timing

Seasonal Variation

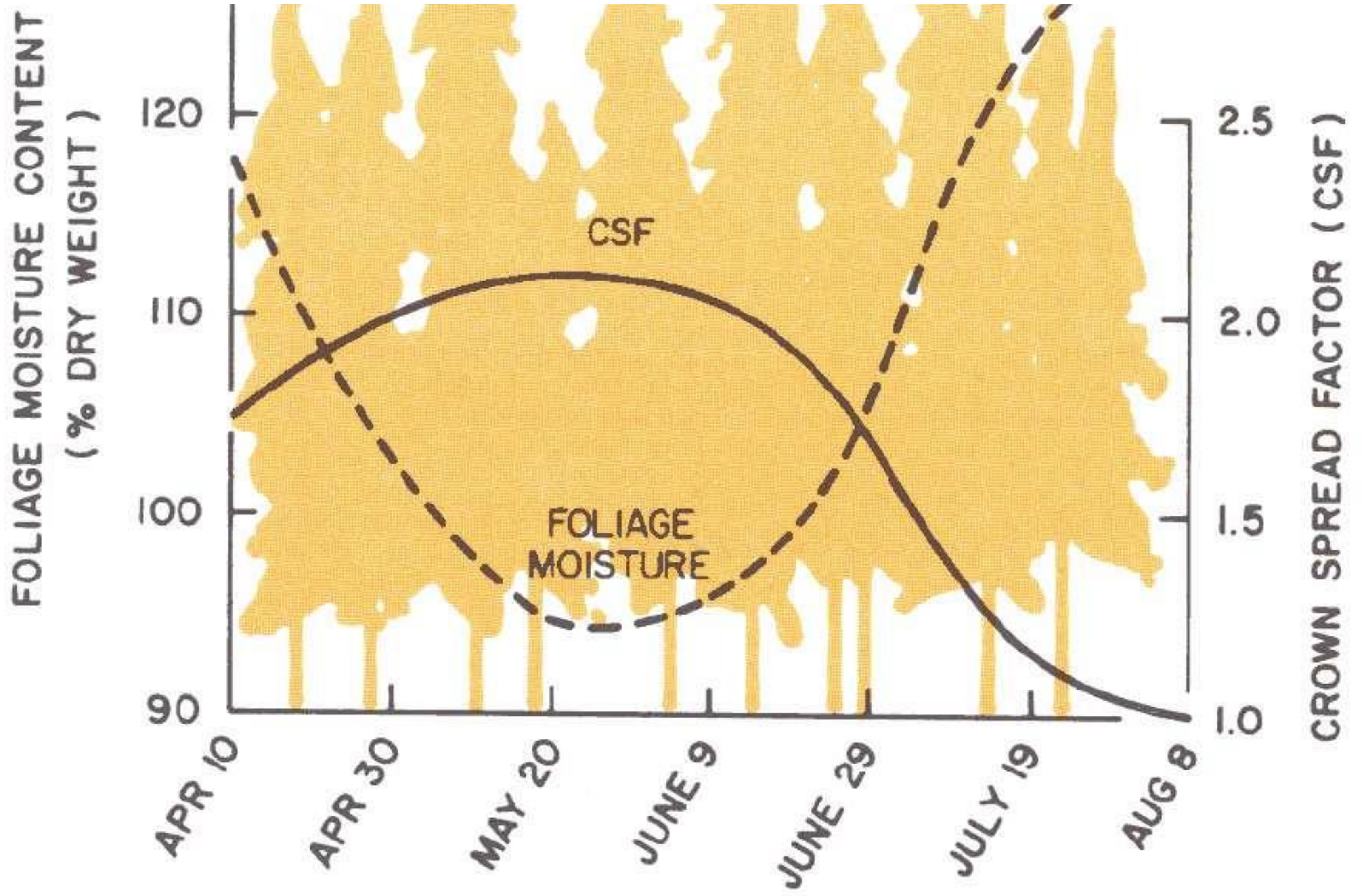
- When talking about the "Dip" Van Wagner stated that:
  - "For practical purposes, it was therefore assumed that its date is fairly constant from year to year, and not much affected by annual trends of soil and air temperature."

Year	Lowests Recorded LFM
1995	5/31/95
1996	6/3/96
1997	5/26/97
1998	5/27/98
1999	5/16/99
2000	6/7/00
2001	5/15/01
2002	5/22/02
2003	6/13/03
2004	5/7/04
2005	5/25/05
2007	5/8/07
2008	6/2/08
2010	5/10/10
2011	5/17/11
2012	5/19/12

Timing of the 'Spring Dip' at the Mio, Michigan
fuel moisture sampling site

One month variation in the timing of the Dip

Van Wagner 1974



Summary

- Foliar moisture content changes are driven by changes in density
- Density changes are primarily due to an increase in starch
- Starch content may be the missing link in the increased flammability during the Spring Dip
- Density or LFM can be measured throughout the season as a proxy for starch content changes
- Dip timing is not constant and it is most likely a function of spring soil and air temperatures
    - Can we model the timing and length of the dip?
- Fire management decisions could be improved by incorporating a live fuel monitoring program and by extending the depth of the current study
    - More interest and support is needed to learn how these factors vary throughout the Great Lakes region
- What’s next?
    - More sites, more partners -> Better information

Special Thanks

United States Joint Fire Science Program for providing funding for this study.

Joint Fire Science Program

Questions?

Next Webinar:

March 27, 2014 at 2:00 PM Eastern (1:00 PM Central)

Characterizing Wildlife Communities of Fire-Dependent Ecosystems of the Northern Lake States and Exchanging Research, Inventory, and Monitoring Knowledge and Ideas

R. Gregory Corace, III (US Fish and Wildlife Service-Seney National Wildlife Refuge)

with

Lindsey M. Shartell (MN Department of Natural Resources)

Dawn S. Marsh (US Fish and Wildlife Service-Seney National Wildlife Refuge)