Fire Ecology and Tree Ring Research at the Cloquet Forestry Center

Information compiled for the Lake States Fire Science Consortium Field Tour
September 2018

Ecological Setting: Over two-thirds of the University of Minnesota Cloquet Forestry Center, the total contiguous acreage of which is approximately 3400 acres, is upland forest with about 62% of our land base (2,130 acres) considered to be fire-dependent plant communities. Following the Minnesota Department of Natural Resources Native Plant Community Classification (MNDNR 2003) the general community types are FDn32 (*Northern Poor Dry-Mesic Mixed Woodland),* FDn33 (*Northern Dry-Mesic Mixed Woodland*), and FDn43 (*Northern Mesic Mixed Forest*). It is understood that in these vegetation types relatively frequent surface fire as well as patchy high-severity fire helped to maintain pine dominance prior to Euro-American settlement. This fact is substantiated by the original General Land Office Survey records for the area including an 1868 GLO plat map showing large swaths of the Forest's uplands sites as "Pine Barrens". Historical photographs documenting early management activities also show the structural and compositional effects of historical fires across the Forest, often with fire-scarred or charred pine trees visible in the image.

Figure 1. Woodland forest conditions at a 1912 tent camp in the general vicinity of the current CFC buildings and grounds. Note the mature red pine seed tree with a fire-charred bole, a young jack pine understory, clumpy red pine regeneration, and the absence of hazel when compared to current conditions. This is one portion of the University forest where mature red and white pine trees were reserved during the 1909-1910 cutover.

Early Fire Management at CFC: Fire suppression was a chief management concern at CFC from the inception of the Forest. Fire breaks were constructed as early as 1912 in an effort to prevent fire from spreading into the Forest from adjacent tracts. Some of these breaks were seeded to clover or planted with potatoes. Small fires ignited within the boundaries of the Forest were caused, in order of frequency, by berry pickers, slash burning, picnickers, the railroad, and fishermen. These fires had the potential to cause great damage to red and white pine seedlings regenerating across the property after the cut over in 1909. In some areas of the forest, large quantities of natural pine regeneration was lost to human-caused fires such as those reported by Forest managers in 1910 and 1917 (CFC unpublished records).

In 1927–1928 fire prevention through public education was an additional focus for Forest staff and included frequent patrols, seasonal manning of a nearby fire tower erected by State Forestry in the mid-1920s, and the proposed posting of "100 fire signs" across the property to alert the public to fire hazard.

Historical Tree-Ring Fire Records: For the last century tree-ring fire records have been of interest only as they pertain to issues directly related to timber management and timber quality. One of the first mentions of tree-ring fire records at CFC is in an article published in the Journal of Forestry in 1923. The article describes the general forest conditions in Camp 8:

> "As is typical of this region, the stand has been subjected to a number of fires so all the trees are more or less cat-faced. These scars show three fires all coming from the same direction. While these fires doubtless have had some effect on the rate of growth it must be remembered that it is common to all stands of like age in this region." (Schantz-Hansen 1924: 802)

A second article in the Journal of Forestry by Schantz-Hansen described Camp 8 conditions in 1931 and mentioned that five fires had burned through the stand, the last in 1894 (Schantz-Hansen 1931: 48). Another article by Verrall (1938), a forest pathologist, mentioned "fire wounds" in two 110-year-old red pine stands at CFC with five fire dates in 1842, 1855, 1864, 1874, and 1894. Beyond these research reports, and several fire-scarred cross sections available for educational purposes, no concerted effort to develop fire history reconstructions for the CFC had been made until 2016.

Recent Efforts in Tree-Ring-Based Fire Reconstruction: Fire history collections from remnant red pine in the Camp 8 stand in Autumn 2016 by Evan Larson (University of Wisconsin-Platteville) and his students yielded more information on the fire history of this site than previously available to CFC staff. They collected fire scar samples from 36 trees in Camp 8, most of which were dead, and applied standard dendrochronological techniques, including crossdating, to the samples. These samples contained evidence of 18 fire events that burned through the stand between 1730–1908 (see Figure 2. Fire History Chart on the next page). This collection identified the seasonality of 94% of these past fire events by examining the intra-ring position of each fire scar. Of the scars with seasonality, 72% indicated burn damage when the trees were dormant and 3% burned at the very onset of growth, collectively indicating that most of these fires occurred during the spring. Additional reconnaissance, sampling, and dating of 28 fire-scarred remnants across core portions of the Forest in 2017 provided the opportunity to begin answering questions related to the historical fire regime of CFC as well as relative estimates of area burned by fire year. Eventually, these 64 dated fire scars as well as fire data from additional samples will be compared to stand-origin information compiled in the 1910s and 20s to conservatively estimate area burned on portions of the original experimental forest prior to successful fire prevention and exclusion around 1930.

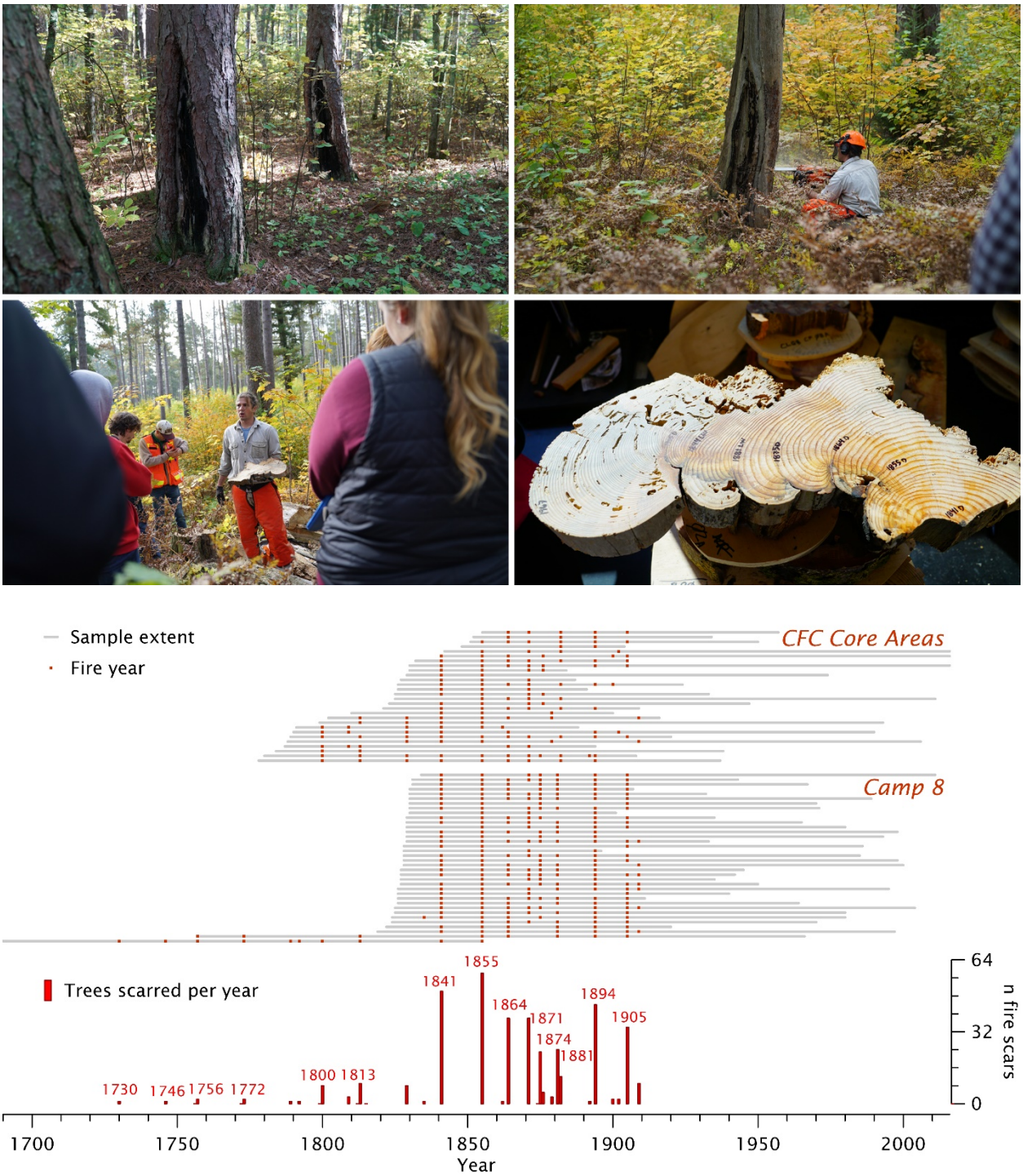

Figure 2. Fire history at the University of Minnesota Cloquet Forestry Center. Images clockwise from top left show fire-scarred red pine in the field, a demonstration of collecting a partial cross section from a standing snag, the polished and crossdated tree-ring sample, and discussing field methods at CFC. Bottom image represents the 64 crossdated fire-scar samples for CFC, with dates of major fires indicated in the bar graph at bottom. Clearly, fire was an important process in the development of the pine forests of CFC.

What do tree-ring records tell us about red pine ecology and silvicultural practices at CFC?

- The fire scar record indicates that the pine stands at CFC developed in the presence of frequent low-severity fires. Fire intervals calculated using tree-level fire scar records ranged from 3–23 years, with a mean return of 13 years for the study area as a whole.

- Local fire history data reinforces the management approach of thinning pine stands early and often in production settings.

- Since timber and fire management efforts began in 1910, many fire-dependent sites at the CFC have missed five or more fire intervals, even when conservatively estimated. This suggests changes not only in stand compositions, structure, and fuel loads, but also changes to soil nutrient cycling, ground flora communities, and associated biodiversity.

- The majority of overstory pine in Camp 8 established in a 28 year fire gap in the 1820s with lagged regeneration following two fires over a short interval, including an 1800 growing season burn and an 1813 dormant season burn. These fires created the soil and light conditions necessary for red and white pine seedling establishment. A longer fire free interval allowed for many trees to become resistant to light surface fires by the next fire year in 1841.

- Wide growth rings, fire-killed branches embedded in red pine cross sections collected <40cm from ground height, and survivorship of fire-scarred red pine sometimes <5cm in diameter suggests historical woodland conditions with lower tree densities than today and frequent, low-moderate intensity surface fires.

- Frequent surface fire created and reinforced relatively open canopy conditions where sunlight reached the forest floor with gaps for young pine establishment in the absence of fire. More open stand conditions encouraged the growth of fire-dependent graminoids and forbs (fine fuels), kept dry sites dry, more fire prone (positive feedback), nutrient poor, and encouraged the perpetuation of pine species. Inversely, the removal of regular surface fire has created a positive feedback loop away from a xeric, fire-prone forest structure and composition towards a more mesic one. A more mesic structure has more fully closed canopy, which increases site-level humidity and retains more moisture, and composition containing thin-barked deciduous species, such as red maple, and heavy-seeded deciduous shrub species, such as beaked hazelnut.

- Maintenance of stands with frequent dormant season fires may be enough to maintain open understory conditions provided that mechanical brush control treatments are implemented prior to establishing a management regime of light underburns.

- Absence of tree-ring fire scar evidence at a site is not evidence of historical fire absence as fire scars are not uniformly created and preserved across the forested landscape. Frequent fire in barrens settings may not have allowed the consistent development and preservation of fire-scarred wood across the CFC. Intensive management activities and stump decay over a century also makes fire-scarred material more difficult to locate and utilize for fire reconstructions on the Forest. An additional 16 undated pine remnants collected in portions of the forest show fire intervals of 3–19 years at these sites.

Fire management questions at CFC:

1. Has the fuels situation changed so much over the last 100 years that we cannot adequately simulate historical fire effects in our fire dependent plant communities?

2. Is the reintroduction of fire necessary for maintaining and promoting the ecological function of fire-dependent plant communities or can it simulated through other forest management options such as thinning, harvest, herbicide, or brush cutting?

3. What commitments to fire and fuel management should accompany efforts to restore or establish open pine stands that reflect the historical structure, composition, and fire regimes of pine stands in the Great Lakes Region? How can management avoid an eventual buildup of brush and fine fuels on sites with more open canopy structures?

4. Should future prescribed fire efforts be focused on the restoration of fire to our fire-dependent old-growth reserves? Or should they be centered on introducing fire to young stands to shape their vigor and the long-term ecological trajectory of the plant community?

5. Do historical fire regimes have value for contemporary forest management? Or are contemporary and future biotic and abiotic conditions so novel that historical baselines should be tossed out in favor of novel management strategies?

Published References

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Acknowledgements: Partial funding for tree-ring fire history research at CFC was provided by the Lake States Fire Science Consortium in 2017. Financial support was provided to Adam Donaldson, an undergraduate researcher at the University of Wisconsin-Platteville mentored by Dr. Evan Larson. Thank you to Adam for his hard work in the field and laboratory!