JFSP PROJECT PROGRESS REPORT

Date: September 30, 2009
Project Title: Fire Regimes of the Southern Appalachian Mountains: Temporal and Spatial Variability over Multiple Scales and Implications for Ecosystem Management
JFSP Project Number: 06-3-1-05
Principal Investigators: Henri D. Grissino-Mayer, Charles W. Lafon, and Sally P. Horn
Federal Cooperator: Rob Klein, Great Smoky Mountains National Park
Total JFSP Project Funding: $299,996
Unspent funds to date: Texas A&M: $20,863, University of Tennessee: $23,778.

Please provide a brief response to each of the following questions:

What have you accomplished this fiscal year?

A. Fire history and forest dynamics from tree-ring and stand data:

Much work has been completed at the three lower elevation (ca. 600 m) sites: Gold Mine Trail (GMT), Rabbit Creek Trail (RCT), and Pine Mountain (PMT). Over 1,500 cores from mixed tree species from 9 plots (0.1 ha each), 183 yellow pine cores from within the sites (external to the plots), and 133 fire-scarred yellow pine sections have been collected and processed at the Laboratory of Tree-Ring Science at the University of Tennessee. In each plot, we conducted inventories of all mature canopy trees (20 x 50 m area), saplings (2 x 20 m area), and seedlings (20 x 20 m area). Duff levels were recorded at 6 points across each 0.1 ha plot.

Gold Mine Trail:

At Gold Mine Trail (GMT), a master tree-ring chronology from 209 dated series was developed that spanned from 1697 through 2006 (Figure 1). Most of the series were from shortleaf pines. The interseries correlation, an indicator of crossdating quality, was 0.54. For southeastern pines, a value over 0.40 is desirable. Average mean sensitivity was 0.27. The oldest collected sample dated back to 1684, but the early rings were complacent and could not be included. Clear marker rings were expressed throughout the chronology. Narrow annual rings included: 1987, 1963, 1936, 1895, 1856, 1826, 1797, and 1773. Several multi-year spans of lower-than-average ring width occurred from 1960 to 2000. Wide rings in the chronology included: 1991, 1990, 1938, 1916, 1882, 1861, 1859, 1761, and 1745. Low sample depth (< 10) prior to ca. 1740 makes that section less reliable. There appears to be a hundred year cycle in the chronology, which is probably related to a long-term climatic factor. Preliminary climate analyses using this chronology (1940–2006) indicated that the yellow pines respond positively to warmer winter temperatures of the current year (January: $p < 0.01$, $r = 0.34$). Growth response will also be tested against precipitation, drought, and several climate indices (*e.g.*, the Palmer Hydrological Drought Index and the El Niño-Southern Oscillation Index).

Samples included in the fire history analyses date back into the early 1700s (Figure 2), but only very few were this old. The record of fire from fire-scar data becomes stronger beginning around 1820. Between 1850 and 1930, fires regularly occurred throughout the stand. A few fires were widespread (e.g. 1903, 1908, and 1919), but the fire found in the most samples occurred in 1929. This fire occurred later in the growing season compared to the majority of other fires. It was also the last major fire to occur in the stand. Only a few, isolated scars appeared in the record after 1930, the last in 1982. These later fires are probably from lightning strikes. The lack of fires after 1930 correspond to the time the park was established (in 1934) and fire suppression tactics became prevalent on public lands. Approximately 60% of fires occurred in the dormant or early part of the growing season, while about 40% were in the middle or late portions. The mean fire return (MFI) for the all-scarred class was 3.7 years, with a range of 1 to 49 fire-free years between events.

Several of the trees used in the fire history died at around 2000. This was likely related to the large outbreak of southern pine beetles that was especially noticeable by 1999. Most of the oldest samples do not have pith dates while center rot was common in many samples. Insect galleries were very common on the fire-scarred samples, and these eliminated or obscured this portions of the wood. Several of the younger samples had piths that dated to between 1860 and 1880. A similar cohort of yellow pines is seen in the plot data (Figure 3), where 6 of the trees established in the 1860s. Many of the yellow pines cored outside the plots at GMT also had establishment dates during those decades. It is likely that a higher severity fire moved through the stand then, clearing and altering it in favor for pine regeneration.

There was sporadic yellow pine, oak, and other hardwood establishment from 1800 through the 1920s. Many of these trees were large in diameter. Visual observation of the size and form of some of the trees at the site indicated that the stand had once been more open. Beginning around 1930, substantial establishment of oaks and hardwoods took place. Through the 1940s, eastern white pine (a fire-intolerant tree species) moved into the stand. Hemlocks (also fire-intolerant) followed later in the 1960s. Most of these younger trees were under 20 cm in diameter.

Three yellow pine species were found at Gold Mine. In the plots, 78% were shortleaf, 14% were pitch pine, and 7% were Virginia pine. For the canopy class species (Figure 4), the top five by stem count percentage were blackgum (21%), sourwood (15%), red maple (11%), white oak (10%), and scarlet oak (9%). Maples dominated both the sapling (76%) and seedling (32%) classes. White oak (14%), sourwood (11%) and blackgum (8%) were also prevalent in the sapling class. Red maple was the most frequently found species found in both sapling and seedling classes at 32% and 76%, respectively. Blackgum, sourwood, and Fraser magnolia were each about 10% of the sapling class. White pines were also numerous, making up 14% of saplings counted and 10% of seedlings. Several oaks were represented in the seedling class, but there was a distinct lack of yellow pines. Only 4% of the saplings were yellow pine, which were Virginia and pitch, compared to the 4% shortleaf composition of the canopy. It is clear that the shortleaf pines are not regenerating. This is likely compounded by the high duff levels (avg.

5.72 cm) at the site which cover the mineral soil that is optimal for seed germination, and the loss of large numbers of mature yellow pines (especially shortleaf) to the southern pine beetle outbreak, reducing the seed source.

Rabbit Creek Trail:

A master tree-ring chronology was developed for Rabbit Creek Trail (RCT) (84 dated series, 0.50 interseries correlation, 0.28 average mean sensitivity) that spanned from 1744 to 2007 (Figure 5). Most of the samples were Virginia pine, followed by pitch pine. Narrow marker rings included: 2002, 1987, 1978, 1963, 1941, 1925, 1891, 1862, 1843, 1818, 1797, 1786, and 1773. Wide marker rings included: 1991, 1990, 1974, 1938, 1893, 1882, 1793, and 1768. Sample depth was below 10 prior to 1800. The hundred-year cycle is less obvious in this chronology than at GMT. Additional series to be included from the fire-scarred samples should improve this chronology.

The fire-scarred samples were more difficult to date than ones from the other sites due to lower quality from wood degradation over time and because the samples contained fewer tree rings. Most of the samples were from remnants (wood lying on the forest floor), with very few from living trees. The history showed a fire regime of sporadic fire activity between 1775 and 1988, with only 1 or 2 trees recording each fire (Figure 6). Most of the fires occurred between 1800 and 1900. A cluster of fires occurred in the late 1880s and early 1890s, but only approximately 6 to 10 trees (as shown in our age structure analysis) established during this time. It is likely many more trees established after these fires, but have since died and were therefore not sampled for this study. Fires were very infrequent after 1920, again corresponding to suppression activity. The MFI for RCT was 3.5 years, with the fire-free interval ranging from 1 to 20 years. Over 84% of the fires occurred during the dormant or early growing season. Middle season fires were more rare (15%) and included the most widely recorded fire (n = 5) in 1894.

A cluster of oaks established during the 1890s (Figure 7), when fires were most common in the stand. Several old pines, mostly pitch, were already present, as well as an oak and one eastern white pine. This one lone eastern white pine (a fire intolerant species) represents the only individual of this species known to have established at any of our sites during the period of fire activity in the 19th Century. White pine establishment was earlier on this site than at the Gold Mine Trail and Pine Mountain sites, starting in the early 1900s and increasing in the 1930s. Mixed hardwoods also established in a similar pattern to the white pines. Hemlocks (again, a fire intolerant species) moved in during the 1940s and were very numerous by the 1980s. We noted two clusters of yellow pine establishment at Rabbit Creek, one in the early-1800s and another centered in the early to mid-1900s (Figure 8). The latter cluster was mainly composed of Virginia pines. One mature Table Mountain pine was found, outside our established plots.

The composition of the canopy class trees was dominated by eastern white pine (34%), hemlock (24%), and red maple (15%) (Figure 9). Virginia pine and pitch pine were 6% and 2%, respectively. White pine and red maple co-dominated both the sapling (36% and 25%) and seedling (28% and 55%) classes. Hemlock (17%) was the next most numerous species in the sapling class, while scarlet oaks were the most numerous in the seedling class (9%). All other species were each less than 5% of the sapling and seedling classes. Pine regeneration (Virginia) was limited to 2% of saplings and 1% of seedlings. Duff levels were high at the site (average depth of 5.2 cm) which hinders yellow pine regeneration.

On this current trajectory, red maple, eastern white pine, and hemlock will dominate the Rabbit Creek area in the future. However, the hemlock wooly adelgid was present in the stand and many of the hemlock trees were already dying from the insect. Several of the white pines in the denser thickets also appeared to be dying.

Pine Mountain:

The Pine Mountain (PMT) master tree-ring chronology we developed (Figure 10) had 94 dated series with a 0.50 interseries correlation and 0.27 average mean sensitivity. From the 1940s to 2000, we found several blocks of years that were narrower than average. Narrow marker rings included: 1987, 1963, 1936, 1925, 1914, 1856, 1843, and 1826. The years 1798 to 1800 were very narrow, with 1799 being an extremely narrow ring that was –4.6 SD below average. Sample depth for these early years was 15 but dropped below 10 prior to 1780. Wide rings at PMT included: 1991, 1990, 1974, 1948, 1938, 1882, 1861, 1847, 1846, 1814, and 1780. There is some evidence of a century-scale oscillation in the chronology.

Fire events occurred regularly at PMT between 1830 and 1940 (Figure 11). A few were widespread, the most prominent being the fire that burned in 1910 and was recorded in more than half of the trees sampled. The last widespread fire was in 1922. Most other fires in the record were more localized, but many were found in multiple samples throughout the site. Only a few fire events were found after 1950, which were probably lightning-related. Similar to our other sites, an obvious lack of fire is evident after the 1940s after fire suppression policies were enacted. The mean fire interval for the all-scarred class was 4.6 years, with the minimum and maximum fire interval ranging from 1 to 55 years. Almost 80% of the fires occurred during the dormant and early growth seasons. The more widespread fires, such as 1910 and 1922, appeared to have burned later, as indicated by the position of the scar in the middle of the ring in many of the trees.

A mix of oaks and yellow pine establishment was consistent from 1810 to 1910 (Figure 12). A few additional hardwoods established after 1910, but the vast majority of establishment for oaks and other hardwoods occurred between 1920 and 1950. The peak of yellow pine establishment also centers in this period, mostly during the 1930s. These were mostly Virginia pine, but one was Table Mountain pine. Eastern white pines and hemlocks appear to begin establishing in the 1940s. The canopy consisted mainly of blackgum (30%), white pine (16%), chestnut oak (15%), and Virginia pine (10%) (Figure 13). While only 8% of the canopy was red maple, that species vastly dominated the percentage of seedlings (81%) and saplings (66%)

counted. Blackgum (7%) and several oak species (5%, or less each) were also represented in the saplings. White pine and chestnut oak each represented 4% of the seedlings. This site appeared drier than the Gold Mine Trail and Rabbit Creek sites, which probably explains why there are fewer hemlocks present. Yellow pine regeneration was negligible (Virginia pine was 1% of saplings). As in other pine stands in the area, evidence of beetle-killed trees were everywhere, and duff levels were high (average depth of 5.9 cm). In the absence of fire, the site will likely be dominated by maples, oaks, and white pine.

Licklog Ridge, House Mountain, and Linville Mountain:

We completed field sampling for these three sites this past summer. Fire-scarred cross sections from living and remnant yellow pines were collected at House Mountain (House Mountain State Recreation Area, Tennessee, 89 cross sections), Licklog Ridge (Great Smoky Mountains National Park, Tennessee, 120 cross sections), and Linville Mountain (Pisgah National Forest, North Carolina, 46 cross sections). The fire history site at Licklog Ridge, south of Cades Cove in GSMNP, contained the highest density of fire history samples and is located within an unlogged watershed. Therefore, we established forest composition plots at this site in stands that are interspersed with or adjacent to the fire history samples. Three 50 x 20 m plots were inventoried within each of four forest types for a total of twelve compositional plots arranged along the topographic moisture gradient. We recorded species and stem diameter, and cored all trees >5 cm diameter, tallied all saplings, and tallied seedlings within ten, 20 X 1 m transects. Duff depth was also sampled at 12 locations within each of the plots. Fire history cross sections and cores have been processed and are currently being dated in the Texas A&M University Biogeography Laboratory.

B. Mapping of Fire Perimeters:

We have completed our analysis on the mapped fire perimeters from 1930 to 2003 in Shenandoah National Park and Great Smoky Mountains National Park. GIS was used to compare fires from the two parks in terms of area burned by elevation, aspect, landform, vegetation type, and spatial distribution on the landscape. In both parks, the majority of the area burned was the result of anthropogenic fires and occurred during several large fire years. Fires were highly spatially aggregated within both parks when compared to the spatial distribution of fire prone landforms. Fire patterns were identified along the topographic gradients, with a higher occurrence of fire on ridgetops, at lower elevations, and on south-facing aspects in both parks. However, fire disturbance was more prevalent in SNP and was less confined by topographic controls. We hypothesize that these trends are the result of a drier climate in the central Appalachian Mountains, resulting in a broader landscape available to fire spread. This appears to be an example of regional scale climate exerting a top down effect on landscape patterns of fire disturbance. A publication presenting these results is being prepared for submission.

NIFMID data and climate data have been collected for the entire southern Appalachian region and we have analyzed regional scale patterns of fire disturbance. Significant relationships have been identified between area burned and number of fires within the region and monthly PDSI. Ralph Baker completed an undergraduate honors thesis on this topic: "Climate-Fire Relationships in the Southern Appalachian Mountains." We plan to continue this analysis by focusing on relationships with teleconnection indices, lightning frequency, and finer scale climatic variation.

C. Fire Effects on Understory Vegetation:

This summer, M.S. student Ashley Pipkin collected cross-sections of ericaceous shrubs (primarily mountain laurel, *Kalmia latifolia*) from the forest understory in four of the fire history sites that we have established for the current project and our previous JFSP-funded project (01C-3-3-09) in the central Appalachian Mountains. Ms. Pipkin's thesis research will reveal how changes in fire regime have influenced the shrub understory and will inform management actions. Many researchers and managers think the shrub thickets have developed as a consequence of fire exclusion.

2. Are you on schedule to complete the project by the JFSP project end date?

Yes. We asked for and were granted a one-year extension to November 30, 2010.

3. Do you have any other issues or concerns with your project (e.g., issues with sub-agreements)?

None.

4. Do you have any comments or concerns that may help JFSP better administer your project?

None.

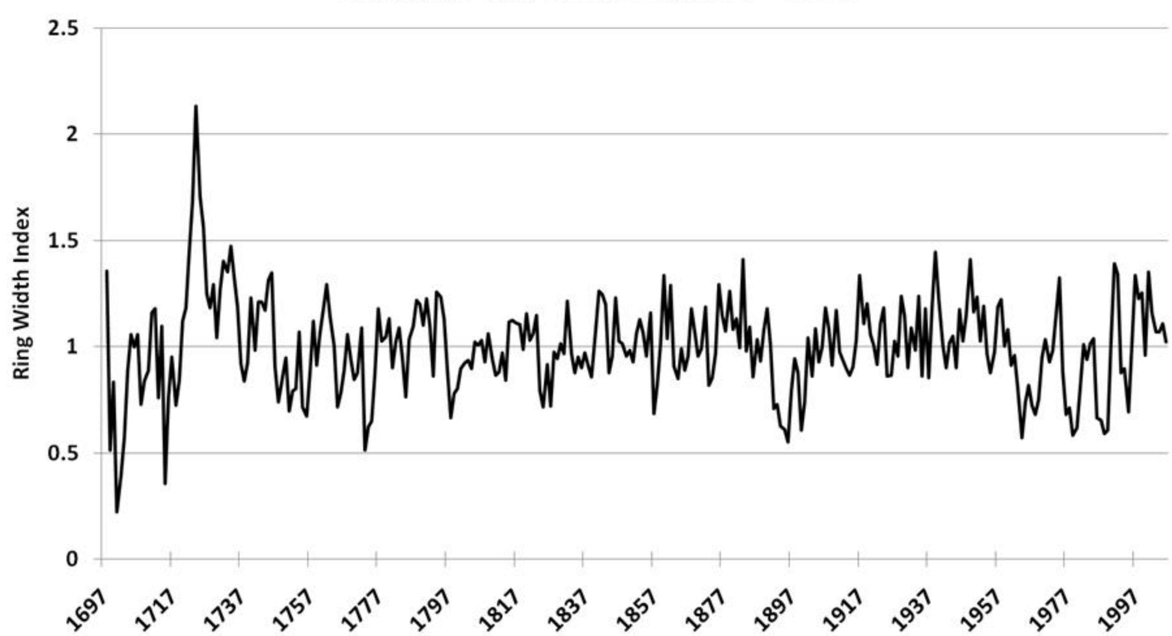

Figure 1. Standardized master tree-ring chronology for Gold Mine Trail. This important chronology, originally begun in 2005, has allowed the dating of hundreds of other tree-ring samples collected for this JFSP project.

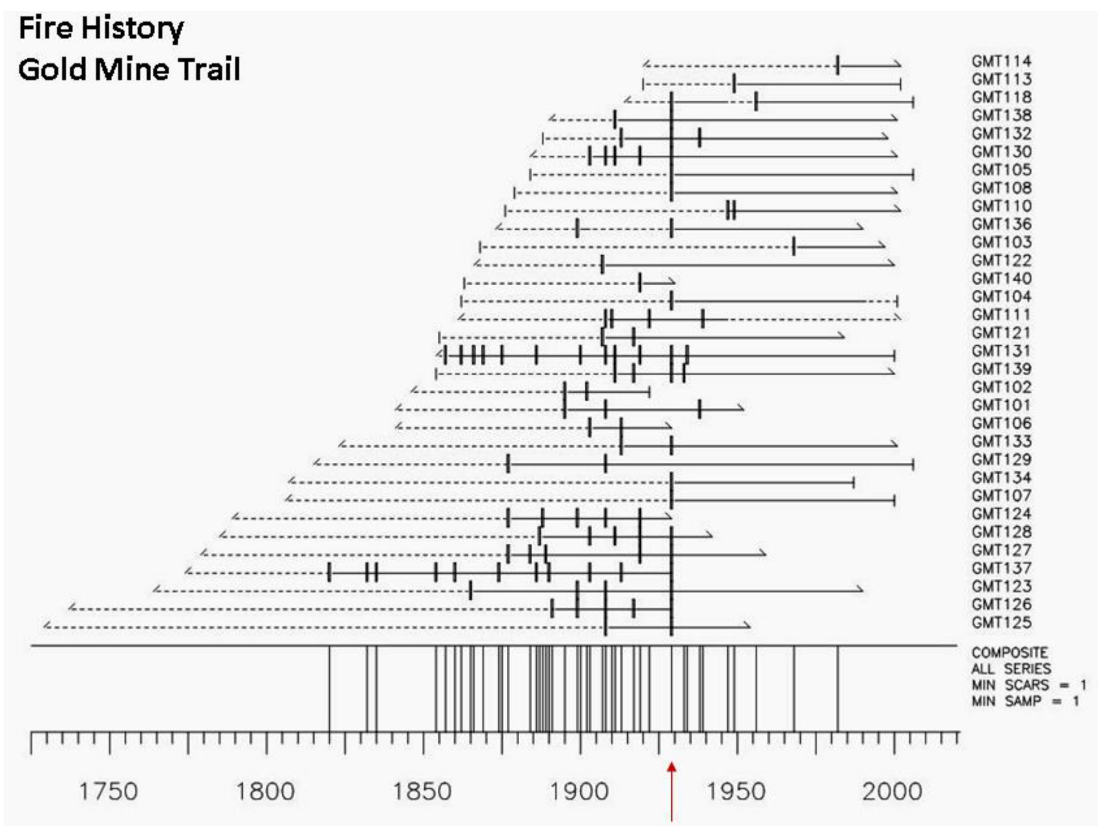

Figure 2. The fire history chart for Gold Mine Trail. Each horizontal line is a tree, while each vertical tic mark is a dated fire scar. Arrow points out the extensive fire in 1929.

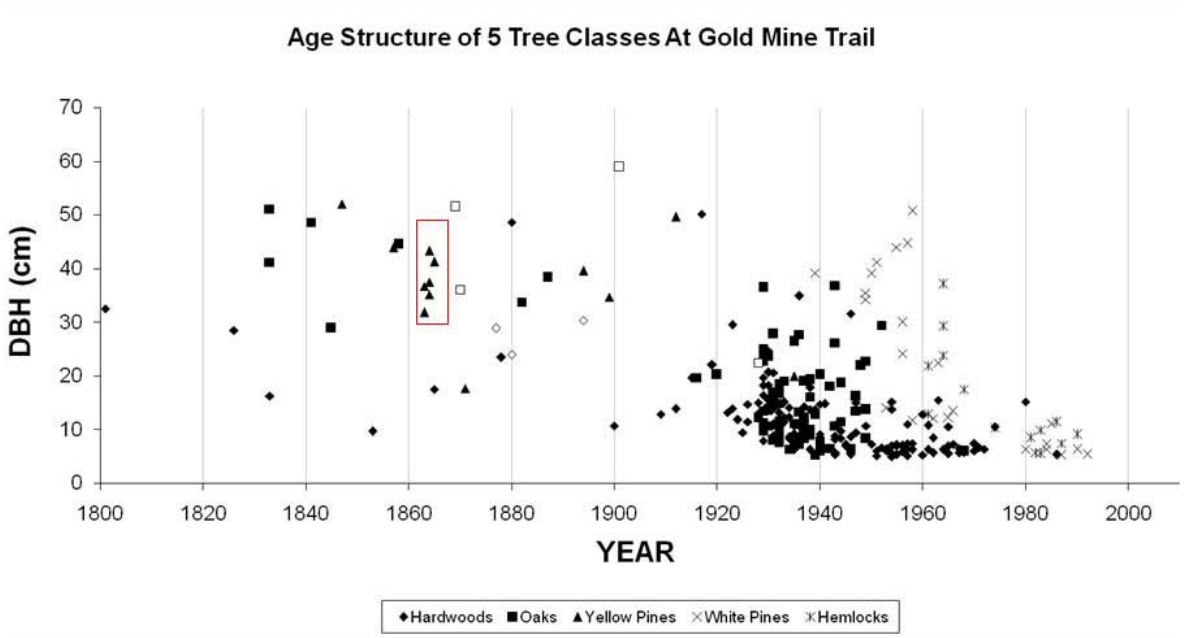

Figure 3. Establishment data for living trees sampled within the fire history area at Gold Mine Trail. Note the pulse of regeneration near the major wildfire of 1929. The red box outlines 6 yellow pines that established within a short time frame, likely indicating a higher severity wildfire.

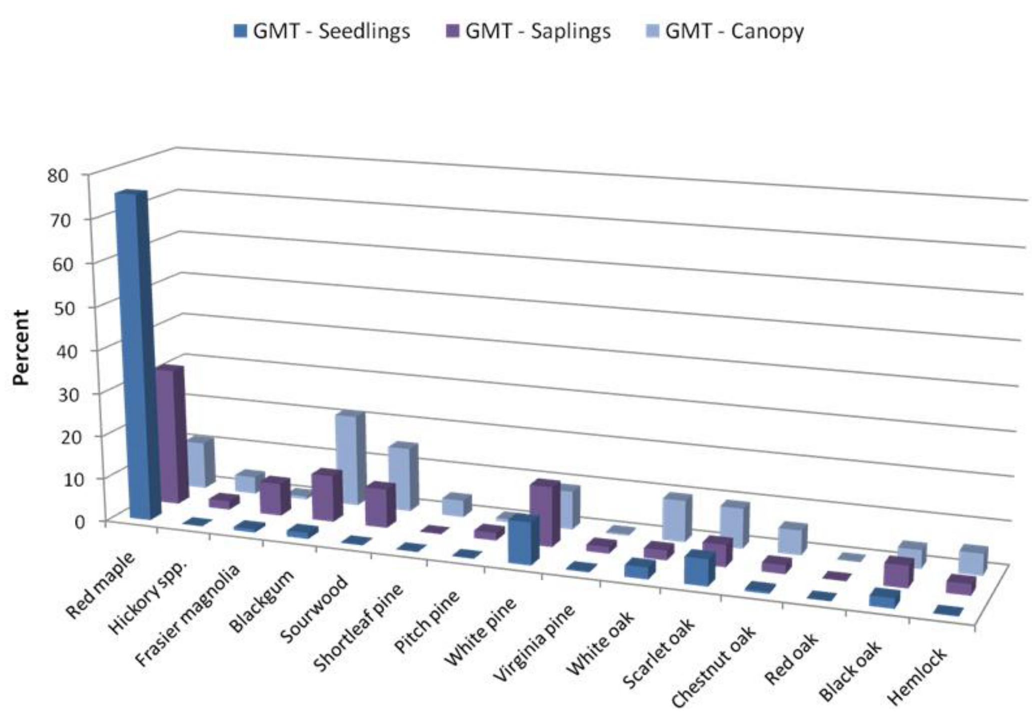

Figure 4. Distribution of canopy class tree species at Gold Mine Trail, arranged by position: canopy, saplings, and seedlings.

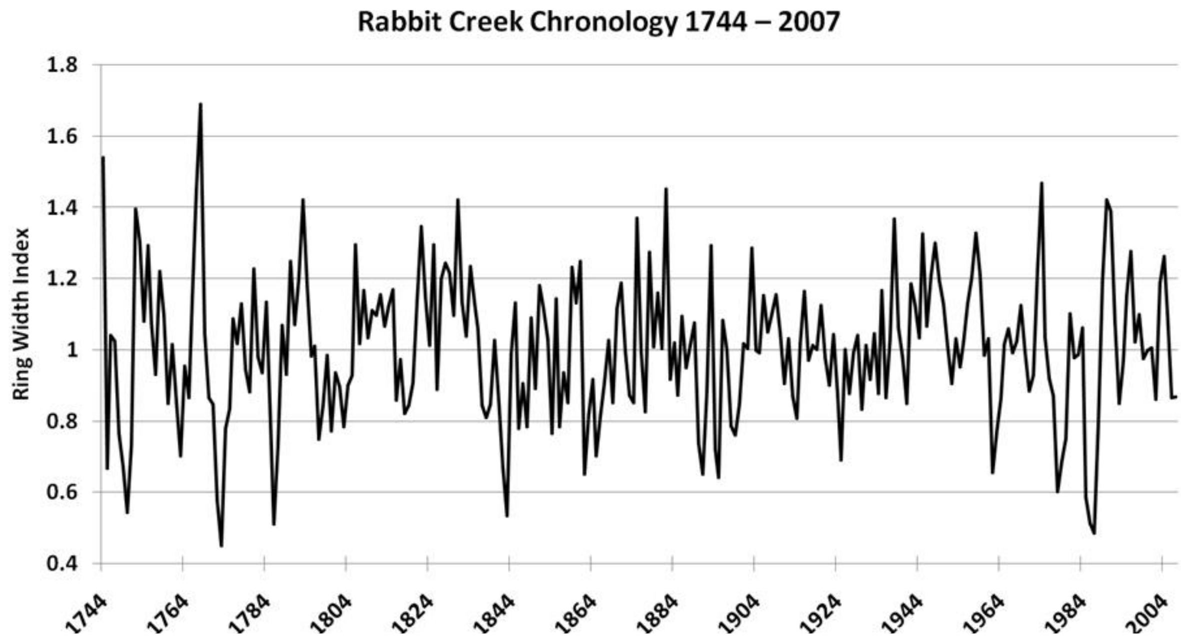

Figure 5. The master tree-ring chronology for Rabbit Creek Trail used to date samples collected for fire and stand history.

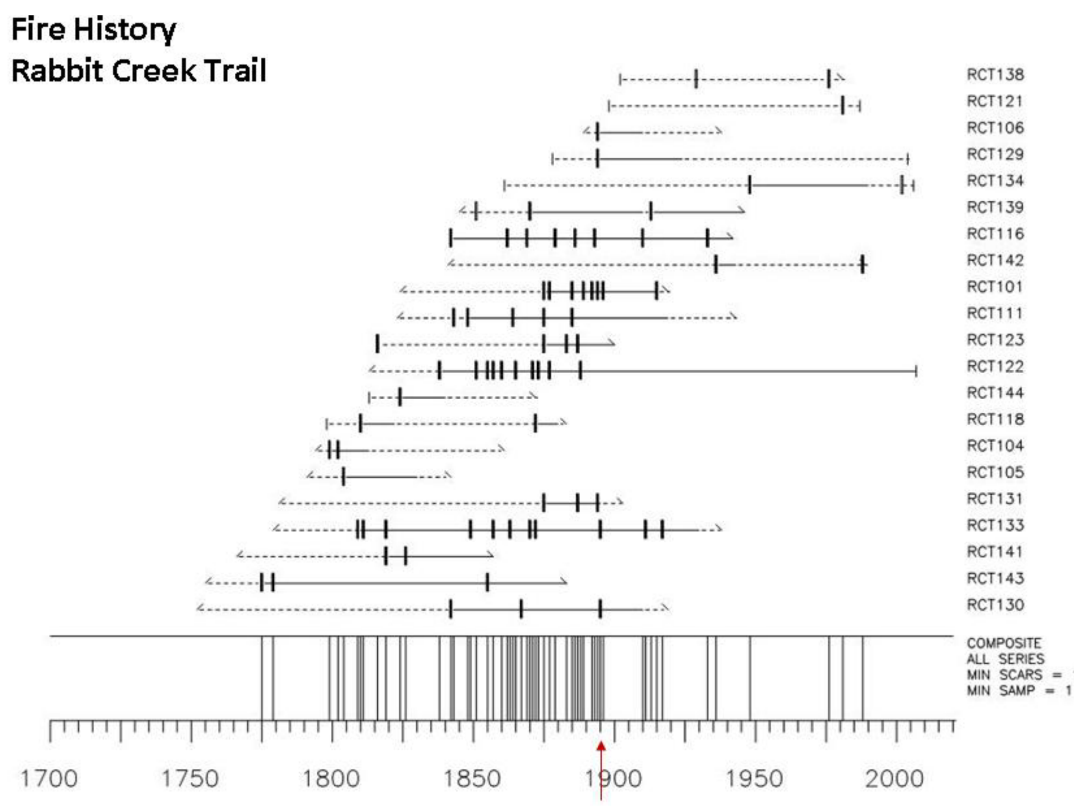

Figure 6. The fire history chart for Rabbit Creek Trail. Each horizontal line is a tree, while each vertical tic mark is a dated fire scar. Arrow points out the extensive cluster of fires in the late 1880s and early 1890s.

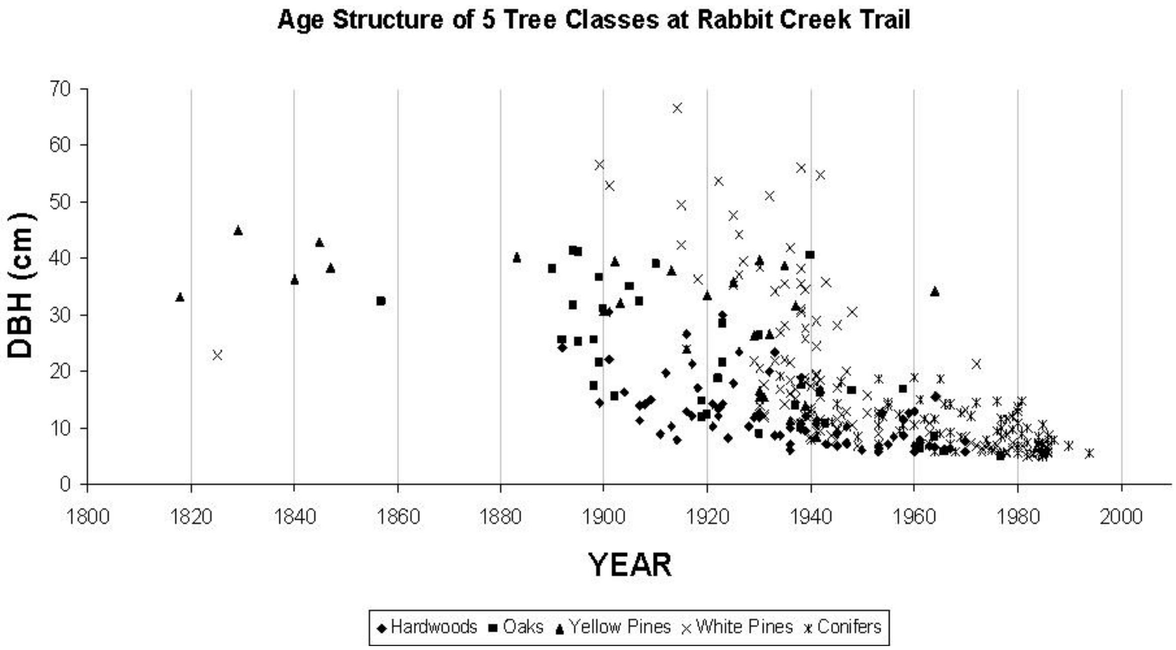

Figure 7. Establishment data for living trees sampled within the fire history area at Rabbit Creek Trail.

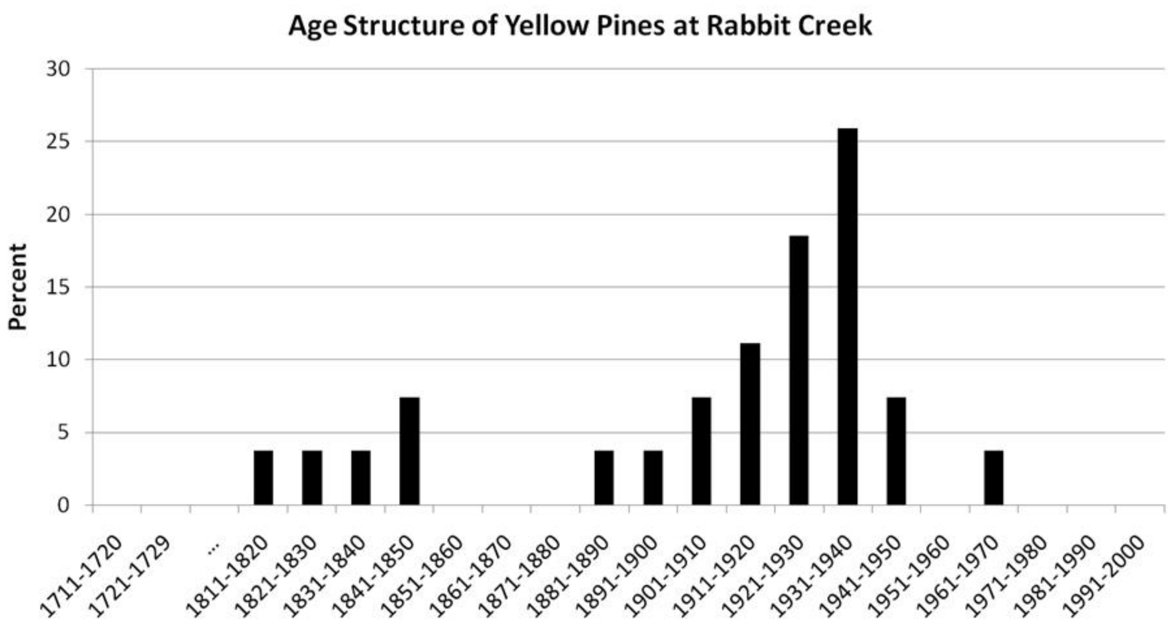

Figure 8. Age structure of yellow pines sampled at Rabbit Creek Trail, showing two periods when yellow pines established, one in the early 1800s and another in the early 1900s.

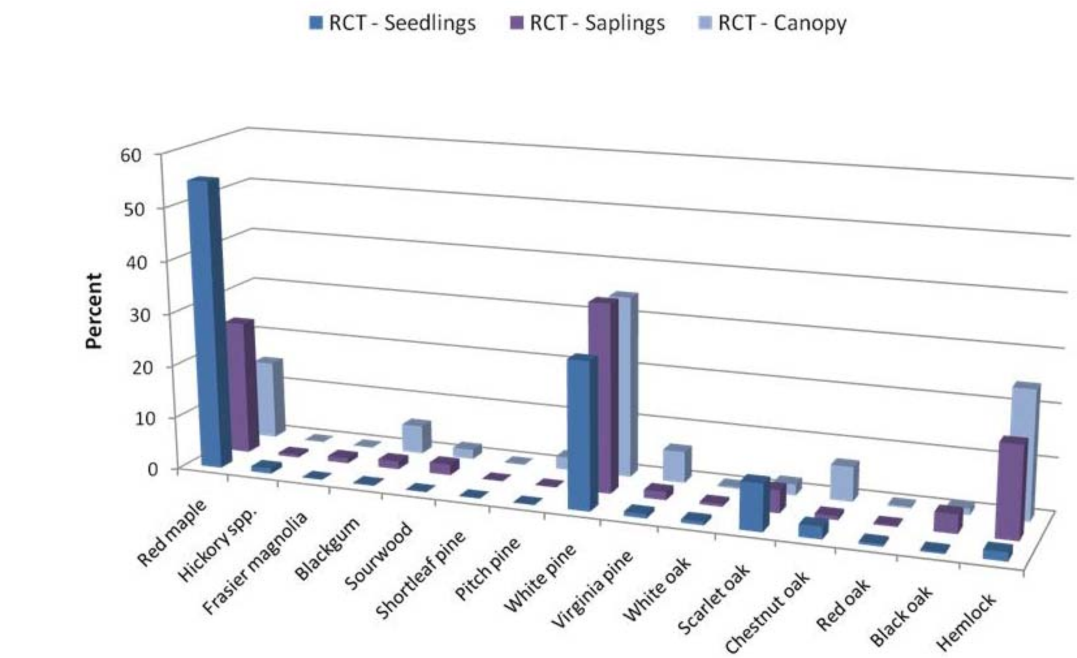

Figure 9. Distribution of canopy class tree species at Rabbit Creek Trail, arranged by position: canopy, saplings, and seedlings.

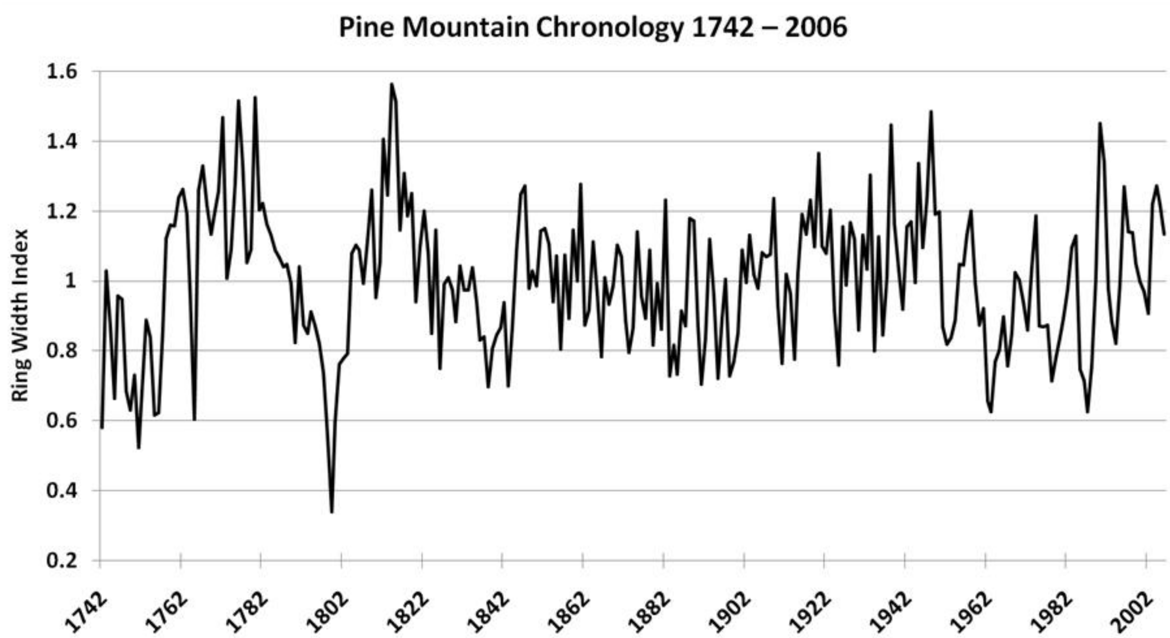

Figure 10. The master tree-ring chronology for Rabbit Creek Trail used to date samples collected for fire and stand history.

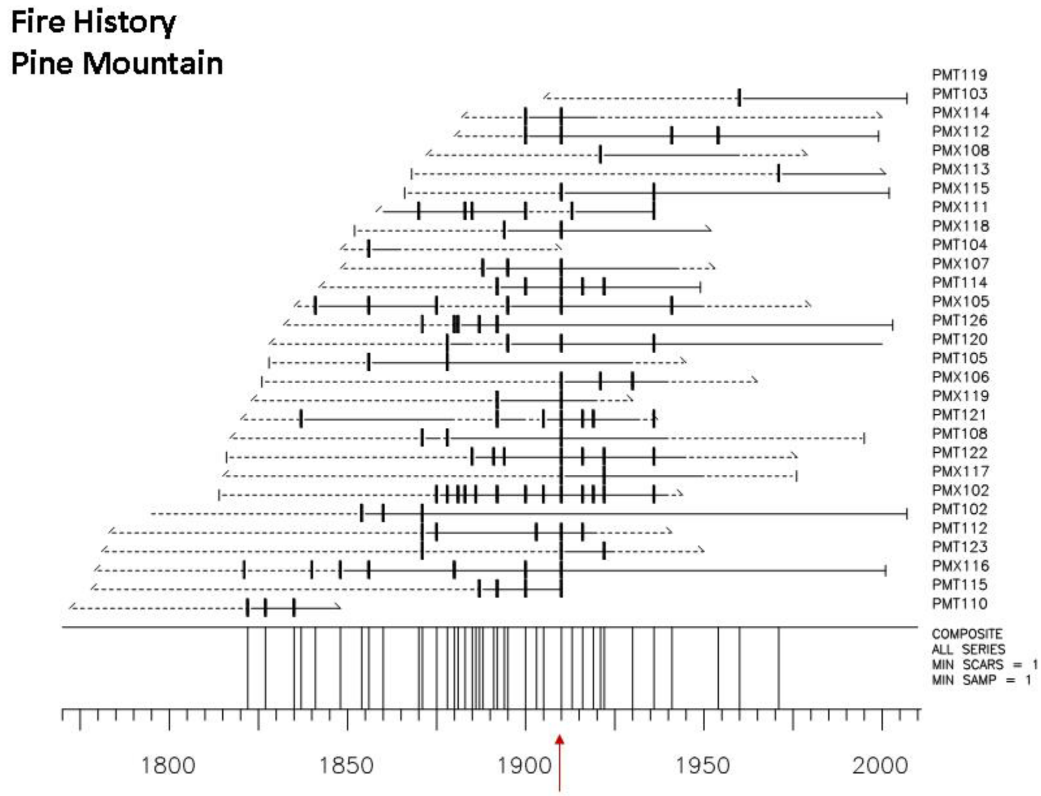

Figure 11. The fire history chart for Pine Mountain. Each horizontal line is a tree, while each vertical tic mark is a dated fire scar. Arrow points out the spatially extensive fire that occurred in 1910.

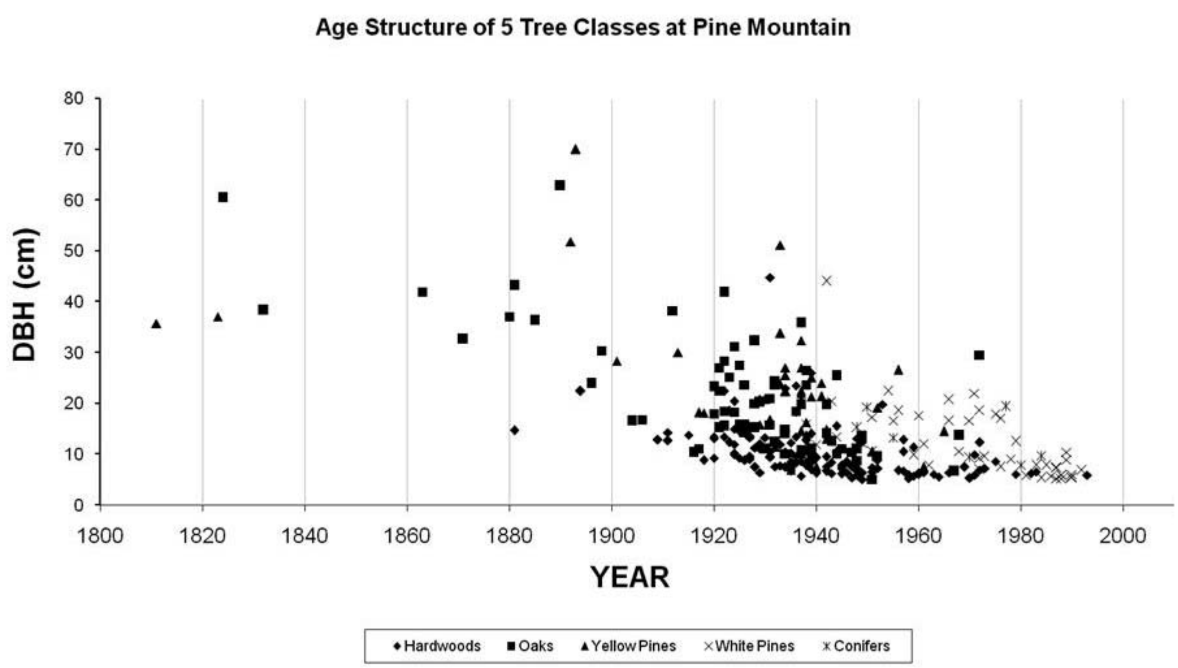

Figure 12. Establishment data for living trees sampled within the fire history area at Pine Mountain.

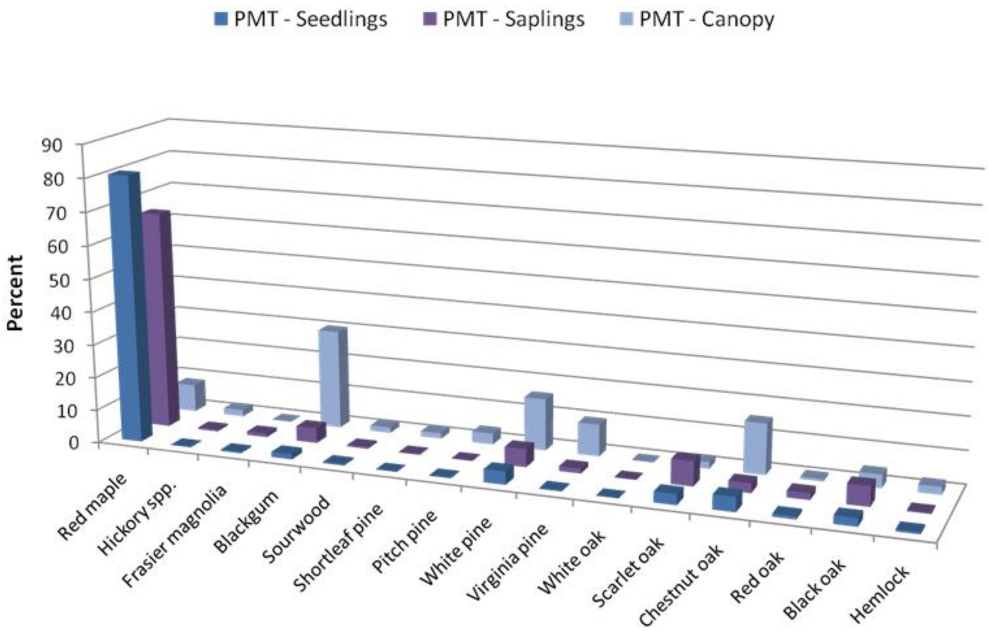

Figure 13. Distribution of canopy class tree species at Pine Mountain, arranged by position: canopy, saplings, and seedlings.