Forest structure in unroaded old-growth: understanding the influence of soils on variability of long-term vegetation dynamics and fire history

The unroaded, unharvested areas on the UP provide a unique opportunity to evaluate forest changes over time and the differences in forest structure in relation to differences in soils. Research in these areas opens a window to the past and focuses on three primary objectives:
1) determine if associations exist between soil-depth and dominant forest vegetation type,
2) determine whether known historical fires were stand-replacing or mixed-severity,
3) provide an initial assessment regarding the spatial scale of historical fires.

Objective 1) Determine if associations exist between soil-depth and dominant forest vegetation type. Soil characteristics (particularly rock cover) strongly influence the development of forest canopies which influence fire regimes and tree survival. We anticipated species composition and tree ages to differ based on soil depth and rockiness, including an expected correlation between deeper soils and higher basal area. Shallow, rocky soils were expected to have fewer trees, a longer fire return interval or lower fire severity, and support veteran ponderosa pines and Douglas-fir legacy trees. In contrast deeper, less rocky soils were expected to lead to a forest composed of more spruce and fir, a fuller canopy, and greater risk of stand-replacing fire. The two small unroaded mesas (Motley and Goodtimes) are each less than 250 acres with shallow soils underlain by partially weathered Dakota sandstone with some open rock outcrop complexes. Relative to these research sites, "deep" soils were classified as 30cm or deeper. In order to test the relationship between soil depth and forest composition, average soil depth and basal area (via a 20 BAF prism) were measured at 40 randomly selected plots on each mesa. Additionally, soil depth to bedrock was measured for all heritage trees (trees ≥ 80 cm dbh) encountered on the unroaded mesas.

Surprisingly, soil depth analysis and curve fitting did not reveal a relationship between soil depth and basal area in the 80 randomly selected plots (Figure 1). However, a striking relationship between shallow soil plots and the presence of heritage trees was revealed. While there were few shallow soils encountered in the random plots, these soils contained a high representation of heritage trees (Figure 2). This corroborates earlier research citing the presence of heritage trees on microsites where shallow soil limits neighboring trees and/or ladder fuels.

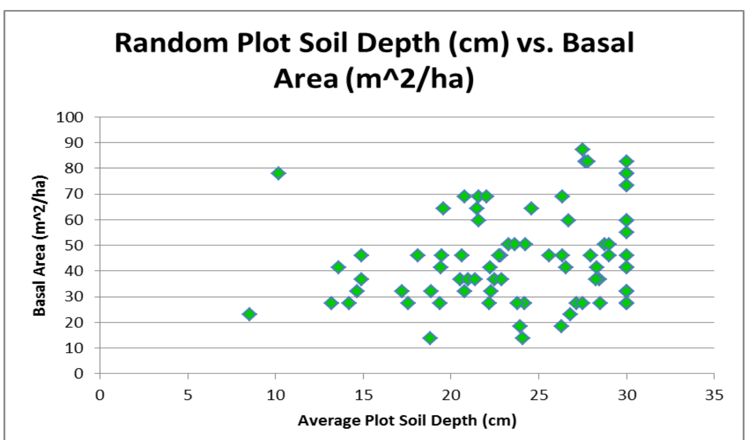

Figure 1

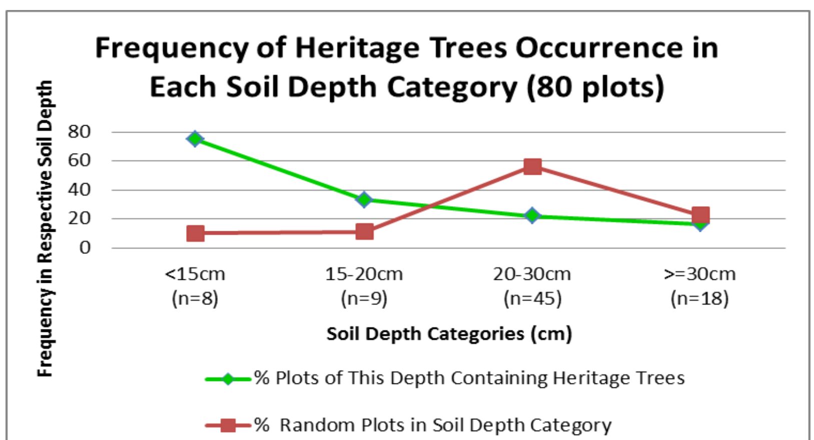

Figure 2

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Objective 2) Determine if known historical fires were stand-replacing or mixed-severity fires. Historical reports and UP fire history research indicate widespread, landscape level fires on the Plateau in 1842 and 1879. Were these historic fires stand-replacing at a landscape level or does the age structure of the current forest indicate mixed-severity fires? If the historic fires were stand-replacing at a landscape scale, then trees sampled via the random plot measurements should indicate an age cap driven by a fire disturbance. We cored the two largest trees in each of 80 random plots for an age cap assessment. Since DBH does not directly correlate to age of the tree, cores were taken from comparably sized trees of different species when DBH was close. A visual search for any very large trees was conducted around each plot. If noticeably larger trees or trees exhibiting physical characteristics of older trees were in the plot vicinity, additional cores were taken.

Tree ages from random plots were compared to null models of tree mortality in the absence of major disturbance events like fire. Many of the larger trees predate the known fire years of 1842 and 1879, indicating that fire intensity did not reach stand-replacing levels at the scale of the unroaded mesas (~250 acres). Tree establishment dates indicate the stand-replacing fires, if they occurred, had patch sizes on the order of 100 acres or less.

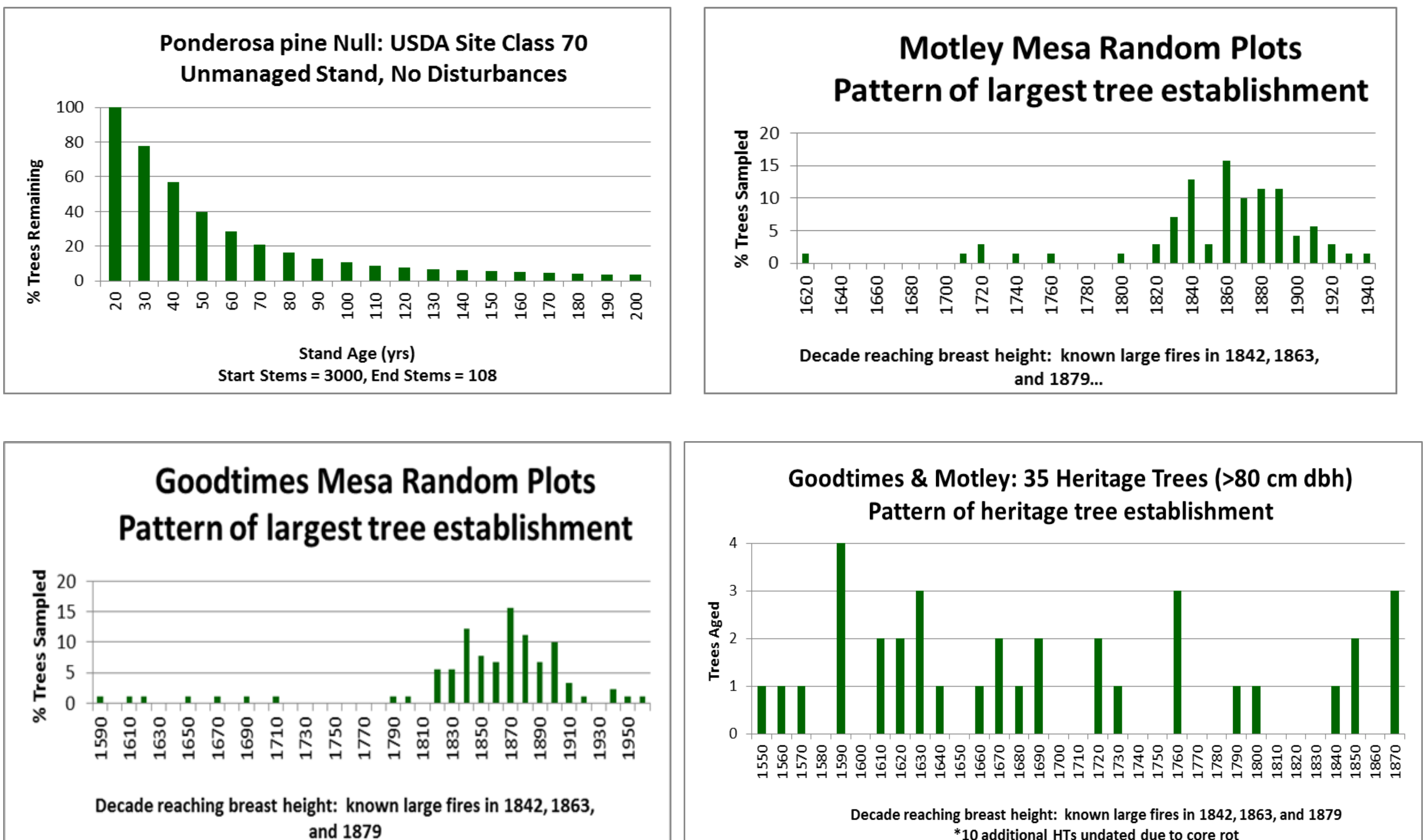

Figure 3

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Objective 3) Provide an initial assessment regarding the spatial scale and severity of historical fires. Based on random plot data, historic fires did not appear to be stand-replacing for conifers at a scale of more than 100 acres. Was fire intensity high enough to be stand-replacing for aspen? We sampled three 1 km aspen transects (one on top of each mesa and one through the drainage between the two unroaded mesas) to look for an age cap that would indicate stand-replacing fire intensity for aspen. Topographic contours were followed to stay within relatively homogenous aspen stands, taking sample cores approximately every 100m, and wherever there was an obvious change in stature, density, or apparent aspen age. Similar to the random plot surveys, a 20 BAF prism was used at each sampling point to identify 4-6 of the largest "in" trees to core and age.

The three aspen transects from the unroaded, unharvested mesas indicated event-driven establishment patterns. Major recruitment pulses in the 1870s and 1880s coincided with historic fires of 1863 and 1872, seeming to indicate these historic fires were stand-replacing events for aspen. The few aspens aged to the 1850s were small diameter trees growing in extremely shallow, rocky soil adjacent to a heritage tree ponderosa pine. These older aspens seem to have been protected from fire by the same rocky microsite characteristics that fostered the heritage ponderosa.

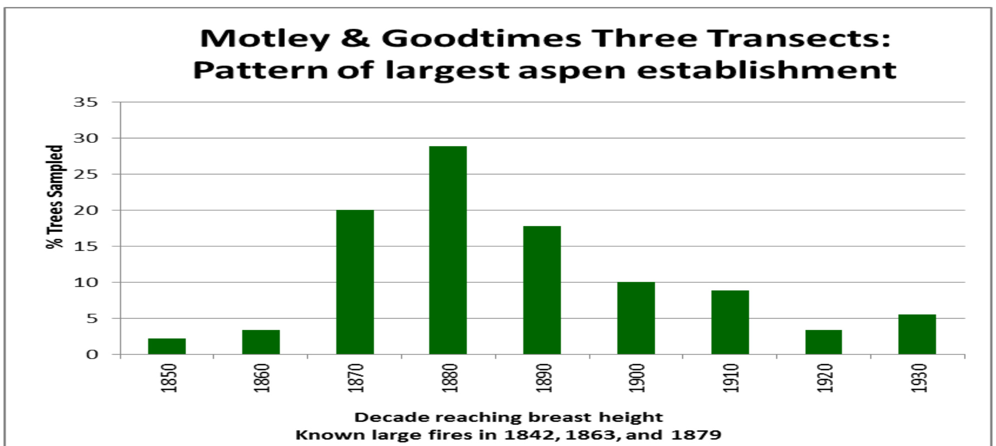

Figure 4

Two further aspen transects were sampled on adjacent mesas north of Goodtimes to determine if the same establishment patterns exist. The Love Mesa transect also displayed a recruitment pulse in the 1880s, corresponding to the 1872 fire. Interestingly, the Sawmill Mesa transect showed no recruitment pulses corresponding to the 1863 or 1872 fires. We conclude that fires in the 1800s were likely not intense enough to kill all conifers over large areas, but were intense enough to kill most aspen stems on three (Motley, Goodtimes, Love) of the four mesas. This knowledge will help foster a better understanding of the historic range of variability and improve the efficacy of contemporary forest management and restoration treatment designs.

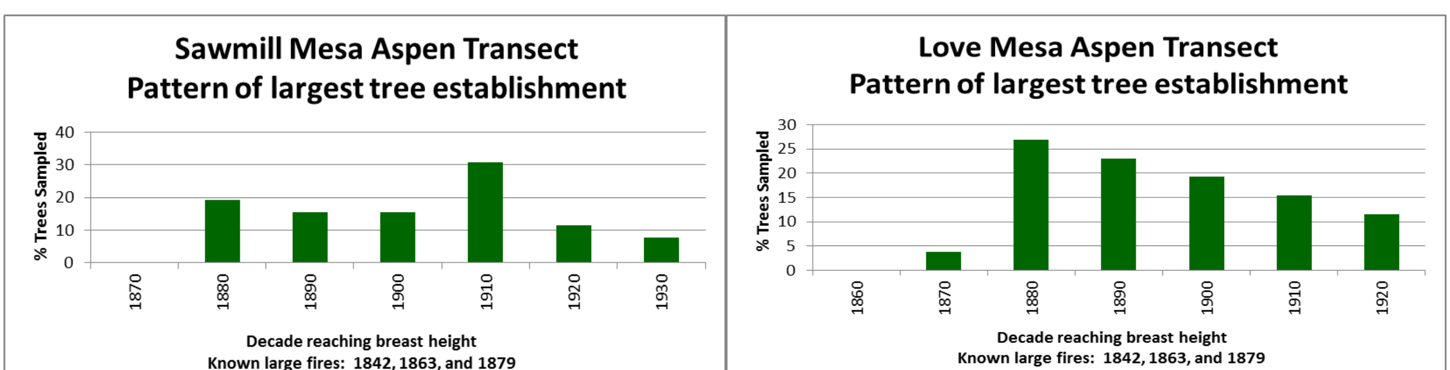

Figure 5