History of Stand Improvement Practices at the Fort Valley Experimental Forest

W. Keith Moser, Russell T. Graham, Andrew Sánchez Meador, Jianwei Zhang, Lance Asherin, Eric Merrill

Overview:

Forest management is best served by data, information, and knowledge generated from long-term and large-scale studies (Zhang et al. 2020). Permanent plots followed over a long time can help us detect and quantify ecosystem changes (Sánchez Meador and Moore 2011). U.S. Department of Agriculture, Forest Service experimental forests, such as Fort Valley Experimental Forest (FVEF) outside of Flagstaff, Arizona, have provided this valuable service for over 100 years. FVEF was established in 1908 in the southwestern ponderosa pine belt with an initial research focus on natural and artificial regeneration, timber stand improvement, forest stand dynamics, and determining which factors influenced tree species distribution (Sánchez Meador and Moore 2011). In the unharvested ponderosa pine forests, stands were historically spatially aggregated (Iniguez et al. 2019; Sánchez Meador et al. 2009). With an eye on improving timber production, researchers at FVEF installed studies evaluating different types of harvesting, such as method-of-cutting studies, which were harvested using three different harvesting systems in 1913 (seed tree, group selection, and light selection) (Sánchez Meador and Moore 2011) or selection management studies (Edminster unpublished report 1991). Not willing to rely on variable density measurements of natural stands, in 1962, the Forest Service installed an intensive density management study of ponderosa pine at Taylor Woods on the FVEF (Bailey 2008; Schubert 1971). This last study guided our understanding of ponderosa pine density management and formed the basis for the ponderosa pine model of the Central Rockies variant within the Forest Vegetation Simulator. All three studies examined the interaction between climate influences and tree response in variable-density and multi-aged stands.

Summary:

- Silvicultural practice is founded on density and composition management and the potential for individual tree and stand volume growth (Smith 1962). Thinning reduces overall stand volume but, in the process, releases more growing space for the residual trees. In situations where economic markets are positive, such reallocation of growing space takes advantage of the price increases as a function of diameter (Assmann 1970) and increasing total value per area.

- The purpose of the method of cutting (MoC) studies at FVEF was to evaluate the feasibility of seed tree, group selection, and light selection regeneration harvests on tree regeneration and growth (Sánchez Meador and Moore 2011). From a stand development viewpoint, the seed trees responded more to release as there were fewer residual trees. The copious regeneration from the early 1900s eventually affected the growth of the residual trees. Light selection stands responded in a manner similar to their pretreatment behavior. Group selection treatments created a mix of dense stands and open areas. There were varying structures, and the patterns were not spatially random.
- Similar to the MoC studies from 1913, the 1924 initiation of a long-term study of uneven-aged management examined tree growth and regeneration patterns. Recent analysis suggests that the size and spatial pattern of the nearest neighbor trees significantly influence focal tree growth. While these competitive effects increased with tree density, the influence was highly variable in open, often more aggregated, conditions. Further analysis found that while drought conditions affected trees regardless of tree density, those in low density or aggregated stands responded more quickly when the drought ended (Moser et al. unpublished data).
- As part of a west-wide study of the level of growing stock and tree response in ponderosa pine stands, the Taylor Woods (TW) LOGS study was established on the Fort Valley Experimental Forest (Schubert 1971). TW was less productive than other locations, so this research provided an example of tree response on aridland forests of the Southwest. As stated above, the original forest at Taylor Woods was primarily composed of trees of the 1919 regeneration event (Bailey 2008; Pearson 1950; Schubert 1971). Three replicated blocks of six density levels were thinned to their target densities in 1962 to establish the study. After remeasurements, each block was thinned to maintain the approximate density level. Stand density did not affect height. Basal area responded to thinning, making it hard to maintain the target Growing Stock Level (GSL) in this study and illustrating the challenge in meeting BA targets in large stands or forests. Lower densities produced larger QMDs, with each GSL being significantly different up to 100 ft^2 ac^{-1}. The stand cubic volume for each GSL was similar to what Meyer (1938) predicted. Merchantable volumes were greatest at the 100, 120, and 150 GSLs. Most thinnings produced merchantable volumes, but over the life of the study, there have been limited markets for those products (Moser et al. unpublished data).

Silvicultural Concepts:

- Silvicultural systems are a planned set of treatments to regenerate, manipulate, and harvest trees, considering the site, climate, and species present (Tappeiner et al. 2007). For example, in more mesic eastern forests, trees in the upper strata only compete with each other and are less influenced by the trees in the midstory and understory (Kelty 1984; Kittredge 1986; Oliver 1975). However, the dry conditions of the Southwest mean that trees in the mid- and understory can impact trees in the upper strata due to competition for soil moisture (Pearson 1950).

- Common treatments that relied upon natural regeneration included seed tree and shelterwood cuts (even-aged) and selection system (uneven-aged) treatments. In a seed tree cut, most of the trees in a stand are removed except those left standing singly or in groups to provide seed to restock the cleared area, which are later removed when satisfactory stocking is achieved. Usually, no more than 10% of the original overstory is left (Hawley 1937). Unfortunately, the overwood was often not removed in practice, resulting in sites like FVEF having very high densities and facilitating the propagation of pests like dwarf mistletoe.
- A shelterwood cut involves the removal of the stand through a series of partial harvests, resembling thinnings, over a relatively short period compared to the total rotation (Hawley 1937). A variant of this treatment practiced on FVEF, and the adjacent Coconino National Forest, was the strip shelterwood, where the stand is not treated uniformly but rather concentrates the harvests in strips adjacent to the residual stand, which provides the seed source to regenerate the newly opened area (Hawley 1937).
- On the uneven-aged side, selection system silviculture is intended to maintain all-aged or uneven-aged stands. Selection silviculture is defined by the residual or target overstory condition instead of the even-aged systems' focus on the successful reinitiation of the stand (Ashton and Kelty 2018).

- In the early era of forest research, the management of young-growth ponderosa pine forests was in its infancy. Results from studies conducted in one area seemed to have limited use in another area. Questions arose about the best way to grow timber: even-aged or uneven-aged management. What silvicultural treatments could best deal with the already burgeoning dwarf mistletoe problem? Method of cutting studies were established at FVEF in the 1910s and 1920s to help answer these questions.
- From the 1930s through the 1950s, research determined that precommercial thinning of dense stands of ponderosa pine was desirable from a timber management perspective (Harmon 1955; Pearson 1950; Smith 1962). As a result, studies of density and growth in prominent species, including ponderosa pine, were established throughout the West (Tappeiner et al. 2015), including at FVEF.
- The 1913, MoC studies determined that seed tree harvest resulted in the most available growing space for a new cohort and the greatest release of residual trees. The BA increments of the two selection treatments seemed to parallel their responses with group selection providing more available growing space for the recruitment of new cohorts. Light selection was closest to a uniform thinning and therefore displayed the more consistent post-treatment increment. Historically intensive harvesting resulted in a stand structure that converted aggregated spatial conditions to those that were more random in pattern. Less intensive harvests accentuated patchiness, homogenized tree size, and removed predominantly larger tree sizes. The 1924 uneven-aged MoC study observed that lower density stands recovered from drought faster than higher density stands.

Figure 1— In the background is a ponderosa pine LOGS control plot in 2017 (photo credit: J. Zhang).

Figure 2— Ponderosa pine LOGS 80 ft^2 ac^{-1} plot in 2017 (photo credit: J. Zhang).

1913 2006

Figure 3— Group selection site in the Method of Cutting study. (Photo credit: 1913: H. Krauch; 2006: A. Sánchez Meador.)

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