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Picture the Past

Using a Fuzzy View of Old-Growth Longleaf Pine to Derive Silvicultural Clarity with Restoration

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The USDA Forest Service (Forest Service)'s historical documents collection at the National Archives includes many high-quality digital public domain photographs of foresters, stand conditions, and forest management practices, as well as a number of other subjects. These images offer researchers and managers numerous opportunities to study the American past and thus better address contemporary forest and forestry issues. To demonstrate this, the following pictures of historical longleaf pine (*Pinus palustris*) woodlands provide a reconsideration of the concept of old-growth forests and desired attributes from them can be encouraged in second growth. In this example, these images illustrate how a thorny challenge for many forest managers—the designation of stands as old growth—can be approached using a nontraditional yet well-defined "fuzzy set" mathematical theory (see also Bragg 2022).

Photograph 1 (Forest Service negative #40845)

Longleaf pine was long considered the premier upland timber species of the southern United States. Once dominant on more than 92 million acres (Frost 2006), the heavy, strong, hard, resinous, and decay-resistant wood of longleaf was highly desired for structural beams, dimensional lumber, flooring, and trim wood, and the species was legendary for its production of naval stores (Barnett 2019). Pressed by this demand and concurrent lumbering, the fact that Forest Service photographer E. Block found in 1903 such an extensive and untouched stand of old-growth longleaf pine is itself remarkable. This example of virgin timber in southern Georgia provides clear evidence of the frequent—likely annual—surface fires that swept across longleaf country, excluding most other woody species from the under and midstory and producing, nearly pure stands. The ancient character of the overstory pines is evident from their flattened, twisted tops perched atop their long, straight, branch-free boles. Some large deadwood is apparent in the form of scattered snags and the "rich pine" heartwood cores on the ground but when compared with old growth in many other forest types, dead wood was often limited in the fire-prone, termite-filled, warm, moist forests of the southern United States (Ulyshen et al. 2018). Although not readily apparent in this image, it is likely this stand is multi-aged, as has often been observed in old-growth longleaf pine, even single-strata stands (e.g., Chapman 1909; Gilliam and Platt 1999; Platt et al. 1988; Varner et al. 2003). It was also not unusual to see variation in spatial patterns of the overstory in virgin southern pine, with different-sized gaps interspersed within a matrix of variably stocked stands (e.g., Chapman 1909; Schwarz 1907). Historical Forest Service photographs such as #40845 can help exemplify the open old-growth forests that are the reference condition and primary restoration goal in longleaf pine. Under conventional set theory, a forest stand is designated as either old growth or not old growth; this "crisp" definition is either/or and is preferred by managers who seek distinctness rather than ambiguity. As a crisp set, few would likely question the designation of the stand in #40845 as old growth.

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Photograph 2 (Forest Service negative #442973)

In contrast with the old timber in #40845, this 1946 image by John T. Cassady shows a young, regenerating stand of longleaf pine in Louisiana. With a few notable exceptions in the background, the virgin pines had been felled some years before and the cutover appears to have been grazed and burned. The stand in this image appears to be at the far opposite end of the age spectrum from the one in #40845; as a crisp set, the designation of #442973 as not old growth is hard to dispute. However, these two examples, though vastly different in average tree age, share a number of similarities, including an openness which has allowed an herbaceous (grass and forb-dominated) understory to persist. Scattered old longleaf pine in #442973 are another legacy that provided a seed source, added structural complexity, and increased age class diversity. Hence, the "apparent age" of this particular young stand is somewhat higher (older) than it would be if the longleaf pine saplings had a closed canopy sufficient to shade out the herbaceous understory; likewise, the remnant old pines and more complicated age class distribution are characteristic of mature, multi-aged stands. In terms of fuzzy set theory, condition sets (such as old growth) have a fractional membership between 0 (i.e., absolutely no membership) and 1 (i.e., absolute unity; Buckley and Eslami 2002). This particular example of a young longleaf stand would have a membership slightly greater than 0—but well less than 1—in the set of old-growth longleaf pine (e.g., that shown in #40845). Providing a fractional value slightly greater than zero for this example is close to a more traditional crisp set assignment as "not old growth" while allowing for recognition of attributes still shared with more mature stands. In other words, fuzzy sets consider a spectrum or "shades of grey" versus an all-or-nothing designation of old growth.

Photograph 3 (Forest Service negative #231687)

This 1928 photograph by Wilbur Mattoon of an unmanaged, even-aged, second-growth stand of longleaf pine from Clay County, Alabama, offers an example of how a fuzzy set approach to old growth could be applied to facilitate restoration. According to the photograph's original caption, the 50-year-old pines in this overstocked stand were up to 100 feet tall and ranged in diameter between 9 and 14 inches; the stand itself averaged 32,000 board feet of lumber per acre. Although the individual longleaf pines were not particularly large, the stand-level volume was considerably greater (2–3 times) than most reported examples of virgin longleaf (e.g., Chapman 1909; Reed 1905; Wahlenberg 1946). This photograph also shows a closed overstory with a limited understory of a few woody plants, and the accumulation of litter on the forest floor and no evidence of scorch on the stems of these pines further suggests successful fire suppression, at least for this 2 ac stand. Even with its high timber volume and taxonomic purity (low tree species richness) consistent with most virgin longleaf pine-dominated landscapes, this crowded stand with its very sparse herbaceous understory is more consistent with young pine stands and hence lower membership in the set of old-growth longleaf. The simple acts of greatly reducing the density of overstory pines and resuming frequent surface fires would immediately increase the stand's apparent age (make it closer to conditions found in the old-growth longleaf pine shown in #40845).

Photograph 4 (Forest Service negative #464978)

This image shows a different scenario commonly found in the longleaf pine distribution of the mid-20th century. By the time photograph #464978 was taken on the Talladega National Forest by Daniel O. Todd, effective fire control and the widespread loss of frequent surface fires allowed less fire-tolerant species, such as loblolly pine (*Pinus taeda*), to dominate the understory of many second-growth longleaf stands. For landowners, the faster-growing and more prolific seeding loblolly, despite having less desirable wood quality, had become the preferred timber species. The eventual replacement of longleaf suggested in this photograph was not considered a problem by most forest managers at the time as a healthy crop of loblolly pine appeared poised to claim the site. In terms of fuzzy set theory, this maturing stand, with its mixture of overstory (older) longleaf and understory (younger) loblolly exhibited some of the age variation observed in old-growth longleaf stands. However, the dense loblolly understory and diminishing importance of longleaf suggest a stand with a younger apparent age (relatively low membership in the set of old-growth longleaf pine) than what would have been possible if the loblolly pine was not present.

These examples of historical longleaf forests demonstrate the potential of using a fuzzy set approach to identify, restore, and manage existing stands to encourage attributes consistent with old growth—in other words, increase their apparent age. Although challenges remain in sufficiently documenting desired vegetation patterns to ensure that this process is maximally effective, understanding how targeted silvicultural treatments can accelerate management outcomes offers considerable promise for meeting ecosystem goals.

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