Long-term Longleaf Pine (*Pinus Palustris Mill.*) Plantation Studies on the Palustris Experimental Forest: Growing Timber to Provide Habitat

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General Overview of Palustris Experimental Forest

In 1935 the 7,500 acre Palustris Experimental Forest was ordained by Congress to provide an area for conducting forestry research. However, work was already underway to establish research studies before the area was officially designated as an experimental forest within the boundaries of the Kisatchie National Forest. At the time, much of the region consisted of cutover pine lands that had been habitually burned by humans, grazed by domestic livestock, and subject to large populations of free-roaming feral hogs. These conditions hindered any sort of forest regeneration. "Stump orchards" were a term often used to describe what appeared as a grassland punctuated by remnants of the stumps of the old pines. The hogs could be particularly devastating to young longleaf pine seedlings whose roots they prized.

The Palustris Experimental Forest was named to recognize longleaf pine (*Pinus palustris* Mill). Longleaf pine was the dominant component of upland pine forests in the southern United States before widespread clearing in the early 1900s. Where 90 million acres of longleaf pine forests were once present, only about 3 percent of that land is currently in longleaf pine. Longleaf pine forests are critical to those who desire to restore native plant communities, and are essential for species adapted to the longleaf pine ecosystem, principal among these are red-cockaded woodpecker (*Dendroica borealis*) and the gopher tortoise (*Gopherus polyphemus*). The Palustris Experimental Forest is located on the southern Coastal Plain in central Louisiana. Climate is generally warm and moist; average precipitation is 1465 mm per year, and fairly evenly distributed through the year. Annual average temperature is 22 degrees C.

Given the need for regenerating millions of acres of cutover pineland, and insufficient knowledge on methods to establish the southern pines, much of the initial research was directed towards artificial regeneration of southern pine. Philip C. Wakeley, pioneering silviculturist, provided leadership for this work, which was conducted with several other scientists, and in concert with manpower provided by the Civilian Conservation Corps. Wakeley and Barnett (in press) state that 750,000 seedlings were planted in studies conducted on the Palustris Experimental Forest between 1928 and 1939; Wakeley directed all of these plantings. This work was summarized in Wakeley's (1954) seminal monograph, "Planting the Southern Pines". Studies were conducted on loblolly (*Pinus taeda* L), slash (*Pinus elliotii* engelm.) shortleaf (*Pinus echinata* Mill.) and longleaf pines.

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While emphasis varied, the studies were generally directed toward reforestation. Early research on cone and seed production and handling was a foundation of reforestation practices. Seedling production studies conducted at a nearby nursery were outplanted on the Experimental Forest to develop nursery technology and identify stock specifications for planting southern pines. Such outplanting studies continue to be established occasionally on the forest, though currently longleaf pine container stock is more commonly used than bare-root seedlings. Trials were established to test different levels of root pruning and depth of planting trials and to test various substances that were sprayed upon bareroot seedlings to decrease desiccation and improve survival. Regional genetic seed source trials in the four main southern pines were established. Direct-seeding technology for southern pines was developed here (Derr and Mann 1971). Direct-seeding was particularly suited for the large landscapes of denuded land to be reforested. These direct-seeding studies have also provided data used to explore natural thinning relationships in dense stands of southern pines (Goelz, in press).

Cattle grazing was once common in pine forests of Louisiana, and there was a large research program involved in range research. While range research is no longer active, a few of the range studies have received new relevance by providing information on the long-term effect of prescribed fire. While these range studies were directed mainly toward the effect of fire on forage production, more recent emphasis has been on plant community composition (Haywood and others 2001). More recent studies with prescribed fire are directed towards restoration of longleaf pine ecosystems. Domestic animals were not the only subject of research for the range scientists. They also studied wildlife including birds and small mammals.

Many of the sites to be reforested were unproductive due to competing low-quality hardwood vegetation; methods to control woody plants were developed on the forest (Peevy 1968, Peevy and Brady 1968, Brady 1971). In a rather novel study, pinestraw was used as a mulch to hinder development of competing vegetation (Haywood and others 2003). Pinestraw collection is also a commercial enterprise, particularly on longleaf pine forests, and research has investigated pinestraw productivity and the ecosystem effects of collection (Haywood and others 1998). Many studies that answered questions concerning the afforestation methods were designed so that they could also address subsequent stand management questions, particularly intermediate silvicultural practices, including prescribed fire, and the growth and yield and economic productivity of artificially-regenerated stands of southern pines. While this research was directed towards timber production, it soon became relevant to management of forestland for wildlife habitat, or more generally, for restoration of the longleaf pine ecosystem (Goelz 2001).

While most of the research on the Palustris Experimental Forest has been applied, more basic research has been conducted on root and whole crown physiology, morphology, and phenology in an effort to elucidate mechanisms of tree response to nutrient, moisture, and light availability, and provide relevant information to evaluate potential effects of long-term climate change (Sword Sayer and others 2004; Sword Sayer and Tang 2004; Tang and others 2003; Tang and others 2004). Another line of research that addresses both fundamental and applied questions concerns the effects of management, particularly tree harvest, on long-term site productivity (Tiarks and others 1997, Scott and others 2004). This research evaluates how compaction and biomass removal during harvesting affects soil physical and chemical properties, and hence productivity of the next stand of pine. This work also evaluates the fate of coarse woody debris and the insect populations that use the material as habitat (Tiarks and others 1999).

Long-term Longleaf Plantations

Some of the oldest, continually-maintained studies on the Palustris Experimental Forest involve plantations of longleaf pine. The three oldest, continually-maintained longleaf pine plantations were established in the winters of 1934-1935 (the two oldest) and 1951-1952. The younger of these three plantations was planted at a 6-by-6 foot spacing across 50 acres. Thinning treatments were applied at age 17, but initially the main emphasis of the research was the production of native forages rather than timber (Grelen and Lohrey 1978). Treatments consisted of four residual basal areas, replicated 8 times; however, one of the residual basal areas was 0, or clearcut, and thus no observations of subsequent forest growth could be obtained from this treatment. At age 30, treatments were expanded to include fertilization and establishment of a subterranean clover (Trifolium subterraneum) understory. Subsequent to evaluation of these treatments, the emphasis of the study evolved to classical forest growth and yield. However, while the production of an economically-valuable stand of timber is important, the greatest application of information on longleaf pine plantations is towards restoration of the longleaf pine ecosystem.

Two plantations were planted in February 1935 to compare burned (40 acres) vs. unburned (60 acres) longleaf pine plantations, and to evaluate different initial spacing and subsequent thinning and pruning. One plantation was burned three times while the other was not burned at all for the first 11 years (prescribed burning is a typical component of longleaf pine management and both plantations were regularly burned following the initial period). Prescribed burning decreased survival only slightly, but doubled the amount of trees that had progressed out of the "grass stage" by age 11. Longleaf pine seedlings are unique among U.S. pines by typically undergoing a grass stage where the terminal bud may stay at ground level for several years before shoot elongation occurs (subsequent research on nursery production and site preparation have succeeded in shortening the grass stage to 1-to-3 years (Barnett and McGilvray 1997).

The initial spacing of the plantations were specified in metric units, as the investigators believed the United States would soon adopt the metric system. At age 20, initial thinnings were applied to the burned plantation, including residual basal areas of 60 to 100 ft^2/acre and 100 "crop trees" per acre; pruning was also applied. By this time, the investigators had resigned themselves to English units. Thinning was reapplied regularly from age 20 to 55, though not every plot was re-thinned every 5-year measurement cycle. At age 30, range scientists evaluated the yield of native herbage in response to residual stand density after thinning; production was measured annually for 5 years, and then at five-year intervals. The herbage was segregated by several important taxa, thus providing data on understory plant community composition. At age 70, the plots are again being thinned. The study is being altered by combining the original sixty-four 0.1 acre measurement plots (and their interstitial border areas) into sixteen 1.225 acre plots. The initial investigators did not necessarily envision the study being maintained beyond age 35 and thus the 0.1 acre plots were too small to allow sufficient numbers of trees per plot after several thinnings. By increasing the plot size to 1.225 acres, the plots will provide a continuing database for another 50 years or more of stand development.

The Best Laid Schemes...

One of the certainties of long-term forest research is that the best-laid plans of scientists eventually go awry. Things happen to long-term studies which are unwanted and potentially confounding. Survival at age 5 was about 55 percent, which was good survival for bare root plantations established during the period. Early disturbances reduced survival to 35% by age 11. The study planted in February of 1935 endured these intrusions:

(1) Hogs uprooted an unknown number of seedlings between 1940-1942.
(2) A wildfire occurred in 1951, though little damage was apparent.
(3) An ice storm in 1951 severely damaged approximately 27 percent of the trees, leaving them leaning or with broken tops (there are numerous trees with forked tops currently in the stand though they tended to be removed in the thinnings).
(4) Hurricane Audrey in 1957 uprooted some trees.
(5) Beetles (black turpentine, Ips, or southern pine beetle) attacked trees, though insecticides were sprayed when the infestation was located. In the past when manpower was more abundant, the area was inspected weekly during logging operations, and otherwise biweekly during the summer.
(6) Prescribed fires (roughly 20 fires during the 70 years) caused scattered mortality. Technicians locat ed on the experimental forest conducted most of the early fires, while Forest Service fire crews con ducted the fires over the last 10-20 years. Anecdotal observation suggests the more recent fires are hotter and more mortality occurs, though only a few trees may die on the 40 acre area during an individual burn. Yes, even adult, healthy, longleaf may be killed by fires.

In spite of these unplanned events, the study has continued to provide information on the growth and development of longleaf pine plantations in response to spacing, thinning and pruning. This fulfills its original objectives. However, the issues have broadened since the study was established. Initially, timber production was the principal motivation. These longleaf pine plantations do produce timber. The best treatment has produced over 8 metric t/ha/yr, a value that is competitive with moderately intensive loblolly pine plantations in the area (loblolly pine is the predominant commercial species in the region). However, currently longleaf pine plantations are not typically established with timber production as the primary objective. Most current longleaf pine plantations are established to restore the longleaf pine ecosystem within its native range. Beyond the general objective of ecosystem restoration is the objective of providing habitat for plant and animal species indicative of the longleaf pine ecosystem, particularly red-cockaded woodpecker and gopher tortoise.

Thus, the long-term records of forest development are relevant to the objectives of establishing and maintaining habitat. For most of the treatments, the plots have passed the age of culmination of mean annual increment. From a timber perspective, the stand is mature and there would be no reason to delay regenerating it. However, these stands will potentially supply habitat for numerous plants and animals for decades, and habitat provided by old longleaf stands is what is desired by public land managers. If red-cockaded woodpeckers colonize the stand, it will provide an opportunity to directly study this critical species on these plots and will provide a final test of ecosystem restoration. The plantations are often used to demonstrate an example of successful longleaf restoration to visiting groups or individuals. Data from these old plantations are also used with data from several other studies to produce a model that describes growth and development of longleaf pine plantations (Goelz 2001; Goelz and Leduc 2001, 2002).

These studies are one example of long-term silvicultural studies that provide opportunities for concurrent research in other disciplines, including fire, range, and wildlife habitat. Through time, the applicability of the research has changed from timber production, and other consumptive uses for forests, to applicability to ecosystem restoration and producing wildlife habitat.

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