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Commentary

Introduction to the Special Issue on Longleaf Pine

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1. Introduction

Longleaf pine (*Pinus palustris* Mill.) is a majestic species that once was the dominant species in the southern United States [1]. It ranged from Texas to Florida and northwards to Virginia, as well into northern Georgia. It has been estimated that longleaf pine expanded west to east, originating from a single refugium in west Texas or northern Mexico following the end of the Pleistocene epoch [2]. Longleaf is considered a climax species [3]. Longleaf is the keystone species in longleaf savannah ecosystems (Figures 1 and 2).

Figure 1. Longleaf pine regeneration in a longleaf pine savannah ecosystem. Note: "bolting seedlings" in the back left. (photograph by Mary Anne Sword, USDA Forest Service).

Figure 2. Patchy longleaf pine savannah ecosystem from above (photograph by Andrew Whelan, Jones Ecological Research Center).

Longleaf pine has traits that make it resistant to frequent fire: intervals of two to three years are optimal. Longleaf has a "grass stage" (Figure 3) where seedlings do not elongate and, above ground, needles grow and resemble bunch grass [4]. This protects apical buds during fire, because the thick tuft of needles shields the apical bud from injury. The grass stage can last from two to ten or more years. During the grass stage, trees allocate more carbon to roots. This increased carbohydrate supply provides the seedling with energy to then bolt in height growth, allowing foliage to largely reach a height where it is not consumed, or less severely ignited during frequent low-intensity fires [4]. Finally, longleaf pine develops very thick bark that protects the cambium from damage [5]. Due to these traits, frequent fires of two to three years, considered the average fire frequency before European settlement, can maintain longleaf pine ecosystems.

Figure 3. Longleaf pine grass stage (photograph by Marry Anne Sword, USDA Forest Service).

Longleaf pine was the source of important products used by Native Americans such as wood for cooking and warming fires, structures and ceremonial life. It also facilitated deer hunting [6]. During hunting, exposed deer retreat into wet dense cane and hardwood bottoms. The Natives would set fire to the bottom, causing deer to dash out into the open where they were easily killed. Although Native Americans did burn to manage to Longleaf pine ecosystems, lightning strikes were by far the dominant form of ignition.

The decline of longleaf is a classic tale of rapidly increasing exploitation, drastically changing and almost causing the cessation of fire in its ecosystems.

Hernando de Soto, with a large contingent of soldiers, arrived in Florida in 1539 in search of gold [6]. Gold was never found, which ended up being a failure of their primary mission. They also brought along multitudes of hogs which would have had great implications, increasing over time to this day. They moved westward and controlled vast areas from Florida to Texas. They managed longleaf pine by mimicking the use of fire by Native Americans. By the end Spanish control of the region in the 19th century, these longleaf pine ecosystems were left mostly intact.

This history of the species following Northern European settlement comes from a classic in-depth overview on the subject [1] except when noted. Upon arrival in Jamestown, Virginia, in 1607, European settlers quickly recognized the potential of the species for home building because of its large size and straight grained wood. They also realized that the trees produced superior valuable navel stores. Longleaf pine was utilized to a low degree at first due to the lack of roads and navigable streams. However, as the use of water-powered sawmills increased over time followed by the steady installation of railroads and water-powered sawmills, Consequentially, longleaf pine exploitation rapidly progressed through its range.

Longleaf pine stands do not regenerate on stands that have been clear-cut. Longleaf pine is sporadic in cone production, and much of its seed is eaten by predators. Seedlings that are established are outcompeted by rapidly growing species such as slash and loblolly pine. Moving forward, the longleaf pine ecosystems were converted to agriculture and managed loblolly and slash pine forest plantations. Fire control became the norm in the southern United States, further eliminating fire-dependent longleaf pine ecosystems. To exacerbate the reduction in longleaf pine, feral hogs became abundant following those originally introduced by DeSoto [6]. Hogs eat the foliage during the grass stage of longleaf pine. As the seedlings in the grass stage increase the size of their root system, hogs dig and feed on them, destroying the seedling. Young longleaf pine roots are very tender and juicy, making them a preferred food by hogs.

Due to the progression of events discussed above, longleaf pine now occupies approximately 3% of its pre-European extant. This has severely reduced biodiversity, severely reducing species depending on these ecosystems and resulting in several species on the endangered list, and many more on the threatened list [7].

There is considerable interest in the restoration of longleaf pine ecosystems (Figure 4). In 2009, America's Longleaf Restoration Initiative was formed [8]. Implementation started in 2010. Its goal was to increase the hectares of longleaf pine in the Southeast from 97,125 to 323,748 ha in 15 years. In 2017, a status report [9] detailed that in 2005, that longleaf pine increased by 82,556 ha; however, the longleaf pine/oak forest type decreased by 84,579 ha. Thus, the land cover of longleaf-pine-dominated forests has basically remained unchanged five years since implementation of the plan. Action plans have been established to reverse this trend.

Figure 4. Restored longleaf pine Savanna ecosystem in Alabama (photograph by Dale Brockway, USDA Forest Service).

This Special Issue provides critical information toward the restoration of longleaf pine ecosystems. I am presenting minor introductions for papers in this Special Issue for different categories: carbon sequestration, fire, genetics and evolutionary traits, and planting stock production.

2. Carbon Sequestration

The notion of using carbon credits through forest practices began in the 1990s and has developing since then [10]. Forestry off-sets and the approaches to quantifying their use have become more understood over time and have slowly been implemented. Longleaf pine is a good candidate for use in carbon credits due to its long-term uses in restoration, long lifespan, and the production of long-term forest products such as utility poles and lumber, where it is the superior southern pine. As an aside, although an insignificant source of stand carbon, longleaf pine raking for landscape mulch provides a considerable source of income for private landowners but has also been shown to decrease soil nutrients and decrease tree growth [11]. The paper on this topic in the Special Issue presents a model for estimating carbon content using general and site-specific data derived from a sizeable dataset from a large portion of the species range [12].

3. Fire

As discussed above, prescribed fire (Figure 5) is critical for the restoration and maintenance of longleaf pine of longleaf pine ecosystems. One paper explores the mechanism of foliage recovery after crown scorch [13] on the impact of prescribed fire on the mortality of understory hardwoods [14], two on patch dynamics [15,16], and one other on the impact of fire on intra-annual nutrient dynamics [17].

Figure 5. Prescribed fire of longleaf pine ecosystem (photograph by Dale Brockway, USDA Forest Service).

4. Genetics and Evolutionary Traits

With climate change, water use efficiency may well become more important. Two papers explore genetic variation in water use efficiency using ^{13}C discrimination as a proxy. They used two extremely different approaches and populations [18,19]. Interestingly, using such divergent approaches and populations, these authors reached the same conclusion. Another paper examines carbohydrate concentrations in stem and course roots of longleaf, slash and loblolly pine [20]. High coarse root carbohydrate reserves were observed in the spring in longleaf pine, much higher than slash (*Pinus elliottii* Engelman.) and loblolly pine (*Pinus taeda* L.) The authors suggest that this patten might reflect selective pressures during the evolution of the three species.

5. Planting Stock Production

Longleaf pine seedling production via containers has been shown to be superior to bareroot seedlings and is the largest source of planting types today. The one paper in this section explores variation in container type and size on seedling quality [21].

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