

NATURAL STAND DYNAMICS IN LONGLEAF PINE: HOW CLIMATIC DISTURBANCES SHAPE THE COMMUNITY

Kenneth W. Outcalt (USDA Forest Service, Athens, GA 30602)

INTRODUCTION

Longleaf pine (*Pinus palustris*) once dominated the overstory of a wide range of southern plant communities including wet flatwoods and savannas of the Atlantic and Gulf coastal plains to higher, droughty sand deposits such as the fall line sandhills and the central ridge of Florida. It was also the dominant overstory tree on the lower rolling sandhills of lower Mississippi, central Louisiana, and east Texas. Longleaf pine even extended onto the mountain slopes and ridges of Alabama and northwest Georgia, where it was found growing at elevations up to 600 m. Frequent low intensity fires favored longleaf over other pines, because it has seedlings better adapted to surviving such fires. These periodic fires, every 2 to 8 years, also shaped the rest of the community, keeping woody shrubs in check while promoting the growth of grasses and forbs.

STAND LEVEL DISTURBANCE

Although fire is a primary driving force in longleaf pine ecosystems, it is not the only disturbance that impacts their structure and composition. A good portion of the longleaf range lies within 100 miles of the coast. Thus, stands have a rather high probability of being impacted by a significant hurricane at least once every 100 years (Hooper and McAdie 1996). During strong hurricanes like Hugo, which hit South Carolina in 1989, the tallest and largest trees receive the most damage and are usually uprooted or broken off (Hook and others 1996). This leaves behind the less severely damaged midstory trees. This scenario creates a sort of natural clear-cut of the overstory with a relatively even-sized sapling and seedling stand remaining. Prior to settlement, the tremendous fuel loadings would have greatly increased the probability of severe wildfires following these hurricanes. With or without such fires, the net result was an open area that could be occupied with longleaf pine regeneration either from existing individuals or by establishment from seeds shed by trees which escaped the fires. The even-aged management system, long used for longleaf pine, mimics these natural disturbance and regeneration patterns.

Because of the numerous thunderstorms that occur in the South, tornadoes are also prevalent within the longleaf range. In South Carolina for example, there are about 10 tornados per year (Purvis 1990). The most destructive are those, which remain on the ground for many miles. Tornadoes leave a path of broken and twisted dead overstory trees. Like severe hurricanes, this creates an open area that is captured by pre-existing longleaf seedlings or colonized by new seedlings from seed shed by adjoining trees. This results in a relatively even sized, although not entirely even-aged, stand of longleaf pine.

SMALL SCALE DISTURBANCE

The importance of lightning as an ignition source for the fire driven longleaf pine ecosystem is widely recognized. Lightning also impacts this system on a smaller scale by causing individual tree mortality. Often small groups of 2 to 4 trees are killed, creating small gaps in the longleaf canopy. Gaps are also created through the cumulative effect of individual tree mortality over multiple storms and years. Thunderstorm activity, and therefore lightning strikes, varies with location across the south. I followed lightning activity for 4 years in longleaf stands on the Department of Energy's Savannah River Site located in west central South Carolina. A total of eight stands at three locations containing 255 ha were monitored for lightning mortality. Lightning directly or indirectly killed 1 tree/6ha/year. A similar study on the Ocala National Forest in central Florida, the lightning capital of the world, had double the rate at 1 tree/3ha/year. Over a 100-year period, lightning mortality would remove 5% of the overstory in the South Carolina stands and 12.5% of the overstory in the Florida stands. This research also showed that it selectively removes the largest trees in the stand.

On sandhills sites, like the Ocala National Forest, longleaf pine regeneration is concentrated in these lightning created gaps. Regeneration, however, is not uniform across gaps. Brockway and Outcalt (1998) showed seedling density was much higher in the center of the gaps with a significant increase beyond 12m from the gap edge, where the gap edge was defined as the bole of trees surrounding the gap rather than the crown drip line. This distribution of seedlings was negatively correlated with fine root and forest floor

biomass. In subsequent research, on the Ocala National Forest, I looked at natural seedling establishment and survival across gaps with diameters of 30 to 40m. Seedling establishment was uniform from the edge to the center of gaps. Survival, however, was significantly lower for seedlings less than 4m from the edge, i.e. under the crowns of edge trees. This was correlated with rainfall distribution within the gaps. The first prescribed burn at the end of the second growing season reduced survival at all locations to less than 5%. A second fire, 3 years later, further reduced seedling survival and eliminated differences between locations.

In another study in the same **longleaf** gaps, I established containerized seedlings at 1, 4, 8, 12, and 16 meters from gap edges. At each location, seedlings were planted in a control patch and inside root control rings 0.5m in diameter and 20cm wide installed so the top was at the soil surface. Mean survival was higher for seedlings planted in rings that reduced root competition. The effect disappeared beyond 12m and from there to the center of the gap, reducing root competition had no effect on survival. This corresponded to the distance where fine root biomass declined in the study by Brockway and Outcalt (1998). A prescribed fire 2 years after planting reduced seedling survival at all locations, but the reduction was greatest under the crowns of edge trees. With reduced root competition, survival of **longleaf** seedlings after 5 years, with a prescribed fire at age 2, was just as good at 4m as in the center of gaps.

Thus, a number of interacting factors cause the distinctive distribution of **longleaf** seedlings and saplings in gaps of droughty sandhills sites. There is a zone from 0 to 4 or 5m on the gap edge where seedling establishment is equal to that found throughout the gap, but first year survival is lower. This is caused by interception of rainfall by tree crowns and likely poorer moisture holding capacity of the thicker forest floor. There exists a second zone that spans the area from 0 to 12m where fine root competition, likely for moisture, reduces survival of older seedlings. The frequent fire that occurs in **longleaf** stands also interacts with differences across the gaps. Seedlings in the 0 to 4m zone are more susceptible to fire mortality because the fuel loads are greatest under the crowns of the edge trees. They are also more susceptible, as are the seedlings in the 4 to 12m zone, because root competition reduces growth rates. This means it takes longer for the seedlings to reach a root collar diameter where they are likely to survive fire. Thus, even if a seedling in the 0 to 12m zone does survive the droughty conditions, it will likely be killed by fire because of its slow rate of growth. Beyond this 12m exclusionary zone is the central area of the gap where seedlings have a higher probability of survival.

CONCLUSIONS

Climatic caused disturbances significantly impact **longleaf** pine communities changing stand structure and providing open sites for regeneration. Severe hurricanes operate at the landscape scale creating a type of natural clear-cut by removal of most of the large overstory trees. Tornadoes, which usually operate at the partial stand scale, also create open conditions where regeneration can occur. Even-aged management of **longleaf** pine mimics these natural disturbance and regeneration patterns. Seed-tree and shelterwood systems create conditions similar to less severe hurricanes that remove only some of the overstory. Lightning strikes, although they affect less area in a stand, are continuously impacting **longleaf** stands creating small-scale gaps of 2 to 4 trees. Regeneration in the small gaps is not uniform because of variation in precipitation, litterfall, and root distribution and their interaction with frequent fire. Managers using the selection system should be aware of this, and create gaps in dry sandhills sites accordingly. The minimum size is about 0.08 hectare or a radius of 16m. The ideal size, however, is about 0.2 hectare or a gap with a radius of 25m, because one gap that size has 27% of its area in the zone where seedlings are likely to survive versus just 12% for two of the small gaps. If gaps larger than 0.2 hectares are desired, they should be oblong in shape with a maximum width of 50m so seeds do not have to travel more than twice the height of seed trees.

LITERATURE CITED

- Brockway, D.G., and K.W. Outcalt. 1998. Gap-phase regeneration in **longleaf** pine wiregrass ecosystems. *Forest Ecology and Management* 106: 125-139.
- Hook, D.D., M.A. Buford, and T.M. Williams. 1996. Impact of hurricane Hugo on the South Carolina Coastal Plain forest. In J.L. Hammond, D.D. Hook, and W.R. Harms (eds), *Hurricane Hugo: South Carolina Forest Land Research and Management Related to the Storm*. U.S. Department of Agriculture, **General** Technical Report SRS-5, Southern Research Station, Asheville, NC. Pp.34-43.

Hooper, R.G., and C.J. McAdie. 1996. Hurricanes and the long-term management of the red-cockaded woodpecker. . In J.L. Hammond, D.D. Hook, and W.R. Harms (eds), Hurricane Hugo: South Carolina Forest Land Research and Management Related to the Storm. U.S. Department of Agriculture, General Technical Report SRS-5, Southern Research Station, Asheville, NC. Pp.417-436.

Purvis, J.C. 1990. South Carolina tornado statistics. Southeast Regional Climate Center, 59p.