Longleaf Pine (*Pinus palustris* Miller) Spatial Concepts and Models Applied to Restoration in Virginia

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Introduction

Longleaf pine, *Pinus palustris* Miller, reaches its northern limit in Virginia and is considered extremely rare in the state with only 4432 trees covering less than 800 acres (Sheridan et al. In Press a). This species is confined to the southeastern United States and out of a historical 90 million acres only 3 million acres remain. There is currently a great deal of interest in restoration of the longleaf pine ecosystem by federal, state, and private agencies for a number of reasons. Longleaf pine is both a valuable timber tree and resistant to fire.

The longleaf pine ecosystem hosts a number of rare plants and animals and has one of the highest levels of species diversity per unit area. The only protected longleaf pine ecosystem in Virginia is the Blackwater Ecologic Preserve in Isle of Wight County which is owned by Old Dominion University. Reproduction of longleaf pine at the preserve is currently inadequate to produce seedlings (Sheridan et al. In Press a).

The preserve has been burned several times to control competition and mimic natural fire regimes. A formal management plan is now being put together for the preserve in order to guide future actions. A helpful adjunct to this plan would be a model to test a number of longleaf pine management scenarios <u>prior to their implementation</u>. Development of a Virginia longleaf pine model would allow managers to avoid compromising trees or seedlings through trial and error restoration methods.

The key questions which I think a model needs to address are:

1. When will trees be large enough at the preserve to produce enough seeds for successful reproduction?

2. What is the mortality rate of longleaf pine trees under current fire regimes at the preserve?

3. What are the temporal and spatial requirements for longleaf pine persistence and reproduction?

4. Are there fitness differences between different longleaf pine populations and do they need to be considered in restoration?

The first question is addressed by Platt et al. (1988) in their excellent paper on the population dynamics of longleaf pine. They found a rather close correlation between the size of the tree and the number of cones produced. Larger diameter trees produce more cones, especially trees over 60 cm. diameter.

In theory increment core data of longleaf pine at the preserve could be used to predict when trees will be large enough for successful reproduction. A minimum of 360 cones per acre are needed just to get the first seedling (Boyer 1998). Sheridan et al. (In Press a) performed a calculation based on longleaf pine seedfall data collected at the preserve and found that there is only a third the amount of seed necessary for reproduction. This low seed production can be explained by the small diameter of most of the trees at the preserve (8-28 cm). Trees in this size class produce approximately 4 cones per tree.

There are 2139 trees covering 143 acres at the Blackwater Ecologic Preserve (Sheridan et al. In Press a). An average longleaf pine density of 15 trees per acre results in 60 cones per acre (15 trees/acre x 4 cones/tree). We need a minimum then of 24 cones/tree to get the first seedling (360 cones/acre x 1 acre/15 trees = 24 cones/tree). The preserve was cut in 1955-1957 and naturally regenerated or planted. The average diameter of the stand is 20 cm. and assuming 40 years of growth the rate of growth is 0.5 cm./year. We therefore need an average tree diameter of 45 cm./tree to get the requisite number of cones per tree based on Platt et al. (1988) figure 4. This translates into another 50 years before we have trees large enough for successful reproduction!

Of course this reproduction model assumes even dispersion of longleaf pine on the Blackwater Ecologic Preserve. In fact longleaf pine tends to be patchy and we would have to modify the calculations in order to account for this. Aggregations of mature trees could result in seedling establishment before the estimated 50 years.

The estimated rate of growth at the Blackwater Ecologic Preserve is not unrealistic since measurements of a longleaf pine stand at Seacock Swamp (Sheridan et al. In Press a) found the rate of diameter growth was only 0.254 cm/yr. There is definitely a need for increment cores at the Blackwater Ecologic Preserve to determine the rate of growth for this longleaf pine population. In addition measurements of cone and seed production need to be initiated. Sheridan et al. (In Press b) found that another Virginia longleaf pine population produced only 22 seeds per cone. This fecundity is half the longleaf average (Croker 1973) and should be measured at the Blackwater Ecologic Preserve.

Annual mortality rates of longleaf pine ranges from 0.08 for trees of 2.54 cm to less than 0.01 for trees greater than 15 cm (Quicke et al. 1997). Quicke et al. (1997) however excluded catastrophic events, such as fire, from their model. Fire is an essential component of restoration and maintenance of the longleaf pine ecosystem and should be considered in such a model. Catastrophes have been included in models of other rare species (Root 1998). In any case a model to predict longleaf pine trees per acre over time in non-catastrophic situations is available.

Modifications for catastrophic events may prove useful to ecologic modelers working on habitat restoration. Platt et al. (1988) reported mortality of 1.75-2.65% for longleaf pine in a fire maintained preserve in south Georgia. This can be contrasted with the rather high 10.3% mortality rate of adult longleaf pine at the Blackwater Ecologic Preserve after burning (Plocher 1993). The Blackwater Ecologic Preserve is going through the initial phase of fire reintroduction so a higher mortality rate should probably be expected in comparison to a regularly burned preserve.

Mortality events do provide an opportunity for seedling establishment in natural stands of longleaf pine (Platt et al. 1988). This ecology has been utilized by intelligent foresters to propose the shelterwood tree harvest method as a low cost method of stand replacement (Croker 1956; Boyer 1979). Unfortunately since so little mature longleaf pine habitat is left this technique has limited applicability. Looking ahead to the day when planted stands reach maturity the shelterwood method will provide an effective way to regenerate without the high costs of planting seedlings. Under natural conditions mortality events produce gaps within the longleaf pine forest resulting in conditions for seedling establishment. This ultimately leads to an uneven aged stand.

Since longleaf pine is a widespread southeastern species one might expect differences in growth and survival when populations are grown outside their source. In the only published comparative growth study of different longleaf pine sources grown in Virginia Allen (1961) found that longleaf pine from south Florida failed in Virginia while material from other regions was somewhat more successful. Sheridan et al. (In Press a) calculated the overall fitness of these sources and determined that native stock was superior for in-state planting. Wells and Wakeley (1970) and Schmidtling and Sluder (1995) determined that longleaf pine could be grown 150 miles north and 300 miles east of its origin with performance equal or superior to native stock. Schmidtling and Sluder (1995) and Rayamajhi (1996) found that climactic factors were the chief controlling factor in longleaf growth and survival with average yearly minimum temperature being the most useful parameter. Longleaf pine can be successfully grown in regions with average yearly minimum temperatures 3^0 lower than their source. An average yearly minimum temperature 6^0 less than the source is deleterious for planting longleaf pine.

Given this basic information a Virginia longleaf pine model may now be developed. The goals should be restoration of the few extant sites and assistance for landowners attempting to grow the tree for profit. Models are available to calculate basal area growth of individual trees (Quicke et al. 1994) which may prove helpful from an economics standpoint. Considering there is less than 800 acres of longleaf pine left in Virginia there is great potential for experimenting with model predictions on land reforested in longleaf pine restoration.

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