A census of longleaf pine in Virginia

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ABSTRACT: A census was conducted to determine both the number of longleaf pines left in Virginia and their stand characteristics. A total of 4432 trees and 121 seedlings were counted in Isle of Wight and Southampton Counties, and Suffolk City, Virginia. Most trees ranged in diameter between 10-20 cm. with the champion tree in Suffolk City at 66 cm. Since remaining longleaf pine stands in Virginia represent only a fraction of the estimated original 1.5 million acres we recommend a restoration and reforestation effort within this tree's historic Virginia range.

"I like 500 species of plants, I like red-cockaded woodpeckers, but I also like money."

- **Leon Neel**

INTRODUCTION

Longleaf pine, *(Pinus palustris* Miller), reaches its northern limit in southeastern Virginia (Frost and Musselman 1987). After four centuries of settlement in this region longleaf pine has been nearly extirpated (Frost 1993) and the species is now considered extremely rare in the state (Ludwig 1997).

Interest in the longleaf pine ecosystem for both conservation and forestry reasons is increasing (Kush 1996) and we felt that an assessment of the status of extant stands in Virginia was a priority. The Virginia Department of Forestry is starting a native Virginia longleaf pine orchard and knowledge of the location, number, and vigor of stands is essential in order to make high quality graft selections for orchard stock. Conservation biologists are interested in determining the present acreage and reproductive vigor of longleaf pine in Virginia; whether native genotypes are better adapted than southern provenances for restoration, and if natural and non-native stands can be distinguished.

METHODS

Extant stands of native longleaf pine were detemmined by consulting the literature (Frost and Musselman 1987; Sheridan 1993), personal references, and fieldwork. Longleaf pine trees planted in yards or for landscape purposes were not included in the census. Sites were visited repeatedly from March to May 1998 and surveyed by individuals or teams. Longleaf pine trees were identified, measured at 1.4 meters with a d.b.h. tape measure, and marked with forestry crayon to avoid double counting. Tree diameter and stand position was then recorded.

The seedling class consisted largely of plants in the grass stage but longleaf pine 1.4 meters or less were also counted as seedlings. Recently germinated seedlings were occasionally encountered and observed. Due to the number of acres investigated and the ease with which they could be missed, no attempt was made to count the number of recently germinated longleaf pine seedlings. Notes were also made on associate plant species within the survey area. Occurrence of longleaf pine was recorded on U.S.G.S. 7.5' topographic maps and acreage then tabulated. Increments were collected from longleaf pine trees at one site (Seacock Swamp) and age determined by counting tree rings. We assumed that no false rings were produced.

Calculations of the fecundity necessary for longleaf pine recruitment at the Blackwater Ecologic Preserve were then performed based on the following assumptions: 360 cones per acre are needed to obtain the first seedling (Boyer1998); 5O2seeds are produced by en average cone (Croker 1973); maximum seedfall at the preserve is 1.6 seeds/m (Plocher 1993); 1 acre = 4840 square yards.

The relative and overall fitness of Virginia and southeastern provenance longleaf pine was then calculated based on seedling survival in a comparative Virginia plantation in the City of Suffolk (Nansemond County) (Allen 1961). Fitness calculations generally include a fecundity parameter. The time for longleaf pine to reach reproductive maturity makes fecundity calculations impractical. Allen's (1961) six-year survival and growth study, however, provides data to estimate the fitness of the different longleaf races when planted in Virginia. Survival and growth are both fitness parameters, particularly since larger trees produce more cones (Platt et al. 1988). Relative fitness for survival and height were determined by dividing the highest percent survival or greatest height growth provenance by itself to arrive at a fitness of 1 (e.g. 0.903/0.903 = 1). The remaining sites were then divided by the most fit provenance and their relative fitness determined (e.g. 0.878/0.903 = 0.97). Overall, fitness was calculated by multiplying survival and height growth relative fitness for each provenance.

RESULTS

Four sites, comprising less than 800 acres, were found to contain longleaf pine in Virginia: Blackwater Ecologic Preserve in Isle of Wight County; Seacock Swamp in Southampton County; Kume property line tree in Southampton County; Union Camp Corporation and adjacent properties along the east bank of the Blackwater River in the City of Suffolk at South Quay (Figure 1). Although Frost (1993) listed a number of Virginia longleaf pine sites from either herbarium specimens, forester reports, or living trees, these four sites are the only ones we can currently verify.

The Blackwater Ecologic Preserve had more trees of larger diameter (312 trees @ 20 cm) than South Quay. The South Quay tract had the largest number of trees (2251), grass stage seedlings (112), acreage (Table 1), and champion tree (66 cm. diameter). (Figure 2). A number of significant plants were found at the South Quay site including extensive stands of the state rare creeping blueberry *(Vaccinium crassifolium* Andrews) and local colonies of the rare pyxie moss *(Pyxidanthera barbulata* Michx.). South Quay is the only site in Virginia where sphagnous depressions containing Atlantic white-cedar *(Chamaecyparis thyoides* BSP) about xeric sand ridges containing longleaf pine and turkey oak *(Quercus laevis* Walter).

The Seacock Swamp site provided a unique opportunity to measure longleaf pine growth at the northern limit. Longleaf pine occurs at this site on mesic sandy ridges intermixed with mature loblolly pine and oaks. A number of old turpentine stumps, tree core data, and land ownership data, suggest this is a natural colony of longleaf pine, which was cut around 1900. Tree diameter data were collected in both 1993 and 1998. The greatest diameter increases were recorded for the largest trees while very little growth was observed for smaller diameter trees. The average diameter increase over 5 growing seasons was only 1.2 cm. (4.8%)! This small average diameter increase may be a result of competition with surrounding mature hardwoods and pines, which dominate the site. Tree diameter was not a good predictor of age (r^2 = 0.19, Fig. 3). In contrast, Platt et al. (1988) found that diameter was a good predictor of age (particularly below 80 yr.) in a south Georgia longleaf stand. This discrepancy may be accounted for by the few trees in our sample and the stressed condition of the stand. Given the small number of trees per acre at Seacock Swamp a release from competition may be necessary to both improve tree growth and enhance the chance of cross-pollination. No seed or seedling has ever been observed on the Seacock Swamp site.

The Kume property line tree in Southampton County is most likely the sole remaining tree from a former longleaf pine stand. We base this conclusion on the large diameter of the tree (53 cm.), the proximity of the South Quay site, and land use practices. Properly line trees are frequently not cut in logging operations and may reflect former forest composition. The Kume property line tree is then probably the last, old survivor of a longleaf pine stand at this site.

To obtain the first seedling at the Blackwater Ecologic Preserve 18,000 seeds/acre are needed (360 cones/acre x 50 seeds/cone = 18,000 seeds/acre). Unfortunately the site was only producing 6475 seeds/acre during the preserve's best recorded seed year of 1987 (4840 yrd^2/1 acre x 9 ft.^{2}/1 yrd^2 x 144 in^2/1 ft.^{2} x 6.4516 cm.^{2}/1 jn.^{2} x 1 m.2/10,000 cm.^{2} x 1.6 seeds/m.^{2} = 6475 seeds/acre).

Virginia longleaf pine had the highest overall fitness when compared to the four southeastern longleaf pine provenances grown in the comparative plantation (Table 2). Virginia longleaf had the highest survival and was only matched by Treutlen County, Georgia stock in height growth. Rapides Parish, Louisiana longleaf pine had an overall relative fitness 93% of Virginia trees while Georgia, Mississippi, and Florida were 85%, 86%, and 17% as fit.

DISCUSSION

Frost (In Preparation) estimated that longleaf pine historically occurred in 1.5 million acres of Virginia as either dominant or mixed stands. This is contrasted with the less than 800 acres documented in this census. Clearly longleaf pine restoration in Virginia has a long way to go.

The absence or very low number of grass stage longleaf pine seedlings in Virginia is cause for concern. The lack of grass stage seedlings at the Kume tract and Seacock Swamp sites may be explained by the shortage of trees for pollination (Kume), inadequate density of trees for cross pollination and lack of seedbed (Seacock Swamp), immaturity of the stand (Blackwater Preserve and South Quay) and lack of sites for seedling recruitment due to fire suppression (South Quay).

Plocher (1993) suggested that the young age of the longleaf pine trees at Blackwater Ecologic Preserve (32 years) may result in low seed production and hence low seedling establishment (5 seedlings/hectare in 1987-1988 bum area 1). Platt et al. (1988) found that age and diameter were strongly related in south Georgia longleaf pine with trees above 60 cm. diameter producing considerably more cones than smaller size classes. There are no trees in this size class or above at Blackwater Ecologic Preserve and only one at South Quay. Furthermore our calculations with 1987 Blackwater Ecologic Preserve data indicate that seed production is a third that required to even establish one seedling per acre (18,000 seeds necessary, only 6475 produced). The shortage of grass stage seedlings at South Quay and the Blackwater Ecologic Preserve is thus most likely caused by the low seed production associated with young trees. Most trees at both sites are below the 30-cm. diameter where few cones and seeds are produced.

Longleaf pine seedlings spring planted at the Blackwater Ecologic Preserve 2 years after a burn had a mortality of 86.9% (Plocher 1993). This high mortality may have been a temporal issue since the recommended planting time for longleaf pine seedling establishment is the fall (Bamett and McGilvray 1997). In addition, the seedlings faced strong competition from surrounding shrubs.

South Quay has a higher number of seedlings than the Blackwater Ecologic Preserve. This greater number of seedlings may be explained by the lack of competitors in sandy gap recruitment sites on xeric ridges. Longleaf pine grows in moister sites adjacent to pond pine habitats at both South Quay and the Blackwater Ecologic Preserve. We found very few grass stage seedlings in these areas compared to the sandy openings on the South Quay xeric ridges. The Blackwater Ecologic Preserve is characterized by less relief than South Quay longleaf pine habitat and as a result more moisture may be available for competitors. Competition can be controlled at the Blackwater Ecologic Preserve by prescribed burning but the natural longleaf pine seedling mortality is 59.5% (Plocher 1993). The challenge is to institute a fire regime, which controls competitors and permits the establishment of longleaf pine seedlings.

The entire Blackwater Ecologic Preserve was clear-cut and burned between 1955 and 1957 based on Union Camp stand records (Plocher 1993). Natural regeneration followed with the exception of the southernmost 1/4 of the preserve, which was planted in Louisiana stock. William Apperson (pers. comm.) observed a sign announcing the planted trees. Plocher (1993) also reported that wetter areas of the Blackwater Ecologic Preserve had trees 50-60 years old suggesting some trees were not cut during the 1950's harvest. Robert Heeren (pers. comm.), retired Union Camp forester, stated that non-native trees were planted on some sections of the South Quay tract, although he could not remember which parcels were planted or the origin of the stock (either Georgia, Louisiana, or both, depending on when the seedlings were obtained). Is there any need concerning ourselves with whether a stand is native, does it matter, and how can these questions be answered?

Our analysis of Allen's (1961) work demonstrates that Virginia longleaf pine are 7-83% more fit than their southeastern counterparts suggesting that native genotypes are locally adapted and offer superior material for in-state planting. Pine species, such as the widespread *Pinus sylvestris,* exhibit a high degree of local adaptation (Savolainen 1994). Seedlings planted as little as 100 km further north than where they normally grew, or at higher altitudes, suffered significant increases in mortality. Populations of this pine species are highly differentiated by the timing of growth cessation and budset. These significant differences in quantitative variation are not exhibited in enzyme loci.

Distinguishing native from planted longleaf pine at Blackwater Ecologic Preserve and South Quay can be approached several ways. Tree ring aging offers the most inexpensive method of determining native trees. Longleaf pine which are older than 50 years fall outside the known period of non-native tree planting and are presumed to be indigenous. In several cases longleaf pine are local within a stand of planted loblolly pine, suggesting they are volunteers from a former longleaf stand, which had been cut and converted to loblolly. This possibility could quickly be addressed with tree ring data since there are not many trees in this category. In other cases old turpentine stumps are found with 70+ year old longleaf pine trees and intact ground cover which is almost certainly an indication of a regenerated stand. The most difficult case involves distinguishing a regenerating native, vigorous stand with active recruitment from a longleaf stand cut and planted with both loblolly and longleaf pine but which also has volunteers from the original harvest. In this case a mix of biometrics and molecular approaches may solve the identity problem.

Does the mix of indigenous longleaf pine and southern genotypes at the Blackwater Ecologic Preserve and South Quay represent a potential problem of reduced fitness through outbreeding depression? Templeton (1986) demonstrated that outbreeding depression occurs when a population is either locally adapted or intrinsically coadapted (genes primarily adapted to genetic environment by other genes). Allen's work (1961) and our analysis of his data indicates a degree of local adaptation by Virginia longleaf pine. Combining Virginia and southern longleaf pine populations (as at South Quay and Blackwater Ecologic Preserve) may then initially result in outbreeding depression. In a worst case scenario outbreeding depression can lead to extinction (Greig 1979).

Outbreeding depression, however, is generally thought to be a transient phenomenon, which is rapidly eliminated by natural selection and can even result in superior coadapted gene complexes (Templeton 1986). The mix of longleaf pine genotypes at two different sites offers the chance to investigate whether outbreeding depression or heterosis (hybrid vigor) is occurring. A suitable control may be found either at a secluded natural stand within one of these tracts or at the natural Seacock Swamp stand.

A prudent conservation and restoration strategy for longleaf pine in Virginia should now attempt to address these important genetic questions. Foresters will want longleaf pine trees that are straight, disease and drought resistant, as well as relatively fast growing. Conservation biologists will want to maximize the preservation of variation present within the longleaf pine population. Given the limited number of trees left in Virginia both approaches are desirable and obtainable. Hopefully a combination of market and environmental incentives outlined by Sheridan and Scholl (1997) will result in the preservation and restoration of the piney woods of Virginia.

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Figure 1. Distribution of longleaf pine in Virginia

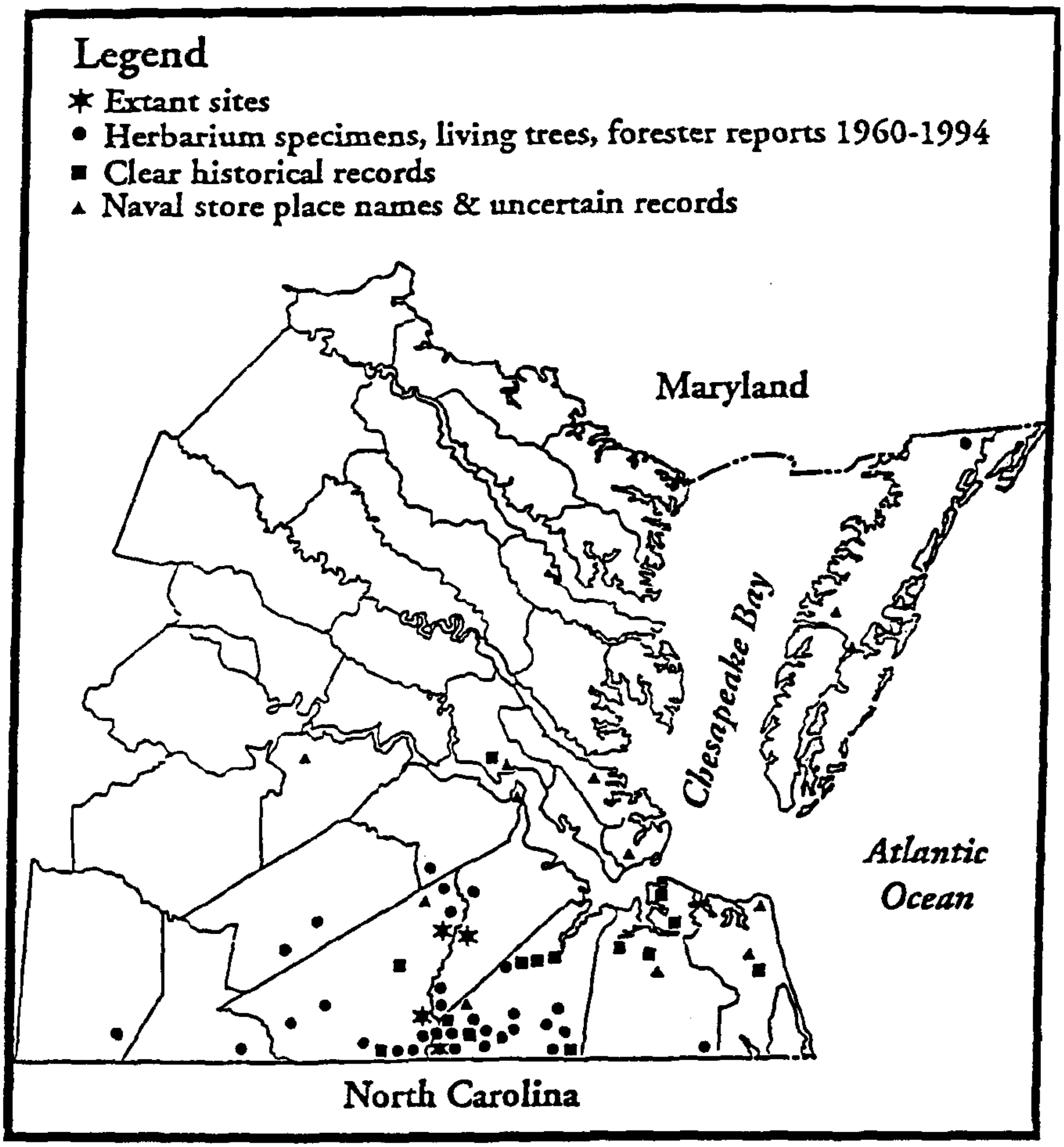

Table 1. Number of longleaf pine trees, seedlings and acreage in Virginia by site.

Site	# trees	# seedlings	acreage
Kume	1	--	--
Seacock Swamp	41	--	195
South Quay	2251	112	459
Blackwater Ecologic Preserve	2139	9	143
Total	4432	121	797

Table 2. Relative fitness of Virginia and southeastern provenance longleaf pine.

	Relative Fitness				
Source	Survival	x	Height	= .	Overall Fitness
Nansemond Co., Virginia	1.0		1.0		1.0
Rapides Parish, Louisiana	0.97		0.96		0.93
Harrison Co., Mississippi	0.90		0.95		0.86
Treutlen Co., Georgia	0.85		1.0		0.85
Hillsborough Co., Florida	0.53		0.32		0.17

Figure 2. Virginia longleaf pine diameter at Blackwater Ecologic Preserve and South Quay.

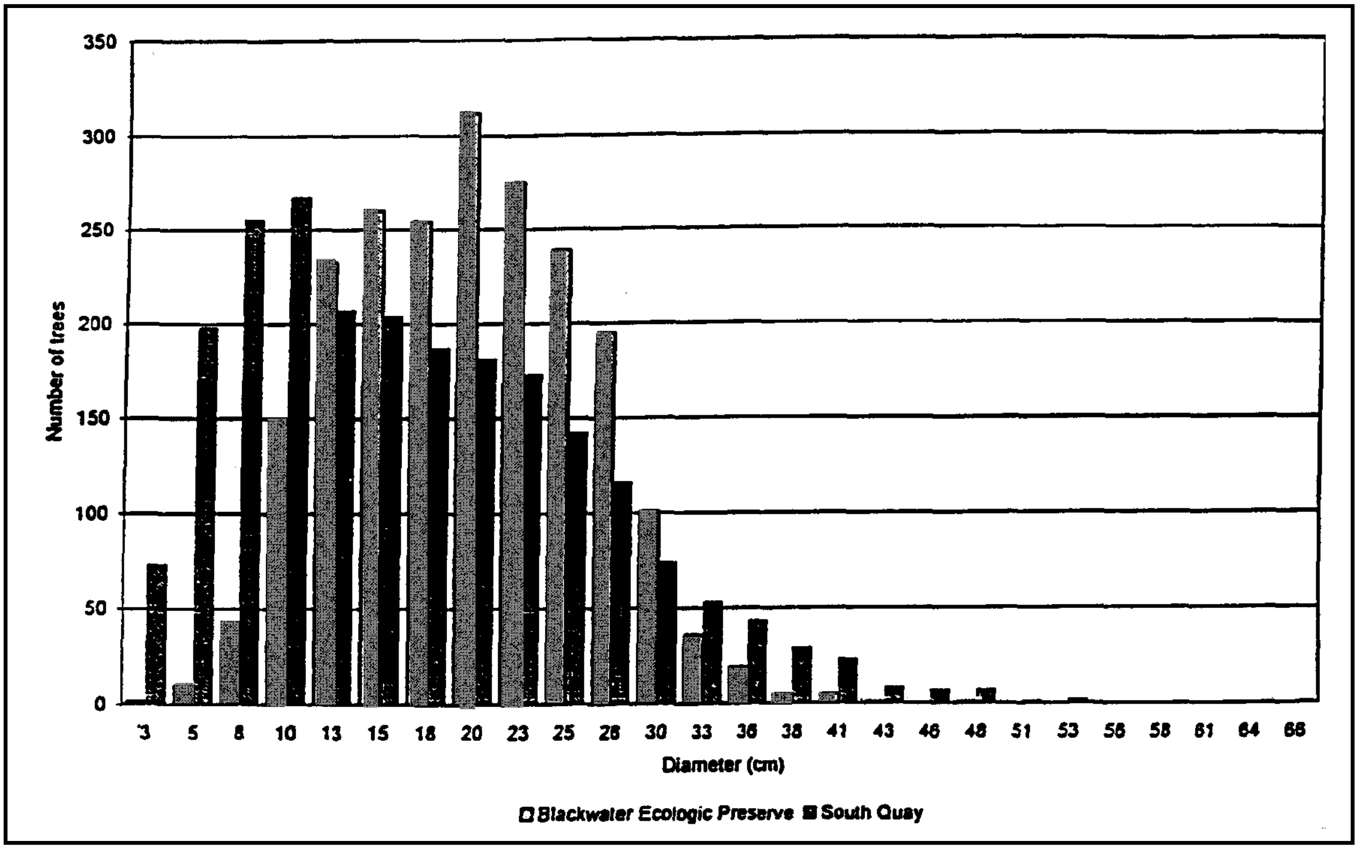

Figure 3. Seacock Swamp longleaf pine (1993) age and diameter comparisons. Diameter is not a good predictor of age (r^2 =0.19).