SITE SUITABILITY FOR SHORTLEAF PINE RESTORATION IN THE EASTERN ALABAMA FALL LINE REGION

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Abstract—Littleleaf disease is the most significant disease of shortleaf pine and has decimated shortleaf pine forests in the Piedmont region of the Southeast. This study used the littleleaf disease hazard soil rating method to evaluate the littleleaf hazard of Piedmont sites owned by Auburn University in the Auburn, Alabama area. The results indicate that a few of these stands are suitable for shortleaf pine management. Furthermore, soil cores were an accurate replacement for soil profiles, and soil series descriptions from the NRCS soil survey were not adequate for remotely assessing a site's littleleaf disease hazard.

INTRODUCTION

Shortleaf pine (*Pinus echinata*) forests were once one of the most widespread ecosystems in the Piedmont and Upper Coastal Plain regions of the southeastern United States (Lawson 1990, Mohr 1901 and 1897, Sargent 1884). Over the last half century, the area of shortleaf pine forests has declined sharply, particularly east of the Mississippi River (Oswalt 2012). Littleleaf disease, which is found primarily in the Piedmont region, is the most significant disease of shortleaf pine and has been responsible for much of this decline. This is due to both actual infection from the disease and to a general aversion towards shortleaf pine management caused by the disease (Campbell and Copeland 1954, Oak and Tainter 1988).

Littleleaf disease is caused by a water mold, *Phytophthora cinnamomi*, that is found in virtually all soils throughout the Southeast (Campbell and Copeland 1954, Mistretta 1984). Under wet soil conditions, *Phytophthora cinnamomi* attacks the fine roots of pine trees and kills them, which can result in the slow decline and mortality of the tree. Mortality depends on how aggressively the tree can grow new fine roots, the duration and frequency of attacks, and the general fertility of the soil. If intervals between wet soil conditions are too short, shortleaf pine cannot adequately grow new fine roots and will die from nitrogen deficiency (Campbell and others 1953, Campbell and Copeland 1954, Mistretta 1984). Due to the dependence of *P. cinnamomi* on wet soil conditions, littleleaf disease is most prevalent in poorly drained, heavy clay soils such as those commonly found in the Piedmont. Shortleaf pine is the most severely affected species, but loblolly pine (*Pinus taeda*) is also susceptible to a lesser degree.

Even in areas of high littleleaf disease incidence, the disease is site-specific based on soil drainage and erosion qualities (Campbell and Copeland 1954). A method for rating the littleleaf hazard of soils was developed by Campbell and Copeland (1954) that involves scoring four metrics of soil erosion and internal drainage: topsoil erosion, subsoil consistency, depth to the zone of greatly reduced permeability (permeability depth), and subsoil mottling. Topsoil erosion is rated as either "slight" (40 points), "moderate" (30 points), "severe" (20 points), or "rough gullied" (10 points); subsoil consistency is rated as either "very friable" (32 points), "friable" (24 points), "firm" (16 points), "very firm" (8 points), or "extremely firm" (0 points); permeability depth is measured in inches and grouped from 24-36 inches (15 points), 18-23 inches (12 points), 12-17 inches (9 points), 6-11 inches (6 points), or 0-6 inches (3 points); and subsoil mottling is rated as either "none" (13 points), "slight" (9 points), "moderate" (5 points), or strong (1 point). The sum of these four scores determines if a soil is at severe risk (0-50 points), moderate risk (51-74 points), or low risk ("healthy;" 75-100 points) for littleleaf disease (a full description of this soil rating method can be found in Campbell and Copeland 1954). This rating method should make it possible to assess potential shortleaf pine restoration sites in the Piedmont and other areas where littleleaf disease is a concern. With increasing interest in restoring shortleaf pine, extension agents, foresters, and forestry educators can contribute greatly to these efforts by instructing landowners on how to assess sites using this method. This paper outlines such an assessment and the soil testing procedure used.

METHODS

The site specific littleleaf hazard rating system was used to evaluate fifty stands on three tracts owned by

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Auburn University. Streamside Management Zones (SMZs) and open areas were not examined. The smallest stand evaluated was 1.2 acres, the largest was 51.9 acres, and the mean stand size was 16.1 acres. Four plots were semi-randomly placed in each stand using a topographical map to ensure coverage of major topographical features (e.g. slopes, ridgetops). Nine stands had less than four plots, due to small size or boundaries inconsistent with the stand map. Plots were navigated to using a F4 Devices Forge hand-held GPS unit (F4 Devices. http://f4devices.com/products/forge). At each plot, soil cores were collected using a 1 inch diameter by 16 inch deep cylindrical metal soil push probe. Prior to collection, the litter layer was cleared away and the soil probe inserted into the ground until substantial resistance was encountered. Once the soil core sample was obtained, it was evaluated for subsoil consistency, permeability depth, and subsoil mottling.

Subsoil consistency was measured by feeling the friability of the B-horizon soil layer (as described in Campbell and Copeland 1954). Depth to zone of greatly reduced permeability was measured as the depth of the soil core, measured in inches. The B-horizon layer was evaluated for subsoil mottling as described in Campbell and Copeland (1954). Erosion was assessed within each stand while traversing the stand, based on the degree of gullying and other visible signs of soil erosion (as described in Campbell and Copeland 1954). However, different ratings were given to individual plots if local conditions were substantially different from those in the rest of the stand.

The shortleaf pine component of each stand was assessed for the amount, size, and over-all health of individual trees. This assessment was limited to anecdotal observations along traverse routes. Stands with apparent, large, many and healthy shortleaf pine individuals were noted as having an important shortleaf pine remnant. Site sampling was conducted from December, 2014 to January, 2015.

Once initial data were analyzed, the numbers of plots required to achieve 10 percent +/- error in each stand were determined, and additional plots were added to thirteen stands to achieve this level of accuracy. Stand ratings were determined from the mean of the plots within each stand, and single sample, one-way t-tests were conducted on stand level data to determine which ones were equal to or over either 75 or 51, using Minitab Statistical Software version 17 (Minitab, Inc. 2015. www.minitab.com). The NRCS Web Soil Survey was used to determine which soil series each plot fell in, and plots were pooled by soil series and compared to each other using ANOVA tests, Tukey's range test, and t-tests. The number of plots required for each stand to achieve 10 percent +/- error was compared to stand size using simple regression analysis. Stands were then pooled based on whether they contained one or more soil series, and the average number of plots required in each group compared with a t-test. The soil ratings of stands noted for shortleaf pine were compared to those of stands without shortleaf pine using a t-test. Minitab Statistical Software version 17 and a confidence level of 90 percent (P-value < 0.1) were used for all tests.

Follow up testing was done in March, 2015, which involved digging seven soil profiles in one stand, evaluating the littleleaf hazard of each profile, and comparing the littleleaf hazard rating obtained from the soil profile to the littleleaf hazard rating obtained from a soil core taken from the center of the soil profile prior to digging the profile. The profiles were placed semi-randomly throughout the stand. Both the permeability depths and total littleleaf hazard ratings obtained from the profiles and cores at each location were compared using simple linear regression.

RESULTS

A total of 216 soil plots were taken in the fifty stands. Of these plots, 157 fell in Pacolet sandy loams, 52 fell in Gwinnett sandy loams, six fell in Enoree silt loams, and one fell in a Hiwassee sandy loam. Between one and eight plots were taken in each stand, with a mean of 4.3 plots per stand. The mean number of plots required for 10 percent +/- error was 1.7. Eleven of the fifty stands had important shortleaf pine remnants.

Two stands had a mean rating of 75 or higher and were rated as healthy. The remaining 48 stands had mean ratings between 50 and 75 and were classified as moderate littleleaf hazard stands. However, 15 of the moderate hazard stands were rated just below the threshold for healthy (between 70 and 75, $P < 0.1$).

There was no significant difference between littleleaf hazard ratings based on soil series type. Slope had no affect either, both within individual soil series or between soil series. There was no significant difference between ratings of stands with or without a shortleaf pine component, and both groups fell within the moderate hazard rating.

There was no significant trend between the size of a stand and the number of plots needed to sample the soil to 10 percent +/- error (slope = 0.01157 R-sq. = 0.6 percent), no difference between the number of plots required per stand based on soil series type, and no difference based on whether stands had one or two soil series (no stands with more than two soil series were tested). Both Pacolet and Gwinnett sandy loams were rated lower than suggested by their soil series survey descriptions. Oak and Tainter (1988) predicted that both of these soil series would be classified as healthy, but in this study both were classified as moderate hazard with a mean rating of 71 each.

Soil profiles yielded deeper permeability depth measurements than soil cores, and this difference increased with permeability depth (slope = 1.84, R-sq. = 74.6 percent, lower 90 percent CI = 1.07). However, this difference did not cause soil profiles to yield higher total littleleaf hazard ratings (slope = 1.03, R-sq. = 98 percent, lower 90 percent CI = 0.89).

DISCUSSION

Between two healthy stands and fifteen stands that were rated on the high end of moderate hazard (70-75), there should be suitable sites for shortleaf pine management on the tested tracts. Data from Campbell and Copeland (1954) indicate that mortality rates may be lower on sites rated from 70-75 than on sites rated below 70. The lack of difference between the littleleaf hazard of stands with or without shortleaf pine indicates that the presence of remnant shortleaf pine is probably due to past management rather than littleleaf disease severity. However, the shortleaf pine assessment did not fully, systematically, or equally cover the sampled stands. To fully compare stands with remnant shortleaf pine to those without, an intentional survey for remnant shortleaf pine would have to be conducted on all the sampled stands.

This study suggests that taking between four and eight plots should yield accurate results for most stands 50 acres or less with two or less soil series. Despite differences in at least one individual measure, soil cores appear to give equivalent results to soil profiles and may be used in their place. Because soil cores can be taken and measured easily and quickly, eight cores are recommended when sampling just one stand. If many stands are being sampled and time is limited, four plots per stand would likely yield suitable results. It is likely that these numbers would work for stands larger than 50 acres, as well.

Soil series descriptions were not adequate for remotely assessing littleleaf hazard. Both Pacolet and Gwinnett soils should be rated healthy based on their soil series descriptions, but both these series were rated moderate in this study. This discrepancy was likely due to erosion that has occurred since the original soil survey was conducted, and suggests that soil sampling is required for accurate littleleaf hazard determination, especially in soils predicted to have low hazard. More soil series should be tested and the results compared to predictions made from the series' survey descriptions in order to further explore this effect. It is likely that soil series descriptions can be used to determine unsuitable sites, because there is a low likelihood of soils showing substantial drainage and depth improvements since original soil surveys were conducted.

CONCLUSION

The Piedmont and Upper Coastal Plain were two of the areas of greatest historical shortleaf pine forest extent, and for current restoration efforts to be complete they must include sites in these regions. In the Piedmont in particular, the littleleaf hazard soil rating method developed by Campbell and Copeland (1954) may be used to assess a potential restoration site's risk of littleleaf disease. An initial evaluation should be made based on the described drainage properties of a site's soil series. If the soil series description suggests that the site is safe from littleleaf disease, eight soil cores should be taken throughout the stand, ensuring coverage of the major topographic features, and rated for littleleaf hazard using Campbell and Copeland's (1954) methodology. If many stands are being measured and time is limited, as few as four cores per stand will likely be sufficient. More cores may be needed if three or more soil series are found on the site. Testing additional soil series and stands with three or more soil series should contribute towards refining this easy and cheap method of evaluating the littleleaf disease hazard on potential shortleaf pine restoration sites in the littleleaf disease range.

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