A COMPARISON OF NORTHERN AND SOUTHERN TABLE MOUNTAIN PINE STANDS

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Abstract—Table Mountain pine (*Pinus pungens*) stands occur throughout the Appalachian Mountains, but ecological research has concentrated on the southern part of this region. In 2006, research was initiated in northern Table Mountain pine stands growing in PA to compare some basic attributes of those stands with previously described ones in TN. Overall, the northern and southern stands were quite similar. Both contained 13 species, 10 of which they had in common. In the overstory, the PA stands had fewer trees, fewer pines, more oaks (*Quercus* spp.), and less basal area per acre than the TN stands. The PA stands also had Table Mountain pines with nonserotinous cones while those in TN had sealed cones. In the understory, the TN stands had more shrub cover, taller shrubs, and much less pine regeneration per acre than the PA stands. The presence of pine regeneration in PA and its absence from TN are likely due to the differences in cone type and shrub cover.

INTRODUCTION

Mountain pine (*Pinus pungens*) is a native hard pine of the Eastern United States. It, along with pitch pine (*P. rigida*), shortleaf pine (*P. echinata*), and Virginia pine (*P. virginiana*), forms small scattered stands throughout the Appalachian Mountains. Table Mountain pine (TMP) stands occur from southern PA to northern GA on thin, dry soils of south- and west-facing ridges and upper slopes between 1 000 and 4 000 feet (Della-Bianca 1990, Williams 1998, Zobel 1969). TMP stands are becoming increasingly valued for diversity by land managers because they constitute an uncommon conifer community in an otherwise hardwood-dominated forest landscape.

Because of this intrinsic diversity value, TMP stands have been rather extensively studied by forest ecologists over the past 15 to 20 years. Before 1990, only eight papers were published and four were authored by the same individual (Barden 1977, 1979, 1988; Barden and Woods 1974). Since 1990, publications on TMP stands have nearly quadrupled to 30 papers; however, virtually all of this research has been conducted in the southern Appalachian Mountains. TMP stands in the northern part of its range have been virtually ignored. The only research focused on northern TMP stands was that by McIntyre (1929) and Zobel (1969). The former studied cone and seed production and the latter included five TMP stands from PA in his monograph on the ecology of the species.

In 2006, an opportunity arose to complete a dendroecology study started in 1991 of three TMP stands in southern PA (the northern end of Table Mountain pine's range). In this paper, we compare the characteristics of those stands (PA) to TMP stands growing at the southern end of the species range in eastern Tennessee (TN).

METHODS

Study Sites

Two of the three northern TMP stands were on Mont Alto Mountain in the Michaux State Forest and the other was on Martin Hill in Buchanan State Forest. All three of the southern TMP stands were on Gregory Ridge in Great Smoky Mountains National Park. All of the TMP stands occurred on the top and upper slopes of north-south oriented ridges. The PA stands were primarily on the west side of the ridges with azimuths ranging from 220 to 290 degrees while the TN stands were on east aspects (azimuths from 90 to 120 degrees). All stands were rocky and steep; slope sometimes exceeded 50 percent. The PA stands ranged in elevation from 1 500 to 1 900 feet a.s.l. while those in TN were about twice as high above sea level (2 880 to 3 540 feet). Soils in all stands were sandy loams that formed in place by the weathering of gneiss, sandstone, and schist parent material (Davis 1993, Knight 1998, Long 1975). Consequently, soils were of low fertility and strongly acidic. All stands appeared to have been undisturbed for decades and were composed of TMP, one or more other pine species, several hardwoods (especially chestnut oak (*Quercus montana*)), and various ericaceous shrubs.

In 1999, in each southern TMP stand, fifteen 0.05-acre (33 by 66 feet) rectangular plots were systematically established to uniformly cover the area as part of a landscape-scale TMP dendroecology project (Brose and Waldrop 2006). In 1991, in the three northern TMP stands, a total of 60 to 65 dominant Table Mountain pines were selected and tagged for use in a dendroecology study. This project was never completed and those stands and tagged trees were relocated in 2006. Two stands still existed and 15 tagged pines were randomly selected in each one, and a 0.05-acre circular plot was established with the tagged tree at the center. The other PA stand no longer existed so a nearby TMP stand was selected as its replacement based on similarity in appearance to the other two PA stands. In this stand, we systematically selected 15 dominant TMPs to uniformly cover the area and established a 0.05-acre circular plot around each of these dominant TMPs.

In each plot, all trees more than 10 feet tall were identified to species, counted, and measured to the nearest inch in diameter at breast height (d.b.h.). These data were subsequently used to calculate importance values for each species (Cottam and Curtis 1956). Pine seedlings and saplings less than 10 feet tall were also tallied throughout the

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entire plot into one of three height classes: less than 2 feet, 2 to 5 feet, and more than 5 feet. We estimated percent cover of evergreen shrubs, almost exclusively mountain laurel (*Kalmia latifolia*), for the entire plot by standing in the center and visually grouping all shrubs together (Marquis and others 1992). Shrub height was measured to the nearest half-foot on one shrub visually judged to be the average height of all shrubs present on the plot. Slope and aspect were also determined from plot center and recorded to the nearest degree and azimuth.

Our null hypotheses were that no differences existed between the PA and TN sites in any of the plot-level response variables, i.e., basal area, trees per acre, seedling and sapling density, shrub cover and height, etc. Each of these was compared between the PA and TN sites using t-tests with separate variances (SAS 2002). To ensure the assumptions of independence and normal distribution were met, the data from the stands in each respective state were pooled. This increased sample size to 45 for each state and limited the effect of any intrastand relationship due to two or more of the individual stands having a shared developmental history.

RESULTS

The PA and TN sites had numerous tree species in common (Table 1). Thirteen tree species were found at each site and ten of these occurred at both sites. Species common to PA and TN were: Table Mountain pine, pitch pine, chestnut oak, scarlet oak (*Q. coccinea*), white oak (*Q. alba*), red maple (*Acer rubrum*), blackgum (*Nyssa sylvatica*), American chestnut (*Castanea dentata*), serviceberry (*Amelanchier* spp.), and pignut hickory (*Carya glabra*). Black oak (*Q. velutina*), flowering dogwood (*Cornus florida*), and sourwood (*Oxydendrum arboreum*) were found only in the TN stands while eastern white pine (*P. strobus*), sweet birch (*Betula lenta*), and eastern hemlock (*Tsuga canadensis*) were present only in the PA stands.

Table Mountain pine was the most important conifer at both sites with importance value (IV) scores of 27 for PA and 31 for TN (table 1). These relatively high IV scores were the result of this species' abundance, size, and stocking. TMP densities were 78 and 161 trees per acre for PA and TN, respectively. This species also had the most basal area with an average of 58 square feet per acre for PA and 78 square feet per acre for TN. Table Mountain pine was quite widespread at both sites; occurring in all 45 plots in PA and 40 of 45 plots in TN. Pitch pine was the only other conifer common to both sites and was an important species in Tennessee (IV = 19) where it averaged 99 trees per acre, 38 square feet per acre of basal area and was found in 37 of the 45 plots. Pitch pine was not nearly as important in PA where its abundance, dominance, and stocking were 7 trees per acre, 4 square feet per acre of basal area, and 17 of 45 plots, respectively, gave it an importance value of 5.

Chestnut oak was the most important tree species in PA with an importance value of 29 (Table 1). In PA, chestnut oak averaged 103 trees per acre, 60 square feet per acre of basal area, and occurred on 41 of 45 plots. Scarlet oak was the second most important hardwood in PA's TMP stands (IV = 17). It was quite abundant and widespread, 88 trees per acre and 38 of 45 plots, respectively, but lacked in dominance with an average basal area of 14 square feet per acre. Chestnut oak also was the most important hardwood in the TMP stands in TN. There it averaged 47 trees per acre, 22 square feet per acre of basal area, and was found on 33 of 45 plots. These characteristics gave chestnut oak an importance value of 12, making it the third most important species overall—well behind Table Mountain and pitch pine. Red maple was a close second in importance (IV = 11) to chestnut oak in the TN stands because it had slightly fewer trees per acres and occurred on slightly fewer plots.

Between the two sites, all response variables were significantly different (Table 2). TN averaged more trees per acre, 435, and more basal area, 205 square feet per acre, than did PA which had 374 trees per acre and 151 square feet per acre. Mountain laurel covered an average of 54 percent of each plot in TN while mean cover in PA was less than half that amount. Average height of mountain laurel in TN was 8.1 feet, double the mean height of mountain laurel found in PA (4.0 feet). TMP regeneration also differed between the sites. In TN, regeneration of any pine species was virtually non-existent; less than five stems per acre and all less than 2 feet tall. In PA, density of TMP regeneration averaged 350 stems per acre and these were found in all size classes: 250 less than 2 feet tall, 75 between 2 and 5 feet tall, and 25 more than 5 feet tall. Although not quantified, it was observed that nearly all TMP cones in TN were sealed shut with resin (serotinous) regardless of how many years they had been on the branches but those in PA were nonserotinous and opened in the fall and winter to disperse the seeds.

DISCUSSION

At first glance, the TMP stands in PA and TN appear to have much in common. All occur on or near the top of steep rocky ridges. All stands have somewhat of a southerly aspect. In both states, pines dominate a discontinuous overstory and a mix of oaks and other hardwoods form the midstory. They share the same two major pine and hardwood species—Table Mountain pine and chestnut oak. They have eight associate species in common. Mountain laurel is found to varying degrees in all stands.

Despite their similarities, we detected significant differences in the overstory, shrub, and regeneration layers between the two states. The PA TMP stands are, in reality, oak-pine stands because they have considerably more oak than pine; the TN stands are the opposite: pine-oak stands with noticeably more pine than oak. This difference in composition is likely due to differences in their developmental history.

The PA stands are near old charcoal iron furnaces (Birkenbine 1894). During the 1800s, this industry completely clearcut forests on a 15 to 20 year cycle. Such an intense, frequent disturbance regime promotes species capable of resilient sprouting and precocial seed production. Chestnut oak has both traits (McQuilken 1990). Sprouting probability ranges from 50 to 100 percent depending on stem diameter and chestnut oak sprouts can produce abundant acorn crops by age 7 or 8. Many forests used by the charcoal iron industry were protected

Table 1—Tree species found in the Pennsylvania and Tennessee TMP stands and their abundance (trees per acre), dominance (ft^2/ac of basal area), stocking (number of plots with at least one stem), and importance value (average of relative abundance, dominance, and stocking expressed as a percent)

Common Name	Abundance	Dominance	Stocking	Imp. Value
Pennsylvania				
Chestnut oak	103	60	41	29
Table Mountain pine	78	58	45	27
Scarlet oak	88	14	38	17
Red maple	47	3	25	9
Blackgum	24	4	22	7
Pitch pine	7	4	17	5
Eastern white pine	11	2	7	2
American chestnut	3	1	4	1
Pignut hickory	3	1	2	<1
Serviceberry	5	2	5	<1
Sweet birch	3	1	5	<1
White oak	5	2	3	<1
Eastern hemlock	3	1	6	<1
Totals	374	151	214	100
Tennessee				
Table Mountain pine	161	78	40	31
Pitch pine	99	38	37	19
Chestnut oak	47	22	33	12
Red maple	42	22	30	11
Scarlet oak	24	13	21	7
Sourwood	15	9	22	6
Blackgum	16	9	17	5
Black oak	16	9	9	3
Serviceberry	4	1	4	2
American chestnut	3	1	4	1
Pignut hickory	3	1	2	1
White oak	3	1	2	1
Flowering dogwood	2	<1	2	1
Totals	435	205	223	100

from fire and livestock grazing (Birkenbine 1894). Decades of this type of disturbance regime likely contributed to chestnut oak dominating these sites and making them oak-pine forests.

The TN stands were never logged but did experience frequent fire and livestock grazing due to their proximity to Cades Cove (Dunn 1988). Throughout the 1800s and early 1900s, farmers of this isolated community burned the surrounding forest to provide forage for their cattle and hogs. The stands were essentially wooded pastures until the 1920s. The hog feeding probably was especially critical to the lack of chestnut oak in the current stands. Hogs feed heavily on nuts in the autumn, and the large acorns of chestnut oak would have been a prime target. Few acorns probably survived to become seedlings. Those that did then had to withstand frequent surface fires and browsing by cattle, other livestock, and wildlife. When the burning and grazing regime abated in the late 1920s and early 1930s with the abandonment of Cades Cove, the growing space was captured by fast-growing pines resulting in the present pine–oak forest.

The TN stands had significantly more mountain laurel than the PA stands and the TN laurel was twice as tall. Not enough is known about the seedbed requirements of

Table 2—Attributes (mean ± one standard error) of the overstory, shrub, and regeneration layers at the Pennsylvania and Tennessee TMP stands. Small, medium, and large TMP seedlings are < 2 feet tall, 2 to 5 feet tall, and > 5 feet tall, respectively

Attribute	Pennsylvania	Tennessee
Overstory density (trees/acre)	374 ± 16	435 ± 21*
Overstory basal area (square feet/acre)	151 ± 11	205 ± 17*
Mountain laurel cover (percent)	23 ± 10	54 ± 18*
Mountain laurel height (feet)	4.0 ± 1.3	8.1 ± 1.5*
Small TMP density (seedlings/acre)	250 ± 108	4.3 ± 3.6*
Medium TMP density (seedlings/acre)	75 ± 39	0.0 ± 0.0*
Large TMP density (seedlings/acre)	25 ± 16	0.0 ± 0.0*
Serotinous cones present (yes/no)	No	Yes

* significant difference at the 0.05 level between states for that particular attribute.

mountain laurel to know if a fire/grazing regime would favor the shrub over a frequent cutting regime. The differences between states may be due to latitudinal and altitudinal variables because mountain laurel cover and height in TMP stands tend to increase from north to south and from low to high elevation (Zobel 1969, authors' pers. obs.).

Perhaps the most interesting difference between PA and TN TMP stands is the difference in pine seedling density and height. The PA stands had abundant Table Mountain pine regeneration of varying heights. Some stems were more than 10 feet tall. The three TN stands had only a few pine seedlings and they were always just a few inches tall.

This stark difference is likely due to two important factors: coverage of mountain laurel and serotiny of the Table Mountain pine cones. The TN stands had widespread, tall mountain laurel to the point that more than 50 percent of the stands were covered. Often, this shrub would be so dense it was nearly impossible to crawl through it. Additionally, the laurel was tall, averaging 8 feet in height. Consequently, these laurel thickets continually cast a dense shade on the forest floor and Table Mountain pine seedlings are intolerant of dense shade (Della-Bianca 1990). Additionally, the Table Mountain pine cones in TN were serotinous. Nearly all the cones for the past several years were still sealed shut with resin and attached to the branches. The TN stands suffered from limited seed fall and limited suitable seedbeds. Consequently, Table Mountain pine regeneration was virtually nonexistent.

The PA TMP stands did not have these same seed fall and seedbed limitations. Table Mountain pine in PA has nonserotinous cones; they open every fall to release their seeds. Consequently, there is a fairly regular seed fall and these seeds have a reasonable chance to find a suitable seed bed because the PA TMP stands also had much less mountain laurel. Coverage and height of this shrub was less than half that of TN and except for a few small areas, moving through the Pennsylvania stands was fairly easy. Where mountain laurel was dense in the PA stands, no pine regeneration was found.

Perpetuation of Table Mountain pine stands in either state requires active management. In TN, prescribed fire is probably the only reasonable method for perpetuating these TMP stands because they are in a national park (no logging and only restricted herbicide use) and the mountain laurel shrub layer is already dense enough to preclude regeneration. Burning of mountain laurel can be difficult due to its high flammability, but the intense fire readily kills the laurel, opens the sealed cones, and creates a suitable seedbed (Waldrop and Brose 1999). In PA, logging probably is a suitable approach because the cones open without fire and the laurel is still a minor obstacle to regeneration. The key will be to sufficiently disrupt the laurel shrub layer to prevent its spread and establish new pine seedlings.

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LITERATURE CITED

Barden, L.S. 1977. Self-maintaining populations of *Pinus pungens* in the southern Appalachian Mountains. Castanea. 42: 316-323.

Barden, L.S. 1979. Serotiny and seed viability of *Pinus pungens* in the southern Appalachians. Castanea. 44: 44-47.

Barden, L.S. 1988. Drought and survival in a self-perpetuating *Pinus pungens* population: equilibrium or nonequilibrium? American Midland Naturalist. 119: 254-257.

Barden, L.S.; Woods, F.W. 1974. Characteristics of lightning fires in southern Appalachian forests. In Komarek, E.V. (ed.) Proceedings of the 13th Tall Timbers fire ecology conference: a quest for ecological understanding. Tall Timbers Research Station, Tallahassee, FL: 345-361.

Birkenbine, J. 1894. The charcoal industry. In: Report of the Forestry Commission to the Pennsylvania Department of Agriculture. Harrisburg, PA: Pennsylvania Department of Agriculture: 118-123.

Brose, P.H.; Waldrop, T.A. 2006. Fire and the origin of Table Mountain pine – pitch pine communities in the southern Appalachian Mountains, USA. Canadian Journal of Forest Research. 36: 710-718.

Cottam, G.; Curtis, J.T. 1956. The use of distance measures in phytosociological sampling. Ecology. 37: 451-460.

Davis, H.A. 1993. Soil survey of Blount County, Tennessee. Knoxville, TN: U.S. Department of Agriculture. 121 p.

Della-Bianca, L. 1990. Table Mountain pine (*Pinus pungens* Lamb). In Burns, R.M.; Honkala, B.H., (tech. cords.) Silvics of North America Volume I. Conifers. Handbook 654. U.S. Department of Agriculture Washington, DC: 425-432.

Dunn, D. 1988. Cades Cove: The Life and Death of a Southern Appalachian Community. University of Tennessee Press, Knoxville, TN: 319 p.

Knight, R.F. 1998. Soil survey of Bedford County, Pennsylvania. U.S. Department of Agriculture, Harrisburg, PA: 138 p.

Long, M.S. 1975. Soil survey of Franklin County, Pennsylvania. U.S. Department of Agriculture, Harrisburg, PA: 165 p.

Marquis, D.A.; Ernst, R.L.; Stout, S.L. 1992. Prescribing silvicultural treatments in hardwood stands in the Alleghenies. Gen. Tech. Rep. NE-96. U.S. Forest Service, Northeastern Forest Experiment Station, Radnor, PA: 101 p.

McIntyre, A.C. 1929. A cone and seed study of the mountain pine (*Pinus pungens* Lambert). American Journal of Botany. 16: 402-406.

McQuilken, R.A. 1990. Chestnut oak (*Quercus prinus* L.). In Burns, R.M.; Honkala, B.H. (tech. cords.) Silvics of North America Volume II. Hardwoods. Handbook 654. U.S. Department of Agriculture, Washington, DC: 721-726.

SAS. 2002. User's Guide. SAS Institute Inc., Cary, NC.

Waldrop, T.A.; Brose, P.H. 1999. A comparison of fire intensity levels for site replacement of Table Mountain pine (*Pinus pungens* Lamb.). Forest Ecology and Management. 113: 155-166.

Williams, C.E. 1998. History and status of Table Mountain pine - pitch pine forests of the southern Appalachian Mountains (USA). Natural Areas Journal. 18(1): 81-90.

Zobel, D.B. 1969. Factors affecting the distribution of *Pinus pungens*, an Appalachian endemic. Ecological Monographs. 39: 303-333.