THE EFFECT OF FIRE ON FLOWERING DOGWOOD STAND DYNAMICS IN GREAT SMOKY MOUNTAINS NATIONAL PARK

Eric J. Holzmueller, Shibu Jose, and Michael A. Jenkins[1]

Abstract—Flowering dogwood (*Cornus florida* L.) survival is threatened across most of its range in forests of the eastern United States by dogwood anthracnose, a disease caused by the fungus *Discula destructive* Redlin. Where anthracnose is present, mortality of dogwood has been severe. Currently, no management techniques exist to reduce impacts of the disease on populations of dogwood. This study examined dogwood in burned and unburned oak-hickory forests in Great Smoky Mountains National Park (GSMNP) to determine if past burning has favored dogwood survival. Stand composition and structure of areas that burned in the 1970s and 1980s were compared to those in unburned areas to determine if dogwood stem density was affected by fire. Heavy dogwood mortality has occurred in unburned areas in western GSMNP over the past two decades. However, dogwood density was greater in areas that burned during the 1970s (232 ± 64 stems/ha) than in unburned areas (54 ± 72 stems/ha; P=0.08). The increase in dogwood stem density in burned plots is likely a result of increased stump sprouting following the fire and the favorable conditions for survival from dogwood anthracnose fire creates. Our results suggest fire may play an important role in dogwood survival from dogwood anthracnose in GSMNP and other areas in the Eastern United States.

INTRODUCTION

Cornus florida L. (flowering dogwood), a common understory species in the Eastern United States, is found in a variety forest types ranging from mesic cove hardwood stands to xeric oak-pine woodlands. Dogwood is shade tolerant but can grow in full sunlight. Dogwood trees produce a calcium-rich fruit during the fall that is consumed by many bird and small game species. Leaves of dogwood trees also contain high amounts of calcium (2.0-3.0 percent, oven dry weight), which makes dogwood an important factor in calcium cycling in eastern hardwood forests (Thomas 1969).

Discula destructiva Redlin, the fungus that causes a disease known as 'dogwood anthracnose', is decimating dogwood populations across the Eastern United States. The fungus is believed to be an exotic from Asia brought over on contaminated nursery stock (Britton 1994). Dogwood anthracnose causes leaf blight and twig dieback. In smaller trees, this can lead to death 1 to 3 years after infection. Larger trees usually tolerate the leaf blight and twig dieback longer, but eventually the disease moves into the stem where cankers develop that girdle the tree. Dogwood anthracnose was first observed in New York City in 1978 (Pirone 1980) and moved rapidly down the Appalachian Mountains over the next decade. The disease is now present throughout most of the Northeastern United States and Appalachian Mountain region, as well as in some scattered pockets in the Midwest.

In areas where the disease has been found, dogwood trees have experienced high rates of mortality. Anagnostakis and Ward (1996) reported an 86 percent mortality rate in dogwood density from 1977 to 1987 in Connecticut, while Hiers and Evans (1997) observed a 91 percent decline between 1983 and 1995 in Tennessee. In Great Smoky Mountains National Park (GSMNP), Jenkins and White (2002) observed similar trends in dogwood decline. Between the late 1970s and 2000, dogwood decline ranged from 92 percent in alluvial forests to 80 percent in oak-hickory forests and 69 percent in oak-pine forests. In an oak-dominated area that burned in 1976, however, dogwood density increased 200 percent (fig. 1).

This research was conducted to determine if similar increases in density occurred in other areas of the park that burned during the 1970s and 1980s. We hypothesize that stands burned during the 1970s and 1980s will have greater dogwood densities than unburned stands.

STUDY AREA

Established in 1934, GSMNP is located in the heart of the southern Appalachian Mountains in eastern Tennessee and western North Carolina. The Park is over 200,000 ha, and its flora is among most diverse in eastern North America. Mean annual temperature in Gatlinburg, TN (440 m a.s.l.) is 12.9 °C; mean annual precipitation is 142 cm. Although the highest point in the Park is over 2,000 m, our study sites ranged

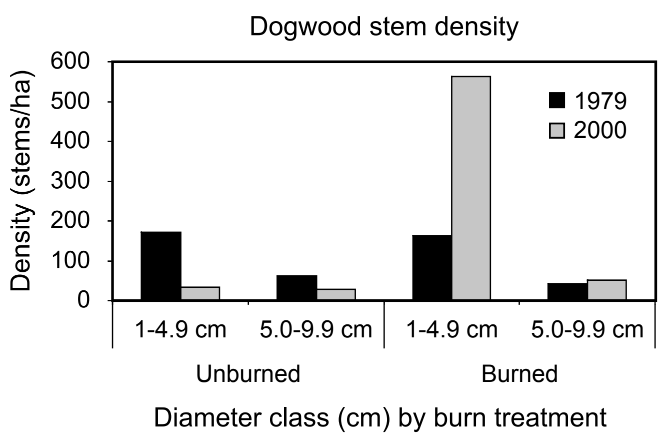

Figure 1—Dogwood stem density in Great Smoky Mountains National Park on burned and unburned plots for two size classes sampled in 1979 and 2000.

[1] Research Assistant, University of Florida, Gainesville, FL 32611; Associate Professor, University of Florida, Gainesville, FL 32611; and Ecologist, Great Smoky Mountains National Park, Gatlinburg, TN 37738, respectively.

Citation for proceedings: Connor, Kristina F., ed. 2006. Proceedings of the 13th biennial southern silvicultural research conference. Gen. Tech. Rep. SRS–92. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 640 p.

between 287 to 975 m, which represents the pre-anthracnose elevation range of dogwood.

We used historic Park maps and fire history records to select burned areas for sampling. We established 29 0.04-ha plots in 7 areas that burned in the 1970s or 1980s. A minimum of three plots were established in each burn. All burns selected were at least 10 ha in size. We randomly selected plot locations within each burn by placing a 50 m buffer within the perimeter of each burn and randomly selecting coordinates. All plots were located in oak-hickory forest stands. In addition, 23 reference plots were sampled in unburned stands. These unburned reference plots had similar slope, aspect, elevation, and vegetation as the burned plots.

Data were collected from 52 plots from 2001 to 2004 during the months of June, July, and August. Diameter at breast height (d.b.h.) of all living overstory stems (>10 cm) was measured to the nearest 0.1 cm and recorded by species. We also measured the d.b.h. of all living dogwood stems, including trees < 10 cm d.b.h., to the nearest 0.1 cm. Understory stems (≤10 cm d.b.h.) of all other species were tallied into 4 diameter classes: 0 to 1.0 cm, 1.1 to 2.5 cm, 2.6 to 5.0 cm, and 5.1 to 10.0 cm.

DATA ANALYSIS

We used mixed procedure analysis of variance (ANOVA) to compare dogwood stem densities among burned and unburned stands. Separate analyses were conducted for each of the 3 diameter classes (0 to 5.0 cm, 5.1 to 10.0 cm, and >10.0 cm) and total density (SAS 2002). The mixed model was made up of two factors: sampling category, which was fixed, and burn area, which was random and nested within sampling category. When analysis revealed a significant difference between the sampling categories, we used orthogonal contrasts to determine the differences between the means of the sampling categories. We used the same technique to compare overstory and understory stem density and basal area.

RESULTS AND DISSCUSSION

Dogwood Stem Density

Total dogwood stem density was greater on burned plots than on unburned plots (232 stems/ha versus 54 stems/ha, P=0.08; fig. 2). We observed the greatest differences in stem density within in the 0 to 5 cm size class: 159 stems/ha on burned plots compared to 21 stems/ha on unburned plots (P=0.16). Since smaller dogwoods are more susceptible to dogwood anthracnose and usually die before larger trees (Hiers and Evans 1997, Mielke and Langdon 1986), it is not surprising that the greatest difference in stem density was in the smallest size class. In the 5.1 to 10 cm class, the difference was smaller but statistically significant: 67 stems/ha on burned plots versus 27 stems/ha on unburned plots (P=0.01). The >10 cm size class, however, showed no difference in stem density; we observed 5 stems/ha on both burned and unburned plots. The stem density in this size class is comparable to pre-anthracnose levels of dogwood observed in GSMNP by Jenkins and White (2002).

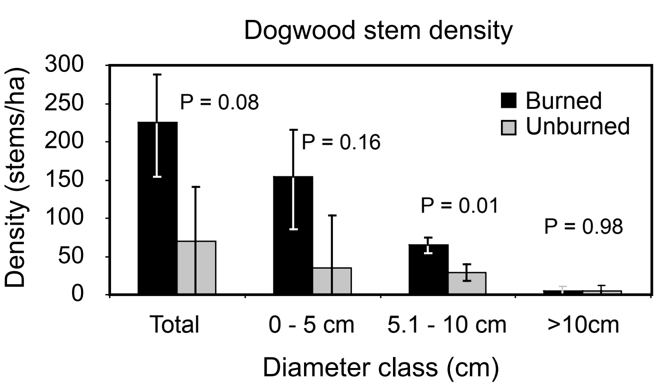

Figure 2— Dogwood density on burned and unburned plots for three diameter classes and all classes combined (total). P-values listed are for contrasts in mean stem density for each diameter class.

Stand Structure

Overstory basal area was similar for the two sampling categories: 21.7 m^2/ha in burned stands versus 23.3 m^2/ha in unburned stands (P=0.31; table 1). Understory basal area was also similar between categories: 7.1 m^2/ha in burned stands versus 7.4 m^2/ha in unburned stands (P=0.83). Overstory stem density was greater on unburned plots (572 stems/ha) compared to burned plots (435 stems/ha; P=0.009). Decreased overstory stem density likely resulted in reduced shading on burned plots. Reduced shading has been shown to reduce moisture levels in stands, which increases dogwood survival by lessening the virulence of anthracnose (Chellemi and Britton 1992). The understory stem density, however, did not differ between burned (3,217 stems/ha) and unburned (2,250 stems/ha) plots (P=0.46).

CONCLUSIONS

Overall, burning appears to increase the survival of dogwood trees in anthracnose-infected stands. Dogwood stem density was greater in burned plots compared to unburned plots. Smaller dogwood size classes benefited from burning more than larger size classes. The increase in dogwood stem density in burned areas compared to unburned areas is likely a result of stump sprouting and reduced shading that created a favorable microclimate for dogwood survival from anthracnose. Although dogwood occurs in a variety of forest types, these results are most applicable in oak-dominated forest types where burning is part of the historic fire regime. Since we

Table 1—Understory and overstory basal area and stem density means for burned and unburned sampling categories. Value of one standard error is in parentheses. P-values listed are for comparison of means between two sampling categories

	Basal area	Density
	m²/ha	*stems/ha*
Understory		
Single burn	7.1 (0.7)	3,217 (600)
Unburned	7.4 (0.8)	2,550 (654)
P -value	0.83	0.46
Overstory		
Single burn	21.7 (0.9)	435 (31)
Unburned	23.3 (1.0)	572 (34)
P -value	0.31	0.009

observed anthracnose on both burned and unburned plots, additional monitoring is needed to determine how long the effect of burning lasts. However, our results suggest that the positive effects of burning on dogwood survival may last for decades. Based upon our results, prescribed burning may offer a viable tool for maintaining dogwood populations in forests of GSMNP and other areas in the eastern United States.

LITERATURE CITED

Anagnostakis, S.L.; Ward, J.S. 1996. The status of flowering dogwood in five long-term forest plots in Connecticut. Plant Disease. 80: 1403-1405.

Britton, K. 1994. *Cornus florida* anthracnose. In: Ferguson, C.; Bowman, P., eds. Threats to forest health in the Southern Appalachians. Gatlinburg, TN: Southern Appalachian Man and the Biosphere Cooperative: 17-20.

Chellemi, D.O.; Britton, K.O. 1992. Influence of canopy microclimate on incidence and severity of dogwood anthracnose. Canadian Journal of Botany. 70: 1093-1096.

Hiers, J.K.; Evans, J.P. 1997. Effects of anthracnose on dogwood mortality and forest composition of the Cumberland Plateau (U.S.A.) Conservation Biology. 11: 1430-1435.

Jenkins, M.A.; White, P.S. 2002. *Cornus florida* L. mortality and understory composition changes in western Great Smoky Mountains National Park. Journal of the Torrey Botanical Society. 129: 194-206.

Mielke, M.; Langdon, K. 1986. Dogwood anthracnose fungus threatens Catoctin Mountain Park. Corvallis, OR/Seattle, WA: U.S. Department of the Interior, National Park Service. Park Science. 6: 6-8.

Pirone, P.P. 1980. Parasitic fungus affects the region’s dogwood. New York Times. Feb. 24: 34, 37.

SAS Institute Inc. 2002. Edition 9.0. Cary, NC: SAS Institute Inc.

Thomas, W.A. 1969. Accumulation and cycling of calcium by dogwood trees. Ecological Monographs. 39: 101-120.