Progression of the Dogwood Anthracnose Epidemic and the Status of Flowering Dogwood in Catoctin Mountain Park

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ABSTRACT

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A dogwood anthracnose impact survey was conducted at Catoctin Mountain Park in the Maryland Blue Ridge Mountains in 1994. The survey was performed 10 years after an initial survey to determine the status of the epidemic. Prior to the epidemic, approximately 1,013 flowering dogwood stems per hectare were present in dogwood anthracnose impact plots established in areas where dogwoods were prevalent. After just over 10 years only 56 stems per ha remained, a 94% loss. To assess the impact of dogwood anthracnose throughout the entire park, an estimate of the flowering dogwood population derived from a park-wide vegetation survey conducted in 1990 and 1992 was compared with an estimate made from a 1976 vegetation survey. Throughout the park there was a 77% reduction, from 128 stems per ha in 1976 to an average of 29 stems per ha in 1990 and 1992. A 1994 roadside survey found that although flowering dogwoods were prevalent along the forest edge, seed set was sparse and there was little regeneration. It is feared that heavy seedling predation by white-tailed deer will impede natural reproduction and deliberate attempts to augment the dogwood population.

The flowering dogwood, *Cornus florida* L., ranges from southwest Maine to north-central Florida and as far west as southern Michigan, Illinois, southeastern Kansas, and eastern Texas (5). Flowering dogwood is a major subordinate species of the eastern forest and valued as a source of food for at least 40 species of bird and 12 mammals (9). Since the late 1970s dogwoods have been threatened by anthracnose caused by *Discula destructiva* Redlin (11). Dogwood anthracnose was first recognized on *C. nuttallii* Audubon around 1976 in the Puget Sound area of Washington (12). Symptoms were later found on *C. florida* in southeastern New York and southwestern Connecticut in 1978 and 1979 (7,10). Since then dogwood anthracnose has spread throughout approximately 26% of the natural range of *C. florida*. In environments where there is a propensity for prolonged leaf wetness, the disease can be particularly severe (3). These environments typically include areas close to water courses, north-facing slopes, and high elevations (1,4,14).

Catoctin Mountain Park is a 2335 ha National Park located at 274 to 573 m above sea level in the Blue Ridge Mountains in north central Maryland. Dogwood anthracnose was first observed at Catoctin in 1983, 4 to 5 years after the earliest reports in the Northeast (8). At the time, this was the southernmost known occurrence of the disease. Trees throughout the park consistently exhibited leaf symptoms and dieback characteristic of dogwood anthracnose and *D. destructiva* was repeatedly isolated from leaves and stems of affected trees. The *D. destructiva* holotype was collected in Catoctin Mountain Park on 8 June 1990 (11).

A disease impact survey conducted in 1984 by the USDA Forest Service, Northeastern Area State and Private Forestry and park resource management staff found that 33% of the flowering dogwoods were dead and only 3% were free of symptoms (8). When the survey was repeated by the Forest Service in 1988, 79% of the trees in the plots were dead (13). As an area with one of the longest continuous records of dogwood anthracnose, Catoctin Mountain Park provides an excellent opportunity to assess the long-term impact of the disease. The purpose of this study was to evaluate the impact by repeating the disease impact surveys as performed in 1984 and 1988, comparing park-wide pre- and post-epidemic vegetation surveys, and conducting disease and reproduction surveys in roadside settings where the flowering dogwood is still prevalent.

MATERIALS AND METHODS

Dogwood anthracnose impact plots. Areas of Catoctin Mountain Park surveyed in 1984 and 1988 were examined between 24 June and 10 August 1994. Since monitoring plots had not been specifically delineated in previous surveys, 17 plots were established in the same general locations indicated on the Catoctin Mountain Park base map for the 1984 survey. Plots had been similarly located in the 1988 survey (13). The 1994 impact plots were geo-referenced with a Trimble GPS Pathfinder Professional global positioning unit (Trimble Navigation, Ltd., Sunnydale, CA) for reference in future long term monitoring studies. Plot locations were mapped with ATLAS Geographic Information System for Windows ver. 1.0 (Strategic Mapping Inc., Santa Clara, CA). Strip cruise plots, 100.6 × 2.5 m (0.025 ha), were established at each site as described in the previous surveys (8,13). The cardinal direction of the cruise was recorded in relation to a permanent stake marker. The diameter at breast height (dbh), 1.37 m above ground, was recorded for all flowering dogwoods greater than 1.37 m tall within the plot and trees were grouped by the size classes: <2.54 cm; 2.54 to 5.08 cm; 5.08 to 7.62 cm; 7.62 to 10.16 cm; and >10.16 cm. Crown symptom classes based on the percentage of the crown exhibiting leaf symptoms and/or dieback (0 = symptomless; 1 = 1 to 25 %; 2 = 26 to 50%; 3 = 51 to 75%; 4 = >75%; and 5 = dead) were determined for each tree. Lack of limbs and dieback in the lower canopy of trees that otherwise appeared symptomless were not considered disease related since natural shading will cause the loss of some lower limbs. Each tree was examined for fruit, which were counted in units of 10 clusters per tree, i.e., 1 = 1 to 10, 2 = 11 to 20, etc. To determine the extent of regeneration, the total area of each plot was thoroughly examined by two observers for flowering dogwood seedlings appearing from ground level to 1.37 m in height.

Permanent vegetation monitoring plots. In another study, permanent 20 × 20 m^2 vegetation monitoring plots were established throughout the park in 1990 to evaluate the impact of white-tailed deer *(Odocoileus virginianus* Raf.) on vegetation. A total of 45 plots (1.8 ha) were located randomly within each of the main forest cover types established from a 1976 survey (R. R. Anderson et al., unpublished). All trees within each plot with a height of ≥1.37 m were examined in 1990 and 1992. Each tree was identified by species, its dbh measured, and its status clas-

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sified as alive or dead. Within each plot, five 2 × 2 m subplots were established, with one located at the plot center and four at equidistant points along the main diagonals. In each year from 1991 through 1994 all woody seedlings, and basal and root sprouts within these subplots, were identified by species and classified by height.

Dogwoods in flower. A survey of dogwoods in flower was conducted on 5 May 1994. The survey was conducted on both sides of Park Central Road, which extends for 6 km through the park. This area was chosen because of the prevalence of flowering dogwoods and because the open canopy along the road provided an optimal setting for regeneration and survival. All dogwoods in flower were counted from the passenger side of a slow-moving vehicle for each 0.16 km segment of each side of the road, with the line of sight extending approximately 6 m from the edge of the road into the forest.

Symptom evaluations and regeneration surveys were conducted at nine of the 0.16-km road edge sections where the tree count (8 to 14) was highest in the flowering survey. The high density sections were chosen to assure that regeneration surveys were conducted in the areas where seed set and regeneration were most likely to occur. Nine plots, 100.6 × 5.0 m (0.05 ha) and totaling 0.45 ha, were established on 18 August and 16 September 1994. Plots were geo-referenced as described above. Trees in each plot were measured and rated for symptoms and fruit set. Each plot was examined for flowering dogwood seedlings as described above.

RESULTS AND DISCUSSION

Dogwood anthracnose impact plots. Dogwood anthracnose was first reported in Catoctin Mountain Park in 1983 (8). The disease probably began to develop several years prior to 1983, and possibly coincided with the earliest reports in 1978 and 1979 in the Northeast. In 1984 there was already 33% mortality and only 3% of the dogwoods were free of symptoms, indicating a well-established epidemic. The 1984 impact survey established the mean of 1,013 stems per ha (8). Since this first survey was conducted shortly after the epidemic began, all trees, including those recently killed, were counted. Therefore, 1,013 stems per ha likely represents the flowering dogwood stand prior to the epidemic. Because the impact plots were installed where dogwoods were known to be prevalent, it is likely that this estimate is high and does not represent the population for the entire park. The epidemic was most destructive from 1984 to 1988 when mortality increased to 92%, a 59% increase in 5 years, and the estimated number of living stems per ha was 79. (Fig. 1) (13). From 1988 to 1994 mortality increased 2%, leaving 56 living stems per hectare, approximately 6% of the original stand. Of the 24 live flowering dogwoods found in 1994, only four were symptomless and eight had crown symptoms of ≤25% (Table 1).

Ten trees bearing fruit were found in six of the 17 plots. Fruit clusters were generally less than 10 per tree. In all 17 plots encompassing 0.425 ha, only three seedlings were detected in two plots.

Permanent vegetation monitoring plots. Live flowering dogwoods ranging from 1.0 to 19.5 cm dbh were found in 25 of 45 plots (55%) in 1990 and 21 (47%) in 1992. The total number of flowering dogwoods per ha declined from 72 in 1990 to 50 in 1992, with live stem densities occurring at 35.0 per ha in 1990 and 22.8 per ha in 1992, a 35% reduction in 2 years. The number of living flowering dogwoods in individual plots ranged from one to eight. Only five plots in 1990 had six or more live flowering dogwoods, and no plot had more than five by 1992. The average number of live stems (29 per ha) found in the park-wide sample was much lower than that of the 1994 impact plots (56 per ha). It is likely that more flowering dogwoods were found in the disease impact plots because these were installed where flowering dogwoods were known to be present, while the vegetation plots were randomized throughout the park and included

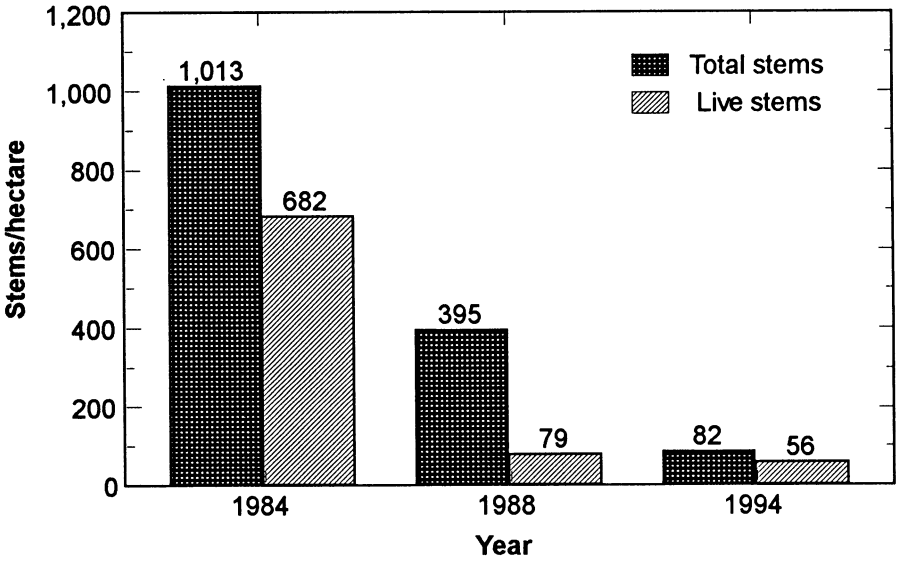

Fig. 1. Number of flowering dogwood stems per hectare in Catoctin Mountain Park in 1984, 1988, and 1994 as determined from 17 dogwood anthracnose impact plots (100.6 × 2.5 m, 0.025 ha).

Table 1. Number of flowering dogwoods found in 1994 at 17 (0.025 ha) plots in Catoctin Mountain Park

		Crown symptom class[a]					
Size (cm)	Total	0	1	2	3	4	5
<2.54	5	0	2	0	0	0	3
2.54 to 5.08	14	2	3	4	3	0	2
5.08 to 7.62	8	2	2	3	0	0	1
7.62 to 10.16	7	0	0	1	1	0	5
>10.16	1	0	1	0	0	0	0
Total	35	4	8	8	4	0	11

[a] Percentage of tree crown exhibiting leaf symptoms and/or dieback: 0 = symptomless; 1 = 1 to 25%; 2 = 26 to 50%; 3 = 51 to 75%; 4 = >75%; 5 = dead.

Table 2. Number of flowering dogwoods found in 1994 at 9 (0.048 ha) plots along Park Central Road, Catoctin Mountain Park

		Crown symptom class[a]					
Size (cm)	Total	0	1	2	3	4	5
<2.54	10	2	2	1	0	1	4
2.54 to 5.08	37	4	14	5	4	3	7
5.08 to 7.62	32	4	13	5	3	3	4
7.62 to 10.16	12	3	2	3	1	1	2
>10.16	1	0	1	0	0	0	0
Total	92	13	32	14	8	8	17

[a] Percentage of tree crown exhibiting leaf symptoms and/or dieback: 0 = symptomless; 1 = 1 to 25%; 2 = 26 to 50%; 3 = 51 to 75%; 4 = >75%; 5 = dead.

areas where flowering dogwoods were not likely to be abundant. A vegetation survey conducted in 1976 examined 13 random length transects established throughout the park (R. R. Anderson et al., unpublished). All stems >1 m high were identified and counted in 696 10 × 10 m plots. A total of 896 flowering dogwoods were found in 196 (28%) of the plots. The estimated flowering dogwood stems per ha in 1976 was 128, compared with the 1990 and 1992 average of 29, indicating a 77% mortality park-wide.

Evidence of flowering dogwood reproduction, either in the form of seedlings or root or basal sprouts, was found in only 10 of the 45 permanent plots established in 1990. A total of only 78 seedlings and root or basal sprouts was noted throughout 4 years of sampling, with none exceeding height class 3 (26 to 50 cm). We saw no signs of flowering dogwood reproduction that led to seedlings or sprouts that were viable more than one growing season. Given that flowering dogwood is a major preferred spring and winter food for white-tailed deer in the mid-Atlantic states (2), we attribute this principally to heavy predation. Including seedlings and sprouts, there were never more than 1.7 to 18.9 stems per hectare from which the park's dogwood population was restocking.

Dogwoods in flower. Although dogwood anthracnose has greatly reduced the flowering dogwood population at Catoctin, dogwoods were frequently seen, particularly when in bloom. Flowering dogwoods were most common at the forest edge, such as along Park Central Road, where a total of 326 trees were counted in the May bloom survey. The road edge provides an open setting that promotes leaf drying, an impediment to disease development.

Within the nine road plots (0.45 ha) examined for disease symptoms and fruit set, 92 trees were found, of which 75 (82%) were living. This is equivalent to approximately 166 live stems per ha for the most heavily populated roadside areas. Most of the trees, 75%, were in the 2.54 to 5.08 and 5.08 to 7.62 cm size classes (Table 2). Approximately 14% had no symptoms, 35% had crown symptoms of 1 to 25%, 33% had 26 to >75%, and 18% were dead (Table 2).

Trees with fruit set were found in eight of the nine plots, however, only 16 of the 75 live trees found produced fruit. Most of the trees with fruit had less than 20 clusters per tree. No seedlings were detected in any of the plots. The scarcity of seedlings noted during the disease impact, vegetation, and bloom surveys is likely a consequence of both the loss of seed-bearing trees and the intensive predation of herbaceous vegetation by white-tailed deer.

Estimates of the flowering dogwood population at Catoctin Mountain Park have shown that the population has declined as much as 77% throughout the park and 94% within disease impact study areas. It is not possible to completely attribute this high mortality to dogwood anthracnose. Other agents, alone or in conjunction with *D. destructiva*, may have contributed. However, the long-term presence of the pathogen in the park and the lack of other biotic or abiotic catastrophes clearly indicate that dogwood anthracnose was primarily responsible. Whether mortality of this extent will occur in other areas where *D. destructiva* occurs remains to be seen.

Despite the disease, isolated dogwoods are readily apparent while in bloom and many trees can be found along the roads and on the fringes of developed areas within the park. Most likely many of the surviving dogwoods are escapes, or tolerate the disease because of reduced inoculum or the advantages of drier microhabitats. Several trees, however, have been found at Catoctin that show some promise of resistance (6). The level and nature of this resistance awaits further study.

Management options for sustaining flowering dogwoods in the park are limited. The residual road edge population provides the best source of seed for natural regeneration. Unfortunately, the total lack of regeneration in the immediate vicinity of these trees is not encouraging. Deliberate augmentation of the population along the road, as well as within and along the edges of developed areas where there is good air circulation, may provide the best opportunity for reviving the aesthetic benefit of this native flowering tree and provide a seed source for wildlife and, it is hoped, natural regeneration. Seed has been collected from trees within the park and propagation for revegetation has begun. If resistance can be confirmed for native selections, clones of these trees will be incorporated into the revegetation program. With any attempt to introduce disease resistant plants or to enhance or encourage the spread of plants from surviving flowering dogwoods, the role played by white-tailed deer will have to be critically evaluated, and in all likelihood means to mitigate impacts from deer will have to be incorporated into the restocking effort. Unfortunately, the continued presence of the pathogen and high deer populations will continue to repress the flowering dogwood population below its natural potential.

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