FOREST HEALTH MONITORING PROTOCOL APPLIED TO ROADSIDE TREES IN MARYLAND

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Abstract. The Maryland Roadside Tree Law places trees in all public road rights-of-way in the State of Maryland, U.S., under the jurisdiction of the Maryland Department of Natural Resources-Forest Service. Passed in 1914, this law is one of the oldest tree conservation laws in the United States. However, little statistical data have ever been generated related to Maryland's roadside trees. This paper provides a methodology for assessing the condition of roadside trees by combining GIS tools, rights-of-way definitions, and components of a national forest health monitoring program. The assessment of roadside trees was carried out in six of Maryland's most urbanized jurisdictions. Results indicate that 14% of Maryland's roadsides are tree lined and that the trees are in good health based on crown and damage indicators collected. Shannon-Weaver index and importance values were calculated to describe species diversity. Views on the efficacy of the law in protecting roadside trees in light of the findings, and the findings themselves, are discussed.

Key Words. Inventory; structure; species diversity; tree preservation laws.

Roadside trees have long been considered a foundation of urban forestry in the United States. Mature street trees are generally considered an important part of a desirable urban landscape (Houde 1997; McPherson and Luttinger 1998). For example, Chicago's roadside trees, while accounting for only 10% of the city's trees, provide 24% of the city's total leaf-surface area (Nowak et al. 1994). Many programs (i.e., Tree City USA) and tools (i.e., tree inventories) used by public arborists have focused solely on the maintenance needs of roadside trees and have neither examined current urban forest health nor collected data to establish health trends over time. Current health evaluations coupled with trend data are powerful and necessary management tools (Ferretti 1997).

Urban trees perform important ecological functions in cities and towns by sequestering carbon, reducing summer cooling costs, removing airborne pollutants, and controlling stormwater runoff (Rowntree and Nowak 1991; McPherson 1994; Nowak 1994; Qi et al. 1998; Beckett et al. 2000). Vegetative canopies provide a cooling effect on microclimate directly by shading the ground surface and indirectly through transpiration (Scott et al. 1999). Roadside trees, because of their proximity to the generation of vehicle emissions, are important in reducing point-source pollution. For example, Beckett et al. (2000) found that roadside trees capture more large-size particulate matter than trees not near the road. These effects have implications for air quality standards, particularly in areas designated by the U.S. Environmental Protection Agency as nonattainment areas.

Roadside trees additionally have high emotional and aesthetic value to residents and high ecological value to urban areas as part of our green infrastructure. Although the environmental, aesthetic, and ecological benefits from urban forests are becoming well known, assessments of the status and health of these vital resources are rare.

ROADSIDE TREES IN MARYLAND

The Maryland Roadside Tree Law places trees in all public road rights-of-way in the State of Maryland,U.S., under the jurisdiction of the Maryland Department of Natural Resources-Forest Service (DNR), whether the road is maintained by the state, county, or municipality (State of Maryland 1994). Passed in 1914, the law is one of the oldest urban forestry laws in the United States and outlines permitting, tree pruning, and tree care procedures of both naturally occurring and planted roadside trees. This progressive, 86-year old law protects and conserves an important natural resource within the State of Maryland.

In order to perform any tree care involving roadside trees, permits must be obtained from the DNR. The law defines tree care as removal, planting or maintenance, application of a pesticide, or any treatment that affects the health or growth of a roadside tree. Unless exempted, removed trees are to be replaced by the permit holder. The Roadside Tree Care Regulations, outlined by the Roadside Tree Law, include standards for general pruning, clearance from overhead facilities, and ground disturbance and protection of tree roots, and are intended to protect and promote aesthetics, tree health, and public safety. Such regulations are effective at minimizing tree failure resulting from improper care (Karlovich et al. 2000).

In the spring of 1999, the Maryland DNR, Maryland Department of Agriculture, and the USDA Forest Service entered into an agreement to quantitatively assess the health of the roadside trees in six jurisdictions in Maryland along the so-called Baltimore-Washington Corridor. The project had two main objectives that will be discussed:

1. provide information about tree size, inventory or stocking levels, and infrastructure conflicts related to roadside trees
2. evaluate the health of the roadside tree resource in the study area

We used GIS tools, rights-of-way definitions, and components of a national forest health monitoring program to fulfill these objectives.

METHODS

The study area encompassed 6,031 km^2 (2,329 mi^2) in the Baltimore-Washington Corridor in Maryland and included five counties (Anne Arundel, Baltimore, Prince George's, Howard, and Montgomery) and Baltimore City. Approximately 3.5 million people, or 74% of the state population, live in this area. The average population density is 969 people per km^2 (2,511 people per mi^2), but changes along the urban-rural gradient from a high of 3,517 per km^2 (9,108 people per mi^2) in Baltimore City to a low of 287 per km^2 (743 people per mi^2) in Howard County.

Table 1 describes the extent and land use of the study area. Approximately one-third of the area is covered by forest and another third is covered by urban land uses. Nineteen percent of the area is covered by impervious surfaces such as roads, parking lots, and sidewalks. The amount of impervious surface area also varies along the urban-rural gradient, from a low of 4% impervious surface coverage in the Brighton Dam Watershed in Howard and Montgomery counties to a high of 42% in Baltimore City.

Plot Selection

The USDA Forest Service's National Forest Health Monitoring (FHM) program focuses on the health and condition of forests in the United States (Burkman and Hertel 1992). Our project conformed to the FHM program protocol and applied its assessment techniques to roadside trees in Maryland.

Table 1. Land cover and land use of Maryland's most urban watersheds; includes Anne Arundel County, Baltimore County and Baltimore City, Prince George's County, Howard County, and Montgomery County. (From Maryland Department of Natural Resources, Chesapeake and Coastal Watershed Service, 2000.)

Land use/land cover	Area ha (ac)
Forest	234,899 (580,428)
Urban	229,262 (566,499)
Agricultural	152,712 (377,347)
Wetland	4,954 (12,241)
Barren	2,999 (7,412)
Total	624,826 (1,543,927)

During the summer of 1999, Maryland Department of Agriculture crews visited 525 plots in the five counties and Baltimore City. To determine plot locations, Department of Agriculture specialists identified land uses in the counties of interest. Plots were stratified into three broad land-use types: urban, agricultural, and forest. A geographic information system was used to generate random points. The points were printed on USGS 1:24,000-scale topographic maps, and the closest road to that point was chosen as the sample road and plot site.

At each site, 0.017 ha (1/24 ac) rectangular plots (3.05 ↔ 55.17 m [10 ↔ 181 ft]) were located along the right-of-way. The plot size was chosen to coordinate with the National Forest Health Monitoring program (USDA Forest Service 1999). The Forest Health Monitoring plots consist of circular 0.017 ha (1/24 ac) plots. In the current study, however, a rectangular plot shape was chosen to allow the entire plot to be located within the right-of-way. The plot was measured from the back of the right-of-way 3.05 m (10 ft) toward the centerline of the roadway. All trees located inside the rectangular plot were sampled. Visual estimates of plot cover were made in 5% classes for each plot. Categories of cover included vegetation, pavement, rocks, and bare soil.

A roadside tree is defined by the Maryland Roadside Tree Care Regulations as "… a plant that has a woody stem or trunk that grows all, or in part, within the right-of-way of a public road" (State of Maryland 1994). Trees whose entire root collar is within the right-of-way are roadside trees. Trees whose root collars are bisected to any degree by the right-of-way or property line are also considered roadside trees. If a tree's entire root collar is outside of the right-of-way, it is not a roadside tree, even if substantial portions of the rooting area or crown extend into the right-of-way. Only trees meeting these definitions were sampled within each plot.

Right-of-way boundaries were estimated in the field based on road construction and types of drainage conveyance. Other indicators used included fence lines, expansion joints, and utility poles and pedestals. Crews received training and documentation to identify right-of-way boundaries.

Roadside Tree Population Structure

Urban forest structure and diversity were characterized using standard ecological indices. McPherson and Rowntree (1989) discussed the usefulness of such indices in describing attributes of urban forests. Species dominance and species diversity in urban forests are important in understanding the degree to which multiple species coexist and share in the delivery of human benefits by the forest. Insight into dominance within a community was gained from importance values. Importance values (IV) were calculated to quantify the relative degree to which a species dominates the roadside tree population. It includes information on both number and size of all individuals and is calculated as

$$\mathrm{IV}_i = \text{relative abundance}_i + \text{relative dominance}_i$$

where relative abundance is the relative number of individuals of species *i*, and relative dominance is the relative cumulative basal area of species *i*.

Species diversity was estimated using the Shannon-Weaver index (H). This ecological measure weights the contribution of each species to community diversity by its relative abundance (Ricklefs 1990). It was calculated as

$$\mathrm{H} = -\Sigma\, p_i \ln p_i$$

where p_i is the proportion of the total individuals belonging to the *i*th species summed for all species.

Health Monitoring Measurements

Many environmental and biological factors affect growth and success of trees. Visual inspections of leaves, branches, stems, and roots can reveal indications of stress on trees (Alexander and Palmer 1999). The present study focused on two such indicators: crown condition and damage. Crown condition was visually assessed by considering branch dieback, sunlight penetrating through crown, density of foliage, vertical crown position, amount of crown exposed to light, and live crown ratio. Damage was assessed by examining the tree and noting physical or mechanical damage to the roots, stem, or branches, and any evidence of decay or disease. For both indicators, causal agents were not assigned.

Data on seedlings, saplings, and trees were collected according to the USDA Forest Service Forest Health Monitoring *Field Methods Guide* (1999). According to the *Field Methods Guide*, seedlings are defined as woody species 30 cm (12 in.) tall or greater and less than 2.5 cm (1 in.) diameter breast height (dbh). Saplings were defined as woody species less than 12.7 cm (5 in.) dbh. Trees included woody stems equal to or greater than 12.7 cm (5 in.) dbh. Seedling data consisted of species, vitality based on amount of healthy foliage present, and number of individuals. Due to time constraints in the field, subplots were used to measure and count seedlings. The subplots were 16.7 m^2 (180 ft^2) and were measured 5.4 m (18 ft) from the centerline of the plot in the direction of the closest intersection.

All saplings and trees were identified by species, given an individual number, measured at breast height, and placed in a height class. Dead saplings and trees were also tallied. Conflicts with sidewalks and wires were recorded. Hazard trees were identified. Saplings were rated for crown vitality, a measure based on the amount of healthy foliage present.

Trees were measured more extensively. Crown measures were taken in two perpendicular directions. Live crown ratio was measured by comparing the live crown to the total height of the tree. Crown exposure was classified based on the number of sides from which the tree crown received light. Crown position was described by the vertical placement of the crown in relation to other trees. Crown density was assessed by quantifying dead and living foliage, branches, and reproductive structures. Crown dieback was assessed by quantifying branch mortality beginning at the fine twigs and progressing towards the trunk. Finally, foliage transparency was appraised by estimating the density of living foliage on branches.

Trees were also evaluated for damage. As with the national FHM program, damage signs and symptoms in this study were recorded if they represented a chronic, long-term threat to the success of the tree or if the damage might lead to tree mortality. The cause of the damage was not recorded because of the complex nature of injury, disease, and decay. Up to three sites of damage were recorded. Each damage site on a tree was described by location, type, and severity. Roots were given highest priority and evaluated first. Other damages were noted going up the tree to the branches and finally the foliage. Types of damages included cankers and galls, advanced decay, open wounds, resinosis or gummosis, cracks and seams, broken bole, brooms on roots or bole, broken or dead roots, vines in crown, loss of apical dominance, broken or dead branches, excessive brooms in live crown, damaged buds and foliage, and discolored foliage. Severity rating describes the amount of area affected by the damage. Severity ratings are specific to the damage type and are recorded in percent classes (USDA Forest Service 1999).

RESULTS AND DISCUSSION

Plot Characteristics

Five hundred twenty-five plots were visited, but only 15% contained trees. On the 79 plots with trees, 141 trees, 125 saplings, 123 seedlings, and 12 standing, dead saplings and trees were found. Twenty-two hazard trees were identified. Mean dbh was 19.8 cm (7.8 in.); median was 13 cm (5.1 in.), with a maximum of 111.8 cm (44 in.). Median ground coverage on plots where trees were found was predominantly vegetative (75.3%), followed by hardscape (24.0%), bare soil (0.8%), and rock (0.1%). However, when all plots were considered, median hardscape coverage increased significantly (40.1%), while vegetative cover decreased (57%). Median coverage for bare soil (1%) and rock (0.9%) were analogous.

Maintenance of Rights-of-Way

The majority of plots (77%) fell within county-maintained road rights-of-way. Seventeen percent fell within State Highway Administration rights-of-way, and 4% fell within municipal road rights-of-way, the majority of which were in Baltimore City. Plots falling within rights-of-way maintained by other agency types were negligible (interstate—2%; other federal and unknown—less than 1% each). This concurs with Maryland Department of Transportation data (Maryland Department of Transportation 1999), which indicate most road miles in Maryland are maintained by county government agencies. Therefore, the State of Maryland should concentrate on county public works departments to coordinate activities involving the state's roadside tree law.

Infrastructure Conflicts

Infrastructure conflicts are frequent concerns of the urban forest manager. In many areas, trees are considered a primary threat to the reliability of electric service, costing utilities more than US$1.5 billion annually (Goodfellow 1995). Baltimore Gas and Electric, whose service territory dominates the study area, spent US$15.4 million on all vegetation management in 1998 (Baltimore Gas and Electric 1999). Of the 266 live trees and saplings found in the study area, only 11.7% were found in conflict with overhead wires. Roadside trees growing beneath overhead facilities account for half the value of publicly owned trees (Doherty et al. 2000). Although a potential source of conflict, roadside trees can coexist with overhead facilities when maintained properly. In the report *Investigation into Preparedness of Maryland Utilities for Responding to Major Outages*, the Maryland Public Service Commission reported that roadside trees were not a significant impediment to any of Maryland's utilities (Maryland Public Service Commission 1999).

Trees additionally conflict with hardscape surfaces. Tree-related repairs to hardscape in U.S. cities are estimated to cost more than US$135 million annually (McPherson and Peper 1995). Francis et al. (1996) found that distance to pavement, diameter of tree, and tree species all contributed to the likelihood of hardscape damage. In the present study, 6.8% of roadside trees were noted as interfering with the sidewalk integrity.

Roadside Tree Population Structure

The species and age structure of a given roadside tree population reflect long-term patterns of tree survival, selection, and replacement. Dominance and diversity measures provide information on both future maintenance costs and benefits provided by the urban forest (McPherson and Rowntree 1989). The Maryland roadside forest exhibits a pattern of weak dominance (Figure 1), meaning that no single species had an importance value greater than 25%. Six species had IVs of 10% or greater. Of these species, *Quercus alba* had the highest IV due to its high total basal area (27,415 cm^2). The next dominant species were *Acer rubrum*, *A. negundo*, *Pyrus calleryana* 'Bradford', *Robinia pseudoacacia*, and *Prunus serotina*. These had high IVs due to their high abundance, ranging from 15 to 30 individuals within the sampled population. The roadside population exhibits a reverse-J size distribution pattern (Figure 2) (McPherson and Rowntree 1989). Populations with this diameter distribution should exhibit high stability, with high levels of replacement offsetting establishment-related mortality (Richards 1983; McPherson and Rowntree 1989).

When diameter distribution is considered alone, it appears the roadside trees in Maryland will be maintained in the current state. However, species composition must be considered to understand the processes affecting roadside tree populations. Species diversity within an urban

Species	Rank	Importance Value
Quercus alba	1	20.6
Acer rubrum	2	14.8
Acer negundo	3	14.3
Pyrus calleryana 'Bradford'	4	13.7
Robinia pseudoacacia	5	11.0
Prunus serotina	6	10.0
Quercus palustris	7	8.3
Platanus occidentalis	8	8.2
Prunus pensylvanica	9	8.2
Cornus florida	10	8.1

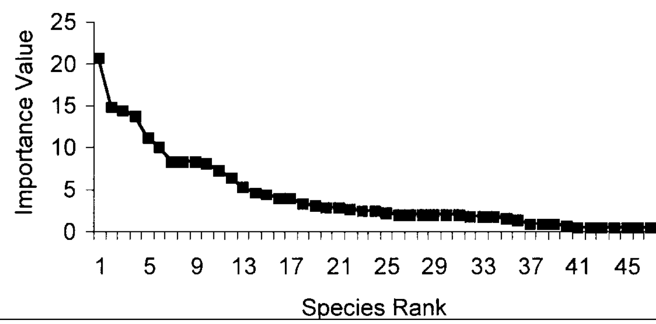

Figure 1. Maryland roadside forest species importance values.

forest community is important in providing resilience in the face of environmental and biological stressors (Galvin 1999). In managed urban environments, natural processes play limited roles in succession and species selection. Planting of trees establishes the species composition of the forest. For Maryland roadside trees, community diversity was calculated for the entire sampled population. The Shannon-Weaver index of 3.31 is above the mean, but within the range, of the same index calculated for 22 U.S. cities by McPherson and Rowntree (1989) (mean of 2.7, range of 2.1 to 3.9)

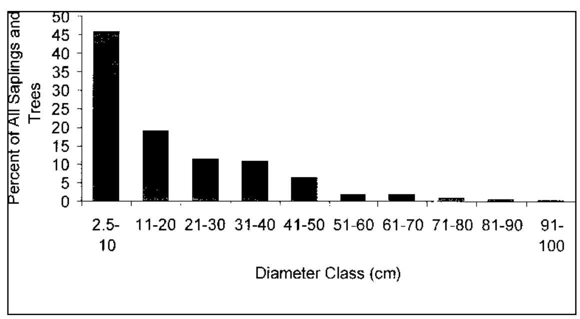

Figure 2. Size distribution of Maryland roadside trees and saplings by 10-cm diameter class.

and indicates a diverse species population. The Maryland roadside forest contained 47 species, of which the most common are listed in Table 2. Thirty-seven species had representatives greater than 12.7 cm (5 in.) dbh. No single species of tree accounted for more than 9% of all trees found, indicating a diverse tree resource along Maryland's roadside. *Acer rubrum*, *Pyrus calleryana* 'Bradford', and *Prunus serotina* were the most numerous trees.

Twenty-seven species were found among the saplings, with three species, *Acer rubrum*, *Cornus florida*, and *A. negundo*, accounting for almost 40% of all saplings. The seedling population comprised 23 species. The most numerous seedling species found was *Ailanthus altissima*. Of the five most numerous seedling species, none were represented in the six most numerous tree species. Thus, there is a divergence in species composition between size classes in the roadside urban forest. These differences probably reflect the different processes influencing community diversity in each class. Tree diversity reflects a combination of historical trees (i.e., *Quercus alba*), maturing new plantings (i.e., *Pyrus calleryana* and perhaps *Acer rubrum*), and recruitment (i.e., *Acer rubrum* and *A. negundo*). The sapling size class, dominated by resilient native species, most likely reflects the maturation of volunteers into the urban forest (i.e., *Robinia pseudoacacia*). However, the general lack of correspondence between seedling and sapling communities suggests that seedlings in Maryland's roadsides are not reaching sapling or tree sizes. This may reflect unintentional management (e.g., mowing) by the appropriate entities or recent change in seed availability, perhaps from continued development in the corridor.

Table 2. Species frequency by size on Maryland roadside tree plots.

Species and frequency (5% or greater)	
Seedlings	
Species	Percent of all seedlings
Ailanthus altissima	24%
Morus spp.	17%
Robinia pseudoacacia	7%
Ulmus rubra	7%
Corylus cornuta	5%
Juglans nigra	5%
Saplings	
Species	Percent of all saplings
Acer negundo	14%
Acer rubrum	12%
Cornus florida	12%
Robinia pseudoacacia	8%
Pinus strobus	5%
Morus spp.	5%
Prunus pennsylvanica	5%
Prunus serotina	5%
Pyrus calleryana 'Bradford'	5%
Trees	
Species	Percent of all trees
Acer rubrum	9%
Pyrus calleryana 'Bradford'	9%
Prunus serotina	9%
Acer negundo	7%
Quercus palustris	6%
Quercus alba	5%

Species diversity was also calculated within diameter class. Species diversity dropped markedly above the 50-cm (19.6-in.) diameter class (Figure 3). Only seven species were represented in the diameter classes greater than 50 cm, dominated by *Quercus alba* and *Platanus occidentalis*, with individuals of *Acer saccharinum*, *Robinia pseudoacacia*, *Quercus phellos*, and *Carya tomentosa* also present. The drop in diversity is exacerbated by the low number of individuals in these age classes, possibly reflecting loss of historical shade trees to introduced disease (McPherson and Rowntree 1989), urbanization, or removal without replacement. Higher diversity in the younger, sapling cohort reflects diverse propagation from surrounding trees, since most are resilient native species (e.g., *Acer negundo* and *Robinia pseudoacacia*) and are not considered horticulturally desirable. These changes in species composition may lead to changes in management requirements and future human benefits (McPherson and Rowntree 1989). For example, *Pyrus calleryana* 'Bradford' is the most

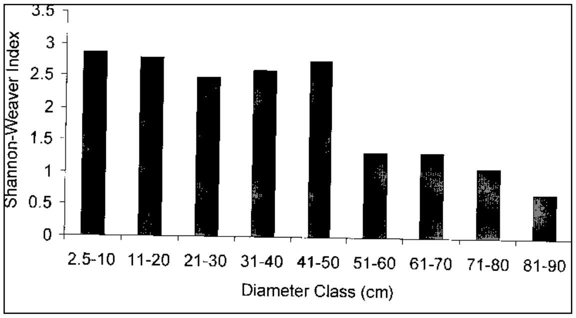

Figure 3. Species diversity for trees and saplings measured by Shannon-Weaver diversity index within 10-cm diameter classes.

numerous species sampled, equal to *Acer rubrum*. This preponderance of pear, a relatively short-lived and failure-prone species, may lead to substantial maintenance and replacement costs in the future (Galvin 1999).

Stocking

Stocking can be defined as the number (or basal area) of trees per unit area. Stocking levels vary depending on management objectives, but, in general, stocking levels consider the space needed to provide resources for each tree and to provide human benefits. In the current study, maximum potential stocking of the 525 plots was estimated at 1,900 trees, based on 15-m (50-ft) spacing (McPherson and Rowntree 1989). In actuality, 266 live trees were found (278 total trees were detected; 12 standing, dead trees were tallied), resulting in stocking at 13.9% of the estimated potential, or 18.2 trees per kilometer (29.3 trees per mile) of roadway. This is considerably lower than the 62% stocking level found in Modesto, California, or the 38% mean stocking level found for 22 U.S. street tree populations (McPherson and Rowntree 1989).

Table 3 describes the stocking levels by road type (county, municipal, state). Kilometers of road in the study area were used with the calculated average stocking percent (13.9%) to estimate the total number of trees within the five counties and Baltimore City at 392,888 trees.

Table 3. Maryland roadside tree estimated inventory level by road type for six jurisdictions in the Baltimore-Washington Corridor.

Road type	Km (%) in study area	Number of plots	Estimated number of trees[*]
County	14,221 (66.4)	406	260,917
Municipalities	4,493 (21)	21	82,428
State Highway Administration	2,699 (12.6)	90	49,504
Total	21,413 (100)	517	392,888

[*]Calculated stocking rate equals 13.9% based on observed trees and was applied to distance of road.

County-maintained roads accounted for 66% of the roads in the study area and contained over 260,000 trees. State and municipal roads accounted for 13% and 21% of the road types in the study area, respectively. It was estimated that state-maintained roads are lined with almost 50,000 trees, while municipal roads contain over 82,000 trees.

Maintaining the stocking levels of the roadside tree resource should be one main function of the Maryland Roadside Tree Law. In fact, the regulations require that when roadside trees are removed, they be replaced with trees of at least commensurate value. The current study found stocking levels to be significantly below potential levels for the area. It may be inferred, then, that the protections contained in the law, or enforcement of them, have been inadequate. Clark et al. (1997) examined tools, such as government regulations and city staffing and funding strategies, that could be used to manage a sustainable urban forest. They determined that laws defining standards of public tree care, such as Maryland's law, were indicators of only "moderate" performance for resource management related to urban forest sustainability. While no data on roadside tree permits or their processing were part of the current study, it is reasonable to assume that the State of Maryland, with laws regulating the care of roadside trees for 86 years, would have a higher stocking level than other jurisdictions without the benefit of similar protections, such as those reported by McPherson and Rowntree (1989). One possible explanation is that there were fewer trees in the State of Maryland in 1914, the year the Roadside Tree Law was passed. It is not known whether net roadside tree stocking levels have increased since the passage of the law, but according to the Maryland Department of Natural Resources-Forest Service, the percentage of land in forest was lower in 1914 than at any time in Maryland's history through the present day (Schwaab et al. 1995).

Forest Health

The National Forest Health Monitoring program has been assessing rural trees in the United States since 1990. In that time, the program has estimated the current status, changes, and trends in forest health on a regional basis (Alexander and Palmer 1999). The techniques used to gather this critical information have rarely been applied to urban areas. Two indicators of forest health were examined in the roadside trees of Maryland's Baltimore-Washington Corridor. The crown and damage indicators are both easy to collect and provide insight into the current condition of the forest.

Crown measurements were made only on trees greater than 12.7 cm (5 in.) dbh. In the 79 plots with trees, saplings, or seedlings, only 141 trees meeting the size definition were found. Crown dieback is a measure of small twig mortality and is an indicator of premature branch death. Large amounts of dieback indicate excessive stress to the tree (Brooks et al. 1991; Stoyenhoff et al. 1998). Of the 141 trees assessed, 32% showed any sign of dieback. Four percent of all trees exhibited dieback of 20% or greater. Table 4 presents crown dieback for the ten most numerous species. A majority of these trees show light to no dieback. Only *Acer platanoides* had dieback at the moderate level (21% to 50%). Two species, *Cornus florida* and *Acer negundo*, had dieback symptoms greater than 50%.

Crown density measures the amount of plant material that intercepts light. Dead and live leaves, branches, and fruit are considered. Density varies naturally between species and over time. Drought and pest outbreaks can influence density values. The higher the density value, the more plant material is intercepting sunlight and more surface area is available for photosynthesis (Stoyenhoff et al. 1998). Ninety-six percent of the trees sampled had good to moderate crown density ratings (data not presented).

Table 4. Percent crown dieback on trees greater than 12.7 cm (5 in.) dbh for major species on roadside tree plots in Maryland.

Species (number of trees in study area, total)	Percent crown dieback class			
	None (0–5%)	Light (6–20%)	Moderate (21–50%)	Severe (51+%)
	Percent of sampled trees			
Acer rubrum (13)	92.3	7.7	0.0	0.0
Acer negundo (9)	88.9	0.0	0.0	11.1
Acer platanoides (5)	60.0	20.0	20.0	0.0
Acer saccharinum (4)	75.0	25.0	0.0	0.0
Quercus palustris (8)	100.0	0.0	0.0	0.0
Quercus alba (7)	100.0	0.0	0.0	0.0
Quercus ellipsoidalis (5)	100.0	0.0	0.0	0.0
Pyrus calleryana 'Bradford' (13)	92.3	7.7	0.0	0.0
*Prunus serotina (*11)	100.0	0.0	0.0	0.0
Cornus florida (4)	50.0	25.0	0.0	25.0

Crown transparency is measured by visually quantifying the amount of light that penetrates through the live portion of the crown. The amount of light visible through the foliated portion of the crown reflects foliage reductions due to stresses, both biotic and abiotic (Brooks et al. 1991). No transparency ratings were categorized as severe, indicating that none had vast gaps in foliage that would allow light to penetrate to the ground. For eight of the ten species, all individuals of the species had normal transparency ratings. Only two species, *Acer rubrum* and *Cornus florida*, had any individuals with a moderate rating (data not presented).

Damage ratings were also taken on all trees. Fifty-nine percent of all trees sampled showed no signs of damage. The most frequent damage was open wounds (including lawn mower scars and other bark damage). Other damages included loss of apical dominance, dead branches, and vines in the crown (data not presented). The damage and three crown ratings indicate that trees are in good health along roadsides in Maryland's six most urban jurisdictions. The drought of 1999 may have had some effect on *Cornus florida*, but this species is also showing effects of disease stresses in this region.

Forest tree health assessments have been used in the past to detect changes in forest condition in natural populations. For example, Hornbeck et al. (1986), Peart et al. (1992), and LeBlanc (1992) detected a decline in montane red spruce *(Picea rubens)* populations during the 1980s, and Payette et al. (1996) and Bell et al. (1998) noted a decline in sugar maple *(Acer saccharum)* populations in eastern Canada and the United States. Hopkin and Howse (1998) documented health differences between forest, urban, and roadside maples in Ontario. Without sound monitoring and baseline assessments, long-term sustainability of urban forest populations cannot be determined. The present study provides the starting point for such a monitoring program and is the first study to systematically assess the health of roadside trees within the Baltimore-Washington Corridor.

CONCLUSIONS

Components of the National Forest Health Monitoring program were used to describe the extent, structure, and health of roadside trees in the Baltimore-Washington corridor. Only 15% of plots sampled were found to contain trees. Such low coverage suggests that the Maryland Roadside Tree Law as written has not been effective at maintaining or increasing stocking in this area. Of plots containing trees, the population was as diverse as other urban forest areas. Assessment of species composition in the smaller size classes indicates that few horticultural varieties were present, indicating few tree species are planted in Maryland roadsides. Various indices of tree health indicate that the roadside tree population was healthy, although *Cornus florida* showed signs of decline consistent with reports of known biotic stresses. Future studies are planned to gain more complete information on the health and structure of Maryland's roadside trees.

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Acknowledgments. The authors would like to thank the following for their assistance with and support of this project: Earl Reaves, Lee Venables, Bob Tatman, Betsie Handley, Sally Hughes, Craig Kuhn, Lynn Alexander, Steve Grossi, Liz Bills, Tom Lupp, Chris Firme, Agnes Roberts, Sue Harold, Barbara Morgan, and Helen Butalla. In addition, the authors would like to thank two anonymous reviewers for their constructive comments. Funding for this project was provided by the USDA Forest Service, Northeastern Area, State and Private Forestry, Newtown Square, PA.

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