

RESIDENTIAL FOREST STRUCTURE IN URBAN AND SUBURBAN ENVIRONMENTS: SOME WILDLIFE IMPLICATIONS IN NEW ENGLAND

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Abstract. Tree populations were compared in residential areas of urban Springfield and suburban Amherst, Massachusetts. The urban environment contains significantly fewer tree species, lower total tree density, no large conifers, a narrower range of tree diameters, and a more park-like condition because the lower margins of tree crowns are positioned higher. Both environments are dominated by relatively few tree species, and contain many exotic species and many species native to the country or region but not occurring locally. The latter compose the majority of metropolitan trees. These differences in residential forest structure contribute to dramatic differences in the composition of breeding birds between the two environments.

Do urban and suburban environments in the same region have similar residential forests or tree compositions? Trees and woody vegetation in general are vitally important components of residential landscapes. Shaping the distant visual landscape, screening unsightly land uses, and providing shade, texture, color, and wildlife habitat are important functions of trees and associated vegetation, especially in cities and suburbs. The extent to which trees provide these amenities depends on their form, site requirements, fruiting and branching patterns, and species composition.

Many studies have addressed problems associated with northeastern street trees — species selection (Francis 1915; Hightshoe 1978), inventory (Sacksteder and Gerhold 1979), maintenance (Grey and Deneke 1978), and diversity and stability of populations (Richards 1983; Sanders 1981). Street trees are community or public resources because they are municipally provided and managed, and they are important determinants of the character of the urban landscape.

Of greater importance from an ecological viewpoint is a consideration of urban trees including not only street trees but also those on adjacent residential land. Street trees likely contribute less to overall tree diversity, variety of growth habits, and wildlife habitat values than do the remaining

trees that make up the residential urban forest. By virtue of their required characteristics (e.g., straight growth, resistance to diseases, tolerance of urban air and soil conditions, lack of litter), street trees rarely comprise a great diversity of species.

Compared with trees on private grounds, street trees are relatively easy to sample. Richards (1983) provides a concise historical review of street-tree studies relating to diversity and stability, and cites examples of the domination of populations of street trees by a relatively few species.

Urban vegetation varies from region to region according to climate, edaphic conditions, the character of the surrounding native vegetation, and the species selected for street-tree planting. In this study I compared new tree populations in residential areas of a large New England city with those in a suburban community.

Methods

Woody vegetation was sampled in 1975 on forty, 1/2-ha plots on two urban residential tracts in urban Springfield, Massachusetts (population 250,000), and on twenty 1-ha plots in two residential tracts in suburban Amherst, Massachusetts (population 20,000). Both communities are located approximately 35 km apart in the Connecticut River Valley, and both lie at the interface of the Appalachian oak and northern hardwood forest cover types. Depending on aspect and soil type, either of these or related types are found, including oak-pine on drier sites and mixed hardwoods on more mesic sites. Tracts in both communities were in homogeneous neighborhoods of single-family dwellings 40 to 60 years old. Lot sizes in Springfield were 0.1 to 0.25 ha; in Amherst lots were 0.5 to 1 ha.

Field measurements of trees included diameter at breast height (dbh), total height, and height to

crown of all trees. Shrubs were counted and recorded as deciduous or coniferous. Tree heights were measured with an altimeter; height to tree crowns was measured with a range pole. Significant differences ($P = 0.05$) between characteristics of city and suburban trees were determined by t-test.

Results

Sampling of all trees and shrubs on 20 ha in each community revealed a total density of 49.35 trees/ha in the urban residential area and a significantly greater density of 138.30/ha in the suburb ($P = 0.05$). Shrub densities were more similar: 144.0/ha in the urban areas and 161.2/ha in the suburb. In Springfield, 74.7 percent of shrubs were coniferous compared with 38.0 percent of Amherst.

Thirty-six tree species were recorded in the urban residential area compared with 82 in the suburb. The most common urban species were Norway maple (*Acer platanoides* and sugar maple (*Acer saccharum*); these two accounted for 37.1 percent of the residential trees in the central city (Table 1). An additional 13 percent were red maple (*Acer rubrum*), so 50.1 percent of Springfield's residential trees are maples. Three-fourths of all of the urban residential trees are of only nine species: the three maples cited, silver maple (*A. saccharinum*), Norway spruce (*Picea abies*), white spruce (*P. glauca*), black oak (*Quercus velutina*), red oak (*Q. rubra*), and eastern hemlock (*Tsuga canadensis*).

The suburban environment also is characterized by a preponderance of a relatively few tree species: only nine tree species account for 61.4 percent of the trees. Some different species dominate here, however; eastern hemlock, sugar and Norway maples, eastern white pine (*Pinus strobus*), northern white cedar (*Thuja occidentalis*), apple (*Malus spp.*), white spruce, flowering dogwood (*Cornus florida*), and red maple. Only one urban residential tree species—red mulberry (*Morus rubra*) — was not found in the suburb.

Introduced exotics accounted for similar proportions of both tree species and of all trees. The urban area contained six exotic species of trees (17.1 percent), which accounted for 24.1 percent of all trees. The suburb contained 24 exotic

Table 1. Common residential trees in Springfield, Massachusetts, by dbh class; species or genera listed represent 5+ individuals

Species or genus ^a	Dbh class (cm)				All dbh classes of trees	Number
	0-20	20-40	40-60	>60		
	-----Percent-----					
Norway Maple (<i>Acer platanoides</i>)**	9.1	81.1	9.8	0	13.4	132
Red maple (<i>Acer rubrum</i>)	5.5	65.5	28.2	0.8	13.0	128
Sugar maple (<i>Acer saccharum</i>)	7.7	79.1	12.8	0.4	23.7	234
Silver maple (<i>Acer saccharinum</i>)	5.1	69.2	12.8	12.8	4.0	39
Catalpa (<i>Catalpa bignonioides</i>)	11.1	77.8	11.1	0	0.9	9
Eastern red cedar (<i>Juniperus virginiana</i>)	77.8	22.2	0	0	0.9	9
Apple (<i>Malus spp.</i>)	59.3	37.0	3.7	0	2.7	27
Norway spruce (<i>Picea abies</i>)**	13.5	83.1	3.4	0	9.0	89
White spruce (<i>Picea glauca</i>)*	67.4	32.6	0	0	4.7	46
Colorado spruce (<i>Picea pungens</i>)*	52.4	47.6	0	0	2.1	21
Pitch pine (<i>Pinus rigida</i>)	20.0	80.0	0	0	0.5	5
Eastern white pine (<i>Pinus strobus</i>)	42.1	42.1	15.8	0	1.9	19
Scots pine (<i>Pinus sylvestris</i>)**	20.0	80.0	0	0	0.5	5
Black cherry (<i>Prunus serotina</i>)	66.7	33.3	0	0	0.9	9
White oak (<i>Quercus alba</i>)	46.2	34.6	11.5	7.7	2.7	26
Pin oak (<i>Quercus palustris</i>)	10.5	31.6	15.8	42.1	1.9	19
Northern red oak (<i>Quercus rubra</i>)	23.8	57.1	11.9	7.1	4.3	42
Black locust (<i>Robinia pseudoacacia</i>)	20.0	60.0	20.0	0	1.0	10
Mountain-ash (<i>Sorbus aucuparia</i>)**	100.0	0	0	0	0	6
Northern white cedar (<i>Thuja occidentalis</i>)*	100.0	0	0	0	1.9	19
Eastern hemlock (<i>Tsuga canadensis</i>)	57.6	42.4	0	0	3.3	33
American elm (<i>Ulmus americana</i>)	0	28.6	42.8	28.6	0.7	7
Other species ^b	36.0	60.0	4.0	0	2.5	25
Total in dbh class						
Number	216	631	117	23	—	987
Percent	21.9	63.9	11.9	2.3	100.0	—

^a * = trees native to North America but not to the Connecticut River Valley in Massachusetts; ** = introduced exotic species.

^b includes 2 introduced exotic species and 1 native — but not locally occurring — tree species.

species (14.6 percent of all tree species, 31.2 percent of all trees, Table 2).

Similar patterns emerge when the proportions of native, but not locally occurring, species are compared: such trees accounted for 13.9 percent of the urban residential species, and 8.9 percent of all trees. In the suburb, these trees account for 14.6 percent and 11.5 percent, respectively (Table 2).

Species distributions, stem diameters, and crown heights reveal differences in overall forest structure between the two environments. The suburban area contains a wider range of tree diameters, and, perhaps more important, supports a far greater proportion of small trees—trees that will eventually replace dying or damaged trees. Most of these are of intermediate size, 20 to 60 cm dbh (Table 1).

Only eight tree species in the urban residential area attained a stem diameter in excess of 60 cm. Four of the five urban oak species were represented by large specimens. More pin oaks (*Quercus palustris*) were found in the largest diameter class than in any other class, the only urban tree to be so distributed. Beside the oaks, silver maples were well-represented by large specimens (Table 1).

In the suburban area, approximately half of all trees were in the smallest diameter class, a fourth in the next largest class, a tenth in the next largest, and a twentieth in the largest size class (Table 2). Because of this regular pattern of tree sizes, the suburban area is well prepared for a stable tree population; replacement trees were consistently more abundant in successively smaller size classes. Many of the urban trees, by comparison, were of intermediate size, with a much lower proportion in the replacement pool of small trees (Table 1). Thus, without a regular distribution of size classes, the urban residential area may be set for alternating periods when many larger trees are present, followed by another when small trees predominate.

Beside having more species of large size (at least 17), a major difference in the suburb was the proportion of conifers in the largest dbh class. No conifers of large size were found in the urban residential area.

The position of the tree canopy is different be-

Table 2. Common residential trees in Amherst, Massachusetts, by dbh class; species or genera listed represent 5+ individuals

Species of genus ^a	Dbh class (cm)					All dbh classes of trees
	0-20	20-40	40-60	>60	Number	
	Percent					
Balsam fir (<i>Abies balsamea</i>)*	70.0	30.0	0	0	0.4	10
White fir (<i>Abies concolor</i>)*	41.2	47.1	11.7	0	0.6	17
Japanese maple (<i>Acer palmatum</i>)**	87.5	12.5	0	0	0.3	8
Norway maple (<i>Acer platanoides</i>)**	75.7	17.0	5.6	1.7	10.4	288
Red maple (<i>Acer rubrum</i>)	39.1	39.1	11.5	10.3	3.1	87
Sugar maple (<i>Acer saccharum</i>)	42.8	14.0	25.9	17.3	10.9	301
Silver maple (<i>Acer saccharinum</i>)	47.5	5.0	21.2	26.3	0.7	19
White birch (<i>Betula alba</i>)**	58.8	35.3	5.9	0	0.6	17
Paper birch (<i>Betula papyrifera</i>)	40.0	48.6	11.4	0	1.3	35
Gray birch (<i>Betula populifolia</i>)	80.0	20.0	0	0	0.9	25
Katsura (<i>Cercidiphyllum japonicum</i>)**	60.0	40.0	0	0	0.2	5
Flowering dogwood (<i>Cornus florida</i>)	93.9	6.1	0	0	3.6	99
Hawthorn (<i>Crataegus</i> ssp.)	64.3	35.7	0	0	0.5	14
American beech (<i>Fagus grandifolia</i>)	40.0	0	20.0	40.0	0.2	5
European beech (<i>Fagus sylvatica</i>)**	33.3	0	66.7	0	0.2	6
White ash (<i>Fraxinus americana</i>)	45.2	23.8	16.7	14.3	1.5	42
Butternut (<i>Juglans cinerea</i>)	46.7	26.2	10.0	6.7	1.1	30
Black walnut (<i>Juglans nigra</i>)	37.5	37.5	25.0	0	0.3	8
Eastern redcedar (<i>Juniperus virginiana</i>)	51.2	41.5	7.3	0	1.5	41
Tamarack (<i>Larix laricina</i>)	20.0	20.0	60.0	0	0.2	5
Yellow-poplar (<i>Liriodendron tulipifera</i>)*	70.0	30.0	0	0	0.4	10
Magnolia (<i>Magnolia</i> ssp.)*	100.0	0	0	0	0.4	11
Apple (<i>Malus</i> ssp.)	71.3	33.0	4.3	0	4.1	115
Norway spruce (<i>Picea abies</i>)**	10.9	52.1	23.3	13.7	2.6	73
White spruce (<i>Picea glauca</i>)	56.0	37.6	5.5	0.9	3.9	109
Colorado spruce (<i>Picea pungens</i>)	42.4	45.5	9.1	3.0	1.2	33
Red pine (<i>Pinus resinosa</i>)	5.9	58.8	35.3	0	0.6	17

Table 2 (continued).

Red spruce (<i>Picea rubens</i>)	11.8	82.5	5.9	0	0.6	17	
Eastern white pine (<i>Pinus strobus</i>)	36.2	29.0	26.1	8.7	7.5	207	
Bigtooth aspen (<i>Populus grandidentata</i>)	88.9	0	0	11.1	0.3	9	
Quaking aspen (<i>Populus tremuloides</i>)	100.0	0	0	0	0.4	11	
Black cherry (<i>Prunus serotina</i>)	83.7	-	16.3	0	0	3.1	86
Pin oak (<i>Quercus palustris</i>)	28.6	42.8	28.6	0	0.5	14	
Northern red oak (<i>Quercus rubra</i>)	28.6	42.8	21.4	7.1	0.5	14	
Black oak (<i>Quercus velutina</i>)	69.2	15.4	15.4	0	0.5	13	
Black locust (<i>Robinia pseudocacia</i>)	20.0	60.0	20.0	0	0.2	5	
Willow (<i>Salix ssp.</i>)	0	67.7	16.7	16.7	0.2	6	
Mountain-ash (<i>Sorbus aucuparia</i>)* *	60.7	35.7	3.6	0	1.0	28	
Yew (<i>Taxus cuspidata</i>)* *	85.7	14.3	0	0	0.2	7	
Northern white-cedar (<i>Thuja occidentalis</i>)*	75.9	24.1	0	0	6.3	174	
Linden (<i>Tilia cordata</i>)* *	33.3	16.7	33.3	16.7	0.2	6	
Eastern hemlock (<i>Tsuga canadensis</i>)	66.0	27.1	5.7	1.2	21.5	594	
American elm (<i>Ulmus americana</i>)	51.0	22.4	10.2	16.3	1.8	49	
Other species ^b	58.4	25.0	8.3	8.3	3.5	96	
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Total in dbh class							
Number	1612	725	291	138	—	2766	
Percent	58.3	26.2	10.5	5.0	100.0	—	

a * = trees native to North America but not to the Connecticut River valley in Massachusetts; ** = introduced exotic species.

^b includes 15 introduced exotic species.

tween urban and suburban residential trees. The urban area tends more toward a park-like condition: in more than 75 percent of the trees, the bottom of the canopy was at least 2 m above the ground. The suburban area has a more equitable distribution of lower canopy heights; the crowns of approximately 50 percent of the trees were at most 1 meter above the ground (Fig. 1).

Species Adaptation and Habitat Values

The distribution of tree species across diameter classes in the two environments, considering the fact that some species reach maturity at smaller sizes, allows some inferences about residential

tree species adaptation in urban vs. suburban areas. This distribution also gives insight into the relative habitat quality of each area, as measured by bird populations. Richard (1983) presents an analysis based on the longevity of street trees as reflected by their size. He recommends planting species that tolerate urban conditions to bring about an adequate supply of replacements, and, thus, a stable population of street trees. Inasmuch as all urban trees are subjected to many of the same stresses as street trees, a similar recommendation can be made from the present data. However, there are two additional points to consider: trees that mature at relatively small size, e.g., dogwoods, may be quite tolerant of urban conditions, but may not show in an analysis based on large size alone; also, the greater range of potential species that can be considered in suburban environments has wildlife habitat implications—tree species vary in their value to wildlife.

This study shows that many native tree species that are present in the suburb (the suburb likely being an arrested transition between field/forest and city) are poorly represented in the urban environment. This statement is true of the conifers, which are notoriously susceptible to damage from air pollution. Considering just the species of which at least 5 individual trees were found, conifers composed 47.1 percent of suburban residential trees (13 species) and 24.9 percent (9 species) of urban residential trees (Tables 1 and 2). But it is also true for species such as the paper birch (*Betula papyrifera*), grey birch (*Betula populifolia*), and American beech (*Fagus grandifolia*), among others. The lack of diversity in populations of street trees is understandable because the special requirements for urban planting restrict the list of candidate species. But urban residential habitats also have little diversity of tree species.

Urban residential habitats have lower diversities of foliage height (number of layers of foliage) for two reasons: the preponderance of trees whose lower crowns are high above the ground, and the preponderance of trees less than 9 m tall (Fig. 2). Foliage height diversity is related to diversity of bird species in temperate deciduous woodlands (MacArthur and MacArthur 1961; James and Wamer 1982); and the relatively low quality of the urban habitat for wildlife, compared with that in the

suburbs, is reflected in lower richness in breeding bird species. In Springfield, there were 19 species of breeding birds in urban residential habitats; the suburban residential habitat contained 50 breeding species (DeGraaf and Wentworth 1981). Several habitat factors differed significantly between the two areas. In the urban area, these factors were lower tree density, fewer coniferous trees, a lower ratio of coniferous to deciduous trees, and a lower mean height of conifers.

Quality of avian habitat should be an important consideration in the selection and management of urban trees. Most residents enjoy seeing wildlife (Dagg 1970). Bird species associated with woody vegetation are generally innocuous, and they add color, sound, and movement to the cultural landscape. Species of birds that are associated with buildings frequently are regarded as pests. In natural forest conditions, plant species generally are considered of lesser importance than the overall form and distribution of the foliage (Karr and Roth 1971) because of the abundance of nesting and foraging sites in a woodland. However, in urban and suburban situations woody vegetation is distributed relatively sparsely, and, thus, is likely a limiting factor in the occurrence of many forest bird species. In these situations, preferences of bird species among tree and shrub species for nesting and foraging are manifest, and have been described for New England (DeGraaf et al. 1975; DeGraaf and Witman 1979). Whether for street-side planting or elsewhere, trees might be selected for their wildlife habitat value as well as for ability to withstand urban conditions.

Early nests of American robins (*Turdus migratorius*) usually are built in conifers; before hardwoods leaf out, eastern white pine, eastern hemlock and northern white-cedar are preferred nesting substrates. Successive nests are likewise built in trees with substantial horizontal branches, and include preferred broadleaved species such as apple (*Malus*) and flowering dogwood (DeGraaf et al. 1975).

Some other birds and their preferred coniferous nest sites include the blue jay (*Cyanocitta cristata*)—eastern hemlock; house finch (*Carpodacus mexicanus*)—northern white-cedar; purple finch (*Carpodacus purpureus*)—red, Colorado,

and white spruces and white fir; mourning dove (*Zenaida macroura*)—most conifers; and chipping sparrow (*Spizella passerina*)—yew and spruces.

Although many of these tree species were found in the urban tracts, most were not abundant. Many of the common bird species in urban habitats are those that are adapted to nesting or foraging in scattered trees; examples are the American robin, warbling vireo (*Vireo gilvis*), northern oriole (*Icterus glabula*), and chipping sparrow.

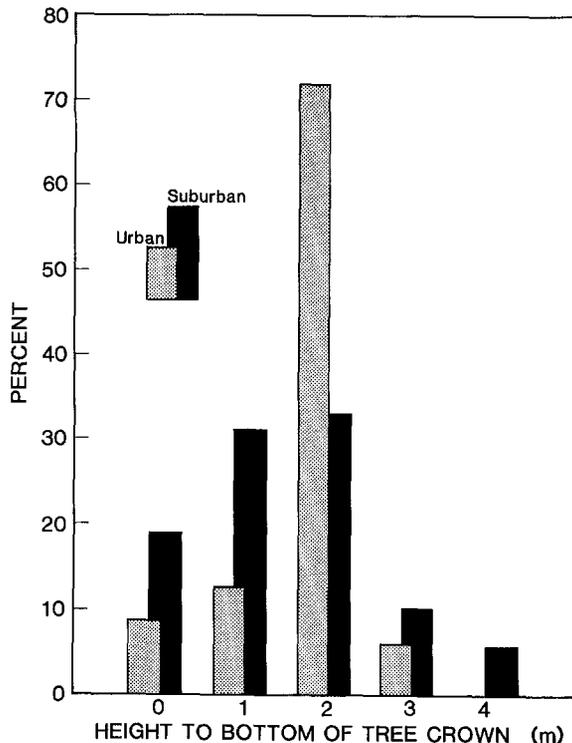


Figure 1. Crown positions of trees in urban Springfield and suburban Amherst, Massachusetts.

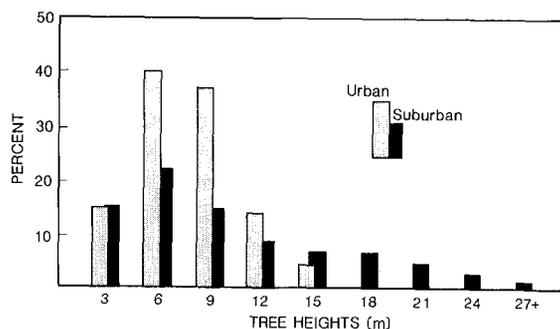


Figure 2. Distribution of tree heights in urban Springfield and suburban Amherst, Massachusetts.

Most forest bird species are found in more closed-canopy conditions. Urban habitats with trees arranged in stands or groves are likely to attract species that were found in the suburban habitat; for example, the scarlet tanager (*Piranga olivacea*) and the wood thrush (*Hylocichla mustelina*).

Conclusions

In this study, conducted in typical southern New England environs, urban tree density and species diversity are approximately one-third as great as in suburbs. The tree populations of both communities are dominated by relatively few species, but by largely different species in each area. Numbers of native, but not locally occurring, species do not differ, but their proportions in the overall tree population are significantly greater in the urban area. The suburban area supports a significantly greater range of tree diameters and a greater proportion of small trees. Relatively few conifers of large size were found; urban residential trees tend toward a more park-like condition—the crowns tend to be positioned higher above the ground. These vegetative differences are accompanied by a significant difference in species diversity of breeding forest birds between the two environments. Of the residential tree characteristics studied, the lower tree density and species richness and the lack of species of high foraging and nesting values for birds likely have the greatest impact on birdlife. Factors other than whether an area is urban or suburban may also be important determinants of residential tree species composition and distribution and wildlife response. The size, and character of municipal open space, the availability of urban forestry or tree programs, and local ordinances may affect the species selected for planting. But, the urban

environment could provide a better habitat if tree species known to have high value for birds were planted and allowed to reach fruit-bearing age.

Literature Cited

- Dagg, A. I. 1970. *Wildlife in an urban area*. Can. Nat., 97:201-212.
- DeGraaf, R. M., H. R. Pywell, and J. W. Thomas. 1975. *Relationships between songbird nest height, vegetation, and housing density in New England suburbs*. Trans. Northeast Wildl. Conf., 32:130-150.
- DeGraaf, R. M., and J. M. Wentworth. 1981. *Urban bird communities and habitats in England*. Trans. North Am. Wildl. Nat. Resour. Conf. 46:396-413.
- DeGraaf, R. M., and G. M. Witman. 1979. *Trees, shrubs and vines for attracting birds—a manual for the Northeast*. University of Massachusetts Press, Amherst. 194 p.
- Francis, H. R. 1915. *Suggestions for proper procedure in systematic street tree planting for towns and villages of New York*. Bull. No. 4, New York State Coll. For., Syracuse. 56 p.
- Grey, G. W., and F. J. Deneke. 1978. *Urban forestry*. John Wiley, New York, NY. 279 p.
- Hightshoe, G. 1978. *Native trees for urban and rural America*. Iowa State Univ. Res. Found. Ames. 95 p.
- James, F. C., and N. O. Wamer. 1982. *Relationships between temperate forest bird communities and vegetation structure*. Ecology, 63:159-171.
- Karr, J. R., and R. R. Roth. 1971. *Vegetation structure and avian diversity in several new world areas*. Am. Nat., 105:423-435.
- MacArthur, R., and J. MacArthur. 1961. *On bird species diversity*. Ecology, 42:594-598.
- Richards, N. A. 1983. *Diversity and stability in a street tree population*. Urban Ecol., 7:159-171.
- Sacksteder, C. J., and H. N. Gerhold. 1979. *A guide to urban tree inventory systems*. Res. pap. No. 43. Pennsylvania State Univ. Sch. For. Resour., University Park.
- Sanders, R. 1981. *Diversity in the street trees of Syracuse, New York*. Urban Ecol. 5:33-43.

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