IDENTIFYING FOREST LANDS IN URBAN AREAS IN THE CENTRAL HARDWOOD REGION

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Abstract: Forests in urban areas are an important component of urban and suburban environments. They provide places for recreation and environmental education, wildlife habitat for species adapted to living near humans, contribute to general human physical and psychological health. Knowing how much and what type of forest exists in urban areas provides critical baseline data for evaluating changes in that resource, and critical data to access factors that influence forest management and health. Forest Inventory and Analysis (FIA) data combined with population estimates constitute two valuable sources of information that show promise in understanding the extent, structure, and location of the forest resource in urban areas of the central hardwood region. Ownership information was examined to assess whether size and/or type of ownership is related to population density. There is increasing parcelization of forested lands and an increase in the numbers of nonindustrial private forest-land owners. Identifying where this parcelization is taking place in relation to population centers is important in understanding the process of fragmentation of forest land. The use of these techniques offer an opportunity to monitor changes in this important resource.

INTRODUCTION

Forested areas are important to the urban and suburban ecosystems of the central hardwood region. They provide sites for recreation, environmental education, and wildlife habitat; improve air and water quality; and enhance our physical and psychological well being. Because forests in urban areas may represent a significant portion of the forest resource in a heavily populated region, knowing their extent, structure and location and being able to monitor changes in these forests can benefit planners and managers. The object of this study is to identify forest land falling within urban areas or closely associated with areas of high human population density.

Many municipalities are involved in issues related to urban forestry, particularly the development of strategies to preserve local forest areas (Ries 1994). Factors such as noise and energy-cost reduction, rain and runoff control, wildlife habitat, recreational areas, and aesthetics must be considered when planning improvements to forests in urban areas (Deneke and Grey 1986). Another consideration is ecological landscaping, for example, the use of trees and shrubs to reduce temperature in urban heat islands. This technique has been effective in cutting energy costs both for cooling in the summer and heating in the winter.

We describe a methodology for identifying forest land in urban areas accurately, consistently, and relatively easily across the central hardwood region. The use of data sources from the USDA Forest Service's Forest Inventory and Analysis (FIA) and the U.S. Bureau of Census provide an opportunity to begin to characterize the forest in "urban" areas. Population and/or household density may be indicators of levels of human influence on forest land that could be useful in developing an understanding of the definition of this urban subset of forest area and where it fits with other uses of the term "urban forest."

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In a study of the structure and function of urban forests in the Chicago area, McPherson and others (1994) determined the amount, location, and character of that resource. The results will allow the assessment of its status and change over time. That assessment and inventories conducted for other municipalities have concentrated on trees along streets and in parks that fall within various jurisdictions. While useful at the local level, such inventories do not allow assessment of the status of forests in urban areas at the state or regional level (Nowak 1994). The method used here allows us to evaluate the stand level characteristics and location of the forests in urban areas at the state level. We will use New York and Pennsylvania as examples of data and methods that could be applied in the Central Hardwood Region.

DATA

The population density and other urban data used in this study are from the 1990 census, collected and distributed by the U.S. Bureau of Census (1990). Population and housing counts are from the Summary Tape File (STF1). Information on population density was calculated as total persons divided by total land area (persons/square mile). Most census data are available at the block or block-group level, which ensures the confidentiality of individual records. Blocks and block groups are census statistical areas, homogeneous in population but varying considerably in size between densely and less densely populated areas. For example, each block group contains an average population of 1,000. Population information used in this study was at the block-group level.

The Bureau of Census identifies areas as "urban" or "rural" at the block level (in NY blocks range in size form 6 to 248,863 acres). An area is considered urban if it consists of a central city or cities and surrounding closely settled territory that together have a population of 50,000 or more. Areas designated as "urban" also include places of 2,500 or more persons (U.S. Bureau Census 1992). The designation is roughly equivalent to a population density of 1,000 persons/square mile plus additional developed areas adjacent to those that are highly populated. However, to discern levels of human influence on forest land, we also used six population-density classes (≥1,000, ≥500 to <1,000, ≥250 to <500, ≥100 to <250, ≥50 to <100, and <50). Urban information and all of the census spatial data used in this study were obtained from 1994 TIGER/Line files (Wyatt and others 1990). Data on population density were obtained from the Land View II CD-ROM (U.S. Environmental Protection Agency and others 1995).

The forest data used in this study were collected by the Northeastern Forest Experiment Station's Forest Inventory and Analysis unit (NE-FIA). The extensive nature of the FIA inventory is suited to summaries and statistics at the state and county level. The forest inventory conducted by NE-FIA is based on a two-tiered, stratified, random sample. The first tier is a grid of 1-acre photo-interpretation (PI) points overlaid on available statewide, small-scale aerial photography. The grid is square with a spacing of approximately 3,900 feet (ground distance) between points, representing approximately 1 acre of 350. Each photo point on the photograph is interpreted using a stereo pair of photographs and a stereoscope, and is classified into a land use (forest or nonforest) and a cubic-foot volume class (if forested). This dataset is one of two used in this study. The second was a FIA plot dataset, a subset of the PI points, which are visited and inventoried for a wider range of attributes and for ground verification of the photo interpretation. The ground sample represents approximately 1 acre in 6,500. The two datasets offer slightly different types of information that describe the forest resource. The first offers greater spatial resolution; the second offers greater attribute resolution.

The locations of FIA plots in New York and Pennsylvania were digitized from aerial photographs registered to U.S. Geological Survey topographic maps. A formal test has not been completed but the locational error of plots in New York has been estimated to be within ± 300 feet. This level of accuracy was more than sufficient for this investigation. There are 5,403 ground locations in New York and 5,298 in Pennsylvania. New York had 95,792 photo plots and Pennsylvania had 88,024. A caution when analyzing FIA plot data for New York is that in this inventory cycle the plots in the Adirondacks that fell on reserved land were not inventoried. Also, no ground plots were measured in the five boroughs of New York City or in Nassau County, as they were allowed to have a nonforest land use. This resulted in a spatial gap in the data set. The photo plots contain no such hole in the spatial distribution across population-density classes. Both types of plots in the Adirondacks would fall primarily in the lowest density class. The opposite is true for New York City and Nassau County for which the population density classes of virtually every area exceeds 1,000/square mile.

METHODS

We devised a method to identify forests in urban areas from the FIA inventory process based on the Forest Service definition of "forest" (at least 1 acre in size and 10% stocked with trees) from both PI points and plot data, and from Bureau of Census population data and definition of "urban." All four definitions were used in a series of combinations (census urban and plots, census urban and PI points, population density ≥1,000 and plots, and population density ≥1,000 and PI points). We provide an example in New York of how the additional data collected on FIA plots can be used to describe forest stand characteristics (forest type, stand size, stand age, and stocking levels) within urban areas. In Pennsylvania, we performed a preliminary examination of the land uses and ownership characteristics of the forest land in each of the population density classes. A 10% sample of both forest and nonforest ground plots was further divided into land use classes modified from the set used in the Chicago study (McPherson and others 1994) and the amount of tree cover present. Additional information on the ownership of this sample was examined to determine which ownerships were associated with different population density classes. Data from the Pennsylvania ownership study was used for this purpose (Birch and Stelter 1994).

RESULTS AND DISCUSSION

The results of all four combinations were compared in both New York and Pennsylvania: census urban and FIA plots, census urban and FIA PI points, population density ≥1,000 and FIA plots, and population density ≥1,000 and FIA PI points. The amount of forestland reported as falling within urban or the most highly populated areas (where population density was used) ranged from 1.2 to 3.1% in New York (241,100 to 598,400 acres) (Tables 1 and 2, Figures 1-4). In Pennsylvania, between .95 and 2.8% of the forestland was reported in those categories (177,800 to 430,500 acres) (Tables 5 and 6, Figures 5-8).

Table 1. Plots and PI points in urban and rural population classes, New York

	Urban	Rural	Off map	Total
Number of blocks	145,436	141,425	0	286,861
Area: 1,000 acres	2,387	29,387	0	31,774
percent	8	92	0	100
		Number of plots		
Forested: number	93	3,006	0	3,099
percent	3	97	0	100
Nonforested: number	278	2,025	1	2,304
percent	12	88	0	100
Total: number	371	5,031	1	5,403
percent	7	93	0	100
		Number of PI points		
Forested: number	1,635	54,318	4	55,957
percent	3	97	0	100
Nonforested: number	4,759	32,870	2	37,631
percent	13	87	0	100
Unassigned: number	202	2,002	0	2,204
percent	9	91	0	100
Total: number	6,596	89,190	6	95,792
percent	7	93	0	100

Tables 3-4 and 7-8 present a breakdown of each urban, rural and population density class by forest and nonforest in New York and Pennsylvania, respectively. In these two states, the census-designated urban areas are forested over at least 25% of their area. In NY the urban class has a proportion of 25:75 (forest: nonforest) land. That proportion is slightly lower in the highest population density class (≥1,000) at 16:84, and slightly higher in the next population density class at 36:64. The proportions are very close to 50:50 for the next three population density classes, until it finally switches over to more forest than nonforest at 70:30 in the lowest population density class. Pennsylvania is similar, containing forested land in 22% of the census-designated urban area.

Table 2. Plots and PI points by population-density class, New York

	Density class						
	≥1000	≥500 to <1000	≥250 to <500	≥100 to <250	≥50 to <100	<50	Total
Number of blocks	12,228	629	460	792	676	981	15,766
Area: 1,000 acres	1,542	718	1,075	4,240	6,907	17,291	31,733
percent	5	2	3	13	22	54	100
	Number of plots						
Forested: number	38	47	88	403	636	1,877	3,099
percent	1	2	3	13	21	61	100
Nonforested: number	205	84	105	431	658	821	2,304
percent	9	4	5	19	29	36	100
Total: number	243	131	193	834	1,294	2,708	5,403
percent	4	2	4	15	24	50	100
	Number of PI points						
Forested: number	709	724	1,367	5,563	9,965	37,629	55,957
percent	1	1	2	10	18	67	100
Nonforested: number	3,434	1,177	1,484	6,333	10,280	14,923	37,631
percent	9	3	4	17	27	40	100
Unassigned: number	128	76	119	359	476	1,046	2,204
percent	6	3	5	16	22	47	100
Total: number	4,271	1,977	2,970	12,255	20,721	53,598	95,792
percent	4	2	4	15	24	50	100

Table 3. Proportion of plots and PI points by rural and urban population classes, New York

	Urban	Rural	Off map	Total
	Number of plots			
Forested: number	93	3,006	0	3,099
percent	25	60	0	57
Nonforested: number	278	2,025	1	2,304
percent	75	40	100	43
Total: number	371	5,031	1	5,403
percent	100	100	100	100
	Number of PI points			
Forested: number	1,635	54,318	4	55,957
percent	25	61	67	59
Nonforested: number	4,759	32,870	2	37,631
percent	72	37	33	39
Unassigned: number	202	2,002	0	2,204
percent	3	2	0	2
Total: number	6,596	89,190	6	95,792
percent	100	100	100	100

Table 4. Proportion of Plots and PI points by population-density class, New York

	Density class						
	≥1000	≥500 to <1000	≥250 to <500	≥100 to <250	≥50 to <100	<50	Total
	Number of plots						
Forested: number	38	47	88	403	636	1,877	3,099
percent	16	36	46	48	49	70	57
Nonforested: number	205	84	105	431	658	821	2,304
percent	84	64	54	52	51	30	43
Total: number	243	131	193	834	1,294	2,708	5,403
percent	100	100	100	100	100	100	100
	Number of PI points						
Forested: number	709	724	1,367	5,563	9,965	37,629	55,957
percent	17	37	46	45	48	70	59
Nonforested: number	3,434	1,177	1,484	6,333	10,280	14,923	37,631
percent	80	60	50	52	50	28	39
Unassigned: number	128	76	119	359	476	1,046	2,204
percent	3	3	4	3	2	2	2
Total: number	4,271	1,977	2,970	12,255	20,721	53,598	95,792
percent	100	100	100	100	100	100	100

Table 5. Plots and PI points in urban and rural population classes, Pennsylvania

	Urban	Rural	Off map	Total
Number of blocks	145,615	172,158	37	317,810
Area: 1,000 acres	1,979	27,498	0.09	29,477
percent	7	93	0	100
		Number of plots		
Forested: number	72	3,069	1	3,143
percent	2	98	0	100
Nonforested: number	259	1,897	0	2,155
percent	12	88	0	100
Total: number	331	4,966	1	5,298
percent	6	94	0	100
		Number of PI points		
Forested: number	1,439	49,267	4	50,710
percent	3	97	0	100
Nonforested: number	4,206	30,733	2	34,941
percent	12	88	0	100
Unassigned: number	199	2,173	1	2,373
percent	8	92	0	100
Total: number	5,844	82,173	7	88,024
percent	7	93	0	100

Table 6. Plots and PI points by population-density class, Pennsylvania.

	Density class						
	≥1000	≥500 to <1000	≥250 to <500	≥100 to <250	≥50 to <100	<50	Total
Number of blocks	8,049	677	678	1,056	663	811	11,934
Area: 1,000 acres	1,304	695	1,688	5,202	6,324	14,260	29,477
percent	4	2	6	18	22	48	100
				Number of plots			
Forested: number	30	36	105	402	652	1,917	3,143
percent	1	1	3	13	21	61	100
Nonforested: number	190	78	192	560	535	601	2,155
percent	9	4	9	26	25	36	100
Total: number	220	114	297	962	1,187	2,518	5,298
percent	4	2	6	18	22	48	100
				Number of PI points			
Forested: number	617	600	1,690	6,421	10,339	31,043	50,710
percent	1	1	3	13	20	61	100
Nonforested: number	3,122	1,388	3,159	8,692	8,247	10,333	34,941
percent	9	4	9	25	24	29	100
Unassigned: number	110	85	188	533	588	869	2,373
percent	5	4	8	22	25	36	100
Total: number	3,849	2,073	5,037	15,646	19,174	42,245	88,024
percent	4	2	6	18	22	48	100

Table 7. Proportion of plots and PI points by rural and urban population classes, New York

	Urban	Rural	Off map	Total
	Number of plots			
Forested: number	72	3,069	1	3,143
percent	22	62	100	59
Nonforested: number	259	1,897	0	2,156
percent	78	38	0	41
Total: number	331	4,966	1	5,298
percent	100	100	100	100
	Number of PI points			
Forested: number	1,439	49,267	4	50,710
percent	25	60	57	58
Nonforested: number	4,206	30,733	2	34,941
percent	72	37	29	40
Unassigned: number	199	2,173	1	2,373
percent	3	3	14	2
Total: number	5,844	82,173	7	88,024
percent	100	100	100	100

Table 8. Proportion of Plots and PI points by population-density class, Pennsylvania

	Density class						
	≥1000	≥500 to <1000	≥250 to <500	≥100 to <250	≥50 to 100	<50	Total
	Number of plots						
Forested: number	30	36	105	402	652	1,917	3,143
percent	14	32	35	42	55	76	59
Nonforested: number	190	78	192	560	535	601	2,155
percent	86	68	65	58	45	24	41
Total: number	220	114	297	962	1,187	2,518	5,298
percent	100	100	100	100	100	100	100
	Number of PI points						
Forested: number	617	600	1,690	6,421	10,339	31,043	50,710
percent	16	29	33	41	54	74	58
Nonforested: number	3,122	1,388	3,159	8,692	8,247	10,333	34,941
percent	81	67	63	56	43	24	40
Unassigned: number	110	85	188	533	588	869	2,373
percent	3	4	4	3	3	2	2
Total: number	3,849	2,073	5,037	15,646	19,174	42,245	88,024
percent	100	100	100	100	100	100	100

The advantage with any of the four combinations of plots, PI points, census-designated urban areas and population density is that the data are readily available nationwide. Thus, it is a methodology for identifying forest in urban areas that can be applied relatively easily and consistently throughout the country. And since both data sources exist over time, this method is applicable to both historical and future data, allowing us to track changes in area, composition, and location of urban forests over time. Differences in regional development patterns and predominate land uses mean that there will be regional differences with respect to the types of land use and tree cover that are captured or missed by this definition of forest in urban areas.

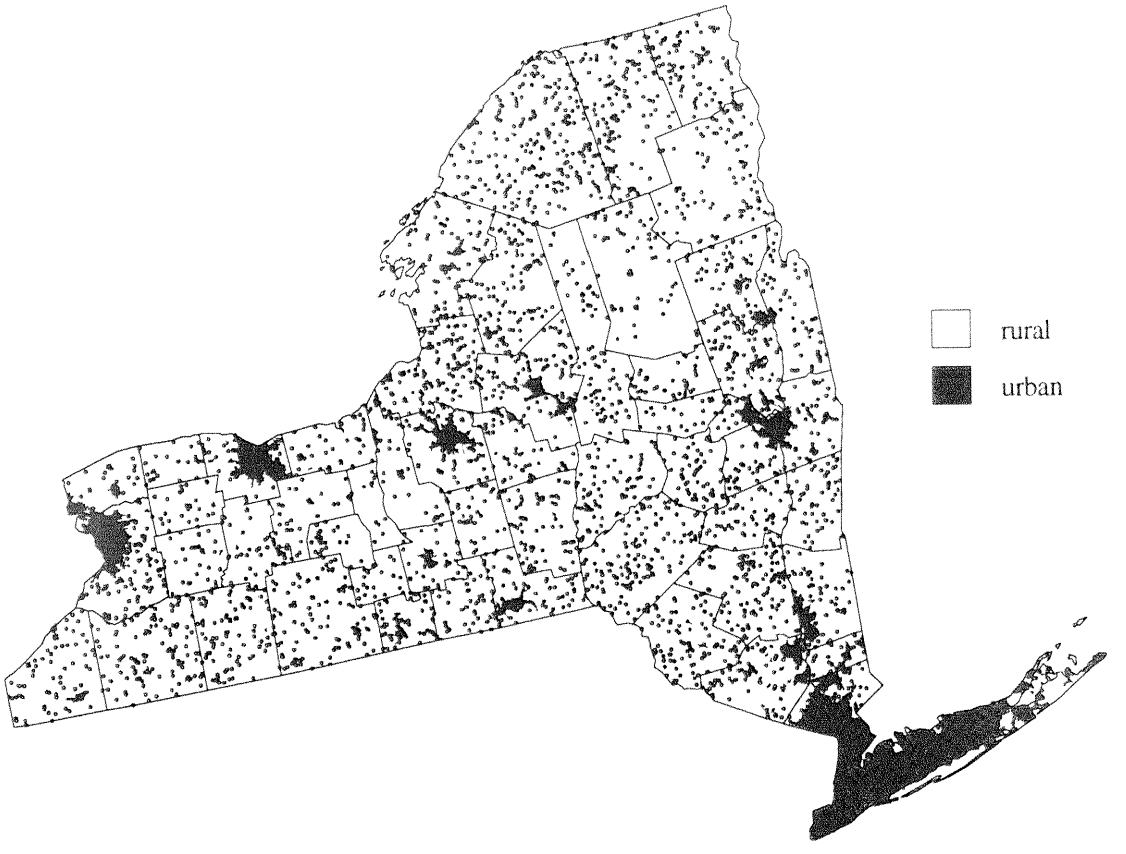

Figure 1. Forested plots and urban/rural classes, New York (population data from the 1990 census; plot data from the 1993 inventory).

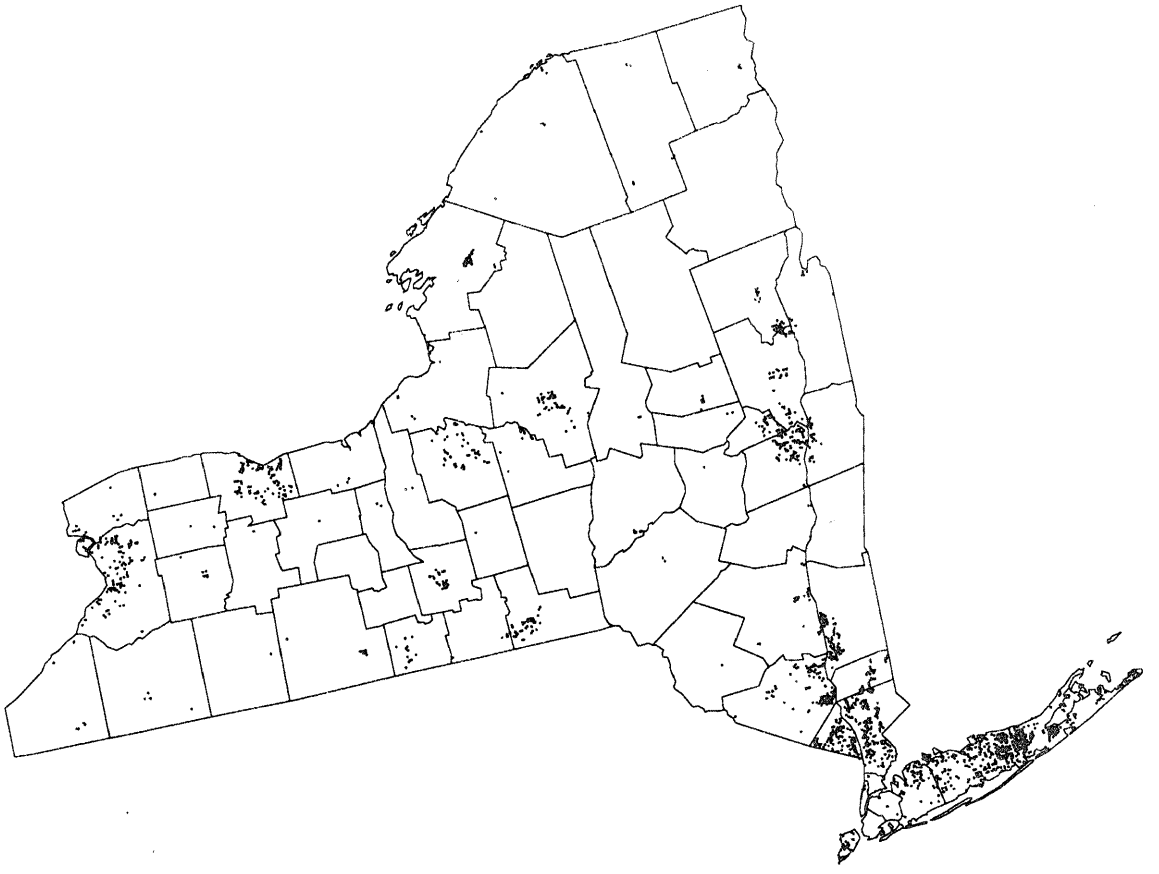

Figure 2. Forested photo-interpetation points in New York within census-designated urban.

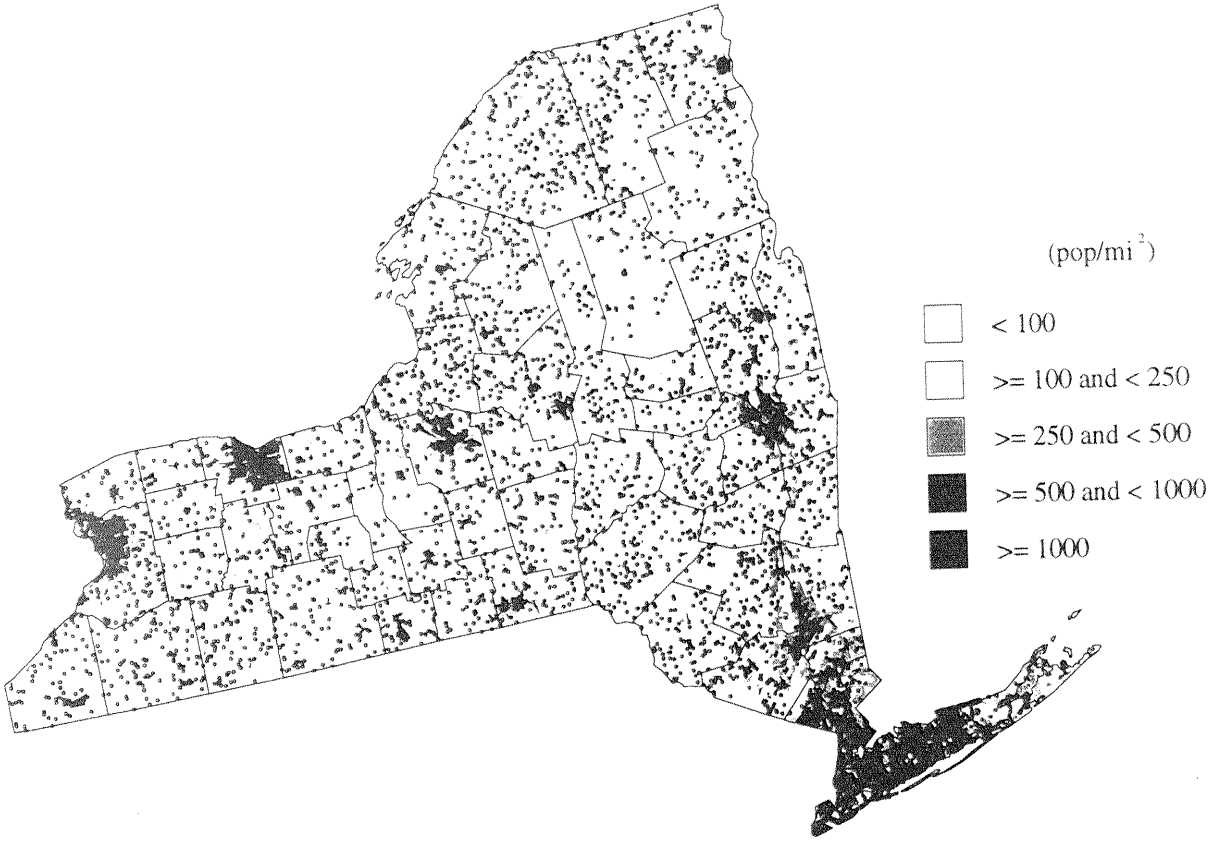

Figure 3. Forested plots and population density classes, New York (population data from the 1990 census; plot data from the 1993 inventory).

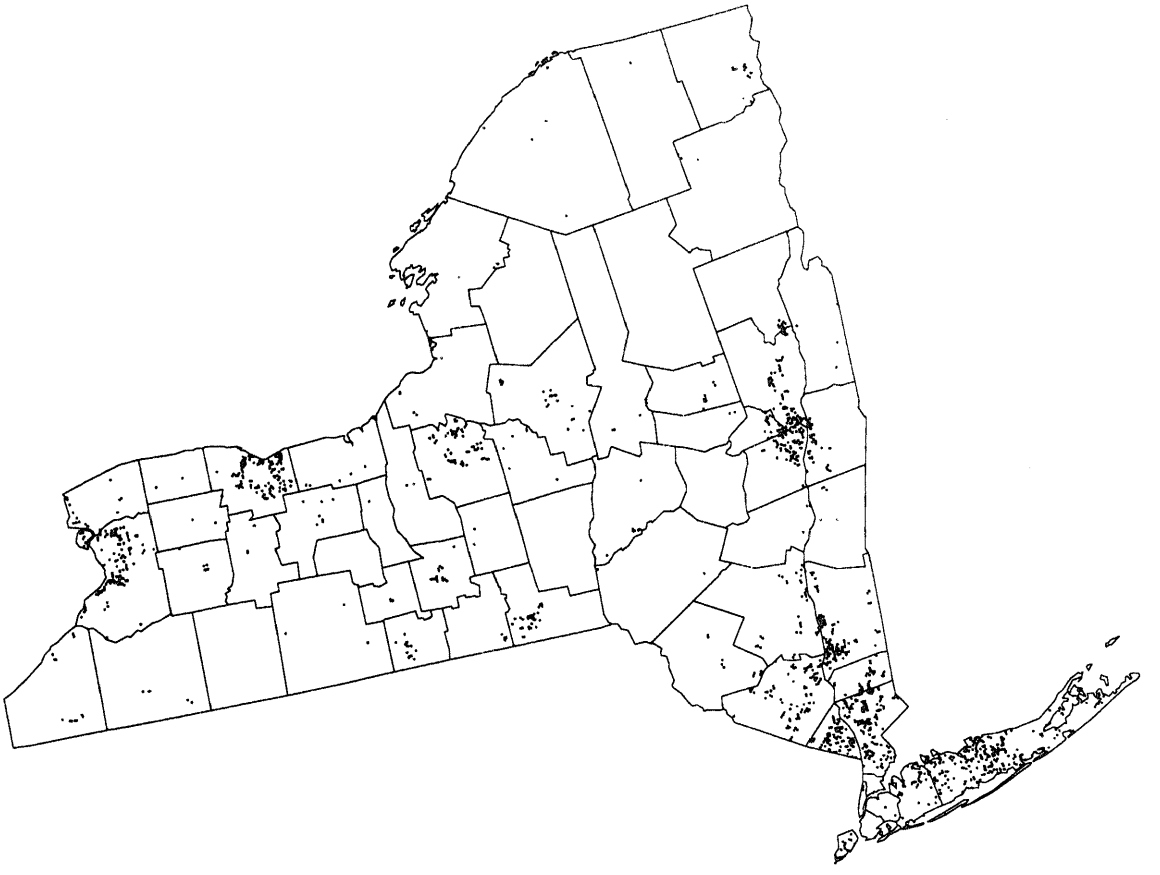

Figure 4. Forested photo-interpretation points in New York within population density class of ≥ 500 persons/mi^2.

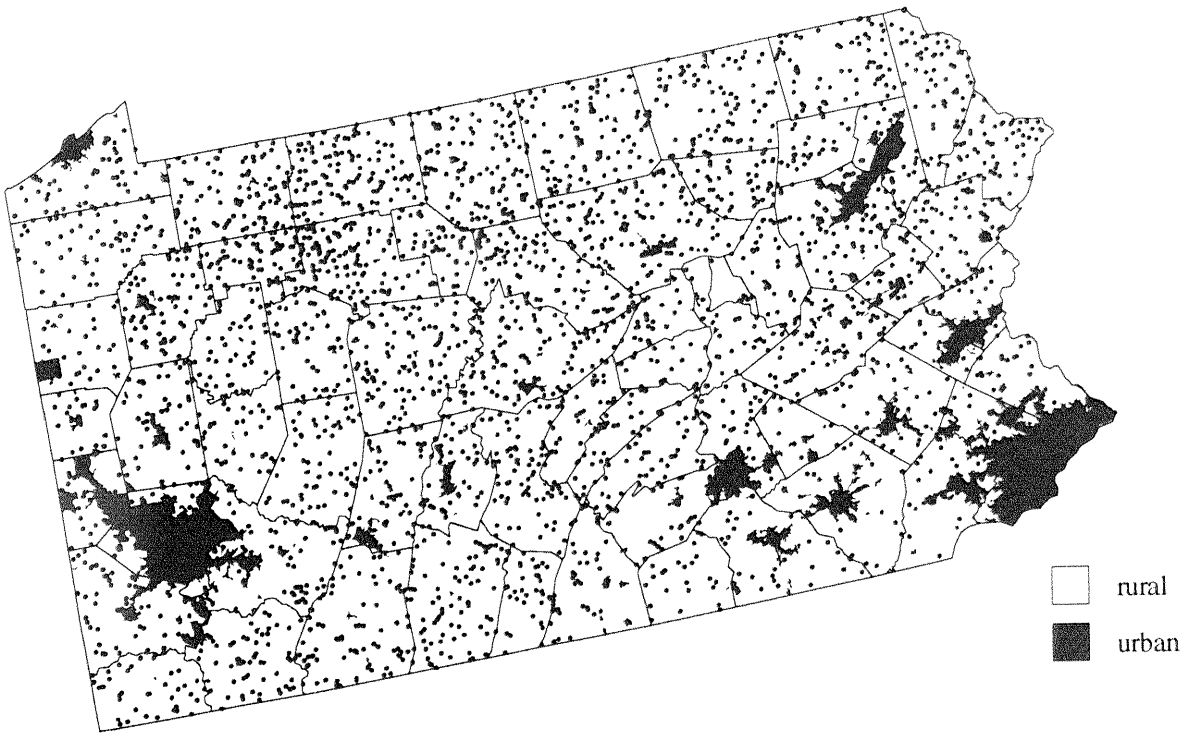

Figure 5. Forested plots and urban/rural classes, Pennsylvania (population data from the 1990 census; plot data from the 1989 inventory).

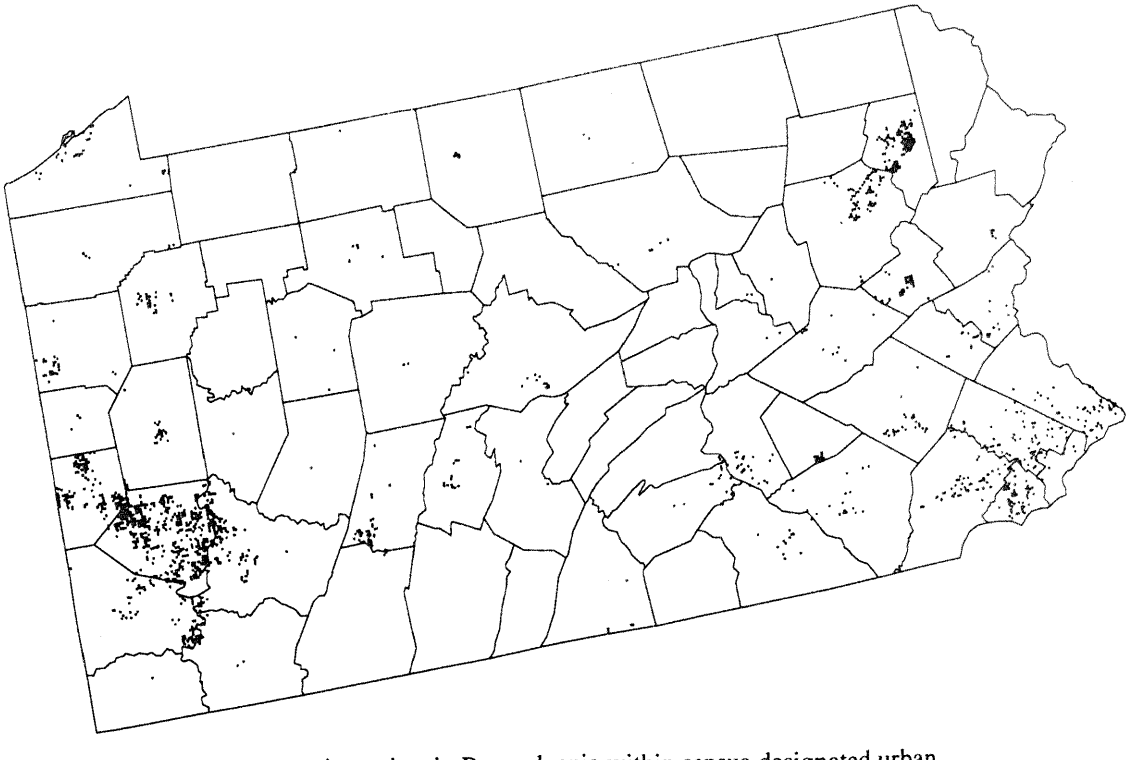

Figure 6. Forested photo-interpretation points in Pennsylvania within census-designated urban.

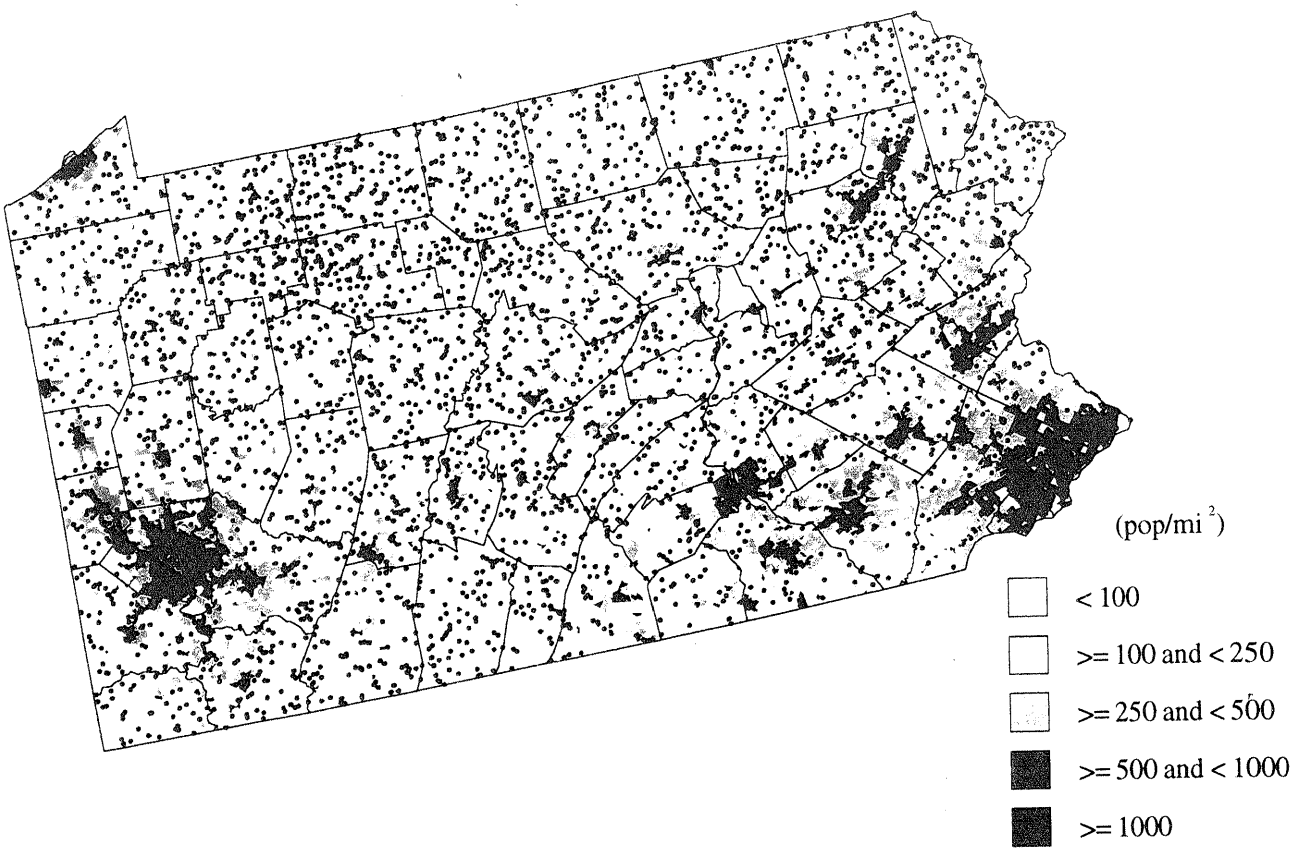

Figure 7. Forested plots and population-density classes, Pennsylvania (population data from the 1990 census; plot data from the 1989 inventory).

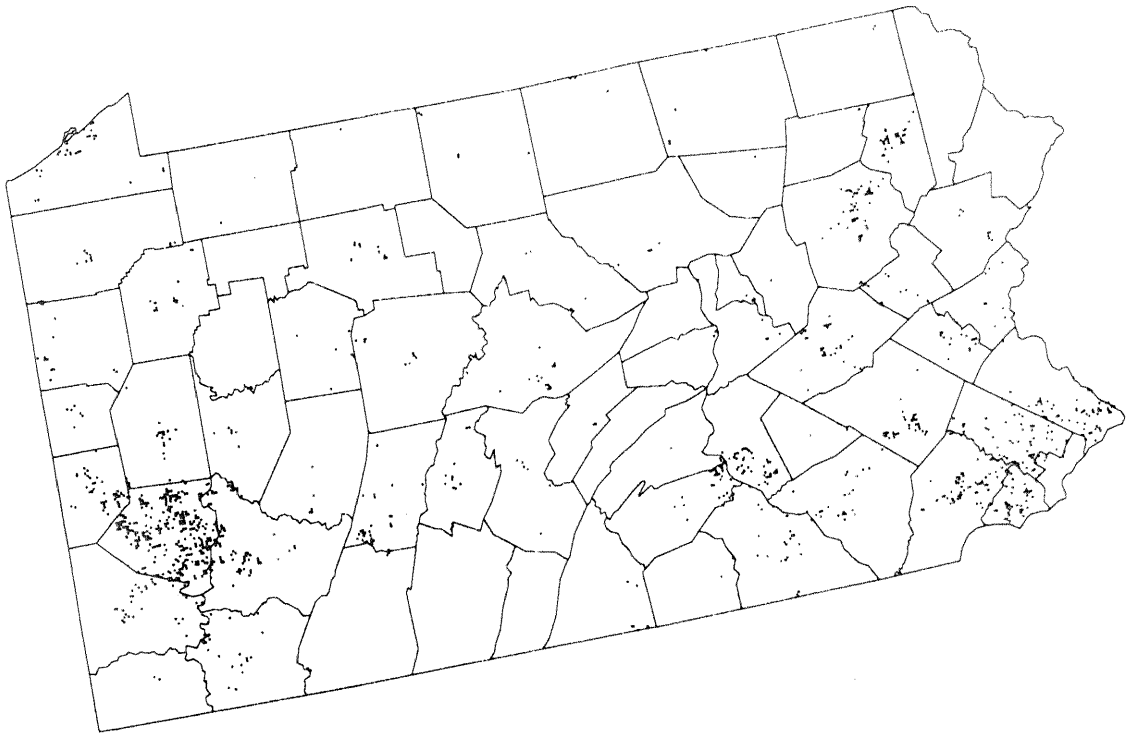

Figure 8. Forested photo-interpretation points in Pennsylvania within population density class of ≥ 500 persons/mi^2.

Differences between census-designated urban and population density. The census-designated 'urban' area appears to correspond most closely to a population density class of ≥500 persons/square mile. Although the basis of the definition is areas with a population density of ≥1,000 persons/square mile, all the additional exceptions in the definition effectively incorporate an equivalent amount of land, although in some cases slightly different locations.

Differences between FIA plots and FIA photo interpretation (PI) points. Although some differences might be expected between methods using the PI points to define forest land and those using the plots, because the former is more likely to capture tree cover versus land use class (e.g., any stand with a managed understory, such as mowing, is considered nonforest due to nonforest land use), little difference was in fact observed. This is mostly likely because in those two states the photo interpreters were also trying to interpret for forest/nonforest land use and land cover simultaneously, and were able to match the on-the-ground class fairly closely. In states photo interpreted since 1994, (Maine, Vermont, New Hampshire) points are being interpreted for forest cover first and then land use, allowing the use of PI points as a better source of data on tree cover (both with the Forest Service definition of one acre minimum area and 10% minimum stocking level (forested) and without that minimum (including the category 'nonforest with trees').

The primary difference between the different combinations of 'forest' and 'urban' was not in this case between the amount of forest in 'urban' areas reported, but in the kinds of information offered from that analysis. Using FIA plots allows a further description of the stand characteristics of the forested plots in each urban or population density class. Tables 9-12 illustrate this in New York, by presenting a breakdown of those plots falling within the census-designated urban area by forest type group, stand size, stand age, and stocking level. This allows us to further describe the characteristics of this forest land occurring in these urban areas. In general, the older and larger stands (sawtimber and pole timber stands more than 45 years old) are in the lower Hudson Valley. The younger and smaller stands (sapling stands 0 to 25 years old) are in the corridor that comprises Buffalo, Rochester, and Syracuse. As with any statistical summary, care must be taken when small subsets of the area are examined that contain few sample plots. This situation might occur if individual urban areas were selected for investigation.

Table 9. Distribution of forest types within the urban area, New York

Forest type group	Percentage of plots
Pines	7.6
Spruce/fir	2.2
Pitch pine	12.0
Oak/pine	4.3
Oak-hickory	23.9
Elm/ash/red maple	13.1
Maple/beech/birch	34.8
Aspen	2.2

Table 10. Distribution of forest stand sizes within the urban area, New York

Stand size	Percentage of plots
Sawtimber	46.7
Poletimber	30.4
Seedling/sapling	22.8

Table 11. Distribution of forest stand ages within the urban area, New York

Stand age (years)	Percentage of plots
0	3.3
25	29.3
45	25.0
65	22.8
85	7.6
105	3.3
Uneven-aged stands	8.7

Table 12. Distribution of forest stocking levels within the urban area, New York

Stocking level	Percentage of plots
nonstocked	1.1
poorly stocked	13.0
medium stocked	29.3
fully stocked	32.6
overstocked	23.9

In contrast to the extensive amount of attribute and descriptive detail offered by the FIA plots, using FIA photo interpretation points allows a better description of exactly where that forestland falling within urban or highly populated areas occurs. As can be seen in Figures 2, 4, 6, and 8, the greater intensity of sample points (approximately 1 for every 300 acres) provides a much clearer picture of where those small, scattered or larger areas of forest within the urban or highly populated areas occurs. The intensity of sampling at the scale of the FIA plots (approximately 1 for every 5,000 acres) is not sufficient to provide this information.

Using census-designated urban offers a very specifically defined and widely recognized and understood definition of urban areas. Using population density (or a similar variable such as household density) provides a means to separate out gradations of probable human use of and influence on the forest—two realities that make the urban forest of such interest for study and monitoring.

These combinations, of FIA plot and PI data with census urban and population density data, do provide a descriptive picture of what subset of the FIA (USFS) forestland falls within urban and highly populated areas. But also of considerable interest is how this reported information compares with the total picture of tree-cover within those areas. Certainly not every element of forests in urban areas is captured and can be described with these inventories. Tree-covered areas less than 1 acre in size or less than 120 feet wide are not included in the FIA plot inventory, nor are certain 'nonforest' land uses such as street trees, or city parks, or trees in residential, commercial, and institutional areas. And although the photo interpretation points in the most recent inventories (starting with New Hampshire) are identifying tree cover separately from land use, in NY and PA the photo interpretation points were largely subject to the same definitions as the FIA plots. This situation does miss many areas with tree cover in urban areas that are often viewed and managed as urban forest. In order to gain a better understanding of how these components are classified or missed under the combination methods used here, additional photo interpretation of a sample of these plots was undertaken in Pennsylvania. An approximately 10% sample (512 of 5,298 plots) was selected across the six population-density classes and photo interpreted again, this time for landuse in the proximity to the one acre sample point. The land-use classes used were a modified version of those in the Chicago study, and included (McPherson and others 1993):

Land use class	Land cover description
Residential	Rural/forested, no yards
	Suburban/many trees, clumps
	Urban/only a few trees
Industrial/commercial/ institutional	Building dominated
	Park dominated
Transportation	Road and railroad
Agricultural	Cropland and pasture land
	Areas surrounded by cropland
Wild/Vacant	Forests dominate

The results were compared for each population density category to determine the types of land use being captured as 'forest' or 'nonforest'. Of particular interest are the types of tree cover and land use captured as the forested category, and the types of tree cover placed in the nonforest category—those areas that might be considered "urban forest" (i.e., all tree cover) but are not captured here (Tables 13 and 14). Table 13 shows the distribution of land uses among forested plots by population density class. It can be seen that in the lower population-density areas (fewer than 100 persons/square mile), agricultural and wild lands dominate. In areas with more than 250 persons/square mile, residential lands dominate and the classes begin to capture forested plots associated with industrial parks, institutions, and transportation corridors. Land uses for the nonforest plots are shown in table 14. The population-density classes of fewer than 250 persons/square mile are dominated by agriculture. With increases in density we observed an increase in institutional, industrial, transportation and residential uses. Many of these classes have trees associated with them that many would classify as "urban forest".

Table 13. Distribution of sample plots by population density class for forested plots, Pennsylvania

Population density class (persons/mi²)	Land use	No. of plots	Percentage in class
<50	Wild	158	85
	Near agriculture	24	13
	Rural residential	5	2
≥ 50 to < 100	Wild	33	52
	Near agriculture	20	32
	Rural residential	8	13
≥ 100 to < 250	Wild	20	51
	Near agriculture	7	18
	Rural residential	11	28
	Suburban residential	1	3
≥ 250 to < 500	Near agriculture	2	18
	Rural residential	4	37
	Suburban residential	1	9
	Urban residential	2	18
	Industrial	1	9
	Institutional	1	9
≥ 500 to < 1,000	Wild	1	25
	Near agriculture	1	25
	Rural residential	1	25
	Suburban residential	1	25
≥ 1,000	Suburban residential	2	67
	Transportation corridor	1	33

Ownership information was examined to assess whether size and/or type of ownership is related to population density. Trends in ownership influence the process of parcelization and fragmentation, forest management and forest use of forest land. We observed that most of the publicly owned forest at the state and national level was in density classes of fewer than 100 persons/square mile. Also, forest industry lands in Pennsylvania occur in less densely populated portions of the state (Birch 1994). Small forest ownerships were more closely associated with population densities greater than 250 persons/square mile. For additional information on the definitions and process of parcelization and fragmentation of the forest in New York, see Birch (1996).

Table 14. Distribution of sample plots by population density class for nonforest plots, Pennsylvania

Population density class (persons/mi²)	Land use	No. of plots	Percentage in class
<50 per square mile	Agricultural	33	60
	Rural residential	12	22
	Vacant	5	9
	Quarry	1	2
	Transportation	3	5
≥ 50 to < 100	Agricultural	34	67
	Rural residential	2	4
	Suburban residential	3	6
	Vacant	3	6
	Quarry	3	6
	Transportation	3	6
	Industrial	2	4
	Institutional	1	2
≥ 100 to < 250	Agricultural	30	54
	Rural residential	5	9
	Suburban residential	9	17
	Urban residential	1	2
	Vacant	1	2
	Industrial	3	5
	Transportation corridor	2	3
≥ 250 to < 500	Agricultural	6	32
	Rural residential	4	21
	Suburban residential	6	32
	Vacant	2	10
	Industrial	1	5
≥ 500 to < 1,000	Suburban residential	4	57
	Agricultural	2	29
	Institutional	1	14
≥ 1,000	Rural residential	2	11
	Suburban residential	5	28
	Urban residential	9	50
	Institutional	1	6

CONCLUSION

Different definitions of urban forest produce different estimates but also reveal important information. Using the Bureau of Census definition of urban has several advantages. It is widely recognized and understood, it is specifically defined, and it can be applied across the country. However, these data do not identify forests outside of census-designated urban areas that also are heavily influenced by human activity. Analyzing where forested plots and photo points fall within different population-density classes allows us to identify other subsets of forest land that may be subject to significant human use and influence.

As mentioned earlier, both FIA ground plots and PI points offer two valuable types of information that describe the forest resource. Each ground plot allows ground verification of the photo interpretation and a large number of variables that provide greater attribute resolution. For example, plots can be described in terms of stand age, stand size, and species composition. Photo interpretation points hold little attribute information but have a much greater spatial resolution, providing an opportunity to better understand where the urban forest occurs.

We present a technique for estimating and describing the forest in urban areas of two of the larger and heavily populated states of the Northeast. We need to apply this technique across the Northeast and in other regions of the country. As new inventories are completed by FIA, we will have an opportunity to monitor changes in this valuable resource.

LITERATURE CITED

Alerich, C.L. 1993. Forest statistics for Pennsylvania—1978 and 1989. USDA Forest Service Resour. Bull. NE-126. 244 p.

Birch, T.W. and C.M. Stelter. 1994. Trends in owner attitudes. In Penn's Woods—change and challenge. April 1-2, 1993, State College, PA. Penn State University. p. 50-60.

Birch, T.W. 1996. Forest land parcelization and fragmentation. In the Empire Forest—changes and challenges. November 13-14, 1995, Syracuse, NY. Syracuse State University of New York. p. 98-110.

Deneke, F.J. and Grey, G.W. 1986. Urban forestry. New York: John Wiley and Sons.

McPherson, M.H., D.J. Nowak, and R.A. Rowntree. 1994. Chicago's urban forest ecosystem: results of the Chicago urban forest climate project. USDA Forest Service Gen. Tech. Report NE-186.

Nowak, David J. 1994. Understanding the structure of urban forests. J. For. 92(10): 42-46.

Ries, P.D. 1994. Applying urban forestry in small communities. In Proceedings of the 6th national urban forest conference. September 14-18, 1993, Minneapolis, MN. Washington, DC: American Forests. p. 58-60.

U.S. Department of Commerce, Bureau of the Census. 1990. Census '90 basics. Washington, DC: U.S. Department of Commerce, Bureau of the Census.

U.S. Department of Commerce, Bureau of the Census. 1992. 1990 census of population and housing, summary social, economic and housing characteristics, New York. CPH-5-50. Washington, DC: U.S. Dept. of Commerce, Bureau of the Census.

U.S. Environmental Protection Agency, U.S. Department of Commerce-National Oceanic and Atmospheric Administration, and U.S. Department of Commerce-Bureau of the Census. 1995. Land View™II. CD92-LV2-01. Washington, DC

Wyatt, J.P., ed. 1990. TIGER: the coast-to coast digital map data base. Washington, DC: U.S. Department of Commerce, Bureau of the Census.