

Projected Urban Growth (2000–2050) and Its Estimated Impact on the US Forest Resource

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ABSTRACT

Urban land in the United States is projected to increase from 3.1% in 2000 to 8.1% in 2050, an area of 392,400 km², which is larger than the state of Montana. By 2050, four states (Rhode Island, New Jersey, Massachusetts, and Connecticut) are projected to be more than one-half urban land. The total projected amount of US forestland estimated to be subsumed by urbanization between 2000 and 2050 is about 118,300 km², an area approximately the size of Pennsylvania. Because of this urban growth, more regional planning and management may be needed to sustain forest products and ecosystem services required by a growing urban population.

Keywords: urbanization, urban sprawl, forest loss, forest sustainability, urban forests

Urbanization affects the forest resource and its management in many ways. Not only does urban development directly displace some trees and forests, it increases population density and associated human activities and infrastructure, which can affect forests and their management. Urban land in the coterminous United States increased from 2.5% in 1990 to 3.1% in 2000, an area about the size of Vermont and New Hampshire combined (Nowak et al. 2005). Expanding urbanization threatens forest sustainability through an increased risk from fire at the wildland-urban interface, exotic pest infestations, unmanaged outdoor recreation, and forest fragmentation. At the same time, expanding urbanization increases the importance of urban forests in terms of their extent and the critical ecosystem services they provide to sustain human health and environmental quality in and around urban areas.

Although urban expansion in the 1990s was significant, patterns of urban growth suggest that the rate of urban expansion is

likely to increase in the coming decades (Nowak et al. 2005). The objectives of this article are to project the potential expansion of urban land over a 50-year period (2000–2050), identify areas with potentially significant interactions between urban expansion and forest resources across the coterminous United States, and discuss its implications for forest resource management.

Projecting Urban Growth

Urban land was defined using the 2000 US Census Bureau's definition, which, essentially, is block groups and census blocks with a minimum population density of 500 people/mi² and less densely settled blocks that form enclaves or indentations or connect discontinuous areas (US Census Bureau 2003). Urban land in 1990 and 2000 was mapped to analyze urban growth by county (Nowak et al. 2005). Patterns of urban growth reveal that the increase in percent urban land within counties (1990–2000) tended to increase with percent of the county classified as urban in

1990. Counties with 40–60% urban land had the greatest increase in percent urban land (Figure 1). This growth pattern was applied to individual counties across the United States based on the percent of the county classified as urban to project urban growth in 10-year increments for the period 2000–2050. Plus or minus one standard error difference in the growth projection was applied to each county growth estimate (Figure 1) to determine an upper and lower bound of the urban land projection for the United States (Figure 2).

To determine the potential impact of urban growth on forestland, the 1992 National Land Cover Database (NLCD; US Geological Survey 2003) was overlaid with urban expansion zones (1990–2000) to determine the percent of urban growth that occurred in forestland within each state (Nowak et al. 2005). This percent ranged from 64.8% in Rhode Island to 0.8% in Nevada. The national average was 33.4%, which is close to the national average forest cover for all land of 33% (Alig and Butler 2004).

Projected urban growth in the state during 10-year periods was combined with the percent of urban growth that occurred in forestland in that state between 1990 and 2000 to project the amount of forestland likely to be subsumed by urban growth between 2000 and 2050. These growth projections assume that the patterns of urban growth that occurred between 1990 and 2000 will continue to occur over the next 50 years. These projections reveal areas where forest resources are most likely to be influenced by expanding urbanization.

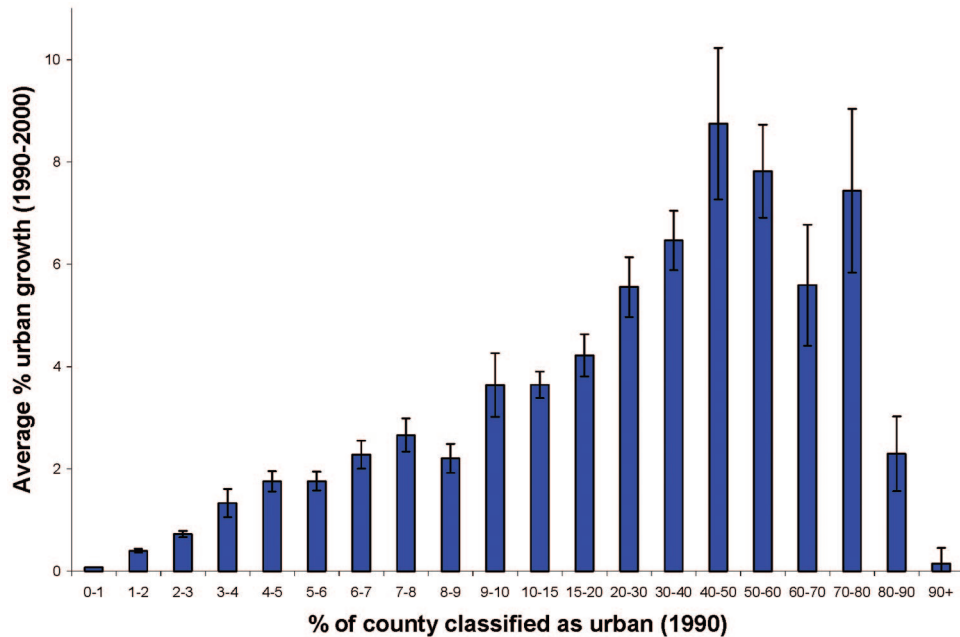


Figure 1. Average increase in percent of county classified as urban (1990–2000) categorized by percent of county that was urban in 1990. Error bars indicate one standard error and were used for projection purposes. Small counties (less than 145 km²) were excluded from the analysis to limit large percent changes from minimal urban growth.

The projections given in this article are based on national average urban growth within counties with varying levels of urbanization and assume that the growth trends of the 1990s will continue, by decade, until 2050. Using a national average to project urban growth will underpredict growth in areas that develop rapidly (above average growth relative to their percent urban) in the next several de-

cadecades and overpredict growth in areas with below average development relative to their percent urban. The projections also increase in uncertainty the farther the projections go into the future. However, the projections reveal the likely patterns of development across the landscape given past growth trends. These trends may vary in the future given changes in land development policies (e.g., Smart Growth Initia-

tives); changes in land value, interest rates, and fuel prices; ecosystem limitations (e.g., water shortages); and other social, economic, or environmental factors. Although various factors may alter the projections of urban growth, the trend is clear that increasing rates and amounts of urban development and associated transformation of forest and other land cover types will occur in the future.

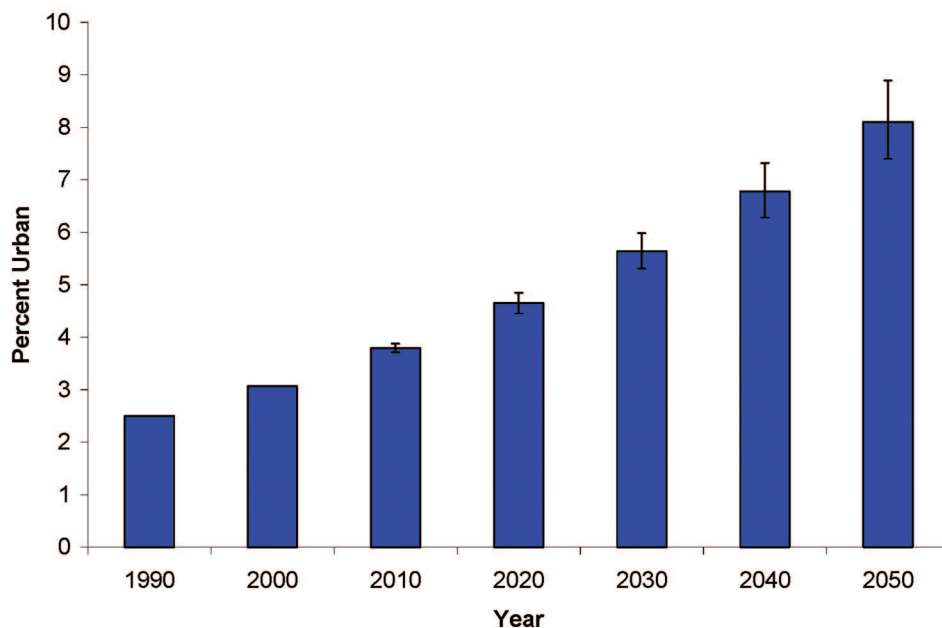
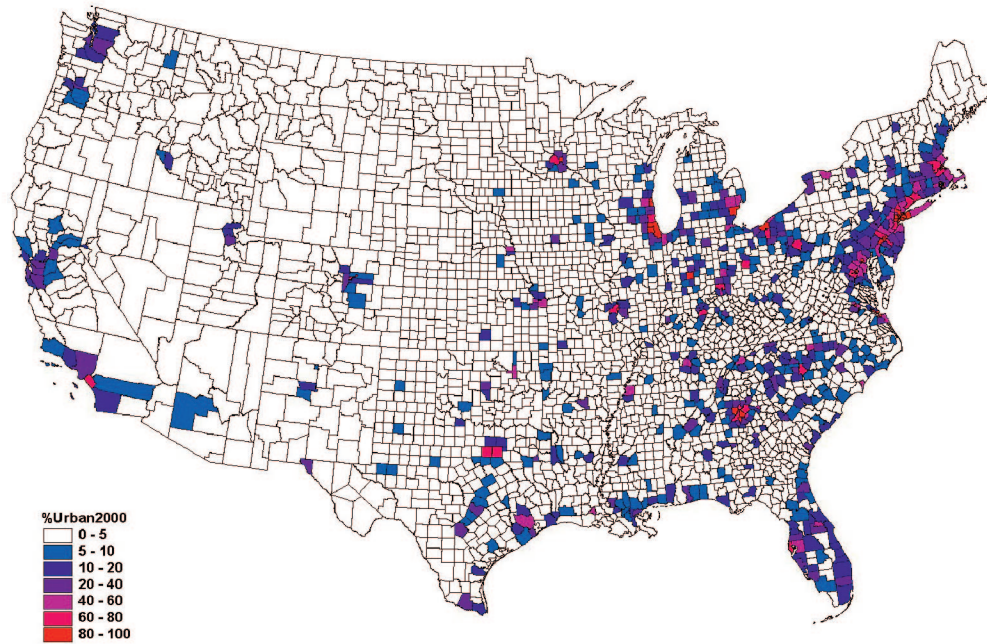
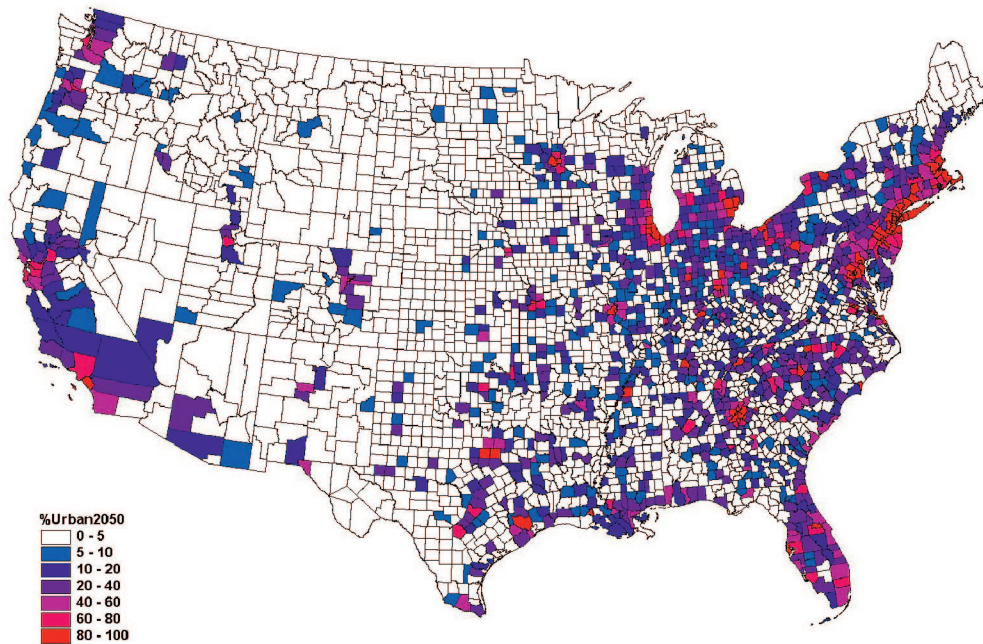


Figure 2. Projected percent of land classified as urban in the coterminous United States. Error bars indicate estimate given plus or minus one standard error of growth (Figure 1).



(a)



(b)

Figure 3. (a) Percent of land classified as urban in 2000, and (b) projected percent of land classified as urban in 2050, by county.

Urban Growth (2000–2050)

Urban land in the coterminous United States is projected to nearly triple over the next several decades, increasing from 3.1% in 2000 to 8.1% in 2050, an area larger than the state of Montana (Figure 2). Most of the

urban growth is projected to occur around the more heavily urbanized areas, with significant expansion in the East and along the West Coast (Figure 3). By 2050, four states are projected to be more than one-half urban land: Rhode Island (70.5% urban), New

Jersey (63.6%), Massachusetts (61.0%), and Connecticut (60.9%; Table 1).

Our projections of urban growth compare favorably with the work of Alig and Plantinga (2004) who project urban and developed land to reach 582,800 km²

Table 1. Projected amount of forestland from the 1992 NLCD to be subsumed by urban growth between 2000 and 2050, by state and region.

State/region	Nonurban forestland (1992) subsumed by urban (2000–2050)				Forestland (1992) in urban areas						Urban land 2050	
	%	Rank	km ²	Rank	1990		2000		2050		%	Rank
					%	Rank	%	Rank	%	Rank		
FL	13.9	8	4,833	10	2.8	14	4.6	12	17.8	8	27.9	7
SC	12.9	9	5,255	7	2.9	13	4.3	13	16.7	10	18.3	12
NC	12.7	10	8,740	1	3.3	11	5.3	10	17.4	9	19.1	10
GA	9.7	12	7,754	2	3.6	10	5.8	9	14.9	12	14.3	18
VA	5.2	25	3,443	15	2.6	16	3.4	17	8.4	21	12.6	20
Southeast	10.4		30,026									
RI	48.2	1	641	35	14.8	4	21.0	4	59.1	1	70.5	1
NJ	40.4	2	2,671	17	18.6	1	24.2	1	54.8	2	63.6	2
MA	37.0	3	3,587	14	17.2	3	23.2	2	51.6	3	61.0	3
CT	35.8	4	2,094	22	17.5	2	22.9	3	50.5	4	60.9	4
DE	32.5	5	365	39	10.4	6	15.1	6	42.7	5	39.5	5
MD	26.6	6	2,386	19	11.9	5	15.2	5	37.7	6	37.5	6
NY	8.9	13	6,811	3	3.0	12	3.7	14	12.3	14	18.5	11
PA	8.8	15	6,348	4	4.0	9	5.2	11	13.5	13	22.1	9
NH	8.7	16	1,627	27	2.0	19	3.3	18	11.7	16	17.1	13
WV	4.0	27	2,090	23	1.0	28	1.3	28	5.3	27	7.7	26
VT	2.1	35	375	38	0.5	34	0.6	35	2.7	35	5.3	31
ME	1.9	37	1,251	30	0.4	37	0.5	36	2.4	36	3.8	37
Northeast	8.9		30,245									
OH	14.2	7	4,460	11	5.5	7	6.8	7	20.1	7	22.9	8
IL	10.1	11	1,832	25	4.7	8	5.8	8	15.3	11	14.6	17
IN	8.8	14	1,501	28	2.6	15	3.6	15	12.1	15	16.7	14
MI	6.2	20	3,696	13	2.3	18	3.1	19	9.1	19	13.7	19
IA	5.7	24	614	36	1.5	24	1.7	25	7.3	25	4.9	33
MO	3.4	30	2,212	21	0.9	29	1.1	29	4.5	30	6.9	29
WI	2.5	32	1,425	29	0.8	30	1.0	30	3.5	32	8.3	25
MN	2.3	34	1,123	31	0.7	32	0.9	32	3.2	33	4.8	34
North central	5.5		16,865									
LA	8.4	17	3,353	16	1.6	22	2.2	22	10.4	18	11.1	21
TN	7.8	18	4,978	9	2.5	17	3.5	16	11.0	17	15.3	15
TX	6.1	21	6,226	5	1.8	21	2.6	20	8.5	20	7.0	28
AL	6.1	22	5,371	6	1.8	20	2.4	21	8.4	22	10.7	22
MS	4.2	26	2,602	18	0.7	31	1.0	31	5.2	28	7.0	27
KY	3.8	28	2,303	20	1.3	26	1.6	26	5.3	26	8.8	24
AR	3.0	31	2,070	24	0.6	33	0.8	33	3.7	31	5.8	30
OK	2.4	33	946	32	0.5	35	0.7	34	3.1	34	4.7	35
South central	5.3		27,849									
WA	6.0	23	4,991	8	1.4	25	2.0	23	7.9	24	9.2	23
OR	1.5	40	1,640	26	0.3	40	0.4	39	1.9	40	3.5	38
CA	3.4	29	3,785	12	1.2	27	1.4	27	4.7	29	15.0	16
Pacific Coast	3.4		10,416									
KS	6.2	19	380	37	1.5	23	2.0	24	8.1	23	3.2	39
ND	1.9	36	47	46	0.3	39	0.4	40	2.3	37	1.0	45
NE	1.6	39	79	45	0.4	38	0.5	37	2.1	39	1.8	44
SD	1.2	41	83	44	0.4	36	0.4	38	1.7	41	1.0	46
Great Plains	2.9		589									
AZ	1.8	38	889	33	0.1	41	0.4	41	2.2	38	5.1	32
CO	1.0	42	747	34	0.1	42	0.2	42	1.2	42	3.9	36
UT	0.6	43	260	40	0.1	43	0.2	43	0.8	43	2.5	40
NM	0.3	44	147	41	0.1	44	0.1	44	0.4	44	2.1	42
NV	0.2	45	42	47	0.1	45	0.1	45	0.3	45	2.2	41
MT	0.2	46	132	42	0.0	47	0.0	47	0.2	46	0.8	47
ID	0.1	47	91	43	0.0	46	0.0	46	0.2	47	1.8	43
WY	0.1	48	21	48	0.0	48	0.0	48	0.1	48	0.6	48
Rocky Mountains	0.5		2,329									
USA ^a	5.3		118,318		1.8		2.4		7.6		8.1	

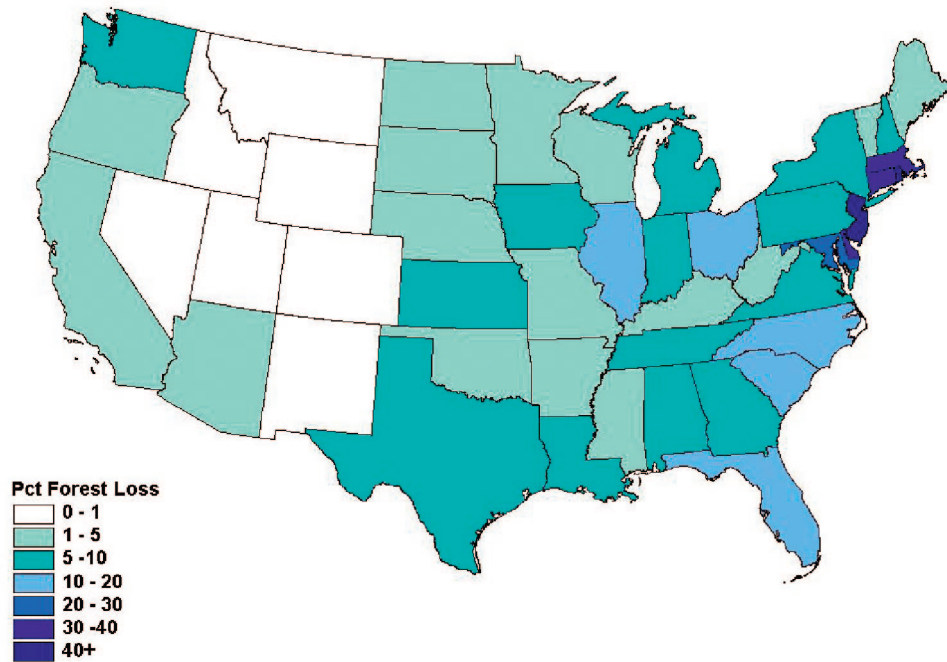
^a Lower 48 states.

by 2030. Developed land (as classified by the 1992 NLCD) outside of urban areas would add an additional 26.1% to the amount of land classified as urban in 1990. Our projection reveals an increase of 440,000 km² of urban land by 2030. If an additional 26.1% is added for developed land, the new total is 554,800 km², which is 5% less than what was projected by Alig and Plantinga (2004).

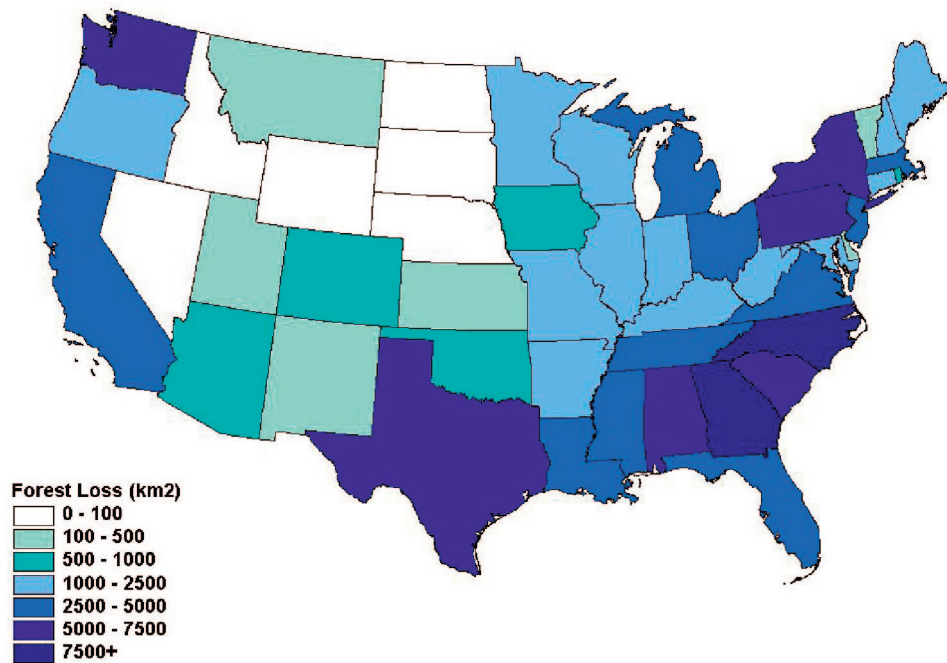
As urban lands expand into surrounding areas, forest resources often are changed or displaced. In 1990, 1.8% of the forestland in the coterminous United States classified by the 1992 NLCD was within urban areas. In 2000, this percentage increased to 2.4%. By the year 2050, 7.6% of the 1992 forestland is projected to be within urban areas (Table 1). By 2050 about 5.3% of forestland outside of urban areas in 2000 will be sub-

sumed by urban growth. This amount varies by state with Rhode Island (48.2%), New Jersey (40.4%), Massachusetts (37.0%), Connecticut (35.8%), and Delaware (32.5%) projected to have the greatest percent of their presently nonurban forestland transformed by urban growth (Table 1; Figure 4a).

Even though a significant amount of forestland will be reclassified as urban land over



(a)



(b)

Figure 4. (a) Percent and (b) square kilometers of nonurban forest subsumed by projected urban growth (2000–2050), by state. On average, about 20% of the projected forestland subsumed by urbanization will remain as forest within the urban boundary.

the coming decades, this change does not necessarily mean that all of this forestland will be lost. Urban areas often retain varying amounts of forest stands within their boundaries de-

pending on development patterns and natural vegetation type (Nowak et al. 2001). Based on the 1992 NLCD, on average, about 20% of the 1990 urban areas were classified as forest.

Although states along the northeastern coast tend to have the highest percent of forestland that is projected to be subsumed by urbanization by 2050 (Figure 4a), southern

states tend to be highest in total amount of forestland to be subsumed (Figure 4b). Between 2000 and 2050, North Carolina is projected to have 8,740 km² of forestland subsumed by urbanization, followed by Georgia (7,754 km²), New York (6,811 km²), Pennsylvania (6,348 km²), and Texas (6,226 km²; Table 1). The total amount of US forestland projected to be subsumed by urbanization between 2000 and 2050 is about 118,300 km², an area approximately the size of Pennsylvania.

Our projections indicate that between 2000 and 2030, 61,000 km² of forestland could be subsumed by urbanization. This amount is less than the 105,200 km² of forestland that Alig and Plantinga (2004) project to be affected by both urban and developed uses between 1997 and 2030.

Urban Growth Implications on Forest and Urban Forest Management

As landscapes urbanize, increased population density, built environments, human activity, and associated emissions tend to increase air temperatures, degrade air and water quality, and reduce human health and well-being. Thus, as areas urbanize, sustaining tree cover becomes increasingly paramount to sustaining human health, environmental quality, and quality of life. Trees and forests can provide many environmental and social/economic services that include clean air and water, recreational opportunities, energy conservation, carbon storage, protection from ultraviolet radiation, cooler air temperatures, habitat for wildlife, forest-based products, aesthetic values, and enhancing social and psychological well-being (e.g., Nowak and Dwyer 2000). The management objectives of urban forestry often are not commodity based, rather they are service based; and sustaining healthy, long-lived, functioning tree canopy is a primary objective of urban forest management. Thus, as the landscape becomes more urbanized, forest management objectives likely will shift from commodity-based management toward more ecosystem services.

As forest and other land cover types are being converted to urban uses, the land base of urban areas and urban trees and forests will increase. This expanding land base along with expanding human populations will increase the importance of urban forests in the coming decades. Enhanced research and management efforts to better understand and improve urban forest health and

ecosystem services and benefits provided by urban vegetation are needed to meet the needs of an expanding urban population.

Between 2000 and 2050, over 5% of existing forestland outside of urban areas is projected to be directly subsumed by urban growth. Although forest stands can be sustained within and around urban areas, the area of individual forest stands often becomes smaller, creating new forest edge and increasing the exposure of forests to urban stresses (Medley et al. 1995). Changes in stand structure along with increased human activity and, often, differing management objectives of urban residents will significantly affect the management of periurban forest stands. Timber harvesting can be reduced in these surrounding stands (e.g., Barlow et al. 1998 and Wear et al. 1999), but, also, increased pressure for recreational activities (e.g., off-road vehicles); greater probability of exotic pest introductions and spread from urban areas (e.g., Asian longhorned beetle and emerald ash borer); and increased housing densities (Hammer et al. 2004), fragmentation (Riitters et al. 2002), and parcelization (Mehmood and Zhang 2001) can greatly affect forest management practices.

Although urban forest management objectives often are ecosystem-service based, it is important to recognize that nonurban forests also provide significant environmental services in addition to forest products. Comprehensive regional forest management plans that integrate the need for urban development along with the need for sustaining ecosystem services can provide optimal management and growth strategies to sustain urban development, forest productivity, and forest ecosystem services. Concerns have grown about the loss of forestland to development, leading to both public and private efforts to preserve forestland as open space (Kline et al. 2004).

Preserving forests not only within but also around urban areas can provide important environmental services for the urban population. For example, New York City is trying to save taxpayers the cost of a billion dollar filtration system by protecting water quality through watershed protection plans that focus on the acquisition of 1,420 km² of land in distant watersheds (Mehaffey et al. 1999). In addition, the US Environmental Protection Agency (EPA) is encouraging smart growth by providing information, model programs, and analytical tools to inform communities about growth and development; working to remove federal barriers that may hinder smarter community growth; and creating new resources and incen-

tives for states and communities pursuing smart growth (US EPA 2005). Thus, more regional planning and management may be needed to sustain forest products and ecosystem services required by a growing urban population.

Conclusion

Urban growth in the United States is going to have an increasingly important impact on forest management, environmental quality, and human well-being in the coming decades. As urbanization increases so will the value of urban forests and surrounding rural forests in providing ecosystem services required by urban residents. It is projected that significant amounts of US forestland will be transformed by urbanization, particularly in the northeastern and southern United States. Future regional resource planning and management activities need to understand, adapt to, and direct the changing landscape to sustain forest health and productivity, as well as human health and well-being, in an urbanizing landscape.

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