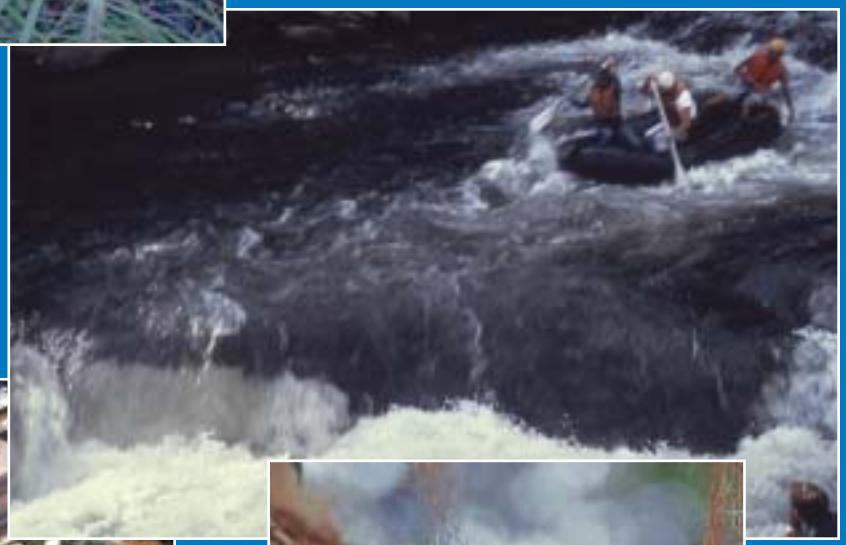
SECTION II:
CONSEQUENCES OF CHANGE

Photo by Hallie Dozier, Louisiana State University

Photo by Larry Korhnack, University of Florida



Photos courtesy of USDA Forest Service

Photo by Hans Riekerk, University of Florida

Photo by Larry Korhnack, University of Florida

Chapter 5

URBAN INFLUENCES ON FORESTS

Wayne C. Zipperer

Research Forester, USDA Forest Service, c/o SUNY-ESF, 5 Moon Library, Syracuse, NY 13210, wzipperer@fs.fed.us

Introduction

A common concern voiced in each Assessment focus group was the loss of agricultural sites and natural habitats to urban use. As children, group members fondly recalled playing in fields and forests. Today, those open spaces are gone, covered by shopping centers, housing subdivisions, or other urban land uses. The conversion of open lands to urban uses is not new. What is different today is the rapid rate of conversion (Boyce and Martin 1993).

Since the 1970s, the South's population has increased dramatically causing extensive urbanization across the region. A strong economy, new telecommunication technology, new transportation systems, and land use planning policies have stimulated development from the edges of cities to formerly remote rural areas. This chapter assesses some of the key urban effects on forest ecosystems and identifies future research and educational needs to address these effects. ▶

Urban Effects on Forest Ecosystems

Urbanization directly alters forest ecosystems by removing or fragmenting forest cover. Urbanization also indirectly alters forest ecosystems by modifying hydrology, altering nutrient cycling, introducing nonnative species, modifying disturbance regimes, and changing atmospheric conditions. Collectively, these changes significantly affect forest health and modify the goods and services provided by forest ecosystems. A list of selected ecosystem goods and services, where goods are valued as items with monetary value in the market place and services are valued economically but rarely bought or sold (Christensen and others 1996), follows.

Ecosystem "goods" include

- Food products,
- Decorative products,
- Wood products,
- Medicinal plants,
- Wild genes for domestic plants and animals, and
- Tourism and recreation.

Ecosystem "services" include

- Maintaining hydrologic cycles,
- Regulating climate,
- Cleansing water and air,
- Maintaining the gaseous composition of the atmosphere,
- Pollinating crops and other important plants,
- Generating and maintaining soils,
- Storing and cycling essential nutrients,
- Absorbing and detoxifying pollutants, and
- Providing beauty, inspiration, and research.

Most ecosystem research has not examined urban effects on ecosystems in the wildland-urban interface. In this section, I draw upon ancillary research in urban and rural landscapes to illustrate the direct and indirect effects of urbanization on forest ecosystems in the interface.

"There is no general recognition of natural capital. That land with weeds on it is worth something—for absorption, filtration, habitat, and oxygen." Mississippi

Photo by Alice Cohen, USDA Forest Service

Figure 5.1
The Appalachian Highlands are greatly impacted by urbanization due to the sensitive ecosystems found there.

Deforestation and Fragmentation

The most obvious landscape effects of human activities are the reduction of total forest area and the fragmentation of remaining forests into smaller, isolated patches. Agriculture is the primary cause for deforestation (Alig and others 2000). However, forest losses to urban uses have increased since the 1970s (Boyce and Martin 1993). In addition, urbanization of agricultural land has caused conversion of forests to agriculture in other places to offset losses (Alig and Healy 1987). In the South, the Piedmont has the greatest rate of forest land conversion to urban uses, but the greatest impact of urbanization may be in the Appalachian Highlands and Coastal Plain because of the sensitive ecosystems found in those regions (Boyce and Martin 1993) (**fig. 5.1**).

Table 5.1—Tree canopy losses[a] in selected areas in the South

Location	Forested area[b]	Time period	Tree canopy loss[b]
	M acres	*Year*	*Percent*
Atlanta *metropolitan area*	1,747	1974-96	26
Chattanooga, TN	110	1974-96	21
Houston *metropolitan area*	692	1972-99	8
Roanoke, VA	313	1973-77	9
Fairfax County, VA	125	1973-97	20

[a] Because measuring canopy losses and fragmentation are scale dependent, a comparison across different studies is difficult. The author uses analyses by American Forests because the same protocol is employed to analyze each region. This use, however, does not imply an endorsement of techniques or models developed to obtain these values.

[b] This value represents area and the loss of canopy cover as classified by a 30-meter Landsat pixel as having at least 50 percent tree cover.

Source: American Forests 2002.

Photo by Hans Riekerk, University of Florida

Figure 5.2
Forest fragmentation is accelerated by the construction of buildings, roads, and parking lots.

Rapid urban expansion occurs not only around major metropolitan areas but also around small towns and villages (see chapter 2). Forest losses to urbanization have not been analyzed comprehensively. Although forest losses in specific places have been studied, findings often are not comparable because of different techniques and scales to measure change and different definitions of forest cover and losses. Analyses conducted by American Forests (2002) show that forest cover for four metropolitan areas—Atlanta, Chattanooga, Houston, and Roanoke—and Fairfax County, a county near Washington, DC, declined by over 585,000 acres over a 24-year period (**table 5.1**).

Regional conversion rates, however, provide little ecological information on site content and landscape context. For example, the data presented in table 5.1 convey no information about losses of critical and threatened ecosystems, rates of fragmentation, size distribution of existing forest cover by particular forest types, or the location and nature of affected watersheds. Such information is critical to understanding the direct and indirect effects of urbanization on ecosystem components and processes and ultimately on goods and services provided by ecosystems. An analysis of the effects of fragmentation has not yet been conducted for the entire South, but some regional studies have been done (Rudis 1995; Turner 1990; Turner and others 1996; Wear and Greis, in press; Wear and others 1998). In general, rates of forest loss are fastest along major communication corridors, near major urban centers, and near recreational areas such as national forests and parks; they are slowest in areas with slow economic development (Boyce and Martin 1993).

Fragmentation, one of the most significant negative effects of human activities on biodiversity (Noss 1987), is accelerated in the interface because of the construction of buildings, roads, and parking lots (Zipperer 1993) (**fig. 5.2**). Fragmentation affects native biodiversity by reducing habitat size, reducing the amount of forest interior habitat, isolating existing populations, and modifying microclimates (Noss and Csuti 1994, Saunders and others 1991). Isolation is increased further by the loss of corridors connecting natural habitats and by natural habitats being embedded in urban landscapes that inhibit organism movement. With restricted organism movement, genetic flow among populations is drastically reduced, leading potentially to inbreeding and local extinctions. For example, the Florida panther (*Felis concolor*) suffers from a high frequency of inbreeding and may be on the verge of extinction (White and Wilds 1998).

Photo by Joseph Schaefer, University of Florida

Figure 5.3
In urbanizing landscapes, edges become dominant features.

In the interface, development creates new edge habitat and alters habitat shape from irregular to highly regular and linear (Godron and Forman 1983, Zipperer 1993). By increasing edge habitat, development increases the number of edge species but decreases the number of interior species (Nilon and others 1994). Edges occur naturally and contribute to the habitat heterogeneity of a landscape. In urbanizing landscapes, however, edges become dominant features principally because of new roads (**fig. 5.3**). Roads also have numerous other ecological effects. A listing of known road effects on species, communities, and landscapes (Baker and Knight 2000) follows:

- Species (fine scale)
  - Direct effects
    - Direct habitat loss/gain to roads and adjoining built area
    - Direct mortality on roads
  - Road-effect zone
    - Habitat loss/gain due to avoidance areas surrounding roads and built area
    - Increased access
      - Increased mortality from hunting
      - Increased harassment of wildlife near roads
      - Increased woodcutting and trampling along roads
      - Increased human-set fires/other disturbances
      - Increased dumping
    - Potential indirect effects of landscape changes
      - Increased edge species/decreased interior species
      - Perils to small populations
      - Loss/gain of important natural disturbance patches
    - Pollution effects
      - Increased lighting
      - Increased dust and fumes
      - Increased noise
  - Connectivity effects
    - Barrier/deterrent to movement
    - Conduit effects
      - Spread of nonnative species
      - Enhanced/decreased movement of native species
- Community and landscape (broad scale)
  - Preferential loss of ecologically valuable communities
  - Fragmentation and isolation of patches
  - Increase in edge area
  - Decrease in interior area
  - Ratios of edge area or interior area to total patch area
  - Decreasing complexity of patch shape
  - Decreasing variation in patch area, edge area, and interior area
  - Fewer large patches and more small patches
  - Landscape texture (local diversity) higher
  - Expansion of other fragmenting land uses from road network
  - Changes in natural disturbance regimes.

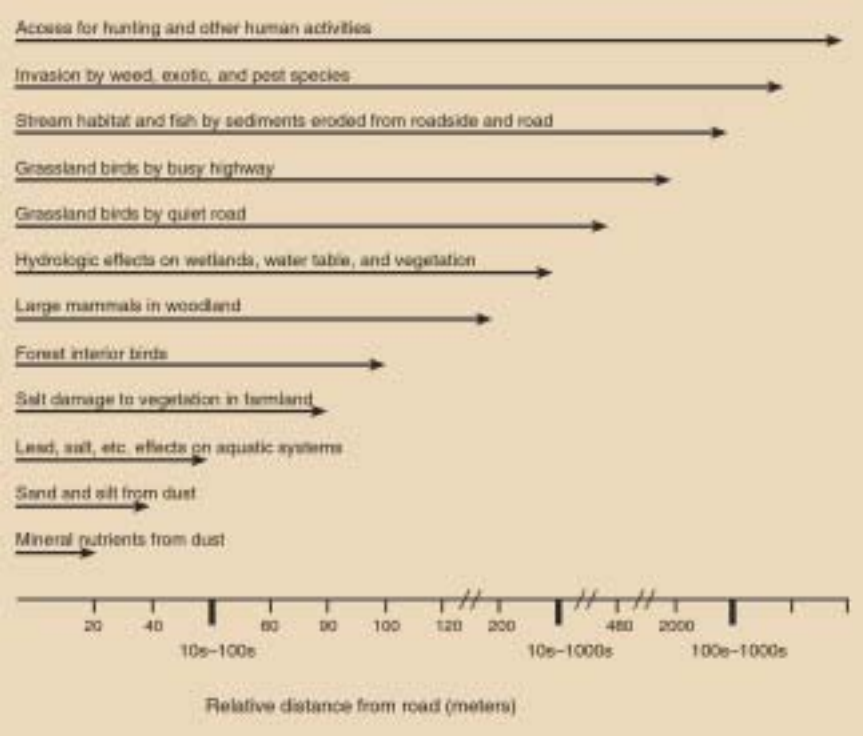


Figure 5. 4
The effect of roads on the adjacent land cover. The horizontal axis is not linear but illustrative to show ranges of effects (Forman 1995).

At the forest edge, the physical environment and biotic community are altered, a phenomenon called the edge effect [see Forman (1995) for a discussion of edges and boundaries]. Physical changes include greater wind turbulence, greater temperature fluctuation, increased lateral light penetration, and drier site conditions. Biotic changes include a proliferation of nonnative species, an increase in plant and animal generalists, an increase in parasitism and predation, and an alteration of ecological processes such as nutrient cycling. These effects vary across a range of spatial and temporal scales for different forest types and species (**fig. 5.4**).

" . . . . If you drive by some parts [of north Georgia] you will see a ridgetop covered with houses or a stream bank that used to be a pastoral setting that now has houses every 50 feet sitting right on top of the streambank." Georgia

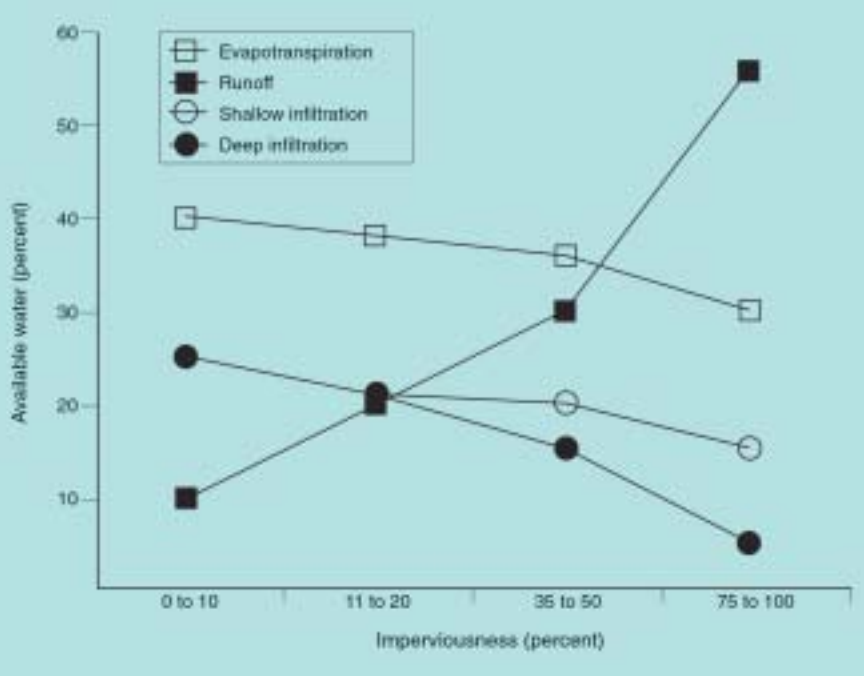


Figure 5.5
Changes in evapotranspiration, runoff, and shallow and deep infiltration with increasing impervious surface cover in a watershed (Arnold and Gibbons 1996, Paul and Meyer 2001).

Hydrology

Urbanization alters water flow in the interface (**fig. 5.5**). Changes include increased amount of impervious surfaces, decreased infiltration, increased surface runoff, and altered flooding regimes (**fig. 5.6**). Impervious surfaces include rooftops, driveways, roads, and parking lots. In low-density residential development (<1 house per acre), the roads may account for more than 60 percent of the impervious surface and exert a greater affect on aquatic systems than rooftops (Schueler 1994). Storm runoff from roads and parking lots often flows directly into streams. Runoff from rooftops often flows out over yards with pervious surfaces. An increase of just 10 percent in impervious surfaces significantly changes streambank stability, water quality and quantity, and biodiversity of aquatic systems (Schueler 1994) (**table 5.2**).

Besides increasing the amount of impervious surfaces, urbanization drains wetlands, channelizes streams, and increases the amounts of sediments, nutrients, and biocides entering the aquatic system. Erosion and sedimentation occur not only from constructing new roads and buildings but also from eroding beds and banks of streams. Sediment loads from inadequately controlled construction sites typically are 10 to 20 times greater per unit of land area than those from agricultural land and 1,000 to 2,000 times those from forests (Weiss 1995). Streambank stability decreases rapidly above a level of 10 percent impervious cover because of increased stream velocity and volume from storm runoff (Schueler 1994). Recent analyses of watersheds by the U.S. Geological Survey (1999) show that urban and urbanizing landscapes have a defining pollution signature for insecticides and herbicides. Conductivity, suspended soils, and concentrations of ammonium, hydrocarbons, and metals in surface and subsurface waters increase with urbanization (U.S. Geological Survey 1999).

Photo by Larry Korhnack, University of Florida

Figure 5.6
Increased impervious surfaces lead to decreased infiltration, increased surface runoff, and altered flooding regimes.

Table 5.2—The effect of different percentages of impervious surface on stream attributes

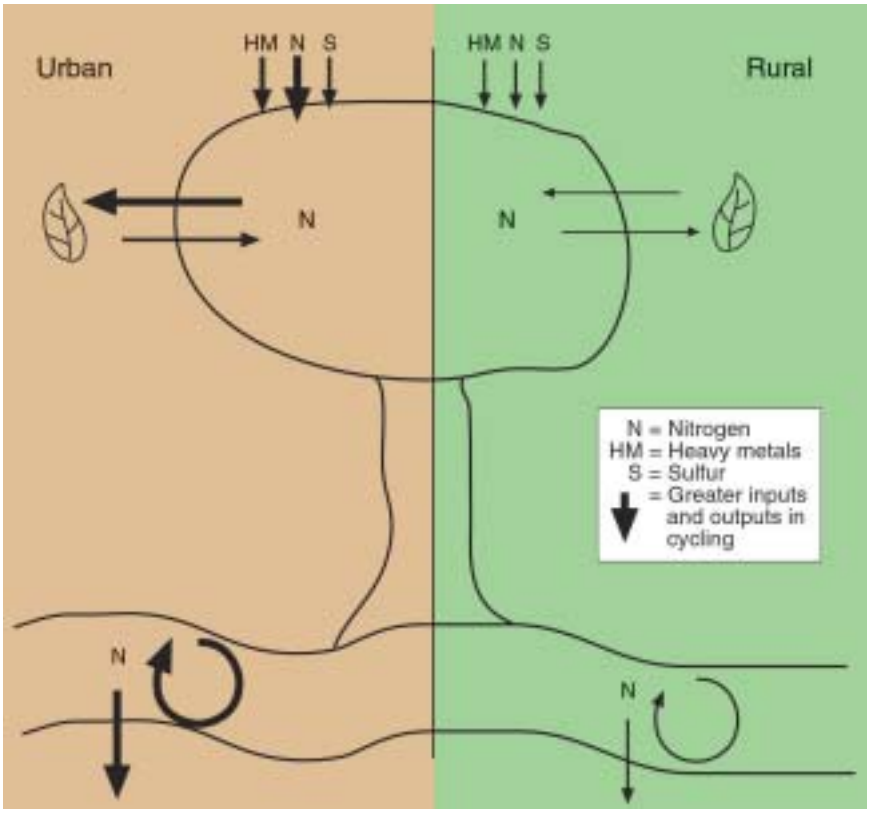
	Impervious surface (percent)		
Stream attribute	**0-10**	**11-25**	**25-100**
Stream stability	Stable	Unstable	Highly unstable
Water quality	Good	Fair	Fair-poor
Stream biodiversity	Good-excellent	Fair-good	Poor

Source: Schueler 1994.

Development in the wildland-urban interface often occurs in the headwaters of many streams and rivers. These very small creeks and streams are home to many endemic species that are extremely sensitive to environmental changes and pollution. Urbanization alters headwaters by covering or ditching them, removing riparian vegetation, increasing water temperature, and altering water quality (Marsh and Marsh 1995, Pluhowski 1970). Research is needed not only to document the extent of land use changes caused by urbanization at headwaters but also to measure biotic and abiotic effects downstream.

Nutrient Cycling

Urban landscapes are a mosaic of different human population densities, building densities, and amounts of impervious and pervious surfaces (Stearns and Montag 1974). Embedded in these urban landscapes are native forest stands. When compared to rural forest ecosystems of similar composition, structure, and geology, forests in urban landscapes differ environmentally, compositionally, and structurally and have different rates for certain ecosystem processes (McDonnell and others 1997) (**fig. 5.7**). Over time, urbanization affects forest ecosystems even if the forests have not been disturbed by development. Mere proximity to urban land use can cause changes. Work needs to be conducted to determine at what level of urbanization shifts in ecosystem species composition, structure, and processes occur, and the corresponding lag times between the respective responses.



Urban		Rural
+	Soil temperature	–
+	Soil hydrophobicity	–
–	Microinvertebrates	+
+	Earthworms	–
–	Fungal hyphae	+
+	Nonindigenous plants	–
–	Stem density	+
–	Leaf letter depth	–
+	Decomposition	–
+	Nitrogen-mineralization	–
+	Nitrification rates	–

Figure 5.7
Generalized illustration depicting structural and functional differences of forests in urban and rural landscapes having similar physical environments and species composition and structure (Kostel-Hughes 1995; McDonnell and others 1997; Pouyat and others 1994, 1996; Rudnicky and McDonnell 1989).

Biodiversity

Biodiversity is an integrator of environmental changes and land transformation on a landscape. Urbanization alters the composition of plant and animal species in both terrestrial and aquatic systems. In general, as one moves from the rural to urban landscape, plant species richness increases, but decreases for amphibians, reptiles, mammals, and birds (Kowarik 1990). Along this urban continuum, the number of native species decreases whereas the number of exotic species increases. Native species are missing from urban landscapes because their habitats may be absent or too small to maintain a viable population. Species also may be unable to adapt physiologically or behaviorally to an urban environment. A study of avian species in the Lake of the Ozarks region revealed that as development increases, habitat specialists decline. Other species, such as those that inhabit edges and are habitat generalists, increase with development (Nilon and others 1994).

Urbanization is not the only human activity that has altered biodiversity locally and regionally. Past and current agricultural and natural resource management practices significantly affect biodiversity (White and Wilds 1998). Five large mammals—bison (*Bison bison*), elk (*Cervus* e. *canadensis*), gray wolf (*Canis lupus*), jaguar (*Felis onca*), and ocelot (*Felis pardalis*)—have been extirpated from the South because of past agricultural and natural resource management practices (Echternacht and Harris 1993) (**table 5.3**). Collectively, agriculture, forestry practices, and urbanization significantly reduce the extent of ecosystems in the South. A listing of critically endangered and endangered ecosystems (85-percent loss) in the South (Noss and others 1995, White and Wilds 1998) follows:

Table 5.3—The number of native, endemic, extinct, extirpated, and federally listed vertebrates in the South

Vertebrate group	Species				
	Native	Endemic	Extinct	Extirpated	Listed endemics
Fishes	535	257	3	2	23
Amphibians and reptiles	242	83	0	0	8
Birds	237	0	2	3	4
Mammals	101	7	0	5	13

Source: Echternacht and Harris 1993, White and Wilds 1998.

Geographic area	Ecosystem type
	> 98-percent loss: critically endangered
Southeast	Old-growth deciduous forests
Tennessee, North Carolina, Virginia	Southern Appalachian spruce-fir
Coastal Plain	Longleaf pine
Florida	Rockland slash pine
West Gulf Coastal Plain	Loblolly-shortleaf pine
Southeast	Canebrakes
Kentucky	Bluegrass-savannah-woodland
Alabama, Mississippi	Blackbelt prairie, Jackson prairie
Florida	Dry prairie
Louisiana	Wet and mesic coastal prairies
Virginia, North Carolina	Atlantic white-cedar
Kentucky	Native prairies
Cumberland Plateau, Tennessee	High-quality oak-hickory
	85- to 98-percent loss: endangered
Central Appalachians	Red spruce
Coastal Plain, Tennessee	Upland hardwoods
Tennessee	Old-growth oak-hickory
Tennessee	Cedar glades
Texas, Louisiana	Longleaf pine
Louisiana	Mississippi terrace prairies, calcareous prairie, Fleming glades
Louisiana	Live oak, live-oak hackberry
Louisiana	Prairie terrace-loess oak forest
Louisiana	Shortleaf pine-oak-hickory
Louisiana	Mixed hardwood-loblolly pine
Louisiana	Xeric sandhill
Louisiana	Stream terrace, sandy woodland savannah
Coastal Plain	Gulf coast pitcher-plant bogs
Virginia	Pocosins
North Carolina	Mountain bogs
Blue Ridge, Tennessee	Appalachian bogs
Highland Rim, Tennessee	Upland wetlands
Tennessee	Aquatic mussel beds
Virginia	Ultramafic glades

For example, agriculture and forestry practices initially reduced the longleaf pine (*Pinus palustris* Mill.) and wiregrass (*Aristida stricta* L.) ecosystems in the Coastal Plain from over 24 million acres to <2 million acres (Noss 1989). Urbanization further reduces the extent of these ecosystems. This change significantly affects the biodiversity of the region. Decline in the population of the gopher tortoise (*Gopherus polyphemus*), a keystone species, was especially damaging. Over 350 species depend on the tortoise and its burrows. As the tortoise is locally extirpated, many of the species depending on it may also disappear.

Likewise, major problems involving nonnative species in the South are not just the result of urbanization but also the consequence of past agricultural, forestry, and wildlife practices (Williams and Meffe 1998). Examples include balsam wooly adelgid (*Adelges picea*), kudzu [*Pueraria montana* (Lour.) Merr.] (**fig. 5.8**), and the wild boar (*Sus scrofa*). Urbanization may increase the susceptibility of a forest to colonization by nonnative species. Forest communities with modified soils, low native biodiversity, absences of predator species, simple food webs, and a high frequency of human disturbances are more vulnerable to invasion by nonnative species than intact communities (Lodge 1993, Meffe and Carroll 1994, Williams and Meffe 1998). These traits often characterize forest communities in urban and urbanizing landscapes (McDonnell and others 1997). We are only beginning to understand how nonnative species alter ecosystem composition, structure, processes, goods, and services. Research needs to consider the positive as well as the negative effects of nonnative species in an ecosystem.

Photo by Hallie Dozier, Louisiana State University

Figure 5.8
Kudzu (*Pueraria montana*) is an invasive nonnative species that is altering ecosystems throughout the South.

"Very often when you're developing a forested environment, that kind of disturbance promotes exotic species that may not compete well in a forested environment but do very well when the area is disturbed." Georgia

Over 6,500 nonnative species occur in the United States (Williams and Meffe 1998). In the South the number of introduced plant species ranges from 362 in Oklahoma to 1,017 in Florida; most States have between 500 to 700 introductions (Williams and Meffe 1998). Fish, amphibians, reptiles, and mammals have also been introduced into the South. Some of these introductions—especially the fish, amphibians, and reptiles—resulted from pets being released into the wild (Williams and Meffe 1998). Since humans are the primary cause for introductions of nonnative species, the potential for additional introductions increases as human population density increases.

High population densities of native species also affect ecosystem composition and structure. Examples include the Canada goose (*Branta canadensis*), raccoon (*Procyon lotor*), and white-tailed deer (*Odocoileus virginianus*) (**figs. 5.9A, 5.9B**). High populations of Canada geese pollute water bodies and contribute significantly to the eutrophication of small ponds and lakes. Population densities of raccoons have increased dramatically in some parts of the South (Southern Appalachian Man and the Biosphere 1996). For example, only 43 percent of the counties in the Appalachian Mountains and Shenandoah Valley (135 counties) had moderate densities of raccoons (5 to 10 individuals per square mile) in 1970. By 1995, nearly 96 percent of those counties had moderate to high densities of raccoons (>10 per square mile). Because the raccoon is a vector for rabies and a predator of ground-nesting animals, this increase, caused by human development, has significant implications for human health and species diversity in the region.

Photo by Larry Korhnack, University of Florida

(A)

Photo courtesy of Virginia Department of Forestry

(B)

Figure 5.9
High population densities of native species, such as (A) raccoons and (B) white-tailed deer, can affect ecosystem structure and function.

A similar increase in white-tailed deer population has occurred. For example, in the Southern Appalachians, only 30 percent of the counties had moderate deer densities (15 to 30 individuals per square mile) in 1970. By 1995, nearly 70 percent of the counties had moderate to high densities (>30 individuals per square mile) (Southern Appalachian Man and the Biosphere 1996). This increase resulted from changes in landscape configuration, lack of predators, and increased food supplies. At moderate to high population density, white-tailed deer can reduce agricultural production, damage urban plants, and denude understory vegetation in forest stands. The loss of understory vegetation significantly affects breeding success of ground-nesting species. The increased number of homes in the interface also contributes to increased white-tailed deer densities by reducing hunter access. Similarly, with the increase in human population in the interface, population densities of domestic dogs and cats are expected to increase. Domestic pets also can significantly affect ground-nesting species (Churcher and Lawton 1987).

Disturbance Regime

Ecosystems are dynamic. Changes occur because ecological, physical, and social components change through time and because of natural and human disturbances. Urbanization is a disturbance agent. Like natural disturbances, urbanization alters composition, structure, and spatial arrangement of ecosystems on the landscape. Unlike natural disturbances, however, changes caused by urbanization often are longer lasting. For example, intensive lawn and horticultural management systems inhibit natural succession. In addition, as the interface is developed, landscape heterogeneity changes. Urbanization decreases the number of native habitat types and increases the number of human structures and habitats (Pickett 1998).

Suppressing disturbances alters landscape heterogeneity (Turner and others 1998). In the South, one of the single most disruptive changes in the natural disturbance regime has been fire suppression (see chapters 6 and 8). The policy decision to suppress fires has endangered the existence of fire-dependent communities and species, enabled xeric communities to become more mesic in species composition, increased the size and severity of forest fires, and reduced landscape heterogeneity (Buckner and Turrill 1998, Stuart 1998) (**fig. 5.10**). Fire suppression also alters the frequency and severity of other disturbances, such as those caused by insects and pathogens (Covington and others 1994).

In human-dominated systems, fires often are suppressed to minimize the losses of personal property and structural damage. To minimize fuel buildup around structures, prescribed burns are conducted. These fires, conducted in late winter or early spring, burn cooler and have different ecological effects than hot fires occurring during the hotter and drier periods (Buckner and Turrill 1998). For example, cool fires may lack the heat and intensity to open serotinous cones of Table Mountain pine (*P. pungens* Lamb.). Cool fires also may create a landscape that is more homogeneous than a landscape with both cool and hot fires.

Fire creates new habitat. Both native and nonnative species quickly colonize this habitat (Stuart 1998). Cool burns and high population densities of nonnative species in urbanizing landscapes may create a more favorable condition for colonization and growth of nonnative species. The effect of cooler, prescribed burns on native and nonnative species needs to be assessed. Changes should be measured at different spatial and temporal scales.

Atmospheric Effects

Air pollutants of concern in southern forest ecosystems include oxides of nitrogen (NO_x) and sulfur (SO_x) and tropospheric or ground-level ozone (O_3). Each of these pollutants occurs naturally, but human activities increase their concentrations in the atmosphere. At high concentrations, these pollutants injure plant tissues, alter ecosystem processes, and predispose forests to other environmental stresses (Berish and others 1998).

Automobiles are the major sources of NO_x (Berish and others 1998). These compounds can react with volatile organic compounds to form O_3 or they can be deposited directly on forests. When deposited, they may alter productivity rates, and increase nitrification and nitrate leaching in terrestrial systems (Aber and others 1989). Although NO_x deposition is greatest in urban landscapes (Lovett and others 2000), increased vehicle travel throughout the interface may enhance NO_x deposition in rural areas.

Utility companies burning fossil fuels are the major sources for SO_x, a precursor to acidic deposition (Berish and others 1998). Long-term exposure to acidic deposition alters soil pH, leaches base cations from the soil, and causes surface water acidification (Berish and others 1998, Likens and others 1996). The greatest cumulative deposition rate of SO_x in the United States was measured in a spruce-fir forest in the Appalachian Highlands (Johnson and Lindberg 1992, Peine and others 1998). The SO_x originated from an adjacent State when the Tennessee Valley Authority increased electricity production to supply new and existing developments and the tourist industry during the summer. Climate patterns carried the pollution over the spruce-fir forest, demonstrating the regional impacts of pollution. New Federal regulations limiting SO_x emissions may reduce the effect of SO_x on forest ecosystems.

Like NO_x and SO_x, O_3 increases with urbanization. Typical summertime daily maximum O_3 concentration in urban and suburban landscapes ranges from 100 to 400 parts per billion (ppb) as compared to 50 to 120 ppb for rural landscapes (National Research Council 1992). Short-term exposure to relatively high concentrations (>150 ppb) can cause acute visible foliar injury in sensitive plants (Krupa and others 1998). Because O_3 enters a plant through leaf stomata, which close when soil moisture is limiting, soil moisture is an important variable affecting uptake and subsequent tissue damage. Greater rainfall at higher elevations may make forests there more susceptible to O_3 damage than forests at lower elevations (Berish and others 1998). Pollution damage to sensitive ecosystems in the Appalachian Highlands may increase as regional and local NO_x and O_3 concentrations increase.

Forest Health

In each of the previous sections, urbanization effects were discussed as independent events. These effects, however, act together. For example, atmospheric deposition alters nutrient availability in the soil and injuries plant tissue. These effects subsequently predispose the forest to pests and pathogens.

How do we know if a forest is healthy? This question was the focus of a workshop attended by scientists, philosophers, managers, environmentalists, and industrial representatives (Constanza and others 1992). They developed the following definition: "an ecological system is healthy and free from 'distress syndrome' if it is stable and sustainable—that is, it is active and maintains its organization and

Photo courtesy of Florida Division of Forestry

Figure 5.10
Many southern ecosystems are dependent on fire for maintaining ecological processes.

Broad and Fine Scales

In the wildland-urban interface, natural habitats are rapidly transformed into urban land uses with significant ecological consequences. Land use planners must reconcile economic development with environmental protection. To understand the ecological effects of urbanization, we need to look at entire landscapes (broad scale) as well as affected sites (fine scale). Traditionally, effects on soils, vegetation, species composition, and hydrology have been analyzed only on a fine scale.

autonomy over time and is resilient to stress" (Haskell and others 1992). Distress syndrome refers to the inability of an ecological system to recover naturally. Urbanization ultimately predisposes a forest ecosystem to a distress syndrome because of a suite of direct and indirect effects including land use conversion, fragmentation, pollution, loss of keystone species, introduction of nonnative species, and altered disturbance regime. With time, the original composition, structure, and function of the forest ecosystem will change in urban and urbanizing landscapes (Zipperer and Pouyat 1995). These new forests will be composed of native and nonnative species that have adapted to the stresses created by the urban landscape. The quality and quantity of ecosystem goods and services provided by these forests have yet to be determined.

" I think we have taken the wrong focus when saving a tree or patch of woods. Rather we need to take a systems approach. We need to look at the natural system and all the components . . ." Virginia

To address urban effects on forest health, an integrative and interdisciplinary approach is necessary. The approach must include terrestrial and aquatic systems and account for ecological processes operating at different spatial and temporal scales. Likewise, the approach must account for the complexity of interactions among the social, ecological, and physical components of an ecosystem.

An Ecosystem Approach

Land use decisions often are based principally on socioeconomic elements of an ecosystem. Biological and physical elements should also be considered in a holistic or ecosystem approach to land use decisions. Since humans derive benefits from all the elements in ecosystems, anything less than an ecosystem approach may yield the wrong conclusions.

An ecosystem approach acknowledges the biophysical and social complexities of ecosystems and the importance of maintaining those complexities to meet human needs. Energy, organisms, and materials flow into and out of ecosystems and are not confined by political or management boundaries. A broad scale or landscape perspective is needed to assess how development alters these flows. A broad perspective also helps planners to see cumulative changes across the landscape.

Needs

Forests will always exist in the South. Their composition, structure, and function will continue to change because of environmental and human effects. During the urbanization process, we need to maintain forest health to provide the goods and services enjoyed and used by humans. To accomplish that objective, we need to sustain ecological and social integrity through an ecosystem approach to management (McCormick 1998). To meet these goals, new research should be conducted and educational tools should be developed.

Research is needed to:

- Quantify population distributions of native and nonnative species.
- Assess the synergistic effects of various land conversions, altered disturbance regimes, and atmospheric pollution on natural habitats and the establishment, growth, and maturity of native and nonnative species.
- Assess how nonnative species are altering the composition, structure, and function of the numerous ecosystems of the South.
- Understand how current fire management policies influence native and nonnative species colonization and growth.
- Monitor urban effects on ecosystem processes such as nutrient and carbon cycling, hydrology, and productivity over the long term. Monitoring is needed across the entire South rather than just at a few localities.

- Develop protocols for restoring or rehabilitating ecosystems affected by urbanization.
- Move beyond smart growth models and start to predict the impacts of land use changes on landscape heterogeneity as well as ecosystem composition, structure, and function. Wear and others (1998) are modeling land use changes in an urban and urbanizing context. This work needs to be expanded to landscapes throughout the region, and results need to be applied to land use decisions.
- Identify the linkages among ecological, social, and physical components of the ecosystem and how social policies and socioeconomic conditions alter those linkages at different spatial and temporal scales.

Education needs are to:

- Establish a center or clearinghouse for research information so that results can be synthesized and packaged for various user groups-natural resource managers, land use planners, and landowners. The center must not only provide information; it also must provide a focus for education. Satellite learning centers also may need to be established to effectively transfer information to different user groups. Currently, scientific information exists to make sound land management decisions, but the information is not being used (McCormick 1998).
- Develop information vehicles to enhance traditional approaches for groups and individuals without Internet connections. The Internet provides a new avenue for dissemination, but access needs to be enhanced, and information needs to be packaged according to user group.
- Develop workshops and short courses not only for natural resource managers but also for mayors, county planning commissioners, and staffers from Governors' and legislators' offices on the importance of a holistic approach to land use planning. These workshops should also provide protocols for land use decisions.
- Update management procedures to reflect current techniques being applied by the management community and evaluated by the research community. Users—researchers and managers—need to be linked through the center so that new needs are identified and new information is disseminated.

Conclusion

Fire blackens the earth temporarily, but asphalt blackens it permanently. While this Assessment acknowledges that fire is an important wildland-urban interface issue, it also recognizes the long-term consequence of losing basic ecosystem goods and services to urbanization. Even if all development stopped today, forests would continue to be affected by urban uses through indirect stresses such as air pollution, global climate change, altered disturbance regimes, and introduction of exotic species. We are just beginning to understand the long-term ecological consequences of these indirect effects on forest ecosystems.

The question is not whether we should develop, but rather how best to use the land to maintain or enhance the goods and services provided by ecosystems (Turner and others 1998). Since the greatest threat to species, habitats, and cul-

tures of the South is the increase in human population, land management decisions need to incorporate the principles of an ecosystem approach to decisionmaking (Dale and others 2000, Flores and others 1998, Zipperer and others 2000). Without ecological planning and collaboration, we are faced with continual urban sprawl and the loss of the ecological uniqueness and cultural diversity that define the South.

Literature Cited

Aber, J.D.; Nadelhoffer, K.J.; Steudler, P.; Melillo, J.M. 1989. Nitrogen saturation in northern forest ecosystems. Bioscience. 39: 378-386.

Alig, R.J.; Dicks, M.R.; Moulton, R.J. 2000. Land use dynamics involving forestland: trends in the U.S. South. In: Proceedings of the 28th annual southern forest economics workshop. Co-sponsored by U.S. Department of Agriculture, Forest Service and North Carolina State University. http://www.srs.fs.fed.us/pubs/viewpub.jsp?index=1343. [Date accessed: February 15, 2002].

Alig, R.J.; Healy, R.G. 1987. Urban and built-up land area changes in the United States: an empirical investigation of determinants. Land Economics. 63(3): 215-226.

American Forests. 2002. Regional ecosystem analysis. http://www.americanforests.org/resources/rea. [Date accessed: January 28, 2002].

Arnold, C.L., Jr.; Gibbons, C.J. 1996. Impervious surface coverage: the emergence of a key environmental indicator. American Planning Association Journal. 62(2): 243-258.

Baker, W.L.; Knight, R.L. 2000. Roads and forest fragmentation in the southern Rocky Mountains. In: Knight, R.L.; Smith, F.W.; Buskirk, S.W. [and others], eds. Forest fragmentation in the southern Rocky Mountains. Boulder, CO: University of Colorado Press: 97-122.

Berish, C.W.; Durbrow, B.R.; Harrison, J.E. [and others]. 1998. Conducting regional environmental assessments: the Southern Appalachian experience. In: Peine, J.D., ed. Ecosystem management for sustainability. New York: Lewis Publishers: 117-166.

Boyce, S.G.; Martin, W.H. 1993. The future of the terrestrial communities of the Southeastern United States. In: Martin, W.H.; Boyce, S.G.; Echternact, A.C., eds. Biodiversity of the Southeastern United States: upland terrestrial communities. New York: John Wiley: 339-366.

Buckner, E.R.; Turrill, N.L. 1998. Fire management. In: Peine, J.D., ed. Ecosystem management for sustainability: principles and practices illustrated by a regional biosphere reserve cooperative. New York: Lewis Publishers: 329-348.

Christensen, N.L.; Bartuska, A.M.; Brown, J.H. [and others]. 1996. The report of the Ecological Society of America committee on the scientific basis for ecosystem management. Ecological Applications. 6: 665-691.

Churcher, P.B.; Lawton, J.H. 1987. Predation by domestic cats in an English village. Journal of Zoology. 88: 416-425.

Constanza, R.; Norton, B.G.; Haskell, B.D., eds. 1992. Ecosystem health: new goals for environmental management. Washington, DC: Island Press. 269 p.

Covington, W.W.; Everett, R.L.; Steele, R. [and others]. 1994. Historical and anticipated changes in forest ecosystem of the inland west of the United States. In: Sampson, R.N.; Adams, D.L., eds. Assessing forest ecosystem health in the inland west. New York: Food Products Press: 13-63.

Dale, V.H.; Brown, S.; Haeuber, A. [and others]. 2000. Ecological principles and guidelines for managing the use of land. Ecological Applications. 10(3): 639-670.

Echternacht, A.C.; Harris, L.D. 1993. The fauna and wildlife of Southeastern United States.

In: Martin, W.H.; Boyce, S.G.; Echternacht, A.C., eds. Biodiversity of the Southeastern United States: lowland terrestrial communities. New York: John Wiley: 81-116. Vol. 1.

Flores, A.; Pickett, S.T.A.; Zipperer, W.C. [and others]. 1998. Adopting a modern ecological view of the metropolitan landscape: a case of a greenspace system for the New York City region. Landscape and Urban Planning. 39: 295-308.

Forman, R.T.T. 1995. Land mosaics: the ecology of landscapes and regions. New York: Cambridge University Press. 632 p.

Godron, M.; Forman, R.T.T. 1983. Landscape modification and changing ecological characteristics. In: Mooney, H.A.; Godron, M., eds. Disturbance and ecosystems: components of response. New York: Springer-Verlag: 12-28.

Haskell, B.D.; Norton, B.G.; Costanza, R. 1992. What is ecosystem health and why should we worry about it? In: Costanza, R.; Norton, B.G.; Haskell, B.D., eds. Ecosystem health: new goals for environmental management. Washington, DC: Island Press: 3-20.

Johnson, D.W.; Lindberg, S.E. 1992. Atmospheric deposition and nutrient cycling: a synthesis of the integrated forest study. New York: Springer-Verlag. 707 p.

Kostel-Hughes, F. 1995. The role of soil seed banks and leaf litter in the regeneration of native and exotic tree species in urban forests. Bronx, New York: Fordham University. 239 p. Ph.D. dissertation.

Kowarik, I. 1990. Some responses of flora and vegetation to urbanization in central Europe. In: Sukopp, H., ed. Urban ecology: plants and plant communities in urban environments. The Hague: SPB Academic Publishers: 45-74.

Krupa, S.V.; Tonneijck, A.E.G.; Maning, W.J. 1998. Ozone. In: Flagler, R.B., ed. Recognition of air pollution injury to vegetation. Pittsburgh: Air and Waste Management Association: 2.1-2.28.

Likens, G.E.; Driscoll, C.T.; Buso, D.C. 1996. Long-term effects of acid rain: response and recovery of a forest ecosystem. Science. 272: 244-245.

Lodge, D.M. 1993. Species invasions and deletions: community effects and responses to climate and habitat change. In: Kareiva, P.M.; Kingsolver, J.G.; Huey, R.B., eds. Biotic interactions and global change. Sunderland, MA: Sinauer Associates: 367-387.

Lovett, G.M.; Traynor, M.M.; Pouyat, R.V. [and others]. 2000. Atmospheric deposition to oak forests along an urban-rural gradient. Environmental Science and Technology. 34(20): 4294-4300.

Marsh, W.M.; Marsh, N.L. 1995. Hydrogeomorphic considerations in development planning and stormwater management, central Texas hill country, USA. Environmental Management. 19: 693-702.

McCormick, F.J. 1998. Principles of ecosystem management and sustainable development. In: Peine, J.D., ed. Ecosystem management for sustainability. New York: Lewis Publishers: 3-22.

McDonnell, M.J.; Pickett, S.T.A.; Groffman, P. [and others]. 1997. Ecosystem processes along an urban-to-rural gradient. Urban Ecosystems. 1: 21-36.

Meffe, G.K.; Carroll, C.R. 1994. Principles of conservation biology. Sunderland, MA: Sinauer Associates, Inc. 600 p.

Nilon, C.H.; Long, C.N.; Zipperer, W.C. 1994. Effects of wildland development on forest bird communities. Landscape and Urban Planning. 32: 81-92.

National Research Council. 1992. Rethinking the ozone problem in urban and regional air pollution. Washington, DC: National Academy Press. 524 p.

Noss, R.F. 1987. Protecting natural areas in fragmented landscapes. Natural Areas Journal. 7(1): 2-13.

Noss, R.F. 1989. Longleaf pine and wiregrass: keystone components of an endangered ecosystem. Natural Areas Journal. 9: 211-213.

Noss, R.F.; Csuti, B. 1994. Habitat fragmentation. In: Meffe, G.K.; Carroll, C.R., eds. Principles of conservation biology. Sunderland, MA: Sinauer Associates, Inc.: 237-264.

Noss, R.F.; LaRoe, E.T., III; Scott, J.M. 1995. Endangered ecosystems of the United States: a preliminary assessment of loss and degradation. Biol. Rep. 28. Washington, DC: U.S. Department of the Interior, National Biological Service. 58 p.

Paul, M.J.; Meyer, J.L. 2001. Streams in the urban landscape. Annual Review of Ecology and Systematics. 32:

Peine, J.D.; Montgomery, L.C.; Stephens, B.R. [and others]. 1998. Air quality management: a policy perspective. In: Peine, J.D., ed. Ecosystem management for sustainability: principles and practices illustrated by a regional biosphere reserve cooperative. New York: Lewis Publishers: 307-328.

Pickett, S.T.A. 1998. Natural processes. In: Mac, M.J.; Opler, P.A.; Haecker, C.E.P. [and others], eds. Status and trends of the Nation's biological resources. Washington, DC: U.S. Department of the Interior, Geological Survey: 11-35. Vol. 1.

Pluhowski, E.J. 1970. Urbanization and its effect on the temperature of streams in Long Island, New York. Res. Pap. 0627-D. Reston, VA: U.S. Department of the Interior, Geological Survey: D1-D110.

Pouyat, R.V.; McDonnell, M.J.; Pickett, S.T.A. 1996. Litter and nitrogen dynamics in oak stands along an urban-rural land use gradient. Urban Ecosystems. 1(2): 117-131.

Pouyat, R.V.; Parmelee, R.W.; Carreiro, M.M. 1994. Environmental effects of forest soil-invertebrate and fungal densities in oak stands along an urban-rural land use gradient. Pedobiologia. 38: 385-399.

Rudis, V.A. 1995. Regional forest fragmentation effects on bottomland hardwood community types and resource values. Landscape Ecology. 10: 291-307.

Rudnicky, J.L.; McDonnell, M.J. 1989. Forty-eight years of canopy change in a hardwood-hemlock forest in New York City. Bulletin of the Torrey Botanical Club. 116: 52-64.

Saunders, D.A.; Hobbs, R.J.; Margules, C.R. 1991. Biological consequences of ecosystem fragmentation: a review. Conservation Biology. 5: 18-32.

Schueler, T.R. 1994. The importance of imperviousness. Watershed Protection Techniques. 1(3): 100-111.

Southern Appalachian Man and the Biosphere (SAMAB). 1996. The Southern Appalachian assessment terrestrial technical report. Report 5 of 5. R8-TP29. Atlanta: U.S. Department of Agriculture, Forest Service, Southern Region. 286 p. http://sunsite.utk.edu/samab/saa/reports/terrestrial/terrestrial.html. [Date accessed: July 31, 2001].

Stearns, F.; Montag, T., eds. 1974. The urban ecosystem: a holistic approach. Community Dev. Ser. Vol. 14. The Institute of Ecology, Report of the Urban Ecosystems Project. Stroudsburg, PA: Dowden, Hutchison and Ross, Inc. 217 p.

Stuart, J.D. 1998. Effect of fire suppression on ecosystems and diversity. In: Mac, M.J.; Opler, P.A.; Haecker, C.E.P. [and others], eds. Status and trends of the Nation's biological resources. Washington, DC: U.S. Department of the Interior, Geological Survey: 45-47. Vol. 1.

Turner, M.G. 1990. Landscape changes in nine rural counties in Georgia. Photogrammetric Engineering and Remote Sensing. 56: 379-386.

Turner, M.G.; Carpenter, S.R.; Gustafson, E.J. [and others]. 1998. Land use. In: Mac, M.J.; Opler, P.A.; Haecker, C.E.P. [and others], eds. Status and trends of the Nation's biological resources. Washington, DC: U.S. Department of the Interior, Geological Survey: 37-61. Vol. 1.

Turner, M.G.; Wear, D.N.; Flamm, R.O. 1996. Land ownership and land-cover change in the Southern Appalachian highlands and the Olympic Peninsula. Ecological Applications. 6(4): 1150-1172.

U.S. Geological Survey. 1999. The quality of our Nation's waters—nutrients and pesticides. Circ. 1225. Reston, VA: U.S. Department of the Interior, Geological Survey. 82 p.

Wear, D.N.; Greis, J.G., eds. [In press]. Southern forest resource assessment. Gen. Tech. Rep. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station.

Wear, D.N.; Turner, M.G.; Naiman, R.J. 1998. Land cover along an urban-rural gradient: implications for water quality. Ecological Applications. 8(3): 619-630.

Weiss, K. 1995. Stormwater and the clean water act: municipal separate storm sewers in the moratorium. In: Enhancing urban watershed management at the local, county, and State levels: national conference on urban runoff management; 1995; Cincinnati, OH. Chicago: U.S. Environmental Protection Agency, Office of Research and Development, Center for Environmental Research Information: 47-62.

White, P.S.; Wilds, S.P. 1998. Southeast. In: Mac, M.J.; Opler, P.A.; Haecker, C.E.P. [and others], eds. Status and trends of the Nation's biological resources. Washington, DC: U.S. Department of the Interior, Geological Survey: 255-314. Vol. 1.

Williams, J.D.; Meffe, G.K. 1998. Nonindigenous species. In: Mac, M.J.; Opler, P.A.; Haecker, C.E.P. [and others], eds. Status and trends of the Nation's biological resources. Washington, DC: U.S. Department of the Interior, Geological Survey: 117-129. Vol. 1.

Zipperer, W.C. 1993. Deforestation patterns and their effects on forest patches. Landscape Ecology. 8(3): 177-184.

Zipperer, W.C.; Pouyat, R.V. 1995. Urban and suburban woodlands: a changing forest system. Journal of the American Association of Botanical Gardens and Arboreta. 10(3): 18-20.

Zipperer, W.C.; Wu, J.; Pouyat, R.V. [and others]. 2000. The application of ecological principles to urban and urbanizing landscapes. Ecological Applications. 10(3): 685-688.

Chapter 6

CHALLENGES TO FOREST RESOURCE MANAGEMENT AND CONSERVATION

Mary L. Duryea and L. Annie Hermansen

Professor, School of Forest Resources and Conservation, University of Florida, P.O. Box 110410, Gainesville, FL 32611-0410, mlduryea@ufl.edu

Technology Transfer Coordinator, USDA Forest Service, Southern Research Station, 408 W. University Ave., Suite 101, Gainesville, FL 32601, ahermansen@fs.fed.us

Introduction

Southern forests produce many ecosystem goods and services, such as clean water, timber, recreation, and wildlife. However, these forests—particularly those in the interface—are changing. Forest tract size is decreasing, and the number of forest owners is increasing. These new forest owners may have different management objectives than long-term residents, emphasizing noncommodity goods and services. At the same time, society's demands on forest resources are expanding. These changes set the stage for innovative management and conservation alternatives. This chapter begins by addressing some of the main issues affecting the management of interface forests. It then addresses the changes and challenges, new approaches and trends, and needs for five major aspects of forest resource management in the interface. Finally, we conclude with a summary of overall management needs. ▶

The Forest Stewardship Program

Private individuals own most of the South's forest lands, many of which need financial and technical assistance to actively manage their forests. To address these needs, Congress enacted the Forest Stewardship Program in 1990. This program has integrated multiple landowner objectives into management planning. The Forest Stewardship Program helps private landowners develop plans designed to increase the economic value of their forests while maintaining their environmental integrity for future generations. In addition, the Stewardship Incentives Program was established to provide financial assistance for conservation practices. This program could be adapted to interface forests.

Managing Forests under Change

As rural land is converted to urban uses, the ways in which nearby private and public forests are valued and managed change a great deal. As one moves along the spectrum from rural to urban, forests become more valued for their non-commodity benefits, such as wildlife viewing and aesthetics. Managers of interface forests must be more prepared than their rural counterparts to deal with human influences and interactions.

Interface forests are changing hands. Sampson and DeCoster (2000) found that there are roughly 150,000 new landowners every year across the United States. In the South, a 12-percent increase in forest landowners was observed from 1978 to 1993 (Wear and Greis, in press). These new owners often have different management objectives than their predecessors or may not know where to go for forestry information (DeCoster 1998). Fifty-nine percent of the approximately 5 million individual nonindustrial private forest (NIPF) landowners in the South emphasize improving wildlife, water, aesthetics, and other natural components on their land as their primary or secondary objective. Only 7 percent of landowners list making money as their primary goal (see chapter 2, fig. 2.7).

Additionally, tract sizes are decreasing. Out of the approximately 5 million landowners in the South, 4.1 million own <50 acres (Wear and Greis, in press). Traditional forest management is seldom applicable to the smaller tracts in the interface; new management options for these forests are thus required.

Managers of public forests and other large forest tracts lying close to cities are also faced with many challenges. Some of the major issues confronting managers of urban national forests (Dwyer and others 2000) are:

- Greater use of the forest;
- Pressures from adjacent owners;
- Development along their boundaries;
- Concerns over landscape views, trash, fire, invasive plants and animals;
- Higher degree of visibility to a greater population; and
- More complex planning and decisionmaking.

The composition, structure, and function of forest ecosystems in the interface are changing due to stresses such as pollution, land use conversion, and introduction of invasive exotic species (**fig. 6.1**) (see chapter 5). An example of a southern landscape-level stress is the current outbreak of the southern pine beetle (*Dendroctonus frontalis* Zimmermann). These beetles increase their populations after natural and human-caused stress events, such as droughts, hurricanes, and

"Two thirds of the state is in forest cover. The trend is an increasing amount of forest cover. But if we could see property lines out there, we'd see many, many more forest landowners owning smaller and smaller parcels of forestland." Virginia

urban development (Personal communication. 2001. James Meeker, Forest Entomologist, Florida Division of Forestry, Forest Health Section, 1911 SW 34th St., Gainesville, FL 32608). Two recent outbreaks in Florida originated in urban areas and spread outward to forests in the interface (**fig. 6.2**). Management to reduce these imposed stressors on forest ecosystems will involve a landscape perspective, which includes the management of adjacent ecosystems. Most management recommendations to sustain healthy forests emphasize minimizing stress due to altered energy, species, and materials flowing into and out of ecosystems. Landscape-level management that incorporates ecological, social, and physical components of several ecosystems is necessary to solve these complex challenges to forest health (see chapter 5).

Management and conservation of forest resources in the interface are further challenged by scale. Federal laws, such as the Endangered Species Act or the Clean Water Act, may impact the whole southern region. State laws and growth management planning may affect forest ecosystems at a State level (see chapter 4). Counties also are seeking to influence their surrounding forests. In 1999, out of 102 local initiatives voted on in the United States to devote public funding to protect open space, 90 percent won approval, committing $7.3 billion (Land Trust Alliance 2001). At local levels, developers are often seeing the benefit of green space and clustered housing, and local governments are adopting ordinances to foster forest and water resource conservation (see chapter 4). All these levels of government, citizenry, and private enterprise affect forest management at all scales from backyards to large forested tracts.

Photo by Hans Riekerk, University of Florida

Figure 6.1
The interface has many new inputs, such as invasive species and pollution.

Photos courtesy of USDA Forest Service

Figure 6.2
Southern pine beetle outbreaks occur after major stress events, such as droughts, hurricanes, and urbanization.

Photos courtesy of USDA Forest Service

Figure 6.3
As demands for water-based recreational activities increase, there are also concerns with assuring that there are adequate water supplies for wildlife and aquatic species habitat.

Managing Water Resources

Changes and challenges—Forests play a critical role in the earth's water cycle. About 80 percent of the Nation's fresh water originates in forests. Forests absorb water, refilling underground aquifers. They cool and cleanse the water, slow storm runoff, reduce flooding, sustain watershed stability and resilience, and provide critical habitat for fish and wildlife (U.S. Department of Agriculture, Forest Service 2000). These benefits are threatened, however, when forests are converted to other uses (see chapter 2, fig. 2.14).

Traditionally, water-quality concerns in the South have revolved around activities such as mining, livestock operations, agriculture, and some forestry activities. The loss of forest land to urban land uses, however, has a far greater affect on water quality (Minahan 2000). Today urbanization is the most pressing land use issue affecting water quality and quantity. The growing population of the South is demanding ever-larger water supplies. Large metropolitan areas, such as Atlanta, GA, rely on upland watersheds to supply their water. In addition, increasing numbers of people are settling and recreating on the primary watersheds for large cities (Minahan 2000). Demand for water-based recreation is also increasing, and there are concerns with assuring adequate water supplies for wildlife and aquatic species habitat (**fig. 6.3**).

Reducing Runoff

Some new approaches for reducing runoff are initiated at the planning and design phases of development and include incorporating less impervious surfaces and cluster development, which results in more green space. Austin, TX, for example, has developed environmental protection and management plans for 11,000 acres of greenbelt to preserve such unique water bodies as Barton Springs, a park with a natural limestone pool in the center of Austin.

". . . . Whatever happens upstream impacts the downstream area. So if you have a fellow that builds a pond on the headwaters and it warms the water, then the folks downstream don't have trout in their stream." Georgia

With demands for water increasing, allocation issues present significant challenges for resource managers, scientists, and citizens. Serious conflicts are emerging over allocation of high-quality, abundant flows of water for many purposes (U.S. Department of Agriculture, Forest Service 2000). Increased demands for water also place increased pressure on public lands, such as national forests, to protect water supplies while at the same time providing recreation opportunities.

When forests at the interface are replaced by impervious surfaces, such as buildings, paved streets, and parking lots, the water cycle is interrupted with some of the following consequences:

- Infiltration of water into soil decreases;
- Stormwater runoff increases, and it must be managed and accommodated in sewers, canals, or other structures;
- Water quality decreases as pesticides, fertilizers, trace metals, and other pollutants are concentrated in the runoff;
- Shallow and deep infiltration decreases;
- Erosion of unprotected soils increases, leading to sedimentation in streams and rivers; and
- Evaporation of water decreases as does its associated cooling effect.

Other concerns from urbanization are the increased need for wastewater treatment and the effects of septic system failures on water quality. To delay the need for sewer system extensions and improvements in interface areas, many residential areas install densely placed septic tanks that are highly susceptible to failures and are the chief contributor of fecal coliform contamination (Minahan 2000). This contamination can result in economic and human health concerns. Nonpoint-source pollution is also a major concern. Sources are widely dispersed across the landscape and are difficult to pinpoint or regulate. Thus, the challenge is to balance population growth and economic needs with the protection of human health and water resources. There is also the challenge of educating those upstream about the "downstream effect"—helping people to realize that what they do on their land affects those who use water downstream.

Managing forest ecosystems at a watershed scale is a pressing challenge for resource managers. Previous land management decisions often were made independent of other human activities on watersheds. Consequently, the cumulative effect of incremental changes in land cover was never assessed, and water quality and quantity declined. To effectively manage water resources, a watershed approach is mandatory. A watershed approach provides a framework to design the optimal mix of land covers, minimize the effects on water resources, and coordinate management priorities across land ownerships. The challenges of managing on a watershed scale, however, are many. Most management strategies are not on a scale commensurate with issues at the watershed scale. Local control or management for system components often takes precedence over systemwide needs. Data are not collected and analyzed on watershed scales. Similarly, the scale of monitoring is too small. There is also a lack of long-term commitment to assess cumulative effects, and it often is not economically feasible to study, manage, and restore at such large scales (Naiman 1992).

Needs—Research is needed to discover:

- Accurate information on how much water comes off forested lands (including national forests), where it flows, and how it is used;
- Long-term hydrological impacts and changes to water at the interface [efforts like the Baltimore Ecosystem Study are needed (Doheny 1999)];
- The role that urban forests play in improving water quality and quantity;

Naturescaping for Clean Rivers

The program "Naturescaping for Clean Rivers" seeks to improve the quality and reduce the quantity of water reaching storm drains and eventually the aquatic systems in Portland, OR. Workshops teach homeowners how to establish and manage their landscape with native plants that require much less water, fertilizers, chemicals, and mowing.

Watershed Protection and Flood Prevention Program

The U.S. Department of Agriculture, Natural Resources Conservation Service, Watershed Protection and Flood Prevention Program works through local government sponsors and helps participants solve natural resource and related economic problems on a watershed basis. Projects include watershed protection, flood prevention, erosion and sediment control, water supply, water quality, fish and wildlife habitat enhancement, wetlands creation and restoration, and public recreation in watersheds of 250,000 or fewer acres (Minahan 2000).

- Interactions among multiple land uses and cumulative effects over time across large landscapes;
- Information to relate water-quality standards to the effectiveness of individual control measures;
- The connections between water-quality standards and specific nonpoint-pollution sources;
- New strategies for managing mixed-ownership watersheds;
- Methods for large-scale watershed restoration;
- Methods of developing land with water conservation in mind;
- Ways to retain natural attributes such as streams, springs, ponds, wetlands, and lakes;
- New conservation practices and methods for reusing wastewater; and
- Information about the use of riparian buffers around streams in interface and urban situations.

Educational efforts and collaborative approaches should center on:

- Improved public awareness and general understanding of watershed issues, how their everyday actions affect water quality and quantity, and the value of reducing water consumption and improving conservation efforts;
- Long-term stewardship programs that include identification of impact sources, monitoring, annual clean-up outings, streamside and lakeshore vegetation maintenance, and restoration projects;
- Programs for developers that demonstrate new designs, plans, and cost savings associated with less impervious surfaces and better stormwater management;
- Wetland and riparian buffer protection programs;
- Demonstration cost-sharing projects that encourage landowners to minimize nonpoint-source pollution by using best management practices; and
- Collaborative partnerships among potential and existing water users at watershed scales to achieve long-term, sustainable watershed health (U.S. Environmental Protection Agency 1998).

Managing for Traditional Forest Products

Changes and challenges—Southern forests make up 40 percent of U.S. timberland, and the forest industry employs more than 660,000 people in the South. Indirectly, the industry accounts for another 1.7 million jobs in the region (Faulkner and others 1998) (**fig. 6.4**). Projections show that the South will continue to be the Nation's leading source of timber, and there are great opportunities to increase timber production on private forests (Cubbage and others 1999). While they are providing traditional forest products, such as timber and fiber, these forests also help maintain areas in green space and provide many other ecosystem goods and services. However, when these lands are within the interface, their management and conservation become increasingly difficult.

The South has a high portion of forests near metropolitan areas where many interface forests are located. Dwyer and others (2000) found that the South had the most cities with forests within 50 miles than any other part of the United States. The highest rural land prices are found in these metropolitan counties, which bring about a corresponding increase in the costs of producing timber there. Because of this, selling interface forests for real estate can be more profitable for both industry and NIPF owners than timber production (see chapter 3). The perceived impermanence of land use in the interface can discourage landowners from making long-term forestry investments in metropolitan counties (Wear and others 1999).

For these reasons, it is not surprising that studies are indicating that timber production decreases the closer forests are to urban areas. Wear and others (1999) report that there is little opportunity for practicing forestry for timber production near population densities of 150 people per square mile or more. Another study in Mississippi and Alabama also illustrated that proximity to urban land uses, higher population densities, and proximity to urban centers all lead to lowered timber-harvesting rates (Barlow and others 1998). For timber production to remain relevant in the interface, private landowners must be able to afford to retain and manage these forests for both timber and the noncommodity goods and services that they provide.

As more people are in close contact with traditional forest management practices, there is more potential for conflict between people who hold different sets of perceptions and values over how or if forests should be managed (Vaux 1982). Public concerns over forest management practices range from environmental concerns over erosion, herbicide use, and maintaining an adequate tree cover to complaints about noise and dust from forestry operations. Increasingly these public concerns are translating into the development of local ordinances that regulate forestry practices (see chapters 4 and 7). This can impact the amount of timber available and the cost of transporting it. Recent studies have shown, however, that a majority of both the general public and NIPF owners support environmental protection and even regulation if necessary (Bliss and others 1993, 1997).

The challenge is for local governments, industry and NIPF owners, and the public to work together to develop innovative solutions that meet the needs of all of the involved stakeholders. Working with the public to demonstrate how sound forest management protects environmental values is critical. The collaboration of forest industry with local units of government can lead to productive relationships that benefit both industry and public interests. These relationships can help increase awareness of the benefits of retaining land in working forests while assuring that citizens' concerns are taken into account.

Because of the changing economic and sociopolitical environment in the interface, traditional forest management may need to be adapted to these special conditions to maintain relevance. Modified practices may include changes in harvest size and location and the use of shelterwood and partial cuts. The use of fire and herbicides for removing understory may also be limited (Bradley 1984). The challenge is to adapt forestry practices to the changing conditions and transitioning values in the interface while maintaining the cost effectiveness of management. Otherwise, the landowner may be forced to consider more profitable options (Bradley 1984).

Where timber production is not an option, nontimber commodity products may be viable alternatives for landowners. Examples of such products include pine straw, firewood, nuts, and medicinal plants. These products may have more relevance for owners of small tracts (see chapter 7). However, much still needs to be known about their management and market potential.[1] Managing forests for carbon sequestration also has potential in the interface. The challenge for foresters

Photo by Tim White, University of Florida

Figure 6.4
Forest industry in the South produces commodities valued in excess of $90 billion, employs more than 660,000 people, and indirectly accounts for another 1.7 million jobs (Faulkner and others 1998). However, challenges for managing forest lands for traditional forest products in the interface are growing.

The Forest Legacy Program

The Forest Legacy Program works in partnership with States to protect environmentally sensitive forest land from conversion to nonforest uses through acquisition and conservation easements (Beauvais 2000). States develop plans that identify environmentally important private forests facing urbanization. These targeted private forests are then eligible for matching funds from Federal and non-Federal sources of up to 75 percent for the acquisition of conservation easements (see chapter 4). Most of the Forest Legacy Acquisition Projects to date have been in the Northeastern and Western United States; but North Carolina, South Carolina, Tennessee, Virginia, Georgia, and Alabama are participating, and Kentucky is beginning the planning process.

"Issue one for me that deals with forestry is the issue of gypsy moths and the problem of spraying for gypsy moths. I was almost sued for spray going onto someone else's property, which is almost impossible to prevent when you're spraying by air. You're trying to save your own investment, yet you run the risk of legal problems from the public at large." Virginia

is to adapt to these diverse management needs and scales. Adapting will require new skills, knowledge, and tools.

Small parcels, multiple owners, and conflicting objectives complicate coordinated management on larger ecosystem scales, such as watersheds. Management across ownerships can ensure healthy ecosystem function while providing the desired goods and services of forests. Partnerships among private landowners and private organizations can help overcome the challenges of managing on a landscape scale.

Needs—Research is needed to develop:

- Models for managing across multiple ownerships and technologies that address a wider variety of management objectives;
- Effective options for maintaining working forests in the interface (see chapter 4);
- Workable solutions for managing the increasing number of small NIPF parcels;
- Ways to market forestry information and services for small tracts;
- Techniques for incorporating new neighbors into forestry decisionmaking;
- Management and market potential of nontimber forest products;
- Alternatives to public policies that discourage forest management (see chapters 3 and 4);
- Technologies for identifying critical forest lands for conservation efforts; and
- Costs and benefits of different forest management schemes in the interface.

Tools, incentives, collaboration, and education needs include:

- Adoption of the National Coalition for Sustaining America's Nonfederal Forests' (2000) Report recommendations proposing education, research, extension, and outreach for stewardship of private forests;
- Landscape- or community-level partnerships and cooperatives for forest management;

Carbon Sequestration

Carbon dioxide (CO_2) in the atmosphere is increasing globally and is the principal contributor to global warming. The two main sources of CO_2 are the burning of fossil fuels and deforestation (Houghton and others 1996). Catastrophic fires in the interface, caused by large fuel buildups, rapidly release large amounts of CO_2. Forest ecosystems store carbon, and exchanging them for asphalt and concrete lowers carbon (C) sequestration. Urban trees often are less healthy and are slower growing than those in natural forests, contributing very little to C sequestration (Rowntree and Nowak 1991). Young, fast-growing forests accumulate C at a greater rate than old forests (Clausen and Gholz 1999). If healthy, fast-growing interface forests can be sustained, C sequestration can be one of their global contributions. Forests at the interface also cool and shade structures in the summer, reducing fossil fuel consumption.

[1]Virginia Polytechnic Institute and State University, Center for Forest Products Marketing and Management. 2001. Non-timer forest products. http://www.sfp.forprod.vt.edu. [Homepage].

- Economic incentives and compensation to forest landowners for providing public values, such as riparian buffers or protection of endangered species as well as timber production;
- Targeting forestry programs addressing a range of management objectives for all sizes of tracts; and
- Educating the citizens in the interface about the importance of forests and the benefits accrued from conserving and managing them.

Managing Fire

Changes and challenges—Fire is one of the most visible and demanding issues facing the wildland-urban interface. Recent wildfires in the West and South have caused millions of dollars of property damage to homes, forests, and rangeland. With decades of fuel buildup and the increasing numbers of people moving to the interface, the challenges of preventing and suppressing fires have increased, and the ability to use fire to maintain and enhance ecological processes has decreased. Temporarily successful fire suppression efforts have led to hazardous fuel buildups across the country. Fire exclusion has also produced a range of forest health and wildlife problems, such as critical epidemic insect and disease conditions and species extinctions (Wade and others 1998).

Prescribed fire is one method for removing combustible fuels and reducing the risk of uncontrolled wildfire. It also can maintain, enhance, and restore processes in fire-dependent ecosystems (Wade and others 1989) (**fig. 6.5**). The use of prescribed fire in the interface may be limited, however, due to the perceptions and attitudes of the public. Many people may not understand its benefits or may decide that the benefits are not worth the risks involved with its application. Many public health and safety issues are associated with burning. Fires can get out of control. They can reduce visibility on highways. Ash may drift into swimming pools, and smoke from fire may reduce air quality (see chapter 8). Another challenge regarding the potential use of fire is that many landowners of tracts in the interface do not want to manage their forests at all (see chapter 2). Community development standards may also encourage unsafe fire conditions.

The Forest Bank™

The Nature Conservancy's Center for Compatible Economic Development was created in 1995 to develop new businesses, land uses, and products that help achieve conservation goals (Gilges 2000). One of its programs, The Forest Bank$_{TM}$, aims to form partnerships with private landowners to protect the ecological health and natural diversity of working forests while ensuring long-term economic productivity (Dedrick and others 2000). Landowners who deposit or transfer their right to grow, manage, and harvest trees are ensured a sustainably managed working forest, a dividend payment, and the right to withdraw the value of their timber in cash. The Virginia pilot study has deposits of over 650 acres of forest at a value of $750,000.

"The ecosystems we have here are dependent on fire. If you don't control the density and the fuel loads with prescribed fire, when they do burn, we are not going to stop them." Florida

Photo by Larry Korhnack, University of Florida

Figure 6.5
Prescribed fire is one tool that fire managers can use to remove combustible fuels and reduce the risk of uncontrolled wildfire.

Florida Wildfire Mitigation Program

After the 1998 wildfires, the Florida Division of Forestry developed a Wildfire Mitigation Program, which includes four Wildfire Management Teams and public information officers to address hazard fuel reduction in the wildland-urban interface. Each regional team is responsible for reducing fuel accumulations in and around communities with subdivisions. They also help to suppress wildfires. The public information officers contact individuals and homeowner associations to describe the benefits of the program and discuss aspects of making their homes "FireWise." They also help identify potential areas for hazardous fuel reduction. Public awareness and education is a key factor in this program (Rhea 2000).

Because of these issues, fire management cannot be the same in the interface as in rural areas. In the South, a vast majority of land is privately owned. A dense road network in the interface provides many firebreaks; but it also brings people into forests. In the West, on the other hand, the Federal Government owns most of the undeveloped land, and the network of roads is not as well developed (Achtemeier, in press). Weather and fuel characteristics that may be optimal for burning hazardous fuel loads or for restoring wildlife habitat in rural areas may not be practical in the interface. For example, prescriptions for achieving optimal fire intensities, fuel consumption, and completeness of burn may need to be compromised to avoid excessive smoke production that could enter neighboring communities or cross highways. Different firing techniques and ignition patterns may also be needed in the interface. Although objectives for rural and interface prescribed burning may be similar, priorities shift in the interface due to human health, safety, and liability concerns. Because of this, smoke management becomes a major priority in the interface.

Where prescribed fire is not a viable option, mechanical, biological, and chemical fuel reduction methods may be needed. Although these methods may effectively reduce hazardous fuels, evidence suggests that only prescribed fire can mimic historical ecosystem processes, such as lightning (Heinselman 1973) (see chapters 5 and 8). Other methods, particularly herbicide use, may face stiffer public opposition than the use of fire or may need to be used in combination with fire to be effective (Brennan and others 1998). With any method, regular retreatment is needed to prevent hazardous fuel buildup.

Many of the homes that have sprung up in the interface are built with little consideration for fire risk or protection. Roofing and siding materials are flammable, addresses are poorly marked, access to water supplies is limited, and access for fire emergency vehicles is poor (Perry 1985). Vegetation may be allowed to grow right up to the sides of homes, with little thought for the associated risks of the building fuel loads. Fuel buildups near structures are particularly troublesome where vacation and second homes lacking year-round maintenance predominate.

The risk of fire increases as more forested and rural areas are opened up to human influences (Rice 1987). Some of these ignitions may be accidental, while many are due to arson. In either case, the frequency and risk of catastrophic wildfires grows. Firefighting agencies must have a higher degree of readiness to respond to fires in the interface due to these factors and the increased values at risk that come with urbanization (Rice 1987). All of these factors have made wildfire protection and suppression increasingly dangerous and difficult.

Fire suppression priorities and strategies also change in the wildland-urban interface. The policy of Federal and State agencies has been to first protect life and structures and then natural resources (Cortner and Lorensen 1997). The problem is that most forest fire suppression personnel are inadequately prepared for fighting structural fires, whereas municipal fire departments are not always fully trained or equipped for wildland fire suppression (Davis 1986). The challenge is to combine structural and wildland fire expertise on interface fires and provide cross-training opportunities and effective cooperation across firefighting agencies (see chapter 8).

Needs—Research is needed to (also see chapter 8):

- Determine public perceptions about prescribed fire and wildland fire, including the barriers to actions that can reduce the risk of wildland fire;
- Develop effective strategies for delivering fire prevention messages;

- Understand the role and influence of local public policy in creating or preventing interface fire-related conflicts;
- Develop effective fire ordinances, land use planning policies, and incentives for reducing fire risks to residences;
- Improve prediction of air quality and visibility impacts from smoke;
- Develop models that incorporate weather and elevation data to better predict and monitor smoke;
- Determine the extent and frequency of traffic problems created by smoke from prescribed fire and wildland fire;
- Improve and validate fire weather and fire behavior prediction models;
- Evaluate firing and ignition techniques for prescribed burning in the interface;
- Develop effective fuel reduction burning parameters including mechanical, chemical, and biological treatments and fuel reduction combinations;
- Improve understanding of the costs, benefits, and tradeoffs of different fuel reduction methods;
- Determine the effectiveness of firewise landscaping designs/structures, including plant and mulch flammability, and structure ignitability characteristics; and
- Develop guidelines for southern land and homeowners for assessing and mitigating fire risk around their homes.

Education, tools, and skills needed include:

- Expansion of fire education programs for homeowners;
- Cross training and enhanced collaboration among wildland and structural firefighting agencies;
- Education and outreach messages about fire for the media and local politicians;
- Collaborative efforts and stronger planning partnerships between stakeholders involved in fire prevention and suppression;
- Fire education at the grade school level region wide, emphasizing differences between wildland fire and prescribed fire;
- Education programs at the college level that emphasize wildfire and prescribed fire, communication skills, conflict resolution, political science, and land use planning in the wildland-urban interface;
- Awareness of and involvement in community-based land use planning and policy issues that affect the wildland-urban interface; and
- Hazard rating systems for interface conditions.

Urban-Wildland Interface Advisory Board

The Urban-Wildland Interface Advisory Board in Birmingham, AL, has been dealing with interface fire issues for over 8 years. Members represent a variety of agencies, including those involved in firefighting, local policymaking, and planning. This advisory board has worked to provide training and activities for professionals and private citizens in interface areas in Alabama. They provide an annual award called "Fire-Safe in the Interface" to individuals or groups that have promoted fire safety in the interface.

Table 6.1—Participation in recreational activities in the South in 1995 and projected increases for 2010, 2030, and 2050

Recreational activity	Number of participants 1995	Projected increase		
		2010	2030	2050
	Million	*Percent*		
Water based				
Canoeing	4.20	79	16	34
Motorboating	15.50	13	33	59
Nonpool swimming	23.30	15	37	64
Rafting/floating	4.90	1	4	18
Visiting a beach	37.70	20	48	76
Wildlife related				
Fishing	20.20	11	24	38
Hunting	6.50	82	68	64
Wildlife viewing	34.20	22	54	86
Land related				
Backpacking	3.60	8	23	42
Hiking	11.30	17	45	78
Biking	15.20	22	55	95
Picnicking	27.40	21	52	80
Sightseeing	33.90	25	61	96

Source: Bowker and others 1999.

GREENWAYS

One way to meet increased recreation demand on public land is through creative mechanisms for acquiring greenways in and near cities, such as local acquisition of open space by local units of government and through land trusts (see chapter 4). With over 5,000 active greenways in the United States, these open-space corridors may be the most significant recreation management change and trend in outdoor recreation in the last 10 years (Betz and others 1999, McMahon 1999). These corridors originate from grassroots efforts by citizens to have green space close to where they live (Betz and others 1999). Some unique characteristics of greenways are their local management and leadership and the partnerships that must be formed to create them (Betz and others 1999). Greenways may be created and managed as connections between natural areas (with an ecological objective), as purely recreation areas, or both.

Managing Recreation

Changes and challenges—Most outdoor recreation activities have been growing steadily in the South over the last few years, and recreation has become a significant part of southern lifestyles (Cordell and Tarrant, in press). A national assessment of demand and supply trends concludes that participation in outdoor recreation will continue to increase nationally, with the greatest percentage increases in the South (Cordell and others 1999a). Southern recreation activities, such as wildlife viewing, hiking, and biking, are expected to increase between 18 and 96 percent by the year 2050 (**table 6.1**) (see chapter 2).

While recreation demand is growing, the opportunities for recreation on nonindustrial private forests are decreasing. As a result, pressure will increase to accommodate recreation demands on public lands, which already have significant budget and capacity constraints (Cordell and Tarrant, in press). The challenge for recreation planners and managers is to provide high-quality recreation experiences while sustaining the quality of natural resources. The soil, for example, must be managed to avoid erosion, compaction, and other degradation under heavy recreation pressures (**fig. 6.6**). The interface land is especially under pressure due to its proximity to large urban populations and declining recreation opportunities in cities.

Photo courtesy of USDA Forest Service

Figure 6.6
Increased demand on public recreational facilities in the wildland-urban interface can lead to overuse of trails and camping sites, resulting in erosion and compaction of the soil.

Providing high-quality recreation opportunities for inner-city residents is another challenge. As recreation opportunities decline in inner cities and force people to look beyond the city limits, many inner-city residents with limited resources or disabilities may be left without access to recreation facilities and services (Cordell and others 1999b) (**fig. 6.7**).

With the unprecedented increases in ethnic, racial, and age diversity in the South (see chapter 2), recreation managers must consider the needs and expectations of the different groups using wildland-urban interface recreation sites. For example, Gramann and Floyd (1991) found that Mexican-Americans rated "doing something with your family" and "doing something with your children" significantly higher than non-Hispanic Whites as favorite outdoor activities.

"We're moving into a multicultural society, and I don't think we [natural resource professionals] have changed to reflect that." Mississippi

Managers must also possess skills to communicate not only with people of different cultures (Magill and Chavez 1993), but also for communicating with people that hold diverse values and perceptions about how the land should be used and managed. As forest recreation demand grows, there is more potential for conflict between different recreation user groups utilizing the same areas. Four-wheel drive enthusiasts, for example, are likely to clash with hikers over how backcountry areas should be used (Cordell and Tarrant, in press) (see chapter 7). The challenge is to plan and facilitate diverse recreation experiences for the variety of user groups by including them in decisionmaking processes and helping them to find ways to share access opportunities.

Photo courtesy of USDA Forest Service

Figure 6.7
Programs, such as the Atlanta-based community project, the Urban Tree House, provide outdoor recreational opportunities for inner-city residents.

Needs—Research is needed to:

- Continually assess and track recreation markets, cultural preference trends, and opportunities for recreation on urban, interface, and rural land;
- Determine the importance of private lands, greenways, and urban forests for recreation, especially to serve the urban public and take the pressures off other natural areas outside the city;
- Identify and monitor forested areas in the South where recreation participation is likely to place increased pressures on forest resources;
- Assess impacts of recreation on natural resources, such as vegetation, soils, and wildlife;
- Identify critical areas in need of rehabilitation and protocols for effective rehabilitation in interface situations;
- Identify the diversity of recreation experiences desired by user groups and how user perceptions influence the quality of their experiences; and
- Identify factors that limit effective communication between recreation managers and the diversity of user groups.

Educational needs are:

- Training courses for future recreation managers that prepare them for the social and political dimensions of their work;
- Continuing education opportunities for current managers; and
- Involvement of diverse user groups in the development of education programs, planning, and management objectives, emphasizing their role in managing and protecting resources.

Managing and Conserving Wildlife

Changes and challenges—Southern forests boast an abundance of wildlife, and wildlife-associated recreation is becoming increasingly popular, with 34 million people participating each year (Faulkner and others 1999). Popular wildlife recreation activities in the South include viewing and photographing wildlife, as well as fishing and hunting (see chapter 2, table 2.4). Urbanization and other human influences often destroy, degrade, or fragment wildlife habitat (see chapter 2, fig. 2.15). These changes are the major contributors to declines in wildlife populations and biodiversity worldwide (Swisher and others 2000) (see chapter 5). The consensus among conservation biologists is that direct habitat destruction is the greatest threat to biodiversity at both the species and ecosystem levels, and is the major factor threatening 80 percent or more of the species listed under the Federal Endangered Species Act (Noss and Peters 1995). As the wildland-urban interface expands, managers must address many new wildlife conservation and management challenges.

The most significant wildlife challenge in the wildland-urban interface is conserving, managing, and restoring wildlife habitat. The interface contains patches that can range from backyards, to small pocket parks, to larger forested tracts. The size, shape, and spatial relationships of patches in the landscape affect the structure and function of ecosystems (Dale and others 2000). For example, many

Habitat Restoration

Ecological restoration and management of wildlife habitat is essential for the health of natural communities and the conservation of biodiversity. Many species depend on particular stages of succession and their related disturbances. The Florida scrub-jay (*Aphelocoma coerulescens*), for example, inhabits pine/oak scrub ecosystems in central Florida. This bird requires a low shrub layer, bare ground, and a few scattered trees, avoiding canopied areas. To manage habitat for this rare bird, conservation groups such as The Nature Conservancy have reintroduced periodic fires that maintain the stage of succession needed by scrub-jays.

"The wildlife is being squeezed into smaller and smaller areas or into areas where there is little space . . ." Virginia

studies have shown that the larger the habitat patch, the greater the number of wildlife species present (Adams 1994). Connecting small forest patches to larger reserves with corridors is especially valuable for wildlife. In one urban wildlife habitat conservation strategy, core habitat reserves with minimal human influences are established. To prevent isolation of these reserved areas, corridors are maintained to link core reserves to each other. The result is an integrated network of habitats. Surrounding the core areas are buffers in which resource management and recreation activities occur (Adams 1994).

Another important wildlife conservation strategy is to preserve all the processes that affect wildlife populations and communities, not just site size and connectivity. The site history, the types of adjacent land uses, and current influences should be taken into account when developing wildlife conservation plans (Nilon and Pais 1997).

Urban interface areas have a large proportion of edge habitats—transitions between two ecosystems (see chapter 5). Soft edges with different layers of vegetation are more favorable to wildlife than hard edges in which forest and grass are adjacent. With the increase of forest/development edges, there is a corresponding increase in edge-adapted species, such as deer and quail, and predator species, such as skunks and raccoons. Forest interior species decline (Nilon and others 1995). Increases in predator species and parasitism can result in higher rates of predation of some species (Andren and Angelstam 1988). Also, as more people move to interface areas, there is an increase in domestic animals, such as cats, which can have devastating effects on many native species, particularly on small birds and mammals (Clifton 1992).

While populations of some species are decreasing in the interface, others are rapidly increasing, causing serious challenges for wildlife managers. White-tailed deer (*Odocoileus virginianus*) populations, for example, have exploded in some parts of the South (see chapter 5), leaving many communities searching for solutions. Citizen complaints have ranged from annoyance about damage to ornamental shrubs and property, to safety concerns about deer-vehicle collisions, and health concerns about the transmission of Lyme disease to humans by deer ticks (Fitzwater 1989, Franklin 1997). At the same time, many interface residents enjoy observing deer and other wildlife near their homes (**fig. 6.8**). Balancing local residents' desires to increase their wildlife contact with their concerns about nuisance and human health problems is a major challenge for wildlife managers in the interface. They must be able to deal not only with people-wildlife conflicts but also people-people conflicts.

The proportion of the U.S. population that hunts and supports traditional game management activities is dropping, while more people are watching, hearing, seeing, and otherwise enjoying wildlife (Cordell and others 1999a). While hunting can help control burgeoning wildlife populations, it may not be accepted by local interface residents. Additionally, safety concerns or laws and regulations administered by State and local governments may prevent hunting (Stout and others 1997). Other methods of control, such as contraceptives, may be one answer but can be expensive and may be opposed by local animal activist groups (Fosgate 2001, Warren and others 1995).

Photo by Linda Robinson

Figure 6.8
The program Landscaping for Wildlife, developed by the Florida Cooperative Extension Service, gives homeowners guides for managing and landscaping their backyards for wildlife.

Landscaping for Wildlife

Some new programs are encouraging landscaping of backyards and neighborhoods to recreate habitats for wildlife in urban and interface communities. One program developed by the Florida Cooperative Extension Service gives homeowners guides for managing and "landscaping forwildlife" (fig. 6.8). The National Wildlife Federation Backyard Wildlife program is a national certification program that encourages everyone from homeowners to teachers and community leaders to consider wildlife needs when planning their landscapes.

Wildlife managers must be able to adapt management to include both consumptive and nonconsumptive uses (Curtis 1978) and be aware of local public attitudes towards wildlife conservation and management. They must also take steps to actively involve stakeholders from a diversity of backgrounds into policy and management decisionmaking processes and programs (Decker and Chase 1997).

Needs—Research is needed to:

- Develop models that identify and evaluate valuable wildlife habitats for local planning, design, and management;
- Identify management options for trails and linear greenways (corridors) for multiple uses including wildlife;
- Improve techniques and guidelines for ecological restoration and adaptive wildlife management;
- Identify relationships between patch habitat history and plant species composition and structure, and determine how these relationships influence wildlife populations;
- Identify mechanisms by which adjacent land use practices and human activities influence patch habitats and animal populations;
- Determine how wildlife species use habitats in urban areas and the range of wildlife habitats in which species reside;
- Develop models for joint action by local, State, and Federal Governments working with private and grass-roots organizations to plan and establish landscape-level initiatives;
- Discover how to lessen people-wildlife and people-people conflicts at the interface and incorporate stakeholders into decisionmaking; and
- Survey public attitudes and perceptions about wildlife management and conservation strategies.

Education needs include:

- Information to educate new interface residents about the environment that they are moving into, about minimizing negative human-wildlife interactions, and about greater tolerance for living with wildlife;
- Programs to show neighborhoods and communities how to enhance and support their wildlife populations;
- Programs for planners and developers to illustrate how to sustain and manage ecosystems and incorporate ecological principles when faced with growth and development; and
- Outreach programs for the many stakeholders involved in conserving and managing wildlife resources to encourage cooperation and collaboration.

Tools and skills needed by wildlife managers include:

- The ability to work closely with community members, landscape architects, planners, engineers, developers, and the public;
- Knowledge of how to use public meetings, surveys, and advisory groups for assessing public opinion on local wildlife issues (this

information can be used in public education efforts and future management decisionmaking); and

- The ability to reconcile the competing interests that different stakeholders have regarding wildlife resources.

Conclusion

Forests in the South are changing in their ownership, tract size, and many ecological qualities, making new adaptive management strategies essential. These forests are influenced by a large number of stakeholders with diverse interests who must be involved in management decisions. The major ecological goods and services that these forests provide are in peril as are many rare forest ecosystems, which are becoming part of the interface. Adaptive management regimes must be applied across the landscape. Government agencies, industry, nonprofit organizations, and citizenry need to be involved and to find alternatives to many of our current customs and approaches. There are some promising new approaches and solutions, but more scientific knowledge is needed to find practical solutions to local problems. Some of the major themes for sustaining and managing these forests are to promote and support:

- Sound stewardship,
- New policies,
- New market-based solutions,
- Landscape-level management solutions,
- Incentives for management,
- Research,
- Dissemination of existing research findings,
- Technical assistance, and
- Improved and expanded education efforts.

Some additional overall needs are:

- Landscape-level management plans for forest ecosystems;
- Collaborative partnerships between private and public managers for conducting landscape-level management;
- Ways to grow without degrading and fragmenting our forested landscape and ways to link ecological principles to land use planning, decisionmaking, and management;
- Identification of the most important, imperiled ecosystems to conserve and manage;
- Improved scientific knowledge and information about forest ecosystems in fragmented landscapes;
- Identification of human perceptions, uses, and values related to urban and interface forests;

- Recognition that intensive forest management is necessary in rural areas to meet our future timber supply and to take the pressure off natural areas and other open spaces;
- Packaging technical information for various stakeholders; and
- Education of and collaboration among multiple stakeholders including developers, forest landowners, policymakers, citizens, and natural resource professionals.

Literature Cited

Achtemeier, G. [In press]. Problem smoke. In: Hardy, C.; Ottmar, R.D.; Peterson, J.L. [and others], eds. Smoke management guide for prescribed and wildland fire. Boise, ID: National Wildfire Coordinating Group.

Adams, L.W. 1994. Urban wildlife habitats: a landscape perspective. Minneapolis: University of Minnesota Press. 186 p.

Andren, H.; Angelstam, P. 1988. Elevated predation rates as an edge effect in habitat islands: experimental evidence. Ecology. 69(2): 544–547.

Barlow, S.A.; Munn, I.A.; Cleaves, D.A.; Evans, D.L. 1998. The effect of urban sprawl on timber harvesting. Journal of Forestry. 96(12): 10-14.

Beauvais, T.W. 2000. The role of the Forest Legacy Program in preventing forest fragmentation of forest ownerships. In: Decoster, L.A., ed. Sustaining private forests in the 21st century: Proceedings of the forest fragmentation 2000 conference. Alexandria, VA: Sampson Group Inc.: 359-361.

Betz, C.J.; English, D.B.K.; Cordell, H.K. 1999. Outdoor recreation resources. In: Cordell, H.K.; Betz, C.J.; Bowker, J.M. [and others], eds. Outdoor recreation in American life: a national assessment of demand and supply trends. Champaign, IL: Sagamore Publishing: 39-182.

Bliss, J.C.; Brooks, R.T., Jr.; Larsen, M.D. 1993. Attitudes in the Tennessee Valley region toward forest practices and policies. In: Proceedings of the 21st annual hardwood symposium of the Hardwood Research Council. [Place of publication unknown]: [Publisher unknown]: 117-127.

Bliss, J.C.; Nepal, S.K.; Brooks, R.T., Jr.; Larsen, M.D. 1997. In the mainstream: environmental attitudes of mid-south forest owners. Southern Journal of Applied Forestry. 21(1): 37-43.

Bowker, J.M.; English, D.B.K.; Cordell, H.K. 1999. Projections of outdoor recreation participation to 2050. In: Cordell, H.K.; Betz, C.J.; Bowker, J.M. [and others], eds. Outdoor recreation in American life: a national assessment of demand and supply trends. Champaign, IL: Sagamore Publishing: 323-350.

Bradley, G.A. 1984. The urban/forest interface. In: Bradley, G.A., ed. Land use and forest resources in a changing environment: the urban/forest interface. Seattle: University of Washington Press: 3-16.

Brennan, L.A.; Engstrom, R.T.; Palmer, W.E. [and others]. 1998. Whither wildlife without fire? In: Transactions of the 63rd North American wildlife and natural resources conference. [Place of publication unknown]: [Publisher unknown]. 63: 402-414.

Clausen, R.M.; Gholz, H.L. 1999. Carbon storage, sequestration and forest management: a synthesis. Gainesville, FL: University of Florida, School of Forest Resources and Conservation. 69 p. [Report to U.S. Department of Agriculture Forest Service on behalf of U.S. Agency for International Development].

Clifton, M. 1992. Urban wildlife: reclaiming their birthright. The Animals' Agenda. 12(1): 12-19, 22-24.

Cordell, H.K.; Betz, C.J.; Bowker, J.M. [and others], eds. 1999a. Outdoor recreation in American life: a national assessment of demand and supply trends. Champaign, IL: Sagamore Publishing. 449 p.

Cordell, H.K.; McDonald, B.L.; Teasley, R.J. [and others]. 1999b. Outdoor recreation and participation trends. In: Cordell, H.K.; Betz, C.J.; Bowker, J.M. [and others], eds. Outdoor recreation in American life: a national assessment of demand and supply trends. Champaign, IL: Sagamore Publishing: 219-321.

Cordell, H.K.; Tarrant, M.A. [In press]. Socio-6: forest-based outdoor recreation. In: Wear, David N.; Greis, John G., eds. Southern forest resource assessment. Gen. Tech. Rep. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station.

Cortner, H.J.; Lorensen, T. 1997. Resources versus structures: fire suppression priorities in the wildland/urban interface. Wildfire. 6(5): 22-33.

Cubbage, F.W.; Siry, J.; Abt, R. [and others]. 1999. Forest productivity and timber supply modeling in the South. In: Ek, A.R.; ZumBahlen, B., comps. Improving forest productivity for timber: a key to sustainability: Conference proceedings. [Place of publication unknown]: [Publisher unknown]: 285-290.

Curtis, R.L. 1978. Public involvement in urban wildlife planning and action programs. In: National urban forestry conference. [Place of publication unknown]: [Publisher unknown]: 85-97.

Dale, F.H.; Brown, S.; Haeuber, R.A. [and others]. 2000. Ecological principles and guidelines for managing the use of land. Ecological Applications. 10(3): 639-670.

Davis, J.B. 1986. Danger zone: the wildland/urban interface. Fire Management Notes. 47(3): 3-5.

Decker, D.J.; Chase, L.C. 1997. Human dimensions of living with wildlife—a management challenge for the 21st century. Wildlife Society Bulletin. 25(4): 788-795.

DeCoster, L.A. 1998. The boom in forest owners—a bust for forestry? Journal of Forestry. 96(5): 25-28.

Dedrick, J.P.; Hall, T.E.; Hull, R.B., IV; Johnson, J.E. 2000. The forest bank: an experiment in managing fragmented forests. Journal of Forestry. 98(3): 22-25.

Doheny, E.J. 1999. Index of hydrological characteristics and data resources for the Gwynns Falls watershed, Baltimore County and Baltimore City, Maryland. Open-File Rep. 99-213. Washington, DC: U.S. Department of the Interior, U.S. Geological Survey. 17 p.

Dwyer, J.F.; Nowak, D.J.; Noble, M.H.; Sisinni, S.M. 2000. Connecting people with ecosystems in the 21st century: an assessment of our Nation's urban forests. Gen. Tech. Rep. PNW-GTR-490. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 483 p.

Faulkner, G.; Gober, J.; Hyland, J. [and others]. 1998. Forests of the South. Montgomery, AL: 26 p. www.southernforests.org/newsite/publications/forest-of-the-south/contents.htm. [Date accessed: February 20, 2002]. [A report by the Southern Forest-Based Economic Development Council].

Fitzwater, W.D. 1989. An assessment of the urban wildlife problem. In: Ninth Great Plains wildlife damage control workshop. [Place of publication unknown]: [Publisher unknown]: 64-69.

Fosgate, H. 2001. The great Hilton Head deer debate. The Forester's Log: the magazine of the Warnell School of Forest Resources, University of Georgia. Spring: 4-5, 8.

Franklin, T.M. 1997. Deer dilemma: accommodating a love-hate relationship. Wildlife Society Bulletin. 25(2): 585-586.

Gilges, K. 2000. The forest bank: a market-based tool for protecting our working forestland. In: DeCoster, L.A., ed. Proceedings of the forest fragmentation 2000 conference. Alexandria, VA: Sampson Group, Inc.: 340-345.

Gramann, J.H.; Floyd, M.F. 1991. Ethnic assimilation and recreational use of the Tonto National Forest. Contract report prepared under Cooperative Agreement PSW-89-0015CA between the Texas Agricultural Experiment Station and the Wildland Recreation and Urban Culture Research Project of the U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. College Station, TX: Texas Agricultural Experiment Station. 98 p.

Heinselman, M.L. 1973. Fire in the virgin forests of the Boundary Waters Canoe Area. Quaternary Research. 3: 329-382.

Houghton, J.T.; Meira Filho, L.G.; Callander, N. [and others], eds. 1996. 1995 climate change: the science of climate change. Contribution of working group 1 to the second assessment report of the intergovernmental panel on climate change. Cambridge, England: Cambridge University Press. 584 p.

Land Trust Alliance. 2001. Voters commit nearly 1.7 billion to open space. Washington, DC: Land Trust Alliance. 1 p. http://www.lta.org/publicpolicy/landvote2001. [Date accessed: January 18, 2002].

Magill, A.W.; Chavez, D.J. 1993. Difficulties with multicultural communication. In: Ewart, A.W.; Chavez, D.J.; Magill, A.W., eds. Culture, conflict, and communication in the wildland-urban interface. Boulder, CO: Westview Press: 119-122.

McMahon, E.T. 1999. Greenways: America's natural connections. In: Cordell, H.K.; Betz, C.J.; Bowker, J.M. [and others]. Outdoor recreation in American life: a national assessment of demand and supply trends. Champaign, IL: Sagamore Publishing: 137-141.

Minahan, K. 2000. The Upper Etowah River watershed: our land, our water, our future: a guide for local residents, policy makers, and resource agencies. Calhoun, GA: The Upper Etowah River Alliance, The Limestone Valley Resource Conservation and Development Council, Inc. 71 p.

Naiman, R.J. 1992. New perspectives for watershed management: balancing long-term sustainability with cumulative environmental change. In: Naiman, R.J., ed. Watershed management: balancing sustainability and environmental change. New York: Springer: 3-11.

National Coalition for Sustaining America's Nonfederal Forests. 2000. A national investment in sustainable forestry: addressing the stewardship of nonfederal forestlands through research, education, and extension/outreach. Falls Church, VA: National Coalition for Sustaining America's Nonfederal Forests. 22 p. http://www.napfsc.org/coalrep.pdf. [Date accessed: January 2001].

Nilon, C.H.; Long, C.N.; Zipperer, W.C. 1995. Effects of wildland development on forest bird communities. Landscape and Urban Planning. 32: 81-92.

Nilon, C.H.; Pais, R.C. 1997. Terrestrial vertebrates in urban ecosystems: developing hypotheses for the Gywnns Falls watershed in Baltimore, Maryland. Urban Ecosystems. 1(4): 247-257.

Noss, R.F.; Peters, R.L. 1995. Endangered ecosystems: a status report on America's vanishing habitat and wildlife. Washington, DC: Defenders of Wildlife. 132 p.

Perry, D.G. 1985. Wildland fires in the wildland/urban interface: evaluating the problem. In: Proceedings of symposium on fire management: the challenge of protection and use. Logan, UT: [Publisher unknown]: 149-151.

Rhea, B. 2000. Florida wildfire mitigation. Wildland Firefighter. 4(2): 16-18.

Rice, C.L. 1987. What will the wildlands be like in the year 2000: future perfect or future imperfect? Gen. Tech. Rep. PSW-101. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station: 26-31.

Rowntree, R.A.; Nowak, D.J. 1991. Quantifying the role of urban forests in removing atmospheric carbon dioxide. Journal of Arboriculture. 17(10): 269-275.

Sampson, N.; DeCoster, L. 2000. Forest fragmentation: implications for sustainable private forests. Journal of Forestry. 98(3): 4-8.

Sedell, J.; Sharpe, M.; Apple, D. [and others]. 2000. Water and the Forest Service. FS-660. Washington, DC: U.S. Department of Agriculture, Forest Service. 26 p.

Stout, R.J.; Knuth, B.A.; Curtis, P.D. 1997. Preferences of suburban landowners for deer management techniques: a step towards better communication. Wildlife Society Bulletin. 25(2): 348-359.

Swisher, M.E.; Mullahey, J.; DeBusk, W.; Main, M. [and others]. 2000. The ecology and economics of Florida's ranches. SS-SA-8. Gainesville, FL: University of Florida, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences. 6 p.

U.S. Environmental Protection Agency. 1998. Clean water action plan: restoring and protecting America's waters. EPA-840-R-98-001. Washington, DC: U.S. Government Printing Office. 89 p.

Vaux, Henry J. 1982. Forestry's hotseat: the urban/forest interface. American Forests. 88(5): 36-46.

Virginia Polytechnic Institute and State University, Center for Forest Products Marketing and Management. 2001. Non-timber forest products. http://www.sfp.forprod.vt.edu. [Homepage].

Wade, D.; Custer, G.; Thorsen, J. [and others]. 1998. Reintroduction of fire into fire-dependent ecosystems: some southern examples. In: Pruden, T.L.; Brennan, L.A., eds. Fire in ecosystem management: shifting the paradigm from suppression to prescription: Proceedings of the Tall Timbers ecology conference no. 20. Tallahassee, FL: Tall Timbers Research Station: 94-98.

Wade, D.D.; Lunsford, J.D.; Dixon, M.J.; Mobley, Hugh E. 1989. A guide for prescribed fire in southern forests. Tech. Publ. R8-TP 11. Atlanta: U.S. Department of Agriculture, Forest Service, Southern Region. 56 p.

Warren, R.J.; White, L.M.; Lance, W.R. 1995. Management of urban deer populations with contraceptives: practicality and agency concerns. In: McAninch, J.B., ed. Urban deer: a manageable resource? Proceedings symposium 55th Midwest fish and wildlife conference. St. Louis, MO: The Wildlife Society, North Central Section: 164-170.

Wear, D.N.; Liu, R.; Foreman, M.; Sheffield, R.M. 1999. The effects of population growth on timber management and inventories in Virginia. Forest Ecology and Management. 118: 107-115.

Wear, D.N.; Greis, J.G., eds. [In press]. Southern forest resource assessment. Gen. Tech. Rep. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station.

Chapter 7

SOCIAL CONSEQUENCES OF CHANGE

R. Bruce Hull and Susan I. Stewart

Professor, College of Natural Resources Virginia Polytechnic Institute and State University, Blacksburg, VA, 24061, hullrb@vt.edu

Research Social Scientist, USDA Forest Service, North Central Research Station, 845 Chicago Ave., Suite 225, Evanston IL 60202-2357, sstewart01@fs.fed.us

Introduction

The natural resource professionals are only one voice in the chorus of the social forces shaping the wildland-urban interface. Other voices include powerful and long-time favorites of the American body politic: the American dream of a single-family home produces an endless demand for forested lots; multinational industries strive to generate the profits and materials that fuel America's economic engine; retail stores insist on space to advertise and market their wares; economic development agencies struggle to spread prosperity, growth, and progress; and environmental preservationists seek to protect wild nature for the spiritual, aesthetic, and moral benefits of current and future generations. To be relevant and effective at influencing the form and function of this emerging landscape, natural resource professionals must recognize and influence the social consequences of landscape change. ▶

This chapter begins by reviewing three types of social consequences produced by this emerging landscape: (1) economic, (2) political and regulatory, and (3) community and landowner. We also discuss the challenges and opportunities natural resource professionals face if they are to remain relevant in the wildland-urban interface.

Consequences of Economic Change

The urbanization of forested areas alters the economics of land management. For example, trees become valued more as amenities than as commodities; return from investment comes more from a property's commercial or residential potential than from its soil productivity. Slowing stormwater discharge becomes as valued as recharging water supply; and mitigating urban heat-island effects overshadows habitat needs of wildlife.

Forest Industry

Forest industries provide economic vitality to local economies. Urbanization clearly changes that economy, but it is not clear whether the net change is positive or negative. Some industries and land uses, such as forestry, are constrained by increased regulation and decreased supply. Other new enterprises, such as retail sales, services, and land development, emerge and create new sources of wealth and new values for forests (see chapter 3).

Conventional wisdom suggests that urbanization shrinks the timber supply. Data are sparse. Some estimates suggest that urbanization reduces commercial inventories between 30 and 49 percent (Wear and others 1999); other estimates are less pessimistic (Barlow and others 1998). We do not have a good understanding of the reasoning owners use to decide whether and when to harvest timber or invest in forest management. But we do know that these decisions become more complex in the interface forest because of additional concerns about neighbor and community perceptions, about amenity and environmental consequences of logging practices, and about increased attention given to fire hazard reduction, wildlife habitat creation, and control over visual access (see chapter 6).

"The inhabitants of areas surrounding the forests are not willing to allow silvicultural practices to occur in those forests adjacent to their property." Florida

Similarly, conventional wisdom suggests that parcelization increases harvesting costs and decreases the profitability of timber production. Supposedly, parcelization leads to more regulation, more onerous negotiations among multiple landowners for access, and a greater emphasis on protecting environmental and amenity resources. However, the actual data are still somewhat inconclusive (for example, Kittredge and others 1999). Another common concern is that wood-processing plants might relocate to find cheaper and more reliable timber supplies. The resulting decrease in timber processing capability hurts local forest owners because they face higher costs for transporting timber to mills. As real estate and amenity values exceed income available from timber harvest, further parcelization may be encouraged. There is limited study about any of these issues. The complex factors that influence the supply of and demand for timber make simple conclusions hard to find. It appears, however, that traditional, rural forestry practices of buying, sell-

Photo courtesy of USDA Forest Service

Figure 7.1
Many employers migrate to the interface following or trying to attract qualified workers.

ing, harvesting, transporting, and processing timber will increasingly struggle for relevance in interface forests (Barlow and others 1998) (see chapter 6).

Nontimber Industry

Nontimber commodity production on interface land is increasingly popular as a means for landowners to supplement their incomes. Because of easy access to markets, "metro farms" generate more revenue per acre than rural land and they "specialize in high-value crops, producing more than two-thirds of vegetable and fruit sales and more than three-fourths of nursery and greenhouse crop sales" (Heimlich and Brooks 1989). Many of these holdings have woodlots that can provide timber for additional revenue. Subdividing and selling small land parcels also generates income. The supplemental income from these and other interface economies can make feasible the continued management of marginally productive forest and agriculture land.

Resource-Dependent Communities

New economies emerge in the interface bringing growth, diversifying employment, and expanding the tax base. Interface residents can commute to employment along surface roads or information highways, bringing their paychecks back to spend at local retail and service businesses. Employers migrate to the interface following or in search of a qualified workforce (Garreau 1991, Johnson and Rasker 1995) (**fig. 7.1**). Taxes on residential properties, merchandise sales, and services, as well as taxes on new information and service industries, supplement tax revenues lost from relocated commodity-producing industries. While urbanization may cause pain by disrupting employment patterns and social networks, many rural communities aggressively seek development opportunities that offer economic growth, improve the quality of life, and provide young people reason to stay in their hometowns (Riebsame and others 1996, Voth and others 1999). Additional information about economic and taxation issues can be found in chapter 3.

Photo courtesy of USDA Forest Service

Figure 7.2
As the urbanizing forest transitions to an urban forest, the costs of planting and maintaining these trees increases, as well as do the perceived benefits of these trees.

Infrastructure Costs and Benefits

The costs of providing roads, schools, water, and related services are higher in urbanizing areas than in either urban or rural landscapes. They are highest in the dispersed development pattern associated with the wildland-urban interface. Parcelization of forested landscapes, therefore, raises an equity question: Who should be taxed or otherwise finance expanding the physical and social infrastructure?

The role of the forest as an environmental infrastructure also changes. The urbanizing forest becomes more valuable because it reduces heat islands and air conditioning needs, slows and absorbs stormwater, and improves air and water quality. Individually, every tree provides benefits and, cumulatively, the forest provides enormous services that can reduce the need for regional power generation stations and equally costly water treatment and processing facilities. As urbanization continues and the interface forest transitions into an urban forest, the perceived benefits from trees change and perhaps increase, as do the costs of planting and maintaining these trees (Dwyer and others 2000) (**fig. 7.2**).

Consequences of Political and Regulatory Changes

Interface forests also differ from their rural cousins in the number and complexity of political issues affecting them.

Multiple Jurisdictions

As human communities grow, they impose more of their structure onto natural communities. With every new jurisdiction comes another planning process and additional stakeholders. Urbanizing forests have overlapping jurisdictional boundaries created by local and State planning entities; fire, water, and soil conservation districts; county and local planning boards; and homeowners associations (see chapter 4).

"No one has a vision for the future. There is fragmentation of everything." Florida

Land management practices and policies often change at property and jurisdictional boundaries, disrupting ecosystem processes and complicating forestry operations that might otherwise cross those boundaries for ecological or economic reasons (Grimm and others 2000). For example, control of insects and fire often requires practices that cross political boundaries.

Increased Regulation

Higher population density increases the potential for neighbors to directly affect one another's quality of life. As a result, regulation of forest and land management practices increases with urbanization. By most accounts, the increased regulation decreases the short-term profit of harvesting timber; estimates vary from several to many percentage points of profit (Kittredge and others 1999). Regulations also may reduce the amount of timber available by restricting how much forest cover must remain after silvicultural operations (see chapters 4 and 6). Enforcing compliance with these regulations requires the public to commit substantial resources (Ellefson and Cheng 1994). A new class of professionals—public regulatory and planning officials as well as consultants to advise private landowners—is created to provide this value-added service. The uncertainty surrounding the future regulatory environment is sometimes blamed for encouraging landowners to harvest sooner, before potentially costly regulation occurs (Johnson and others 1997). Though they are not yet well documented, potential long-term benefits from increased regulation include prolonged and improved environmental conditions. For example, soil productivity is maintained and water pollution is decreased.

Photo by Larry Korhnack, University of Florida

Figure 7.3
New owners and neighbors of interface forests are often motivated and organized to influence natural resource policies and management.

Participation in Land Use Planning

Land use decisions in interface areas generate more controversy and attention than in rural areas, and involve more plentiful and more diverse public participation. There is considerable debate about whether and how newer residents affect public participation in local governance (Lee and others 1990, Smith and Krannich 2000). Typically, newer residents give environmental concerns a stronger voice, at least relative to commodity production concerns. However, research suggests that new and long-time residents differ little in their environmental concerns (see chapter 4). What may differ are the power and ability each group has to express their concerns. New residents tend to have more resources and be less dependent upon local means of production, freeing them to be more critical of the local situation. Some new residents also possess greater skills for manipulating political and media systems (**fig. 7.3**). Consequently, the involvement of new residents sometimes helps long-time residents voice previously muted environmental concerns. Regardless of the cause, the concerns heard by land use planners and managers do change (Voth and others 1999).

Because of urbanization, the decisionmaking process changes. It tends to become increasingly formal as a community grows. The personal contacts of long-time residents may not be available to newcomers as a means to influence land use decisions. To neutralize this advantage, newcomers are more likely to use alliances with national and regional organizations, and to insist on more formal procedures of participation and decisionmaking, such as hearings and impact statements.

New residents may have different needs and preferences for recreation and community services. Community growth increases the amount of land developed and the demand for community resources. New development is often

Photo by Larry Korhnack, University of Florida

Figure 7.4
New interface residents may object to traditional land uses such as forestry or agriculture due to reasons such as increased traffic and mud on roads.

concentrated near sensitive and publicly owned amenities, such as water edges and ridge lines, further increasing the pressure on these amenities and the number of people concerned about them. Some studies find that newcomers are more likely to object to traditional land uses such as forestry and agriculture because they find them offensive or dangerous, or because these uses compete for land with other, preferred uses. Forestry practices produce odor, noise, traffic, pesticide drift and mud on the road, and compete with housing developments and retail stores for the same land (**fig. 7.4**). Traditional, or long-term residents, sometimes object to newcomers because of concerns about trespass, vandalism, and increased regulation brought on by the pressures of population growth. Research findings tend to be case-specific because no two communities are alike (Lee and others 1990).

Property Rights

Growth in interface communities has a profound effect on property rights, on how they are formally defined and enforced, on how they are informally understood and used, on what rights are most important and to whom, and on who has the power to change them. As land use changes, so do practices and understandings associated with that use. What is appropriate and reasonable in a subdivision can seriously conflict with what is appropriate and reasonable where commodity production dominates. For example, running the four-wheeler or "mudder" through the best wetland near one's home may be considered harmless fun in a rural setting, but a punishable violation of both wetland regulations and trespass laws in an urbanized area. Putting a bird feeder in one's yard is something a rural or suburban homeowner might do, but in some suburbs the homeowner would be well advised to check the zoning covenants first. Interface forests tend to see an increase in formal postings, boundary delineation, zoning code enforcement, and remedies to property disputes via legal rather than informal means. Both the rights and the obligations associated with property ownership are treated more formally. Further discussion on private property rights and public attitudes is provided in chapter 4.

"We have a very strong sense that if you have a piece of land you can do whatever you want with it, regardless of how it impacts your neighbor. It is your sacred right." Texas

Landowner Assistance Programs

Some programs attempt to stimulate forest management and reforestation through subsidies of advice, money, and materials to increase acres covered with forest and the supply of timber (see chapter 6). There is evidence that some timber-producing landowners would actively manage for timber even without the subsidy, while nontimber-producing landowners will not harvest timber even with a subsidy. Both types of landowners take the landowner assistance subsidy, but the result does not increase the timber supply (Kluender and others 1999). Whether an assistance program is designed to increase timber output or improve environmental quality, it may not reach many new landowners because program eligibility often requires too large a parcel or too specific a resource output, such as pine timber or a stream buffer. Moreover, the increasing number of new landowners overwhelms the capacity of traditional landowner assistance personnel and programs. New methods are needed to reach these landowners.

Consequences of Community and Landowner Changes

Urbanization brings with it new landowners, as well as changes in community structure and quality of life. As with economics and policy, there are both positive and negative consequences of settling in interface forests.

Changing Management Preferences and Practices

Development of the interface changes the mixture of forest owners, whose preferences and practices may or may not be the same as their predecessors'. For example, private forest landowners increasingly value amenities such as scenery, wildlife viewing, privacy, and recreation (**fig. 7.5**). Of decreasing importance are the income-related values of forests, such as timber, real estate investment, grazing, and hunting leases (Birch 1997). When harvesting does occur, it is often done under more restrictive conditions than in the past. There are fewer verbal agreements and more written contracts, more independent or third-party estimates of volume and stumpage price, more restrictions on what and how trees are harvested, and increasingly specific site restoration requirements. Moreover, landowners are more willing to sacrifice profit from timber production in exchange for improved environmental quality and higher amenity values (Hickman 1983). It seems, however, that parcel size matters. Owners of large tracts of forested land are more concerned with the income-generating potential of their forests. These large-tract landowners still own most private forests in the South, which bodes well for a continued supply of traditional forest products.

Many new forest landowners do not feel membership in the forestry community or a connection to those who manage and harvest timber (Bliss and others 1994, Kuhns and others 1998). Social science surveys show marked similarity between owners of nonindustrial forest land and the general public in their concerns about environmental quality and forest practices, such as being against large-scale clearcutting (Jones and others 1995). Consequently, landowners in the interface may perceive the forestry profession as less relevant and less trustworthy. Professional gardeners and landscape architects may become the primary contacts and sources of information about forest and land management. The rapid turnover of landowners, whose average tenure is just 7 years in some Southern States (Birch 1997), combined with absenteeism, suggest that many may know little about their land and have limited contact with the professionals who traditionally offer management advice. Very few forest owners (only 5 percent by some estimates) have written plans for the management of their forests. Traditionally, forestry advice has been distributed primarily in forest management plans, but these new landowners may not need or want such formal plans.

Photo by Larry Korhnack, University of Florida

Figure 7.5
Private forest landowners increasingly value amenities, such as birdwatching, over income-related values of forests.

"A lot of the people moving into our area are leaving a metropolitan setting. They can sell one acre in the city and come up here and buy ten acres and think they got a bargain price. Locals could not do that." Georgia

Photo courtesy of USDA Forest Service

Figure 7.6
More frequent contact with nature and less exposure to urban stressors are presumed benefits of moving to the wildland-urban interface.

Social Capital and Turbulence

A community's networks, expertise, and shared mutual aid are its social capital. Communities use this capital to solve problems and improve quality of life. New settlers impact this capital. They are often wealthier, better educated, and more politically astute. They may bring resources such as knowledge and money to the local community. They are less concerned about alienating the local institutions on which many long-time residents depend for livelihood. New residents often insist on more formal decisionmaking processes, as previously mentioned. Long-time residents may feel disenfranchised and threatened by these changes, although those who did not share in the previous power structure may support the new methods and directions of community governance (Smith and Krannich 2000). Interface communities can be destabilized by the relatively high percentage of transitory and absentee landowners. Many landowners in high-amenity areas have dual residencies and migrate with the seasons; some may be absentee inheritors or investors with little local loyalty and no regular contact with their neighbors or the landscape. However, long-term residents can be just as transitory (McHugh and others 1995).

"I think the quality of life up here is what they're after. They [urbanites] want to get away from Atlanta—the stress, the traffic, etc." Georgia

Community Infrastructure

Urbanization changes the economy, diversifies employment opportunities, improves access to and quality of health care, creates a better funded and more diverse educational system, and improves the transportation network. Many rural communities seek these changes and offer them as a rationale for rural economic development (see chapter 3). They directly improve residents' quality of life and create incentives and opportunities to keep talented, young adults from moving to more economically thriving locations.

Physical and Psychological Well-Being

The pollution, crime, and stress of urbanized, industrial, and congested areas can create health risks. A persistent explanation for the migration out of urban areas has been the pursuit of cleaner, healthier, saner, and safer lifestyles (Jacobs 1997, Schmitt 1969). Having more frequent contact with nature and less exposure to urban stressors are presumed benefits of settling in the wildland-urban interface, one that society might wish to encourage by facilitating further settlement (**fig. 7.6**). However, increasing population density in interface forests generates urban-like congestion and decreases open green space, degrading the very qualities that motivated migration and, perhaps, encouraging migration to yet more remote areas. Thus, settling forested landscapes increases both the social benefits and the social costs. Finding an acceptable balance between these costs and benefits is an ongoing challenge, and one that does not readily lend itself to scientific analysis because it involves political tradeoffs and because changes in the environment and how it is valued are often unpredictable. Science may help decisionmakers, however, by monitoring these changes and making the consequences of change more obvious.

Visual Amenities

The once unbroken forested horizon is now dotted with houses and streetlights. Perhaps the most obvious consequence of interface development is the mixing of humans with nature and the consequent visible transformation into housing developments of open spaces, agricultural fields, and forested ridges (**fig. 7.7**). Scenic vistas and visually appealing landscapes are valued resources that increasingly dominate management concerns on public and private forests. Federal and State laws, local ordinances, and other mechanisms have multiplied in recent decades to protect scenic views and create scenic easements (Smardon and Karp 1993). Again, research fails to indicate which policy direction is best. Land development increases the aesthetic resource by clearing forests, creating vistas and open spaces, and increasing access to scenery. Land development creates roads, recreation settings, and houses with picture windows from which to view the scenery. Too much development, though, degrades the resource by blocking or altering vistas so that the views are no longer attractive.

Recreation Demand and Supply

Settlement of interface forests impacts the supply of recreation resources. More tracts of smaller size make it more difficult to contact landowners and negotiate use of private land for recreation. Settlement generally decreases access by nonowners to forested locations (see chapters 2 and 6). Increased posting of private land, by contrast, may increase recreational access if it produces formal leases for recreational activities such as hunting (Cordell and others 1993). The increasing parcelization of land means that new owners, and their acquaintances, will have greater access to their land for nature-based recreation activities; however, most Americans do not own land and, thus, do not enjoy this access. Back-country recreation opportunities, such as hunting and enjoyment of solitude, require vast areas over which to disperse people. These opportunities are likely to decrease where ownership density is increasing. By contrast, front-country activities such as bird watching, picnicking, day walks, and drives may increase as access becomes easier. Finally, the increased demand on public and private recreation resources can produce conflict. If newcomers prefer the same recreation activities as longtime residents, then crowding may result. If they prefer different activities, scarce

Photo courtesy of Virginia Department of Forestry

Figure 7.7
One obvious consequence of interface development is the mixing of humans with nature.

Photo by Larry Korhnack, University of Florida

Figure 7.8
Recreational opportunities are needed for diverse users.

resources are likely to be redirected to provide and maintain these new activities, potentially sacrificing the quality of the traditional activities.

Lifestyle changes associated with interface forests also impact the demand for recreation resources. The 2-week summer vacation to distant locations is becoming less popular. It is being replaced by single-day and long-weekend holidays to local attractions (Hornback 1991). Meanwhile, participation in many nature-based recreation activities continues to increase faster than population growth, with wildlife viewing leading the way (see chapter 2). The result is a rather dramatic change in the staffing and management needs of recreation settings. Visitation tends to be distributed year-round rather than seasonally. Because visitors will come from within the region, they are more familiar with specific areas and more discerning. Recreation destinations with lower quality facilities and services lose popularity. In addition to experiencing a different pattern of visitation, recreation sites attract more diverse users (**fig. 7.8**). This trend is not unique to interface areas. The American population is aging and becoming more ethnically diverse, suggesting that future users will prefer a different mix of recreation activities than was demanded by the white, young, middle-class visitors that dominated demand during most of the 20th century, and for whom many of the existing parks and recreation programs were designed (Cordell and others 1999) (see chapter 6).

Needs

Lee's (1984, p. 131) challenge to natural resource professionals almost 20 years ago remains relevant today:

> . . . the problems of managing forests and wild lands on the urban fringe require specialized knowledge and skill that do not currently exist. The manipulation of natural ecosystems to produce a multitude of benefits requires not only scientific knowledge but also the skill to resolve conflicts between competing uses and to integrate a variety of management techniques to achieve special purposes. Foresters are perhaps the most suitable professionals for these tasks. Their general education and training in specialized techniques have enabled them to address complex problems in wild-land management. These same capabilities also suit them for solving problems of converting forest from wood production to residential environments and for continued residential use. The greatest challenge to foresters who seek to solve problems on the urban fringe will be to learn how to become effective agents for local residents, planners, developers, and environmentalist. This challenge will force foresters to rethink the purposes for which lands are managed and to reintegrate those purposes with emerging forms of technology and socioeconomic organization.

New Content and Methods for Outreach

In general, landowners are placing higher value on soil, amenities, wildlife, and other nontimber forest resources. Natural resource advice must change to reflect these new needs. However, new landowners are less trusting and have had less contact with the professionals who traditionally offer forest management advice. The traditional outreach mechanism—the forest plan—is neither familiar nor appealing to the new clientele. Clearly, new methods for communicating with landowners and distributing forestry advice and assistance are needed. The American Nursery and Landscape Association estimates that American households

spend $15 billion or more annually for professional help with their gardens and trees. DeCoster (2000) estimates that this translates into $648 million per year spent on forested homesites. That is more than 12 times the average annual amount of all U.S. Department of Agriculture forest incentive programs. Little of this business presently goes to forest professionals because they generally have not effectively marketed their services to these new forest owners. Forestry professionals need to supply:

- brochures, fact sheets, and personal assistance, which may be more effective with this audience than workshops, forest plans, and demonstration projects (DeCoster 2000, Kuhns and others 1998); and
- "how to" pamphlets or training sessions. Making these available through home improvement stores may reach more interface forest landowners.

New Skills

Managing the parcelized forest, with its environmental constraints and diverse landowner objectives, requires knowledge and skills that either do not yet exist or are not widely available. Harvesting remains one of the most affordable ways to manipulate vegetation, even if its primary goal is enhancing amenity values such as scenic views, hiking trails, and wildlife grazing areas. In addition, management of wildlife for nuisance control can be as important as management for wildlife viewing and hunting. Bears, deer, and geese destroy vegetation, become disease vectors, interfere with traffic, damage property, and generate fear. Needs include:

- small-scale, less-capital intensive, amenity-enhancing forest harvesting technology; and
- techniques to manage wildlife pests and amenities as well as fire and disease on small tracts of land.

In addition, natural resource professionals must work effectively with diverse groups. An important and defining characteristic of interface forestry is the large number of stakeholders with diverse interests who involve themselves in management decisions. Forestry practices are now evaluated by multiple parties and subject to the jurisdiction of multiple institutions. Hence, new skills to handle the more complicated contracts and project implementation are needed. Natural resource professionals need:

- tools and skills to work with land use planning processes, zoning appeals, public meetings, fire departments, insurance agents, and other public institutions.

New Partners

Natural resource professionals must seek new partners and constituents. If they wish to stem the rising tide of forest fragmentation, natural resource professionals must work with the institutions that create interface forests and have influence over their management. Tax accountants and estate planners should be recruited to influence owners of large forested tracts from which fragmented forests are created. Media that influence migration, such as country living magazines and retirement community promoters, could be targeted with messages about the concerns and practices of natural resource management in interface forests. Similar messages could be shared with State and local agents of economic

development, such as chambers of commerce, Governors' offices, industrial parks, and other groups that try to attract industry and qualified workers into communities. Natural resource professionals should:

- target messages for social institutions driving land use change, and
- form partnerships with these institutions.

Partnerships might be formed with the professionals who increasingly are primary sources of land management advice for landowners. Examples include the lawn and garden care industry, home and garden stores, landscape architects, land use planners, and suburban homeowner associations. Insurance companies might be persuaded to offer financial incentives for forest treatments that reduce the risk of fire. Water utilities can explain water demands of landscaping. Power utilities can explain benefits of shading. Local municipalities can promote the benefits of retaining tree cover for stormwater management. Distribution of advice, incentives, and best management practices through these conduits may be more effective in reaching the increasing number of landowners. Many new landowners fail to see how traditional natural resource professionals can help them. Natural resource professionals should:

- form partnerships with professions and organizations that currently serve interface landowners such as the lawn and garden care industry.

Cooperative and Cross-Boundary Management

Property parcelization need not lead to increased ecosystem fragmentation. A forest ecosystem becomes fragmented when landowners implement different and uncoordinated management objectives. Natural resource professionals need mechanisms that enable and encourage cross-boundary ecosystem management. Several such mechanisms are currently available, but more are needed. Cooperative programs, for example, use funding from public or nongovernment institutions to bring together landowners within a geographic region, such as a watershed, to structure management goals and practices. Typical goals of a cooperative are preservation of wildlife habitat and water storage, which require coordination across vast areas. Partnerships permit economies of scale and solve access problems so that management practices such as burning, spraying, and harvesting become viable (Campbell and Kittredge 1996). Natural resource professionals need:

- mechanisms that enable and encourage cross-boundary management.

Setting New Goals and Developing a New Language

Natural resource professionals should resist the urge to declare that all fragmentation and development threaten the "health" and "sustainability" of forests. Many landscape architects and environmental planners believe they are creating healthy and sustainable residential developments. The whole idea of sustainable development and smart growth is built on that premise. The forest means different things to different stakeholders. Similarly, health and sustainability mean different things to different people.

Contemporary forest planning and management involve a large number of stakeholders who think and speak differently about forests and forestry. As a result, the practice of forestry, now more than ever, requires knowledge about the languages, values, and beliefs of these stakeholders. This is particularly true for inter-

face forestry. Controversy about how to manage interface forests is due, in part, to stakeholders' differing ideas about ecology, about the appropriate role of human technology in nature, and about what goods and services forests should provide. People vary in their beliefs about how nature works, about whether nature or humans know best, and about whether management should emphasize timber or biodiversity. These diverse understandings limit the ability of natural resource professionals and State and Federal agencies to manage landscape change and forest productivity. Forestry's language, motivations, sciences, and practices were not developed to address the undertakings and concerns of interface residents. Foresters need:

- a new language and conception of forestry; and
- new ways to describe the goals of forest management—goals such as sustainable development and residential quality of life.

Conclusion

The social consequences of managing interface forests are considerable in scope and magnitude and certainly comparable in importance to the environmental consequences. There are no clear policy implications, however, because fragmentation produces benefits and costs, winners and losers. While the timber supply may shrink, other economic opportunities emerge and noncommodity values of forests increase. While the amount of fragmented land may increase, many people gain from the improved access to green spaces, employment opportunities, and social services. While planning may become more difficult because of increased interest in and jurisdiction over forest land, the quality of input and the quality of the plans may also improve. One thing is certain: the owners and neighbors of forests are changing, and natural resource professionals need to change if they are to remain effective and relevant.

Social issues, including demographics, migration, economics, and policy, are the primary forces behind the creation of interface forests. Social institutions, including education, regulation, cooperative management, and tax incentives, are the primary mechanisms to manage these forests. Natural resource professionals can work toward three broad goals in interface areas: (1) they can seek to slow fragmentation and preserve contiguous forested areas, (2) they can guide development and fragmentation to maximize benefits and minimize costs, and, perhaps most importantly, (3) they can adapt to the changed landscape and develop new techniques that allow them to practice their crafts. Growth controls and tax incentives slow and direct fragmentation and development of interface forests. However, they are seldom permanent solutions. Demand for housing sites, fueled by the allure of living near nature, enriches landowners who divide and sell real estate. The challenge is to influence how development occurs and to find ways to work in a fragmented forest.

Literature Cited

Barlow, S.A.; Munn, I.A.; Cleaves, D.A.; Evans, D.L. 1998. The effect of urban sprawl on timber harvesting: a look at two Southern States. Journal of Forestry. 96(12): 10-14.

Birch, T.W. 1997. Private forest landowners of the Southern United States, 1994. Resour. Bull. NE-138. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 96 p.

Bliss, J.C.; Nepal, S.K.; Brooks, R.T.; Larson, M.D. 1994. Forestry community or granfalloon?: do forest owners share the public's views? Journal of Forestry. 92(9): 6-10.

Campbell, S.M.; Kittredge, D.B. 1996. Ecosystem-based management on multiple NIPF ownerships. Journal of Forestry. 94(2): 24-29.

Cordell, H.K.; Betz, C.J.; Bowker, J.M. [and others], eds. 1999. Outdoor recreation in American life: a national assessment of demand and supply trends. Champaign, IL: Sagamore Publishing. 449 p.

Cordell, H.K.; English, D.B.K.; Randall, S.A. 1993. Effects of subdivision and access restrictions on private land recreation opportunities. Gen. Tech. Rep. RM-231. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 21 p.

DeCoster, L. 2000. Summary of the forest fragmentation conference: how forests are being nibbled to death by DUCs, and what to do about it. Sustaining private forests in the 21st century: Proceedings of the forest fragmentation 2000 conference. Alexandria, VA: Sampson Group, Inc. 382 p.

Dwyer, J.F.; Nowak, D.J.; Noble, M.H.; Sisinni, S.M. 2000. Connecting people with ecosystems in the 21st century: an assessment of our Nation's urban forests. Gen. Tech. Rep. PNW-GTR-490. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 483 p.

Ellefson, P.; Cheng, A.S. 1994. State forest practice programs: regulation of private forestry comes of age. Journal of Forestry. 92 (5): 34-37.

Garreau, J. 1991. Edge city: life on the new frontier. New York: Anchor Books. 548 p.

Grimm, N.B.; Grove, J.M.; Pickett, S.T.A.; Redman, C.L. 2000. Integrated approaches to long-term studies of urban ecological systems. BioScience. 50(7): 571-584.

Heimlich, R.E.; Brooks, D.H. 1989. Metropolitan growth and agriculture: farming in the city's shadow. Agric. Econ. Rep. 619. Washington, DC: U.S. Department of Agriculture, Economic Research Service. 20 p.

Hickman, C.A. 1983. Changing attitudes towards timber marketing from NIPF lands in east Texas. In: Nonindustrial private forests: a review of economic and policy studies: symposium proceedings. Durham, NC: Duke University, School of Forest and Environmental Studies: 311-317.

Hornback, K. 1991. Socio-economic outlook: outdoor recreation 2000. Trends. 28(2): 14-19.

Jacobs, J. 1997. New pioneers: the back-to-the-land movement and the search for a sustainable future. University Park, PA: Pennsylvania State Press. 262 p.

Johnson, J.D.; Rasker, R. 1995. The role of economic and quality of life values in rural business location. Journal of Rural Studies. 11(4): 405-416.

Johnson, R.L.; Alig, R.J.; Moore, E.; Moulton, R.J. 1997. NIPF landowners' view of regulation. Journal of Forestry. 95(1): 23-28.

Jones, S.B.; Luloff, A.E.; Finley, J.C. 1995. Another look at NIPFs: facing our "myths." Journal of Forestry. 93(9): 41-44.

Kittredge, D.B.; Rickenbach, M.G.; Broderick, S.H. 1999. Regulation and stumpage prices: a tale of two States. Journal of Forestry. 97(10): 12-16.

Kluender, R.A.; Walkingstick, T.L.; Pickett, J.C. 1999. The use of forestry incentives by nonindustrial forest landowner groups: is it time for a reassessment of where we spend our tax dollars? Natural Resources Journal. 39: 799-818.

Kuhns, M.R.; Brunson, M.W.; Roberts, S.D. 1998. Landowners' education needs and how foresters can respond. Journal of Forestry. 96(8): 28-43.

Lee, R. 1984. Implications of contemporary community organization and social values for forest management on the residential/wildland interface. In: Bradley, G., ed. Land use and forest resources in a changing environment. Seatle: University of Washington Press: 119-132

Lee, R.G.; Field, D.R.; Burch, W.R. 1990. Community and forestry: continuities in the sociology of natural resources. Boulder, CO: Westview Press. 301 p.

McHugh, K.E.; Hogan, T.D.; Happel, S.K. 1995. Multiple residence and cyclical migration: a life course perspective. Professional Geographer. 47(3): 251-267.

Riebsame, W.E.; Gosnell, H.; Theobald, D.M. 1996. Land use and landscape change in the Colorado Mountains I: theory, scale, and pattern. Mountain Research and Development. 16(4): 395-405.

Schmitt, P.J. 1969. Back to nature: the arcadian myth in urban America. Baltimore: John Hopkins University Press. 236 p.

Smardon, R.C.; Karp, J.P. 1993. The legal landscape: guidelines for regulating environmental and aesthetic quality. New York: Van Nostrand Reinhold. 287 p.

Smith, M.D.; Krannich, R.S. 2000. 'Culture clash' revisited: newcomer and longer-term residents' attitudes toward land use, development, and environmental issues in rural communities in the Rocky Mountain west. Rural Sociology. 65(3): 396-421.

Voth, D.E.; Jardon, M.; McCauley, C. [and others]. 1999. Devolution and rural development in forest-dependent communities: an assessment of literature, on-going practice and potential for an integrated, community-based approach. Mississippi State, MS: Southern Rural Development Center. http://ext.msstate.edu/srdc/activities/vothcomplete.pdf. [Date accessed: September 2000].

Wear, D.N.; Liu, R.; Foreman, M.; Sheffield, R.M. 1999. The effects of population growth on timber management and inventories in Virginia. Forest Ecology and Management. 118: 107-115.