Sustaining Healthy Ecosystems

Sustaining healthy ecosystems, the second environmental objective addressed in this report, is fundamental to the environmental progress necessary to support population growth and economic development.

The term "ecosystem" refers to all the plants and animals in an area, the interactions between them, and the physical environment in which they live. This objective addresses the health of Georgia's ecosystems and their capacity to provide services that support basic human needs – a capacity that is essential to support a growing population and economy and to the sustainability of life on the planet.

Ecosystems provide a variety of services every day. Ecosystem services include production of food and fiber, removal of pollution and purification of air and water. Healthy ecosystems help regulate the climate, control flooding, and provide habitat for fish and wildlife, including species that are commercially important. They support recreational activities, like fishing, hunting, and hiking, with the economic benefits they bring. Healthy ecosystems also provide less tangible spiritual and educational values.

Healthy ecosystems are a kind of natural capital that helps support our quality of life, like the financial capital that helps support our economy. However, human activities – particularly the way we use and alter land – can degrade this natural capital and the services on which we rely.

Evaluating the health of Georgia's ecosystems starts with examination of the land itself. The way that land is used, and the way it has been altered as Georgia's population has grown, affects the state's ecosystems.

This report tracks those effects by looking at two important components of ecosystems: the habitat they provide and the species of plants and animals that live in that habitat. Habitat refers to the physical features of an area and the vegetation found there, which determines the suitability of that area for different species.

While there are few accepted standards or thresholds that define the health of an ecosystem, a number of measures are generally accepted as indicators of ecosystem health that can be used to compare regions and to track changes in ecosystems over time (Table 2.1).

Table 2.1 *Indicators of the condition of the state's natural resources.*

Natural resource	Indicators of condition
Land	Land cover types: • Hardwood forests • Forested wetlands • Urban land
	Impervious surfaces
Habitats and species	Streamside forests
	Freshwater fish community status
	Coastal habitat conditions
	Terrestrial habitat quality
	Protected species
	Habitat protection

Georgia's natural heritage: Biological diversity

Georgia has an extraordinarily rich natural heritage. Variations in topography and geology across the state produce a wide variety of ecosystems. Terrestrial ecosystems range from the live-oak seaside forests of the coast to the rock outcrops of north Georgia. Aquatic ecosystems include small streams, large rivers, lakes and estuaries where the state's major rivers meet the sea.

This ecosystem diversity, in turn, supports a highly diverse mix of plants and animals. Compared to similar ecosystems around the world, the hardwood forests in north Georgia, mixed forests in the Piedmont, and longleaf pine forests in the Coastal Plain all have exceptional biological diversity, as do many of the state's streams and rivers.

Georgia is part of a global "hotspot" of diversity for plants and animals. Nationally, Georgia ranks sixth among the states in overall species diversity. It ranks second in the number of amphibian species, third in freshwater fish and crayfish species, and seventh in reptile and vascular plant species. More than 60 species are only found in Georgia, a number exceeded by just 11 states.

What are ecoregions?

Ecoregions are large areas, covering tens of thousands of square miles, that are geographically and ecologically defined. An ecoregion has a common underlying geology and distinctive land forms, climate, soil types and plant and animal communities.

These factors all shape the development of ecosystems and, as a result, ecoregions are often used for assessments of environmental conditions and ecosystem health.

Six major ecoregions are found in Georgia (Figure 2.1). The Blue Ridge ecoregion is in the northeast corner of the state. The Ridge and Valley and Southwestern Appalachians ecoregions are in northwest Georgia. Because these two ecoregions have many features in common, they are treated together for the purposes of this report.

The Piedmont lies south of the Blue Ridge and Ridge and Valley ecoregions and covers the remainder of north Georgia.

Two ecoregions lie south of the Fall Line, a geologic feature that runs across the center of the state. The Southeastern Plains ecoregion is immediately south of the Fall Line and covers much of the southeastern U.S. In Georgia, this area is often called the Upper Coastal Plain.

Finally, the Southern Coastal Plain lies along the much of the southeastern Atlantic and Gulf coasts. In Georgia, this ecoregion is often called the Lower Coastal Plain or Coastal area.

This chapter first addresses two indicators of changes in land condition: land cover and impervious surfaces. It then discusses six indicators of the condition of different habitats and the plants or animals that live in those habitats. The habitats and species discussed include those that are land-based (terrestrial) as well as those that are water-based (aquatic). For several of the indicators, results are summarized by ecological region or ecoregion (see sidebar and Figure 2.1).

Backgrounder

Tracking Changes in Georgia's Landscape

The introduction of this report highlights the changing face of Georgia in terms of population, economy and energy use. These drivers are also changing the face of Georgia in terms of its landscape and the health of the ecosystems that landscape supports. One way to track these changes is look at changes in land cover over time.

The term "land cover" refers to the mix of vegetation, human structures, bare ground and water at the surface of the earth. Some types of land cover, like forested wetlands, are simply the vegetation naturally found in an area. Other types, like agriculture, are lands converted or altered for human use.

Changes in land cover over time can be identified by reviewing satellite images. These images can be converted into maps showing the types of land cover across the state — a mix of natural vegetative cover and lands altered by human activities (Figure 2.2).

Researchers at the University of Georgia have tracked changes in Georgia's land cover between 1974 and 2005. This research provides some of the indicators used to evaluate progress toward the objective of sustaining healthy ecosystems, as well as the objective described in the next chapter, ensuring resources to support a growing economy.

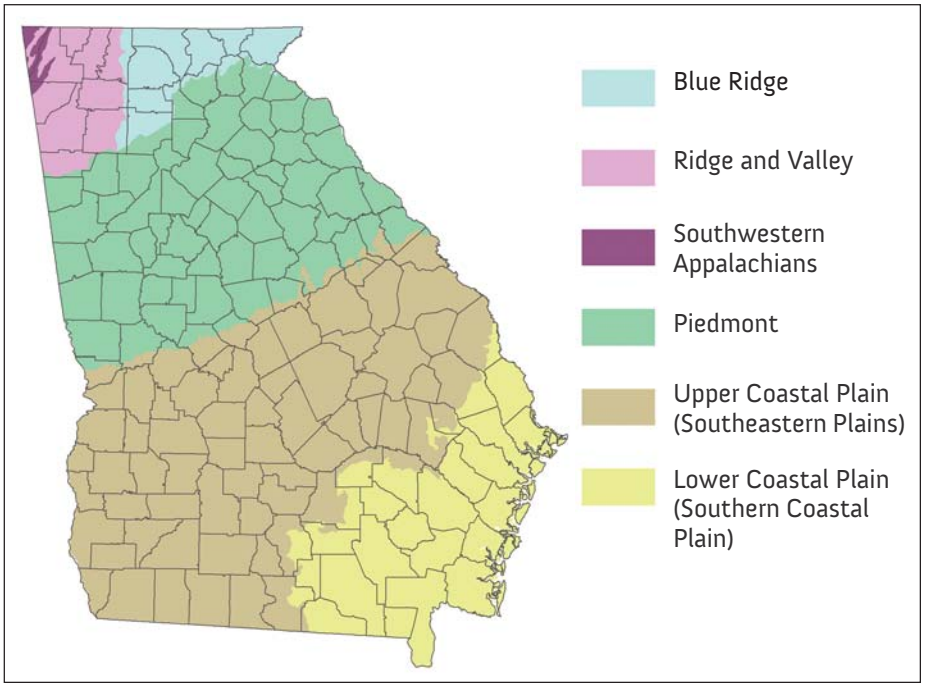
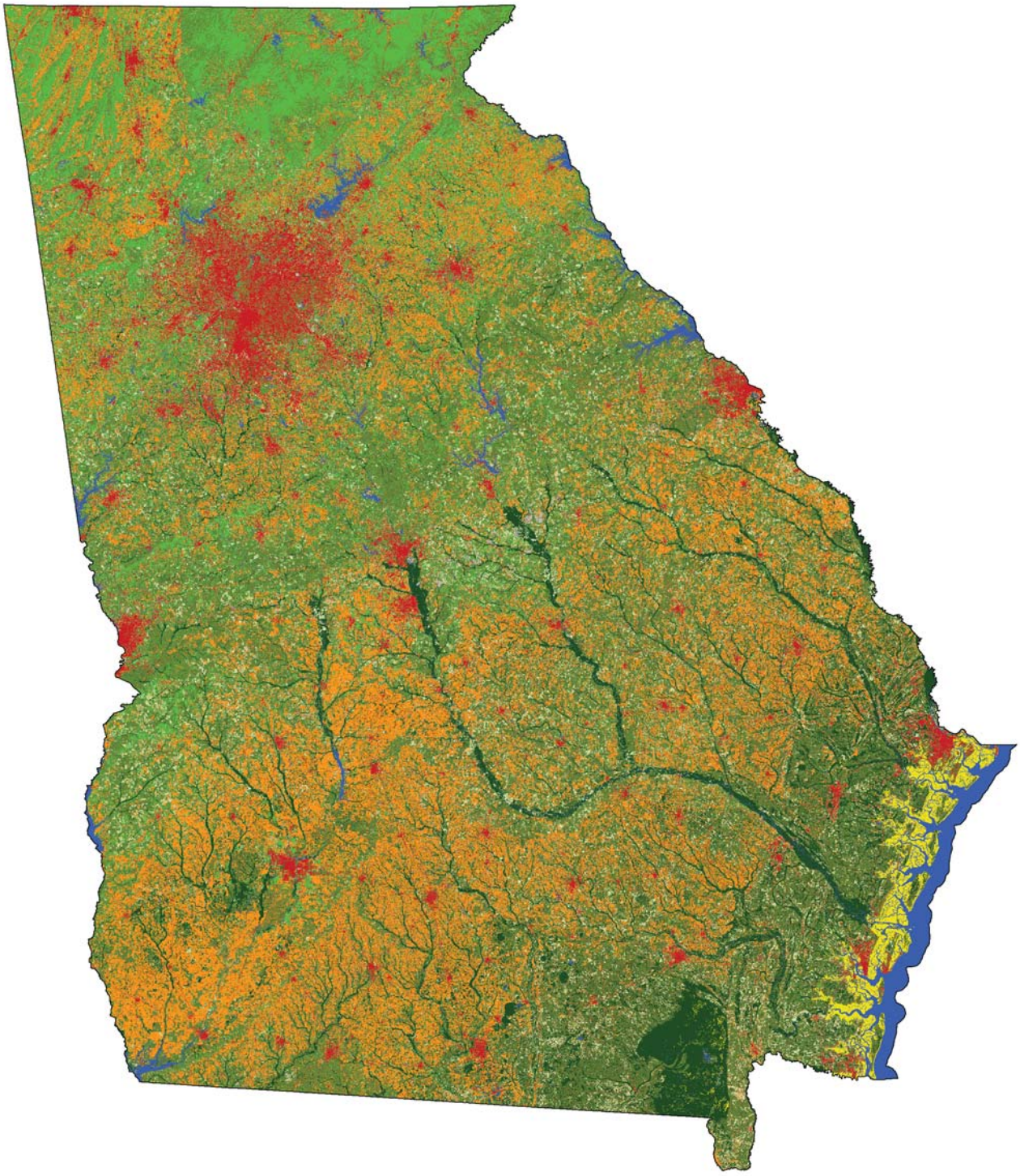


Figure 2.1 *Georgia's ecoregions. (U.S. EPA)*



High- and low-intensity urban

Row crops and pastures

Clear-cut or sparse

Deciduous forest

Evergreen and mixed forest

Forested wetlands

Non-forested wetlands (freshwater/salt/brackish), beaches and dunes

Open water

Figure 2.2 *Land cover in Georgia, 2005. (Natural Resources Spatial Analysis Laboratory, University of Georgia)*

Land Cover Types

Indicator of the condition of Georgia's **Land Resources**

As the first indicator of ecosystem health, this report tracks broad changes in three types of land cover: hardwood forests, forested wetlands and urban land cover. Land cover provides general information on habitat condition, one aspect of ecosystem health. Changes in these land cover types indicate associated changes in habitat – or the physical features and vegetation likely to be found there – and the suitability for different plant and animal species.

Hardwood forests and forested wetlands are native land cover types found across large areas of the state. Intensive management is practiced on a very small percentage of the total acreage of hardwood forest and forested wetlands, and these land covers can provide high quality habitat for plant and animal communities.

The significance of the two, however, varies by ecoregion. In north Georgia, hardwood forest is one of the most extensive land covers. In south Georgia, hardwood forests are less extensive and forested wetlands are much more significant as critical native habitat. Because of this difference, evaluation of land cover change by ecoregion focuses on hardwood forest in north Georgia and forested wetlands in south Georgia.

Urban areas, in contrast, have more intensive land use and have been significantly altered by human activities. The changes in habitat and in the plants and animals often found in these areas contribute to a decline in ecosystem health.

Statewide, between 1974 and 2005, urban land cover consistently increased, and the land covers associated with critical natural habitat steadily declined (Figure 2.3). Nearly 2.4 million acres of hardwood forests and forested wetlands were lost during this time period (Table 2.2). More than 2.6 million acres of urban land cover were added.

Looking at these changes by ecoregion shows that, over much of the state, the land covers associated with good wildlife habitat declined (Figure 2.4).

Land cover types that indicate habitat condition

Hardwood forest. Forest composed of at least 75 percent deciduous trees in the canopy, deciduous woodland. Hardwood forests provide native habitat across much of north Georgia.

Forested wetlands. Cypress gum, evergreen wetlands, deciduous wetlands, depressional wetlands and shrub wetlands. Forested wetlands provide critical native habitat across much of south Georgia.

Low-intensity urban. Single-family dwellings, recreation, cemeteries, playing fields, campus-like institutions, parks and schools. Low-intensity urban land cover is associated with some loss of native terrestrial habitat.

High-intensity urban. Multi-family dwellings, commercial/industrial, prisons, speedways, junk yards and confined animal operations. Transportation, roads, railroads, airports and runways. Utility swaths. High-intensity urban land cover is highly altered, resulting in substantial loss of native terrestrial habitat.

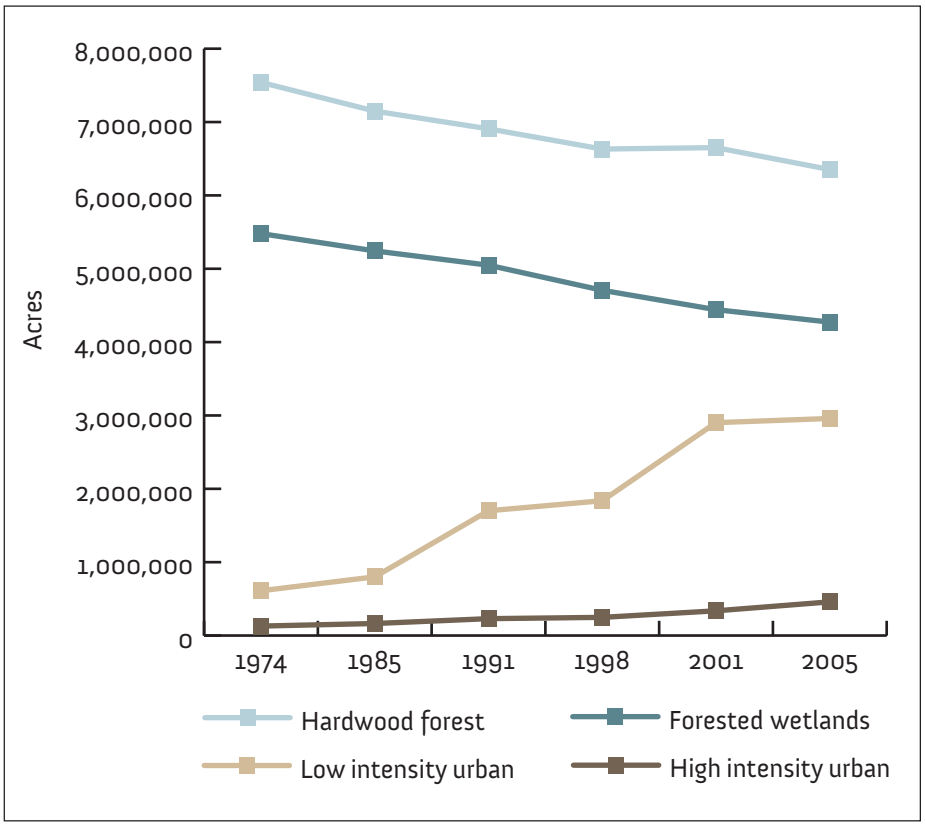


Figure 2.3 *Amount of hardwood forest, forested wetlands and urban land cover, 1974 - 2005. (Natural Resources Spatial Analysis Laboratory, University of Georgia)*

Table 2.2 Changes in Georgia's land cover, 1974 - 2005. (Natural Resources Spatial Analysis Laboratory, University of Georgia)

	Percent of state land, 1974	Percent of state land, 2005	Change in number of acres	Percent change
Low-intensity urban	2	8	2,348,000	385%
High-intensity urban	< 1	1	329,690	255%
Hardwood forests	20	17	-1,188,000	-16%
Forested wetlands	14	11	-1,207,000	-22%

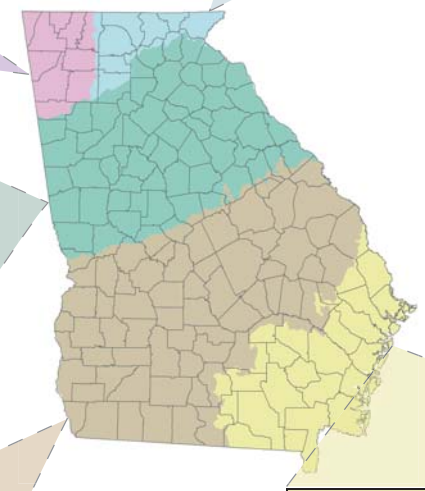
The Piedmont and Blue Ridge ecoregions lost 1.2 million acres of hardwood forests and the Upper and Lower Coastal Plains lost more than 1.1 million acres of forested wetlands. The ecoregions in northwest Georgia gained just over 150,000 acres of hardwood forest.

The majority of hardwood forest loss occurred in the Piedmont. Sixteen counties, located across the Piedmont, had losses greater than 25,000 acres and together accounted for more than 50 percent of the loss in the north Georgia ecoregions.

Forested wetland losses were greatest in the southeastern part of the state. Taken together, the losses in seven counties (Bulloch, Burke, Clinch, Echols, Screven, Ware and Wayne), each losing more than 30,000 acres, accounted for nearly 25 percent of the total loss in the Upper and Lower Coastal Plains.

Ridge & Valley and Southwestern Appalachians	Change in acres	Percent change
Hardwood forest	153,810	22%
Low intensity urban	161,828	332%
High intensity urban	22,865	310%

Blue Ridge	Change in acres	Percent change
Hardwood forest	-60,616	-5%
Low intensity urban	91,336	619%
High intensity urban	4,398	736%



Piedmont	Change in acres	Percent change
Hardwood forest	-1,147,928	-29%
Low intensity urban	1,084,650	393%
High intensity urban	203,034	281%

Upper Coastal Plain	Change in acres	Percent change
Forested wetlands	-580,695	-23%
Low intensity urban	706,397	353%
High intensity urban	68,331	187%

Lower Coastal Plain	Change in acres	Percent change
Forested wetlands	-548,615	-23%
Low intensity urban	304,087	427%
High intensity urban	31,061	259%

Figure 2.4 Changes in Georgia's land cover by ecoregion, 1974 - 2005; change in acres and percent. (Natural Resources Spatial Analysis Laboratory, University of Georgia)

Land cover change and population growth

Across the U.S., and in Georgia, urban or developed land cover has increased more rapidly than the population. The U.S. Environmental Protection Agency reports that, from 1982 to 2002, the amount of developed land in the U.S. increased by 48 percent — a rate of increase nearly two times that of the population.

The urban land cover data used here provides information for a similar time period that can be compared to this national trend. Between 1985 and 2005, Georgia's population increased 53 percent while urban land cover in the state increased 255 percent — a rate of increase that is more than four times greater than that of the population.

For more information on land cover changes across the U.S., see EPA's 2008 Report on the Environment, available at http://www.epa.gov/roe.

In all ecoregions, the greatest percent change was in the urban land cover types. The bulk of new urban lands in Georgia – more than 2.3 million acres – are low-intensity urban areas.

Nearly half of the increase in low-intensity urban lands occurred in the Piedmont. The counties that added the most acres of low-intensity urban area were in the metro Atlanta area, with Gwinnett, Fulton and Cobb counties each gaining 80,000 to 90,000 acres.

The greatest percent increase in urban land cover was seen in counties that, in 1974, had very little urban area. Oglethorpe, Forsyth, Paulding and Bacon counties all had increases of 1,000 percent or more, representing a growth in low-intensity urban area of 10,000 to 33,000 acres in each county.

While much of the increase in low-intensity urban lands occurred in the metro Atlanta area, substantial increases were also seen around the state's other major cities, near smaller cities, and in rural areas (Figure 2.5). The ways in which low-intensity urban lands are commonly developed have contributed to the decline in native habitat provided by hardwood forests and forested wetlands, and have had effects seen in the other indicators discussed in this chapter.

Looking ahead, as the state continues to grow, the challenge will be to shift to development approaches, such as conservation design and low impact development, that help maintain areas of natural habitat and contribute to the objective of sustaining healthy ecosystems.

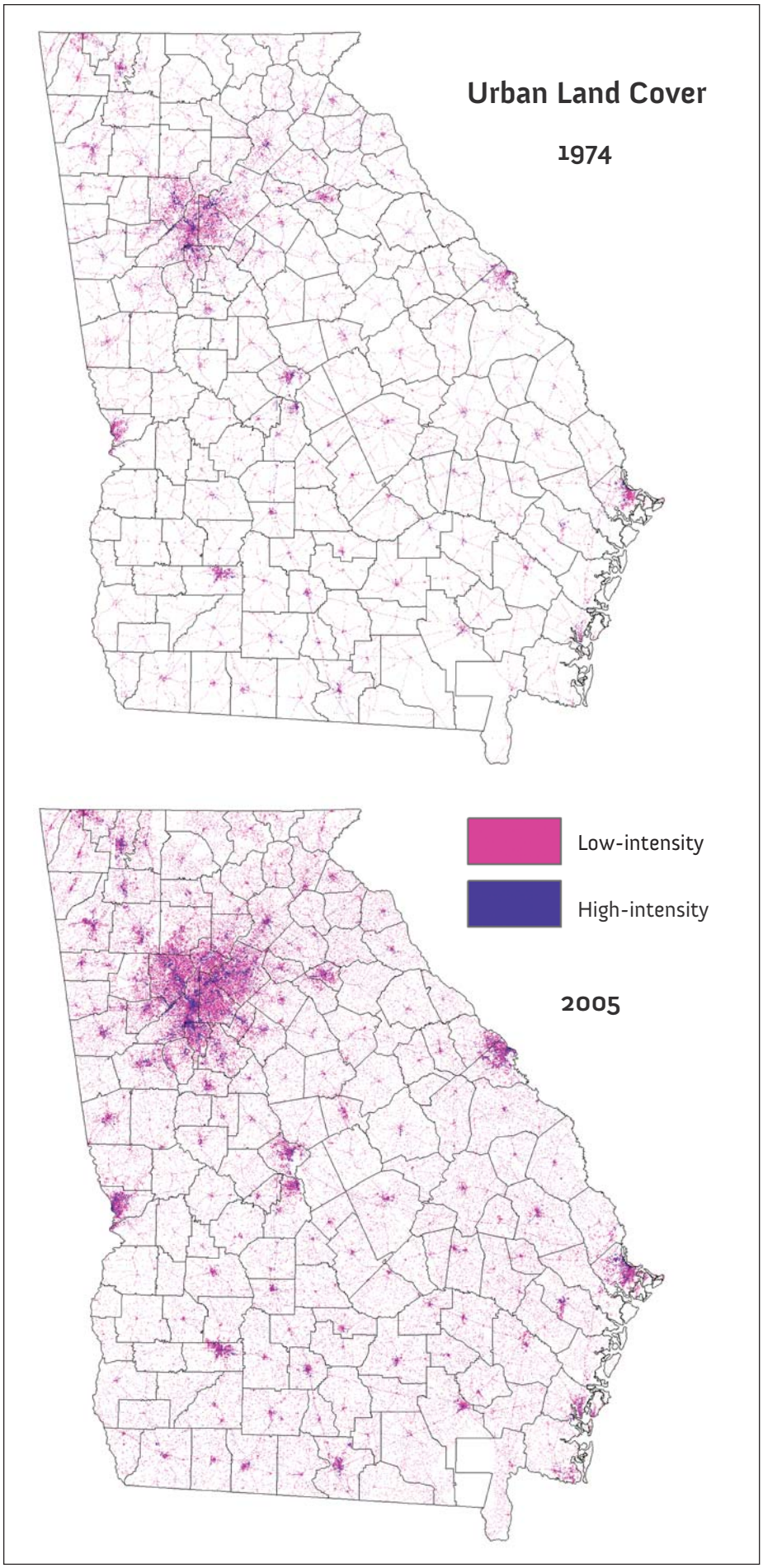
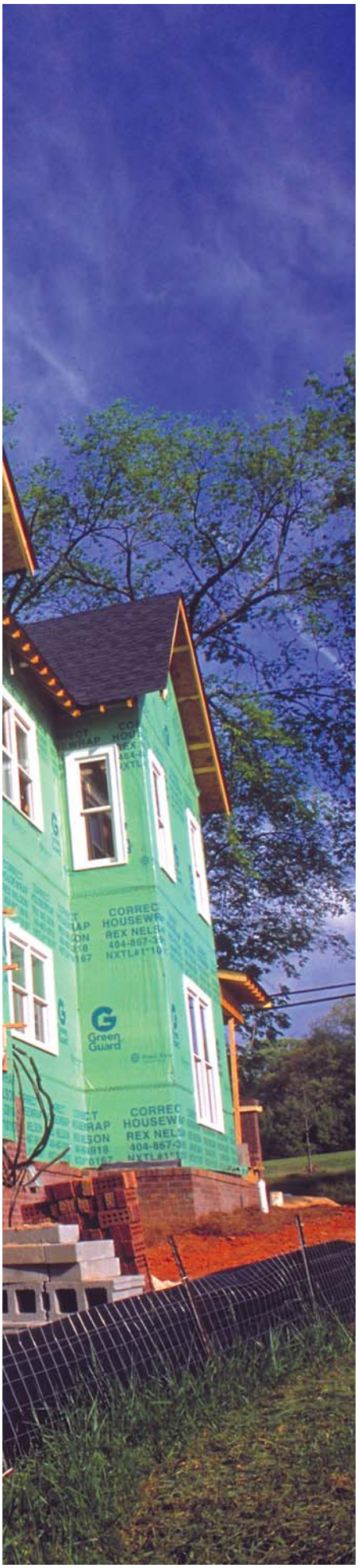


Figure 2.5 *Urban land cover, 1974 and 2005. (Natural Resources Spatial Analysis Laboratory, University of Georgia)*



Impervious Surfaces

Indicator of the condition of Georgia's **Land Resources**

The extent of impervious cover in Georgia's small watersheds

Ten percent impervious cover in a watershed is widely recognized as the threshold where impacts on the health of aquatic ecosystems can be expected.

A number of studies have found that, when impervious cover in a watershed exceeds 10 percent, the diversity of animals in streams generally declines, along with other indicators of ecosystem health. Environmentally sensitive species become less plentiful, leaving ones more tolerant of poor quality water.

In 1991, 26 of Georgia's small watersheds had more than 10 percent impervious cover. By 2005, that number had grown to 75.

The maximum amount of impervious surface is also increasing. In 1991, only one small watershed had more than 30 percent impervious cover. By 2005, seven small watersheds had more than 30 percent impervious cover and, for the first time, two had impervious surfaces covering more than 40 percent of the watershed.

One significant outcome of common approaches to converting land to urban cover is an increase in impervious surfaces. Impervious surfaces include those through which water cannot penetrate, such as paved streets, roofs and parking lots. These constructed surfaces prevent rain from soaking into the ground and cause stormwater to run off more quickly.

An increase in impervious land cover is a striking aspect of the changing face of Georgia's landscape — one that significantly impacts the health of aquatic ecosystems. More rapid stormwater runoff leads to increased stream flows after rain, which increases the risk of flooding. Stormwater from impervious surfaces can carry a range of pollutants that can degrade water quality.

More rapid runoff also contributes to erosion, altering the physical structure of streams. And, during dry periods, the decrease in the amount of water filtering into the soil means there is less groundwater to sustain low flows in streams.

In areas with 10 percent to 20 percent impervious surface, twice as much water flows as runoff to rivers and streams as in forested areas. As impervious surfaces increase to between 35 percent and 50 percent, the amount of water flowing as runoff is three times greater than it would be on a natural landscape, greatly increasing impacts on the water cycle, the physical structure of streams and aquatic species.

Researchers at the University of Georgia have compiled data on the extent of impervious surfaces in Georgia. Statewide, impervious cover increased by 81 percent between 1991 and 2005, an addition of nearly 370,000 acres. While the greatest number of acres was added in the Piedmont ecoregion, increases were seen across the state (Table 2.3). A majority of the state's 159 counties saw an increase in at least one small watershed (Figure 2.6).

The impact of these changes is evident in the condition of streams and aquatic ecosystems across the state, as seen in subsequent indicators, and in the growing cost of managing the stormwater that runs off these impervious surfaces.

As Georgia continues to grow, land development practices that increase pervious surfaces – surfaces that allow rain and stormwater to soak into the ground – will be necessary to sustain the health of Georgia's aquatic ecosystems and to ensure sufficient water resources to support a growing economy, the objective described in the next chapter.

Table 2.3 *Changes in impervious surface cover, 1991 - 2005. (Natural Resources Spatial Analysis Laboratory, University of Georgia)*

Ecoregion	Change in acres of impervious surface	Percent change
Ridge and Valley & Southwestern Appalachians	27,783	89%
Blue Ridge	7,535	121%
Piedmont	238,532	111%
Upper Coastal Plain (Southeastern Plains)	62,344	42%
Lower Coastal Plain (Southern Coastal Plains)	32,434	63%

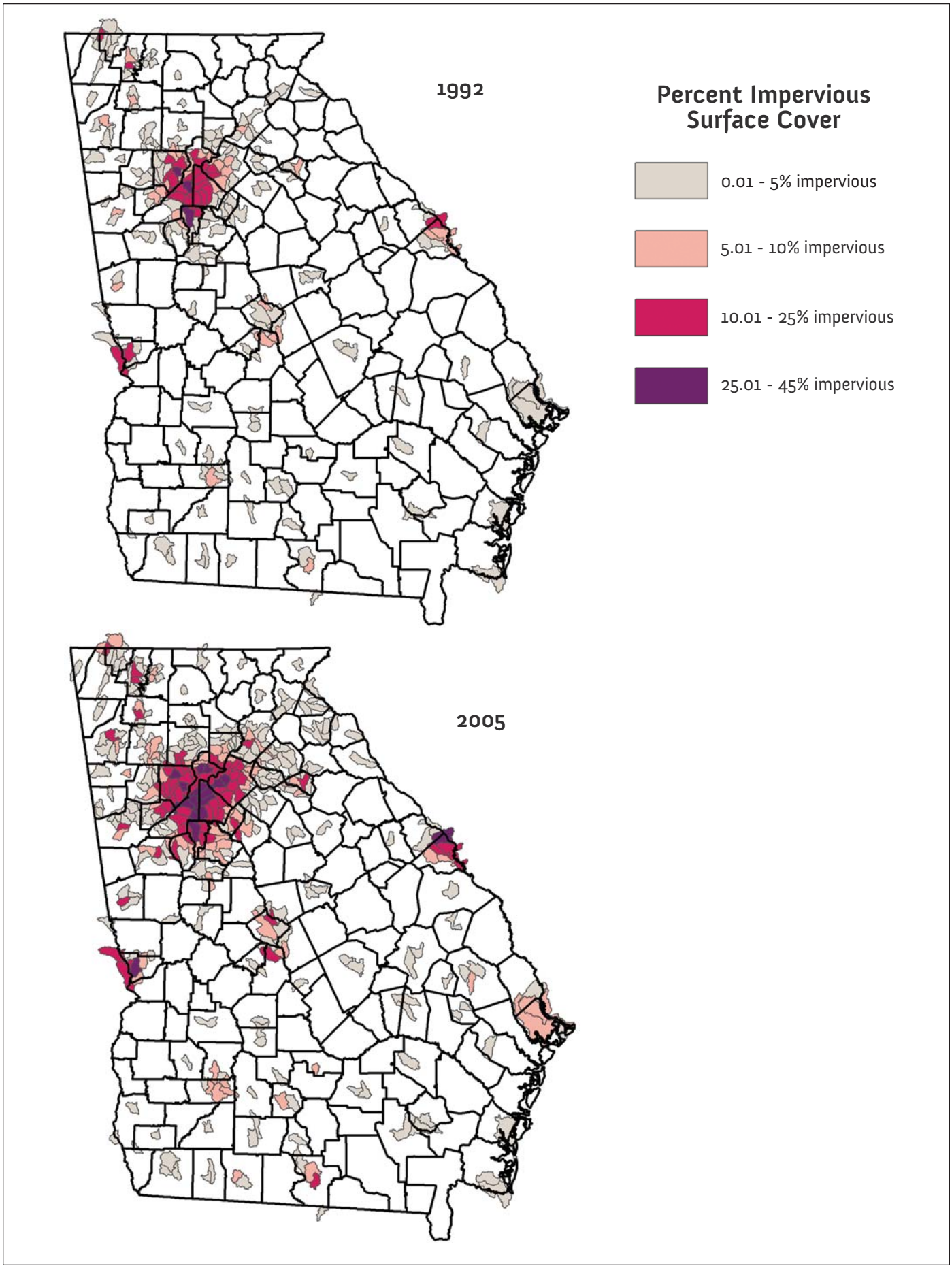


Figure 2.6 *Percent of impervious surface cover in small watersheds, 1992 and 2005. The small watersheds in this figure are equivalent to the 12-digit hydrologic cataloging units (HUCs) defined by the U.S. Geological Survey. (Natural Resources Spatial Analysis Laboratory, University of Georgia)*

Streamside Forests

Indicator of the condition of Georgia's **Habitats and Species**

The land along streams and rivers is particularly important to the health of aquatic ecosystems. Streamside or riparian lands lie directly along rivers, streams and other bodies of water. If forests or other natural vegetation is maintained in these areas, riparian lands can provide a number of ecosystem services.

Plant roots help stabilize stream banks and prevent erosion. Riparian vegetation traps and removes pollutants, maintains stream temperatures and produces organic matter that aquatic animals use as food. It also provides habitat and travel corridors for wildlife and adds aesthetic value to the landscape.

Conversion of riparian forests, however, has historically been common in urban areas and on some lands managed for agriculture and forestry. Researchers at the University of Georgia have evaluated trends in streamside forests in areas within roughly 400 feet of the state's streams and rivers (about 200 feet on each side of a stream or river).

A decline in the extent of streamside forests is evident across much of the state (Figure 2.7). Between 1974 and 2005, 41 of the state's 52 large watersheds showed declines in riparian forests. The greatest losses were in the Upper Chattahoochee (16 percent), Middle Savannah (14 percent), Upper Ocmulgee (12 percent), and Middle Chattahoochee (12 percent).

The watersheds where the amount of streamside forests stayed the same or increased all lie in parts of the state where forestry and agriculture are the predominant land uses. For both agriculture and forestry, voluntary programs increase the protection of environmentally sensitive areas. These programs include a specific set of best management practices, as well as incentives to take sensitive lands out of production. The trend in streamside forests provides evidence that, in some areas, these voluntary programs are working to alter common practices in ways that support the objective of sustaining healthy ecosystems.

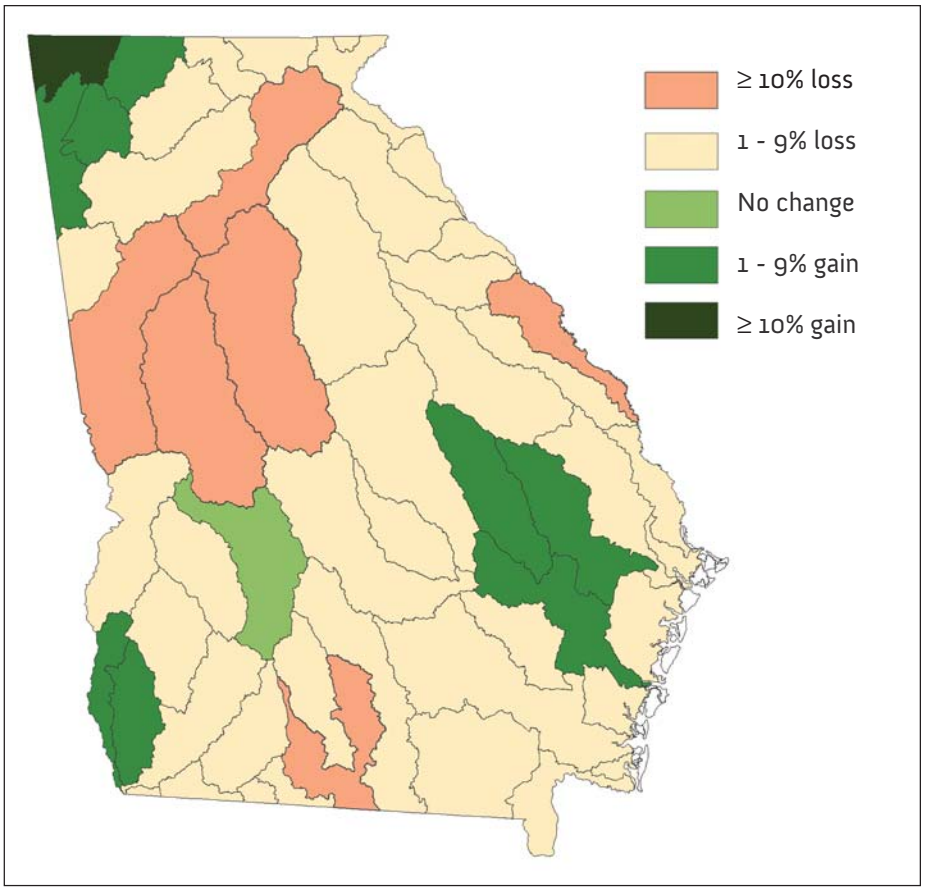


Figure 2.7 *Percent change in streamside forests, 1974 - 2005. (Natural Resources Spatial Analysis Laboratory, University of Georgia)*

Freshwater Fish Community Status

Indicator of the condition of Georgia's **Habitats and Species**

Changes in land cover, conversion of streamside forests and other human activities can affect the health of aquatic ecosystems. For streams and rivers, ecosystem health can be evaluated by tracking the condition of fish communities. Since 1998, the Wildlife Resources Division has used the Index of Biotic Integrity (IBI) to determine the status of the state's freshwater fish communities.

The fish IBI combines several measures — including the different types and number of fish species, the physical condition of the fish and their position in the food chain — to generate scores of excellent, good, fair, poor and very poor. The ratings can then be used to compare regions.

Since 1997, 664 sites have been evaluated in the Piedmont, Upper Coastal Plain and Ridge and Valley ecoregions (Figure 2.8). Nearly half of the sites evaluated between 1998 and 2007 had fish communities in poor or very poor condition. Only 21 percent were in good or excellent condition.

Fish communities in the Ridge and Valley ecoregion scored somewhat better than those in other ecoregions. In the Ridge and Valley, 32 percent of sites scored good or excellent and 39 percent scored poor or very poor. In the other two ecoregions, only 17-21 percent scored good or excellent and 50-51 percent scored poor or very poor.

When fish communities are in poor or very poor condition, the water quality is considered poor, and the fish IBI is one measure that EPD uses to identify

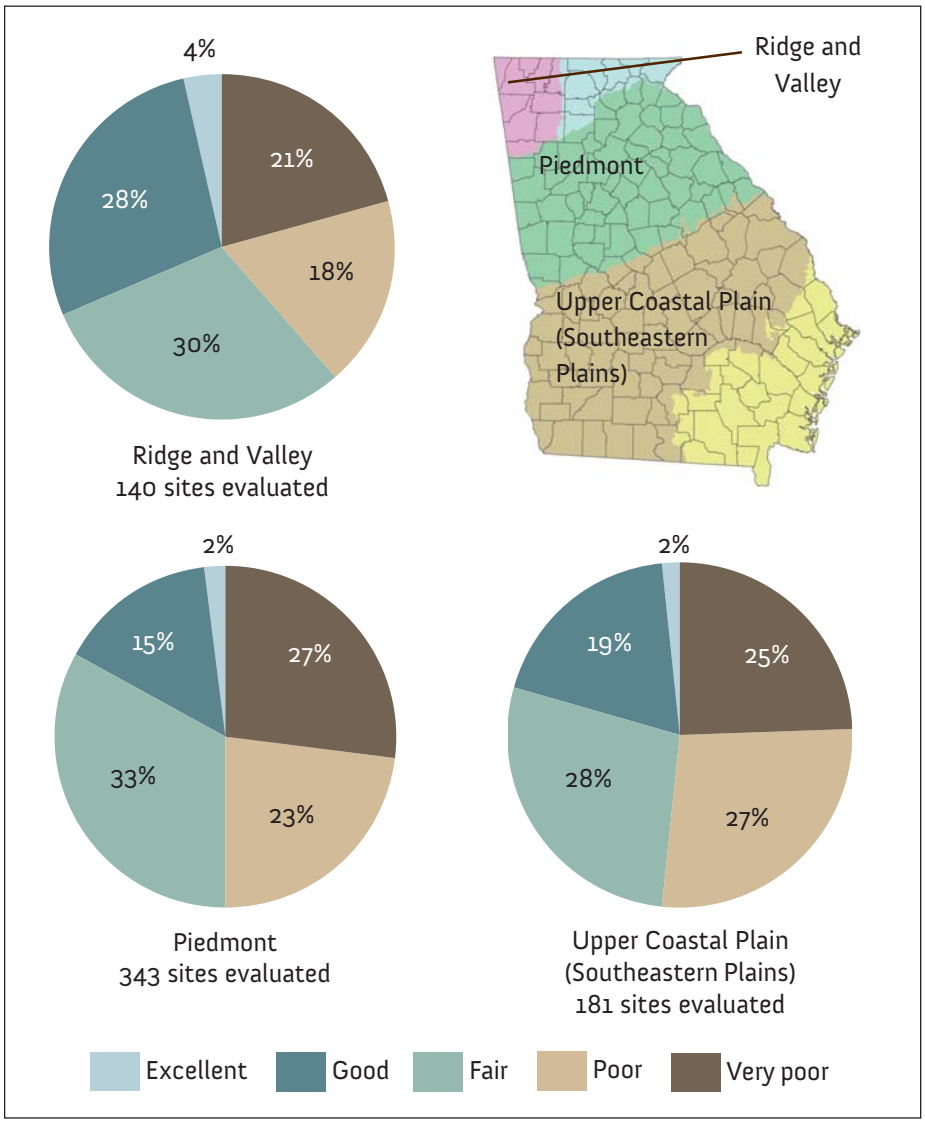


Figure 2.8 *Scores for the fish Index of Biotic Integrity by ecoregion. Indexes for the Blue Ridge and Lower Coastal Plain ecoregions have not been completed, so stream health in these areas has not been evaluated. (Wildlife Resources Division)*

How do streamside forests affect trout?

Streamside forests provide a number of ecosystem services. One of the most important of these benefits is temperature control. Trees and shrubs provide shade, which keeps the water temperature cooler. Lower temperatures allow the water to hold more oxygen, which in turn creates a healthier habitat for aquatic species.

A study of trout streams in north Georgia showed that as the percentage of riparian vegetation decreased, water temperatures rose. Young trout fared poorly in the warmer water.

Researchers estimate that decreasing the width of riparian vegetation by 50 percent, from roughly 100 feet to 50 feet, would increase temperatures by 3-4 degrees Fahrenheit and cause the total weight of all trout to decline by more than 80 percent.

For more information on riparian forests and trout streams in north Georgia, see http://www.rivercenter.uga.edu/publications/pdf/buffer_science.pdf.

What can we learn about recreational fishing quality from examining fish communities in Georgia streams?

The Georgia Wildlife Resources Division evaluates the status of fish communities in wadeable streams using the Index of Biotic Integrity (IBI). The IBI looks at all species of fish and examines their numbers and relative contribution to the overall population.

Sportfish examined include largemouth, redeye, shoal, smallmouth, and spotted bass; white bass and striped bass hybrids; bluegill, flier, redbreast, redear, warmouth, and spotted sunfish; rock and shoal bass; brook, brown and rainbow trout; black and white crappie; channel, blue, and flathead catfish; and chain and redfin pickerel.

Good IBI scores and good fishing are linked because fish are indicators of the events and processes that go on throughout a watershed over time — from the chemical components in the water and soil near the stream to the breakdown of leaves in the stream that support the food chain.

If the IBI score for a stream is high, many fish species are present, habitat is plentiful, adequate food is available, and the fish are healthy and growing well.

Healthy fish communities in small streams can also translate into healthy fish communities in larger rivers. As wadeable streams merge to form large streams and rivers, if good environmental and habitat conditions occur along the way, healthy fish communities can continue to thrive. Eventually, these large rivers flow into lakes and estuaries, helping to support recreational fishing quality in these water bodies as well.

waters that do not meet water quality standards. Another measure used is the type and condition of small insects and insect-like animals that live in or near the bottom of streams and rivers.

These animals, called benthic macroinvertebrates, are an important source of food for fish and an essential link in the aquatic food chain. Like the fish IBI, this evaluation uses multiple measures to score community status as very good, good, fair, poor or very poor. Streams with poor or very poor scores for fish or benthic macroinvertebrates are added to the state's list of waters with poor water quality.

Overall, in 2006 and 2007, 40 percent of the river miles evaluated had poor or very poor scores for fish or benthic macroinvertebrates and were added to the state's list of waters with poor water quality (Table 2.4). Fish and benthic communities in poor or very poor condition were the second most common indicator of poor water quality in eight of the state's 14 major river basins.

These results are due, in part, to land-based activities and nonpoint source pollution that may result. Sediment, in particular, clogs aquatic habitat and stresses fish and macroinvertebrate communities. Other pollutants, including nutrients, metals and pesticides, are also transported with sediment.

Much of the sediment in Georgia streams is a result of past and present land uses. Historically, agriculture was a major source of sediment, and some of that sediment still affects the state's aquatic ecosystems.

Currently, a major source of sediment is the conversion of land into higher intensity uses, including construction of roads, houses and businesses. Eroding stream banks are also a source of sediment today, as impervious surfaces increase the amount and force of stormwater that runs through streams in urban and developing areas.

Erosion and transport of sediment may be reduced as more protective approaches to development, land disturbance, and stormwater management are adopted. As the state continues to grow, ongoing monitoring of fish and benthic communities will be important to track the impacts of land conversion on aquatic ecosystem health.

Table 2.4 *Assessed river miles with poor quality fish or macroinvertebrate communities, 2006-2007. (EPD)*

River basin	Total river miles	Percent of river miles assessed	Percent of assessed river miles with poor quality fish or macroinvertebrate communities
Altamaha	3,430	1%	62%
Chattahoochee	8,172	12%	42%
Coosa	7,126	14%	40%
Flint	9,122	11%	28%
Ochlockonee	1,716	2%	52%
Ocmulgee	7,268	13%	52%
Oconee	6,773	9%	48%
Ogeechee	6,981	2%	10%
Satilla	3,629	3%	0%
Savannah	7,413	5%	48%
Suwannee	4,961	3%	21%
St. Marys	485	2%	0%
Tallapoosa	774	18%	44%
Tennessee	2,300	11%	49%
Total	70,150	8%	40%

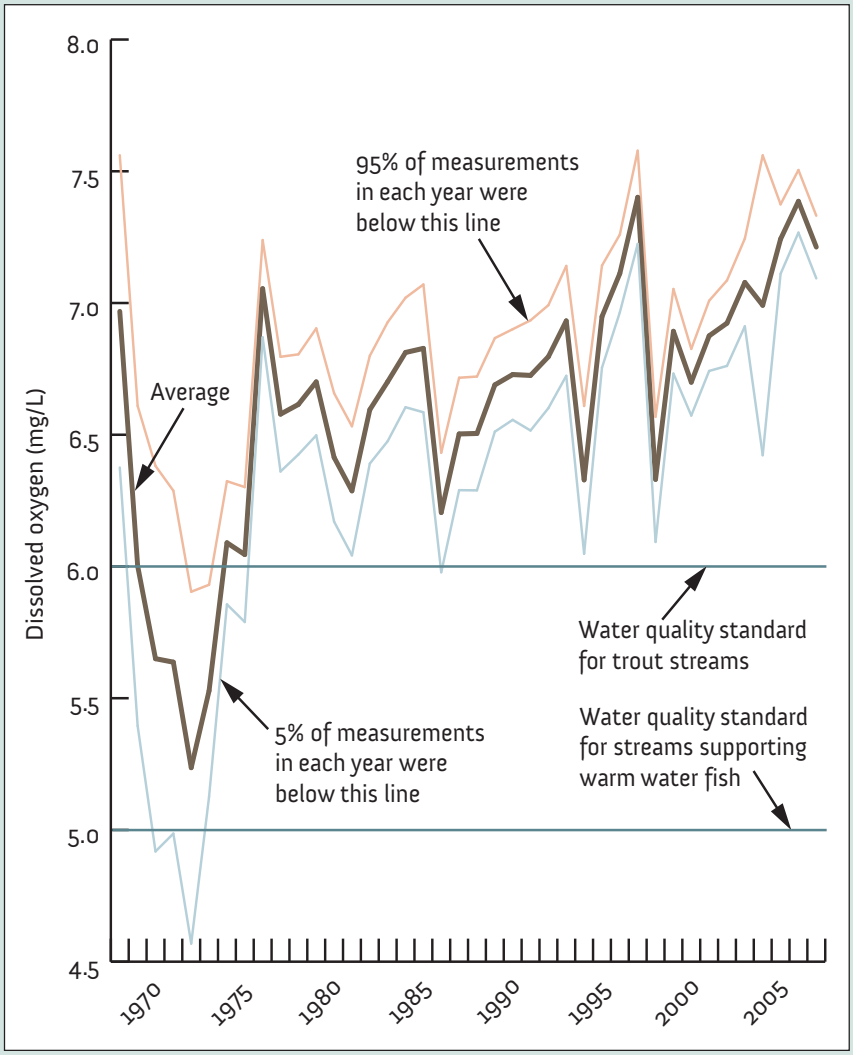
Backgrounder

Dissolved oxygen in surface water

In the early 1970s, growing concern about water quality was triggered, in part, by fish kills caused by low levels of dissolved oxygen. Dissolved oxygen refers to the amount of oxygen in the water. Just as humans cannot survive without oxygen, fish and other aquatic life must have an adequate amount of oxygen in the water to live.

Dissolved oxygen has been a common indicator of a water body's ability to support aquatic life since the 1970s. Levels of dissolved oxygen can be affected by water temperature and the amount of decaying organic matter and pollution in the water, among other factors. Pollution that increases the demand for oxygen can have a significant effect. As bacteria use oxygen to break down the pollutants, levels of dissolved oxygen can decline substantially.

As described in the preceding chapter, long-term trends in water quality are monitored at 40 locations around the state. Average dissolved oxygen levels at these 40 stations have been good since the late 1970s (see figure). Average levels during the summer, when concentrations of dissolved oxygen are naturally the lowest, consistently met or exceeded the water quality standard.



Average amounts of dissolved oxygen at 40 trend monitoring stations, May - September. Levels above the water quality standard are needed to support healthy aquatic communities. Dissolved oxygen levels decrease when temperature increases and levels are generally lowest during the summer, making May to September the critical months for assessment.

In addition to long-term trend monitoring, EPD monitors waters in all river basins on a rotating schedule. As described in the preceding chapter, monitoring results are used to identify stream and river segments where water quality standards are not met.

Of the river miles tested in 2006 and 2007, 91 percent met the water quality standard for dissolved oxygen.

These results reflect major improvements in wastewater treatment by industries and municipalities.

Violations of the dissolved oxygen standard are currently more common in south Georgia than in north Georgia. In south Georgia, low dissolved oxygen can result from natural conditions. Low dissolved oxygen levels are more likely to occur in streams with slower moving water, shallow depths, and higher temperatures – all conditions that are common in the southern part of the state. EPD plans to review the dissolved oxygen standard to improve its application to streams that are naturally low in dissolved oxygen.

Coastal Habitat Conditions

Indicator of the condition of Georgia's **Habitats and Species**

Measures of coastal habitat conditions

- Dissolved oxygen is required by all aquatic life.
- Chlorophyll, a plant pigment, is measured to indicate the amount of algae in the water.
- Nitrogen and phosphorous are nutrients that can contribute to undesirable levels of algae.
- Benthic invertebrates, animals that live on the bottom of water bodies, are an important source of food for fish, shrimp and crabs.

For the interim report on the ecological condition of Georgia's estuaries, see: http://crd.dnr.state.ga.us/assets/documents/GAreport3062306final LOWRES.pdf.

How does the Southeastern coast compare to the U.S.?

The 2005 National Coastal Conditions Report II compared assessment results for regions across the U.S. The Southeastern coast, including sites in Georgia, was among the healthiest in the nation. Twenty-three percent of sites in the Southeast were rated in poor condition, compared to 40 percent in the Northeast, 40 percent along the Gulf Coast, and 23 percent on the West Coast.

Georgia's coastline includes 14 barrier islands, approximately 500,000 acres of salt marsh, and extensive estuaries where the state's major rivers flow into the ocean. Like freshwater ecosystems, coastal ecosystems supply vital services.

They provide habitat for many species, including economically significant species like shrimp and crabs and other marine animals. They act as buffers against flooding and erosion and have natural mechanisms for filtering pollutants. The health of these ecosystems can also be affected by land cover change and other human activities.

The most recent assessment of Georgia's coastal and estuarine habitats was conducted by DNR's Coastal Resources Division as part of the National Coastal Assessment. One hundred sites were sampled in 2000 and 2001 and an interim report, "The conditions of Georgia's estuarine and coastal habitats 2000-2001," was published in 2005. Multiple measures were combined into a composite index of water quality and a composite index of sediment quality. The condition of the benthic community, bottom-dwelling invertebrates that live in the sediment, was also evaluated.

The assessment indicates that Georgia's estuarine habitats are in fair to good condition (Figure 2.9). Water quality ratings were generally lower than other measures. Elevated levels of phosphorus and chlorophyll and low levels of dissolved oxygen and water clarity were found. These factors, however, may be due to natural conditions, complicating interpretation of the results.

Water quality measurements were weighted and combined into a composite index of water quality. Weighting the measurements resulted in 80 percent of sites scoring fair for water quality and 11 percent scoring poor. Sediment quality was generally good, as was the condition of the benthic community. For both, 93 percent of sites ranked good or fair. Of the estuaries with poor benthic conditions, 80 percent also had poor water quality and/or poor sediment quality.

Most sites rated fair or poor were associated with developed watersheds, although some showed no correlation with human activities. Nonpoint source pollution is one of the primary threats to coastal water quality and, as development continues in these areas, managing these pollution sources will be increasingly important to protect and/or restore coastal and estuarine habitats.

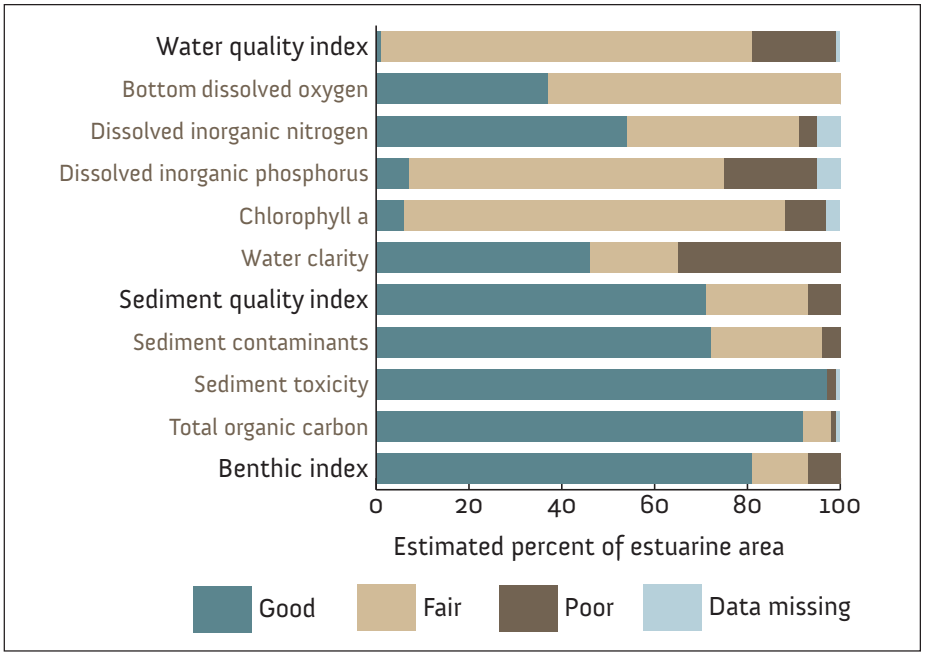


Figure 2.9 *Overall condition of coastal habitats, 2000 - 2001. (Coastal Resources Division)*

Like freshwater and coastal aquatic systems, terrestrial habitat is altered by changes in land cover like those discussed at the beginning of this chapter. Clearing forests or converting vegetated lands to more intensive human uses eliminates some habitat and divides other habitat into smaller and smaller pieces. Native vegetation also may be replaced with nonnative species. These changes can contribute to the decline of wildlife species, including sensitive species that need interior forests.

One way to evaluate habitat quality is to look at areas of natural vegetation and identify those that have the size, shape and location to provide high quality habitat. This type of analysis was conducted for the Wildlife Resource Division's 2005 Wildlife Action Plan. The analysis was based on land cover data from 1998 (the most recent information available at that time).

Figure 2.10 shows ranking of habitat quality based on the size and configuration of areas of natural vegetation. As of 1998, only 36 percent of the state's lands had some type of natural vegetative cover, such as natural forest, wetland or marsh. As seen in the figure, the amount of high quality habitat is small and varies by ecoregion.

At 78 percent, the Blue Ridge ecoregion had the greatest amount of natural vegetation and extensive areas of high quality habitat. The Coastal Plain, in contrast, had 33 percent natural vegetation and fewer areas of highly ranked habitat. The Piedmont had 35 percent natural vegetation with smaller patches of highly ranked habitat.

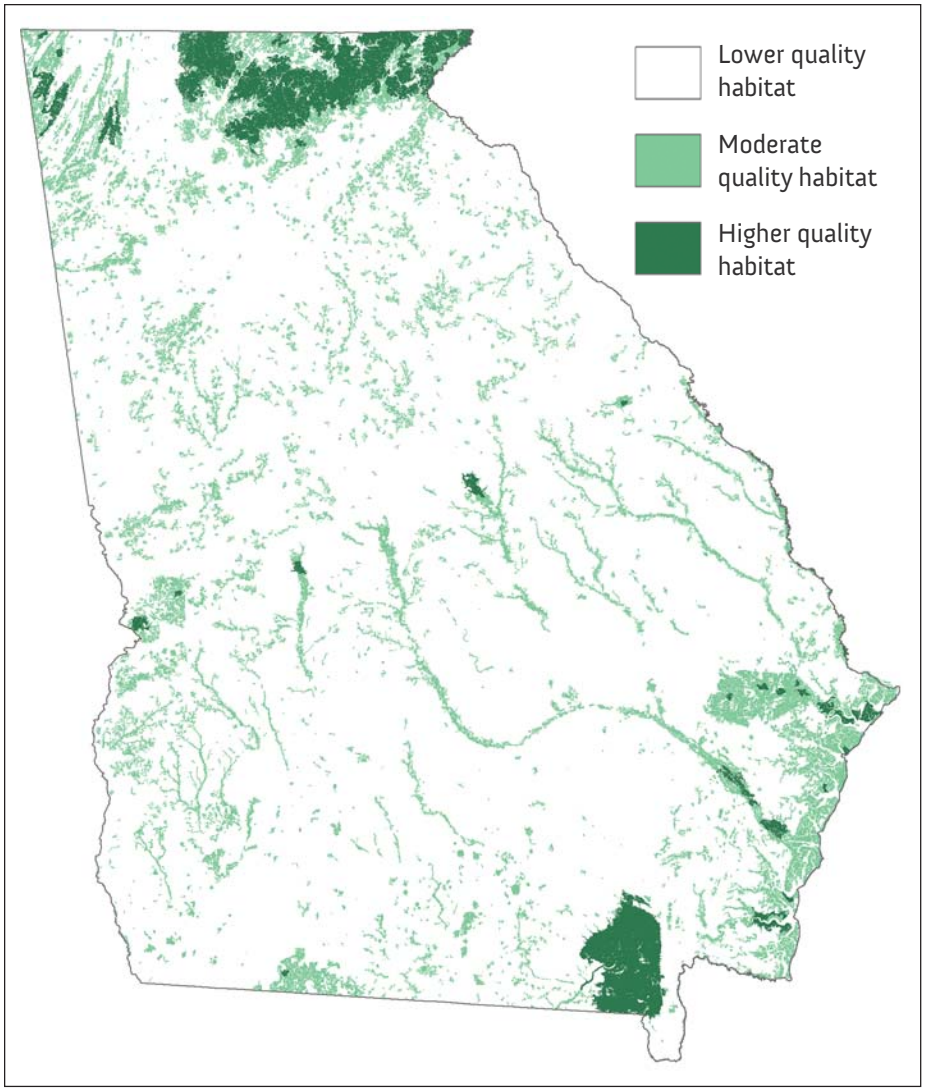


Figure 2.10 *Natural vegetation rankings, 1998. (Wildlife Resources Division)*

Terrestrial Habitat Quality

Indicator of the condition of Georgia's **Habitats and Species**

What is high quality habitat?

High quality habitats play a key role in long-term maintenance of wildlife populations. Habitat quality is determined, in part, by the size and shape of intact areas or patches of natural vegetation.

High quality patches of habitat are generally larger, provide different types of habitat on the edges and in the center, and are relatively compact. In larger areas with well-defined central cores, species are less likely to suffer from predators, parasites or human encroachment.

Fragmentation refers to breaking areas of continuous habitat into smaller, more isolated parts. Fragmentation decreases habitat quality. Populations of plants and animals may become isolated or too small to continue breeding. Travel corridors also may be eliminated, disrupting short and long-term migration patterns.

Many high quality patches, including large tracts of public land in the Okefenokee Swamp and the Oconee and Chattahoochee National Forests, are part of a network of conservation lands.

This information can be used to identify lands that are important to protect in each ecoregion. For the Wildlife Action Plan, the habitat quality analysis was combined with information on predicted distribution and observed occurrence of rare species to highlight conservation opportunity areas (see Appendix K at http://www1.gadnr.org/cwcs/index.html).

While the overall habitat quality is lower, lands on which natural vegetation has been altered can still be of value to native wildlife. Agricultural fields, pine plantations and forests in developed areas, for example, can provide nesting sites, feeding areas and migration routes for birds and animals. These lands can also be managed in ways that support native wildlife and are compatible with protection of adjacent areas of high quality habitat.

The sources of habitat loss are similar across the state. The rapid pace of land conversion and habitat fragmentation are among the most common causes in all of Georgia's ecoregions (Table 2.5).

Table 2.5 *Major sources of habitat loss by ecoregion. (Adapted from the State Wildlife Action Plan, Wildlife Resources Division)*

Ecoregion	Major sources of habitat loss
Southwestern Appalachians/ Ridge and Valley	- Increase in residential and commercial development along major highways and on outskirts of metro areas - Prior conversion of forested lands to agricultural uses - Poor water quality - Alteration of streamflows and groundwater levels
Blue Ridge	- Increase in residential and commercial development along major highways and on outskirts of metro areas - Poor water quality - Conversion of hardwood and pine-hardwood forests to pine plantations - Fire suppression
Piedmont	- Rapid pace of residential and commercial development - Poor water quality - Prior conversion of forested lands to agricultural uses - Conversion of hardwood and pine-hardwood forests to pine plantations
Upper Coastal Plain (Southeastern Plains)	- Prior conversion of forested lands to agricultural uses - Poor water quality - Conversion of hardwood and pine-hardwood forests to pine plantations - Fire suppression
Lower Coastal Plain (Southern Coastal Plains)	- Rapid pace of residential and commercial development in coastal counties - Prior conversion of native pine forests to pine plantations - Fire suppression - Alteration of streamflows, floodplains/wetlands and groundwater levels

As described in the introduction to this chapter, Georgia's aquatic and terrestrial ecosystems support extraordinary levels of biological diversity. This diversity, however, is threatened, in part, by some of the ways in which land is used and the ways land has been altered as the state's population has grown.

Biological diversity can be difficult to measure directly. As an alternative, the number of species whose survival is at risk provides an indicator of changes in biological diversity, and therefore changes in ecosystem health.

Georgia's Wildlife Resources Division maintains a list of the state's protected species. This list includes animals and plants that are endangered, threatened, rare or unusual in the state. When the list is short, it indicates progress in protecting the health of our ecosystems; when it is longer, it indicates that human activities are negatively impacting ecosystem health.

The protected species list was updated in 2007. It now includes a total of 318 species (Table 2.6). The update added 121 species. Many of the new additions are plants, and plant species now make up nearly 50 percent of the protected species in the state. A number of crayfish and freshwater mussels were added as well, raising the number of invertebrate species on the list to 51. Most of the invertebrate species are aquatic. Aquatic animals (fish and invertebrates) now make up more than one-third of Georgia's protected species.

These changes reflect the degree of threat to these species, based on current habitat conditions and/or estimated population levels. For some species, they also reflect improvements in the information used to evaluate their status. That is, biologists now know more about the status of some species; they cannot, however, be sure that these species have become more imperiled in recent years.

A species can be added to the list for a number of reasons, including changes to the species' habitat; over-collecting for commercial, sporting, scientific or educational use; disease or predation; and inadequate regulations. The most severe threat to Georgia species is habitat loss. It is not, however, the only significant threat. Turtles and crayfish, for example, are threatened by over-collection.

Table 2.6 *Plants and animals on Georgia's protected species lists, 2007. (Wildlife Resources Division)*

	Endangered	Threatened	Rare	Unusual	Total
Mammals	6	2	2	0	10
Birds	5	4	11	0	20
Fish	32	8	17	0	57
Amphibians	0	5	4	0	9
Invertebrates	28	19	4	0	51
Reptiles	5	6	3	2	16
Plants	56	63	32	4	155
Total	132	107	73	6	318

Protected Species

Indicator of the condition of Georgia's **Habitats and Species**

Recent changes in Georgia's list of protected species

Georgia's protected species list was updated in 2007. Since the last update in 1992, 121 species were added and 18 species removed.

Also, 43 species that were already on the list had their status changed. The status of 19 of these improved and the status of 24 declined.

More information on Georgia's protected species can be found on the conservation page at http://www.georgiawildlife.com.

Habitat Protection

Indicator of the condition of Georgia's **Habitats and Species**

Differing levels of protection

Only 8 percent of the state's land area currently has some degree of natural habitat protection.

Habitat types that cover large areas of the state (e.g., hardwood forests) tend to have a small percentage protected, while those that occupy a small fraction of the state (e.g., coastal dunes) have a higher percentage of their total area protected. As a result, some important habitats currently have very little protection.

Bottomland hardwoods, for example, cover more than 1.2 million acres in Georgia, but receive little protection. Only 7 percent is permanently protected with limited impacts on natural habitat, despite its significance as high quality habitat for a variety of species.

Longleaf pine, an ecosystem known for its high level of biological diversity, has a higher level of protection (13 percent is permanently protected). However, much of the native longleaf pine forest has already been converted to other land uses. Once found across the Southern coastal plain, intact longleaf pine habitat now exists on less than 4 percent of the land where it historically occurred.

The final indicator of ecosystem health looks at land stewardship — the management of land to protect natural habitat and maintain biological diversity.

The Georgia Conservation Lands database is one source of information on habitat protection. The database includes records of federal, state, local government, and private lands in Georgia that are managed for conservation of animals, plants and natural habitats, as shown in Figure 2.11.

The federal government manages more than 70 percent of Georgia's conservation lands. The state manages more than 20 percent, including lands owned by the state and those leased from other owners. Private conservation groups and local governments manage the remainder.

The degree of habitat protection provided on individual parcels depends on the land owner and their management objectives. Some lands, like wilderness areas and areas under perpetual conservation easement, provide permanent protection of natural habitat. Other lands, like state parks and wildlife management areas, are mostly maintained in a natural state, although some areas are altered in ways that include removal of natural habitat. Habitat on leased lands may currently be protected, but year-to-year leases do not ensure permanent protection of habitat on these lands. Lands such as military bases and national forests include large areas where natural habitat is protected, while some areas are altered for other uses, such as timber harvest.

Despite these different management objectives, conservation lands all provide protected habitat for plants and animals and help maintain healthy ecosystems. Conservation lands also provide economic benefits. Visits to Georgia's state parks, for example, are estimated to generate more than $769 million per year for the state and local communities. Conservation lands are also community assets that can contribute to higher property values in the areas around them.

A 2003 study by the U.S. Geological Survey concludes that only 8 percent

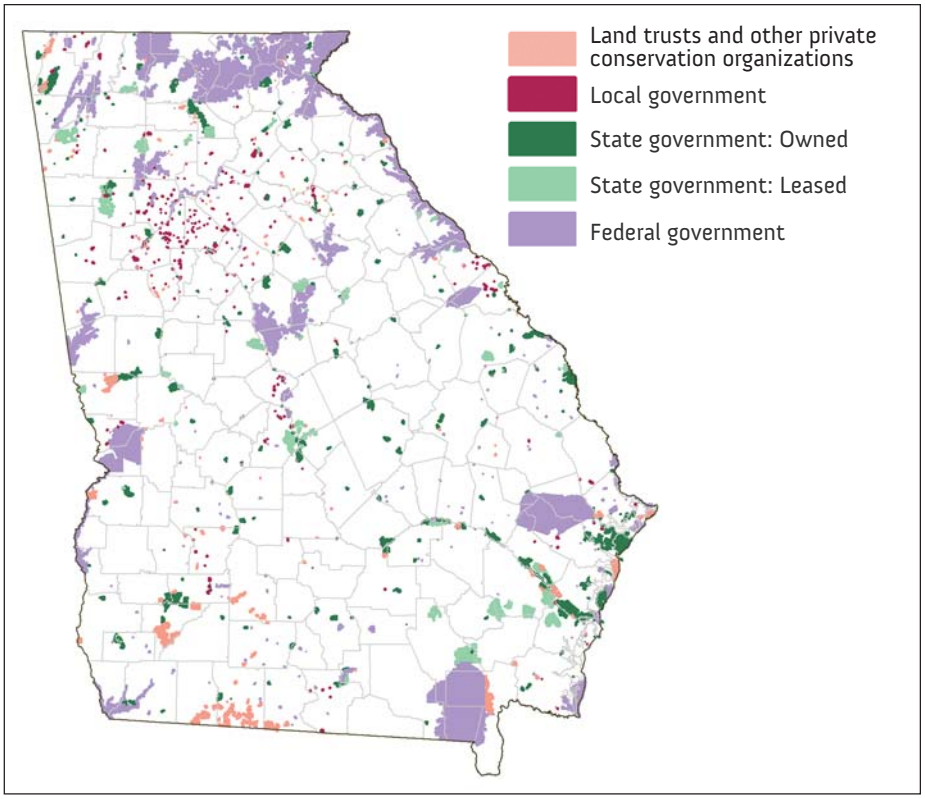


Figure 2.11 *Georgia conservation lands by ownership, 2008. (Wildlife Resources Division)*

of Georgia's total land area is managed for conservation and has some level of protection for natural habitats. Of these conservation lands, only a small portion – equal to 3.5 percent of the state – is permanently protected in its natural state through ownership, legal mandate or conservation agreement. Permanently protected lands include wilderness areas, state parks, wildlife management areas, and lands held by land trusts, among others.

Researchers with the U.S. Geological Survey have evaluated the extent of protection that conservation lands provide for habitats of terrestrial animals found in Georgia. Researchers identified areas where each of 405 animal species are expected to be found. These areas were compared with the location of protected lands to determine the level of habitat protection for terrestrial animals in place as of 2003.

Of the 405 species, 29 have less than 1 percent of their habitat protected from conversion (Figure 2.12). More than two-thirds have less than 10 percent of their habitat protected from conversion — a total of 295 species.

This level of habitat protection was found for all major groups of animals:

- 71 percent of amphibian species
- 73 percent of breeding bird species
- 73 percent of mammal species
- 74 percent of reptile species

Only 32 species — 7 percent of the total number of animal species in the state — had more than 20 percent of their habitat protected.

These results are not surprising, given the low percentage of protected lands across the state. This research, however, provides information that can guide efforts to protect additional land. The Wildlife Resources Division has combined it with habitat quality rankings, described earlier in the chapter, to identify areas with opportunities for conservation (see Appendix K at http://www1.gadnr.org/cwcs/index.html).

Ninety-two percent of Georgia's land has no protection of natural habitat and thus is subject to conversion and habitat loss. The vast majority of this land is held by private landowners.

As Georgia continues to grow, voluntary habitat protection on private lands will be increasingly important. A variety of options are available to private landowners interested in protecting habitat and helping sustain healthy ecosystems across Georgia (see page 52).

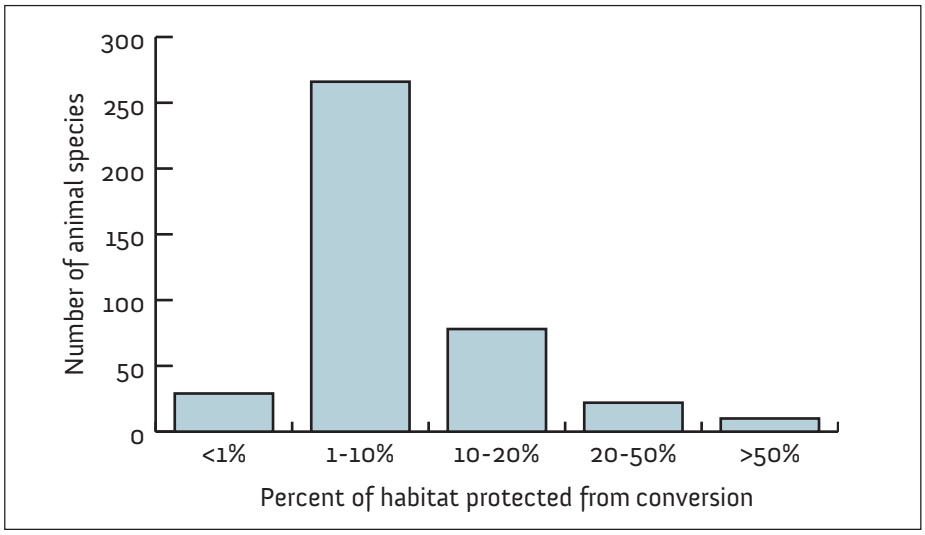


Figure 2.12 *Protected habitat for terrestrial animals, 2003. (U.S. Geological Survey)*

Voluntary action by private landowners is critical to protect habitat

More than 90 percent of land in the state is in private ownership and just a small percentage is managed for conservation or protection of natural habitats.

As Georgia continues to grow, sustaining the state's ecosystems will require protecting high priority habitat and critical species. Taking such actions on public lands alone will not be enough. Managing private lands for conservation will also be needed, and private landowners can play a critical role in conservation.

The State Wildlife Action Plan, adopted by the Wildlife Resources Division in 2005, emphasizes protection, restoration and maintenance of natural habitats. Identifying critical habitats, voluntary and incentive-based programs for private lands, and habitat restoration and management by private conservation organizations and public agencies, are all major elements of the plan.

To read the full plan, go to: http://www1.gadnr.org/cwcs/Documents/strategy.html.

Backgrounder

Incentives for Habitat Protection on Private Lands

Land ownership can be thought of as a bundle of sticks, with each stick representing a particular right. A landowner interested in habitat protection or other conservation goals may sell or give away some or all of his or her property rights through fee simple acquisition, conservation easements or transfer of development rights. Conservation use valuation assessments also provide incentives for protection of private lands. With this tool, however, the landowner does not transfer property rights.

Fee simple acquisition. A landowner sells the rights, title and interest in the property to a buyer, who then owns and manages the land. Public agencies and private nonprofits may be interested in acquiring land for specific conservation purposes. If a sale to a qualified conservation organization is made at a discounted price, or if the land is donated, landowners can receive significant tax benefits. The difference between the market price and the sale price is considered a charitable deduction, which can reduce federal and state income taxes. Georgia also has a state income tax credit for donations and discounted sales of land.

Conservation easement. Conservation easements are a valuable tool for protecting conservation values in perpetuity. A conservation easement is a legal agreement that transfers certain development rights to a third party, usually a land trust or government agency. Conservation easements are negotiated by the landowner and the conservation organization. This provides the flexibility to allow certain uses, such as continued farming or forestry, while protecting the land's conservation values. The degree of restriction determines the value of the easement and the tax deduction or other tax benefits available to the landowner.

Conservation easements are tied to the land so the property can still be bought or sold. Future owners must follow the provisions of the easement, and the land trust or conservation organization is responsible for monitoring and enforcing easement terms. For agricultural lands, the federal Farm Protection Program can provide matching funds to purchase permanent conservation easements that keep the land in agricultural use.

Transfer of development rights. A few localities in Georgia have developed programs that allow the transfer of development rights. Under these programs, development rights are separated from one parcel and sold for use on another parcel. The landowner then enters into a conservation easement that permanently restricts development on the original parcel.

Conservation use valuation assessment. Some lands, including agricultural lands, forest lands and environmentally sensitive areas, are eligible for reduced property tax rates through conservation use valuation. These properties are assessed according to soil type and productivity rather than fair market value, which generally means a significant reduction in property taxes. Property must meet eligibility requirements set by the county and landowners must sign an agreement to keep the land in its current use for 10 years. Landowners can reenroll after 10 years to continue the conservation use valuation assessment.

(Georgia Wildlife Resources Division and Arizona Open Land Trust)