Category IV
Landscape

Then ~ The Delaware River Basin drainage area encompasses 12,765 square miles, draining 1% of the land area of the United States. These lands are varied in both terrain and use, from rolling farmland and forest, to marshes and fishing villages along the Bay . . . at the time of discovery by Europeans [it] comprised an ever evolving system, accepting and discharging into the Atlantic Ocean the fresh water and silts from mountains and plains . . .[and] aquifers were fully and generally discharged to surface streams. In this dynamic system, the activities of man were nearly inconsequential . . . Today, the activities of man vastly affect the behavior of water and the ecology of the Basin.

Level B Study, May 1981, p 8
Delaware River Basin Commission

USGS reports that the total area of forests and wetlands has a positive effect on aquatic invertebrates, while urban area growth, impervious cover, population density and total point source flow (discharges to waterways) often has a negative effect.

Today

The activities of man continue to affect the behavior of water and the basin ecology, but a desire to minimize those effects has been embedded in environmental management programs for several decades. Water quality success stories based on regulating discharges are by now legendary, illustrated by the return of shad populations to the Delaware River. Other successes are included in the timeline in the Water Quality section of this report. Today, the landscape is the next frontier in water resource management.

Landscapes and Water Resources

Natural landscapes and human alteration of that landscape – measured as land cover and land use – play a crucial role in water resource condition. Human use of land and changes to its physical state can be major factors in the alteration of ecological processes at both local and global scales. Many if not most physical and chemical changes in waterway systems are linked to land use, although some of the linkages are complex and difficult to quantify. USGS has found significant relationships between landscape condition and the health of aquatic communities (Table 3.1.). The 2003 Final Report of the New Jersey Comparative Risk Project identified landscape change as "lying at the heart of many environmental problems," and when compared to an array of known or perceived threats, land use change, in the view of the experts, "produced by a wide margin the largest negative ecological and socio-economic impacts" including: habitat loss and fragmentation; permanent ecosystem destruction; increases in stormwater flows and flooding; skewed employment patterns and property values detrimental to older communities; traffic congestion; and public health impacts. (Final Report of the NJ Comparative Risk Project, March 2003, pp 17–18).

1682 William Penn establishes Philadelphia.

1700 Population of Philadelphia reaches 5,000.

1790 John Fitch's 1st successful steamboat operation connects Philadelphia and Trenton.

1832 Opening of the Delaware (PA) and D&R (NJ) Canals.

1871 Philadelphia's City Hall – world's tallest masonry structure and largest municipal office building in US.

1880s Ship building is a major industry in the basin.

1908 Steel for 1st skyscraper produced at Bethlehem PA.

1909 W. Wright first to take aerial photos of landscape.

1920 Basin population 4 million

Historic Land Use

The pre-industrial basin landscape was predominantly woods and wetlands, with expanses of farmland and nodes of human settlement. Decades of development and harvesting resulted in filled wetlands and a decrease of forests, so that by 1930, forests and wetlands had been reduced to 32% and 3% of the landscape, respectively.

Conservation efforts, shift in raw material needs for production and better understanding of the services that wetlands and forests provide have to some extent reversed the old trends. By the mid-1990s forested land had nearly doubled from its 1930 level, basin land in agricultural use had been reduced by more than half, and wetlands had slightly increased. The National Wetland Inventory Status and Trends report attributes recent increases to the creation of ponds which do not provide the same function as vegetated wetlands.

Between 1930 and 1996, urbanized land nearly quintupled from 3% of the basin to 14%.

Landscape Change

Assessing changes to the landscape —how we use and manage it, how much remains in a "natural" state—is a requisite for setting baselines for comparison, for identifying watersheds or areas of immediate concern, and for anticipating effects on water resources. Unfortunately, while we possess the technical ability to interpret data from satellite and aerial images, the financial ability and political will to do this at geographic scales and reference periods that would be most appropriate for water resource management has been inadequate. An explanation of the issues related to compiling information for this Report accompanies an assessment of needs and recommendations at the end of this section.

Reporting

Indicators of landscape condition included in this report are:

- Population change
- Population density
- Land use 2001
- Land use change 1995–2001
- Land consumption
- Natural landscapes: forests, wetlands and wetland buffers

A feature on *Natural Capital*, the economic value of ecological goods and services, completes this section.

Land Use Category*	Examples of Uses/ Activities included in category	Potential Impacts	Land Use Trend
Developed	Low, medium and high intensity residential, commercial & industrial uses; transportation, communication & utilities; athletic fields, parks.	• Water use • Hydrology: Increased flashiness[@] of stream flows • Increased pollutant loadings to streams	↑
Agriculture	Cropland, orchards, vineyards, pasture, livestock operations	• Water use (crop dependent) • Increased nutrients • Increased sediment & erosion • Increased pesticides, fungicides	↓
Forest	Deciduous, evergreen and mixed forests	• Provides carbon & nutrient uptake • Improves air quality • Provides habitat • Moderates temperature	↓
Wetlands & Water	All wetland types (not differentiated)	• Carbon and nutrient uptake • Provides habitat • Provides flood protection	↔
Other	Barren land, mining, etc	Impacts vary	↔
* Note:	Land use trend derived from NOAA-CSC change analysis 1996-2001. Categories were combined into five major types to extract a coarse change analysis for the basin.		
@	Flashiness means higher peak runoff and shorter periods of peak discharge.		
↔	Nominal change; within range of analytical accuracy		

Table 4.1: Potential Impacts of Land Use on Water Resources

1930s D&R canal used to carry drinking water from the Delaware to meet needs of northeastern NJ

1940 Delaware Canal becomes part of the PA State Park system.

1954-55 Zero oxygen conditions from shore to shore for 20 miles of the Delaware River.

1972 US space station provides 1st land use imagery. *Landsat 1* launched to generate multispectral image of land use and land cover.

1980 Superfund (CERCLA) enacted by Congress.

1993 EPA orders US Steel to clean up contamination at Fairless Hills PA.

1995 Bethlehem Steel closes after 100 years of iron making.

2000 Basin population nears 7.8 million.

Indicator • Population Growth and Distribution

Not Rated

Indicator Description

Population growth is an indictor of potential stress on water resources and natural landscapes. People create demand for water and wastewater provision, buildings, roadways, and parking, all of which increase the potential for impairments to water quality and aquatic resources.

For this report US Census tracts were aligned with 236 watershed units for analysis, and the watersheds aggregated into the basin reporting regions. Results are also reported by political units, e.g., counties and municipalities.

Desired Condition

Accommodate growth while protecting and enhancing water resources (BP 3.4, CCMP Actions L1-18).

Status

Basin population grew 6% between 1990 and 2000.

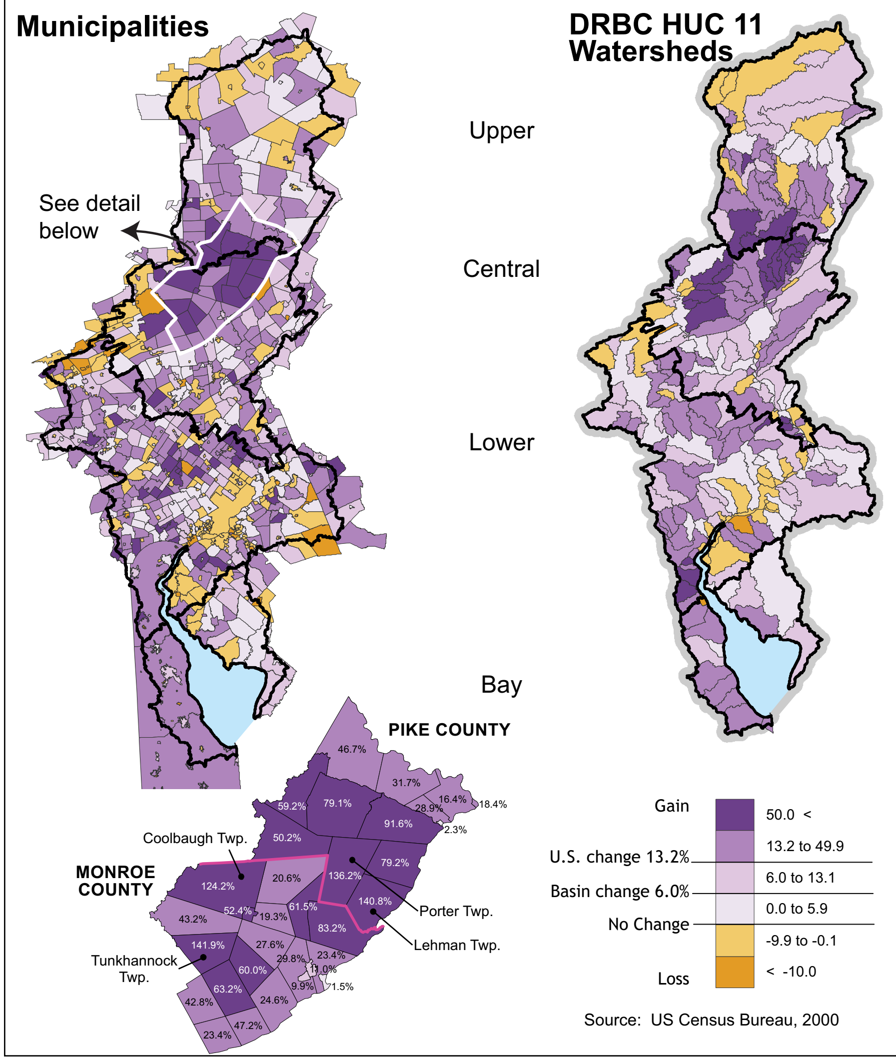
The population of the basin was 7.76 million in 2000, an increase of 436,354 (6%) over 1990. There was greater growth in the first half of the decade than the latter half (Table 4.2). Basin population is expected to approach 9 million by 2030 (Fig. 4.1). For comparison, the 2000 populations of New York City and the State of New Jersey were 8.0 and 8.4 million, respectively.

Population is unevenly distributed across the basin (Fig. 4.2). The vast majority (78%) of residents live in the Lower Region and nearly half (3.7

Table 4.2 Population Change

	Population	Change
1990	7,322,320	
1995	7,591,690	269,370
2000	7,758,675	166,984
Total Increase		436,354

Fig. 4.2 Percent Change in Total Population 1990–2000



Source: US Census Bureau, 2000

Fig. 4.1 Delaware River Basin Population

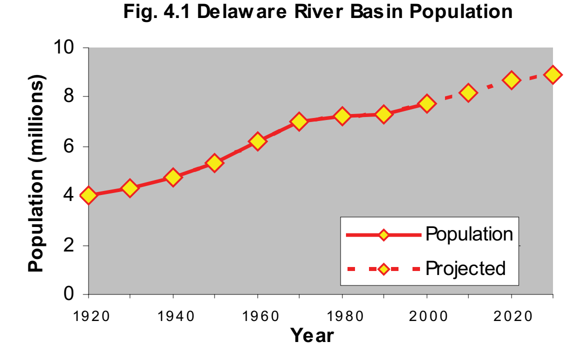


Fig. 4.1. By 2030 the Basin population is expected to approach 9 million.

Fig. 4.3 Basin Population 2000

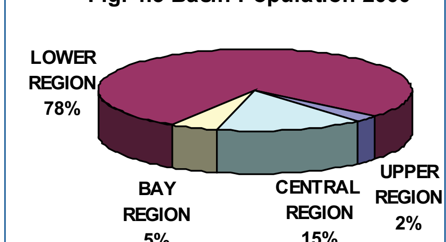
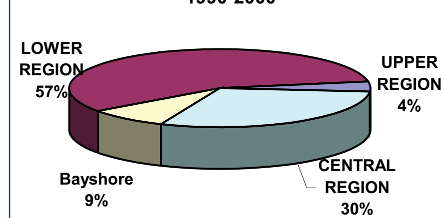


Fig. 4.4 Contribution to Population Change 1990-2000



million) reside in the Upper Estuary watersheds which include the greater Philadelphia metropolitan area.

Population growth also has an uneven pattern. Not surprisingly, the Lower region still accounts for most of the increase, but the Central Region, especially the Upper Central Watersheds, experienced a significant increase, accounting for 30% of the basin's population growth. See Figures 4.3 and 4.4.

Across the 236 watersheds:

- The greatest population increase occurred in the Neshaminy Creek PA watershed which added more than 23,000 new residents between 1990 and 2000. The Christina River watershed (Lower Estuary) ranked second, adding just over 20,000 in the same time period.
- The greatest percentage increases occurred in the Upper Central region, where the 600 square mile Lackawaxen watershed added 10,000 new residents, a 25% increase (Fig. 4.5).
- Pike and Monroe Counties, straddling the divide between the Upper and the Central regions, are the fastest growing counties in Pennsylvania. Not surprisingly, watersheds that include Pike and Monroe counties accounted for 77% of the population increase in the watersheds of the Central and Upper regions.
- Eight of the ten most densely developed watersheds, located in the Philadelphia metropolitan area, lost a combined total of more than 66,000 people between 1990 and 2000.

Trends

In the eighty years between 1920 and 2000, the population of the Delaware River Basin has nearly doubled. While population continues to increase in general across the basin, older communities, most notably the City of Philadelphia, continue to experience population loss. And while established areas—portions of the Schuylkill watershed, for example—continue to grow, new development is making inroads into areas once sparsely developed, such as the Lackawaxen watershed (Fig. 4.6 and 4.7).

Recent population estimates for 2006 show a continued decline in Philadelphia, as well as in Schuylkill County PA, Delaware County NY, and Cape May County NJ. The reasons for the decline in each of these areas vary significantly.

Continued increases are evident in the Central (Pocono) region: Pike and Monroe counties in PA, Sussex in NJ. With the exception of Cape May County NJ, areas within the Bayshore Region are also developing rapidly as

> Identifying watersheds with substantial population change highlights where changes in landscape function and water quality might be expected to occur, and where preventive management measures could be employed to mitigate impacts.

indicated by substantial increases in the Delaware counties of Kent and Sussex, and Cumberland County NJ.

In summary, some sparsely developed watersheds are undergoing substantial growth and some established urban areas are being slowly abandoned. This trend has substantial implications for water resource management, including landscape alteration, construction and maintenance of new infrastructure systems, and abandonment or inefficient use of existing infrastructure.

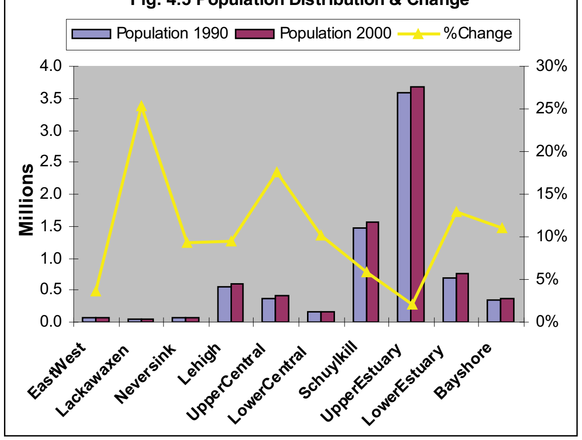


Fig. 4.5 Population Distribution & Change

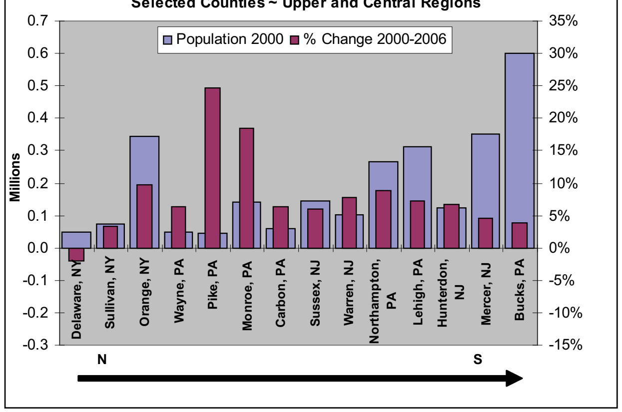


Fig. 4.6 Recent Population Change
Selected Counties ~ Upper and Central Regions

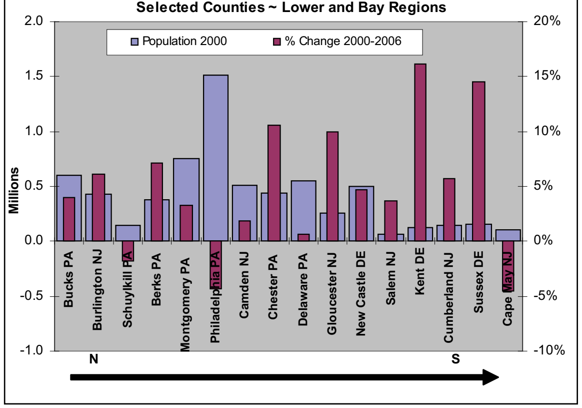


Fig. 4.7 Recent Population Change
Selected Counties ~ Lower and Bay Regions

Indicator • Population Density

Not Rated

Indicator Description

Population density is an indicator of potential stress on water resources and natural landscapes and can be used as a surrogate for impervious cover, which has emerged as an important indicator of potential water quality impairment. Studies have correlated population density and impervious road area with negative impacts to water quality, fish and aquatic invertebrate communities, algae and changes to stream flow.

However, while density can indicate a potential for harm, in most instances building communities in compact form is more desirable than spreading lower density development and road networks throughout a watershed or region.

Desired Condition

Accommodate growth while protecting and enhancing water resources (BP 3.4, CCMP Actions L1-18)

Status

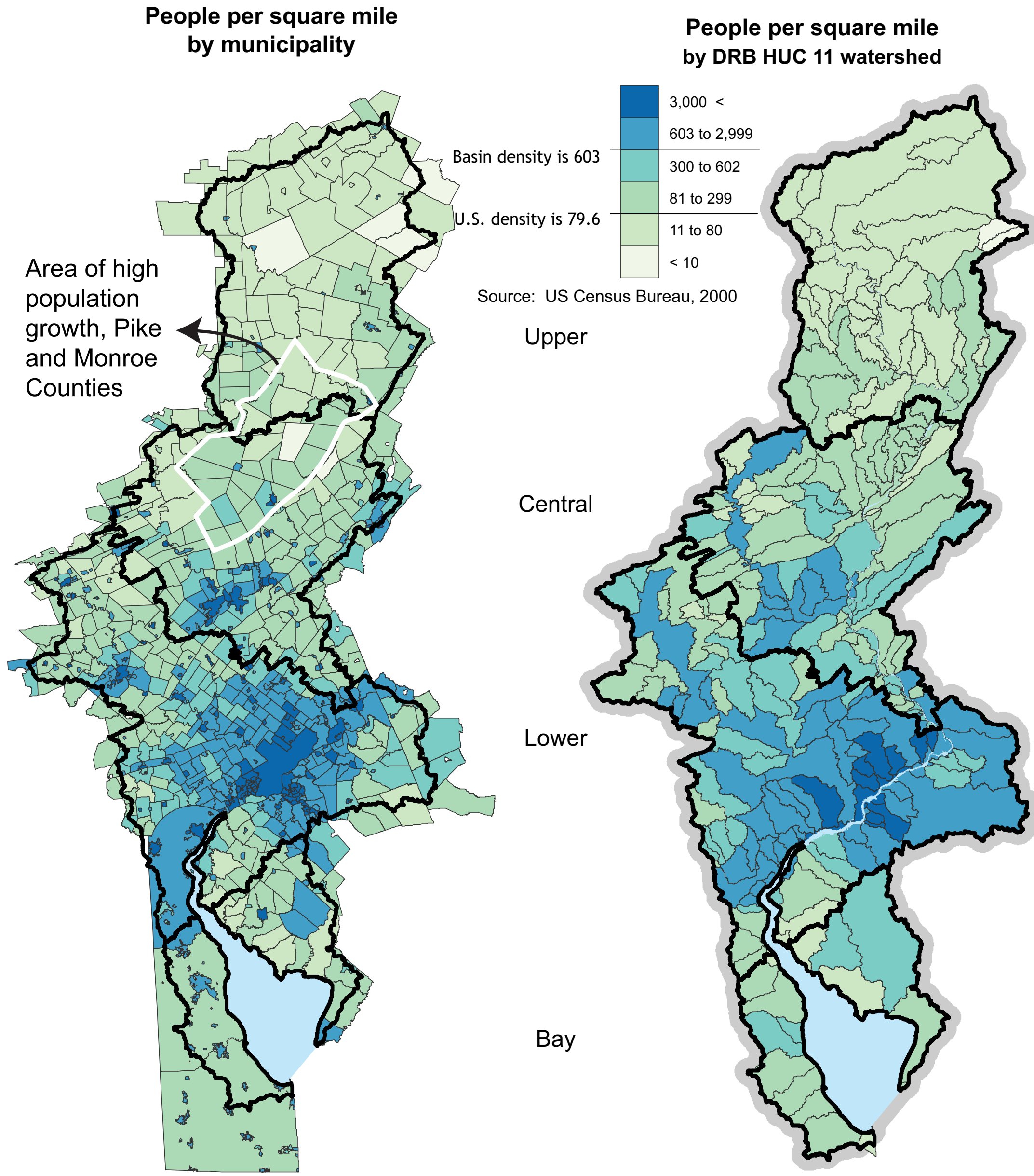
Density continues to increase in the basin, and averages 603 people/sq. mile.

In 2000, the average basin density was 603 persons per square mile (p/mi^2) or about 1 person/acre. Population density varies dramatically across the Basin and among watersheds (Fig. 4.8). Population density in the Upper and Central regions is about 204 p/mi^2, while the Estuary density approaches 1,050 p/mi^2. The US census classifies densities greater than 1,000 p/mi^2 as *urban*.

Generally, density is lowest in the uppermost watersheds of the Basin (ranging from 30 to 100 p/mi^2), increasing with proximity to the River and its confluence with major tributaries. After peaking at the greater Philadelphia metropolitan area (>2,000 p/mi^2), density decreases again in the more southern watersheds of the Lower and Bay regions.

Headwater streams are especially vulnerable to impacts. Historically, these areas have remained sparsely developed due to distance from other population centers, poor accessibility and problematic terrain. In the last decade, high housing costs within and beyond the basin have fueled a sharp increase of new housing

Fig. 4.8 Population Density



Learn about LID at http://www.lowimpactdevelopment.org/

and seasonal home conversions in the headwaters of the Upper Central and Lackawaxen watersheds on the Appalachian plateau. Compare the relative increase in population with population density for municipalities in Pike and Monroe (PA) counties in the inserts in Figures 4.2 and 4.8.

Differences in development patterns and population changes within watershed units can be seen by comparing the municipal and watershed density maps.

Trends

As population is increasing, density is also generally increasing. The greatest percentage increase was in the Lackawaxen (25%), the Upper Central (18%) and the Lower Estuary watersheds (13%). However, some watersheds, especially those with older urban communities, lost population.

For example, the ten most densely populated watersheds are located in the Upper Estuary around Philadelphia. Between 1990 and 2000, eight of these lost population; in those watersheds alone population declined by nearly 60,000 which may indicate an aging population and reduction in household size. Population losses can also indicate abandonment of existing housing and eventual disuse of the existing capacity of support infrastructure such as transportation, water supply and waste treatment systems.

During the same decade, slightly more than 63,000 people were added to the population of the watersheds in the Upper Central region—including areas of Pike and Monroe County PA—where developed land increased by more than 80,000 acres at the rate of ~1.3 ac/person. More than 74,000 acres of forested watershed land was converted for development and agriculture.

Actions and Needs

- Attention to where and how we develop could greatly aid in preventing or limiting negative effects on water resources. More densely developed communities offer many cultural, health and economic benefits, and the downside of imperviousness can be offset by smarter development and land management.
- Improving stormwater management practices—to capture rain water onsite and to eliminate combining storm flow with sanitary sewer flows—and adding vegetation to cityscapes can mitigate many of the negative impacts of existing communities on water resources. New development can be designed and built to meet Low Impact Design (LID) standards.

There is a critical need to understand the relationship between land cover and water quality and quantity, and population growth and development within the Delaware River watershed.

-Delaware River Watershed Source Water Protection Plan
Philadelphia Water Department (PWSID#1510001)
June 2007

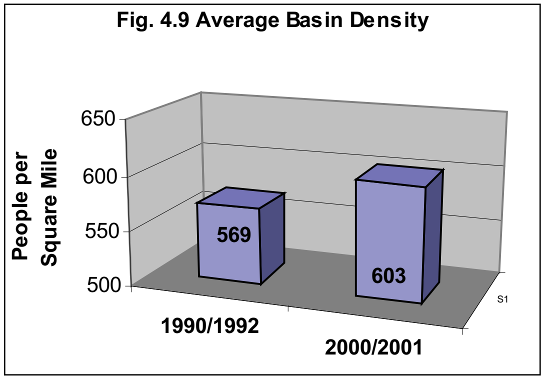


Fig. 4.9 Average Basin Density

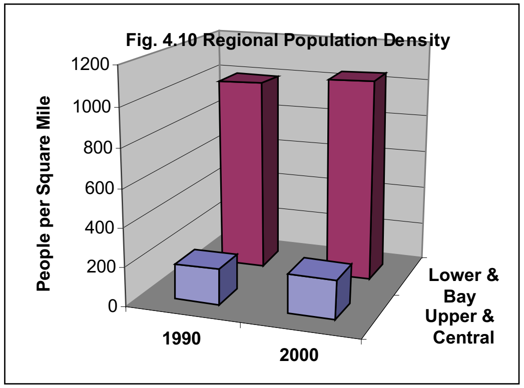


Fig. 4.10 Regional Population Density

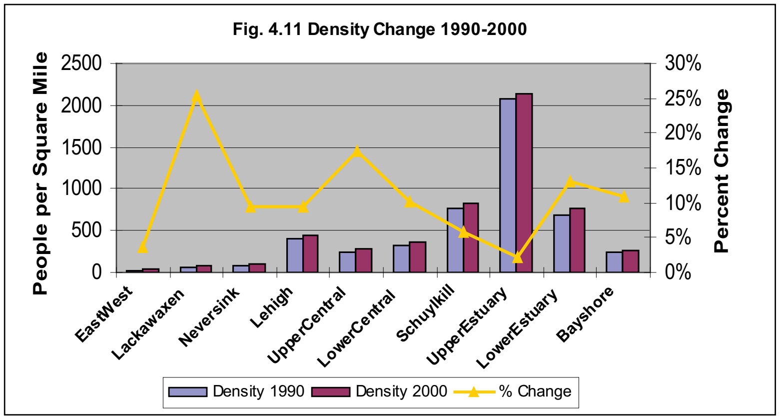


Fig. 4.11 Density Change 1990-2000

Indicator • Land Use 2001

Not Rated

The 2003 Final Report of the New Jersey Comparative Risk Project identified land use change as lying at the heart of many environmental problems, producing by a wide margin the largest negative ecological and social impacts.

Indicator Description

Land use plays a crucial role in water resource condition. The alteration of the landscape for human use can be a major factor in the alteration of ecological processes at local and global scales. Most physical and chemical changes to waterway systems are linked to land use and landscape change, although many of those links are complex and therefore difficult to evaluate and quantify. Potential impacts to water resources are shown in Table 4.1.

Desired Condition

Maintenance of the integrity and function of high value water resource landscapes and habitat for species diversity (BP Goal 3.2, CCMP Actions L1-18).

Status

As of 2001, 55% of the basin landscape was dominated by forest cover, 26% was in agricultural use, and developed land accounted for nearly 15% (Fig. 4.12).

Wetlands, a crucial landscape for water resources and biodiversity, are represented as only 4% of the landscape. This figure may under-represent the full extent of wetlands across the basin, especially isolated wetlands or wetland systems under forest canopy which are abundant in the watersheds of the Upper and Central Regions, but counted as forest in this assessment. Tidal wetlands, a dominant feature of the coastal fringes of watersheds in the Lower and Bay Regions, are more accurately captured.

Land use differs remarkably among the watersheds of the basin (Fig. 4.13). In the Upper and Central Region watersheds, forest cover dominates. The watersheds of the Lower Region have a higher percentage of developed land, while agriculture and wetlands are the more dominant features of the Bay Region.

Development has historically occurred at river confluence points, and the development at the confluence of the Lehigh (LV3) and the Schuylkill (SV3, UE1) with the Delaware River are very visible on Figure 4.14.

The concentration of human development and uses, such as ports and industry, in the Lower Region watersheds is related to water quality problems in this portion of the River. See the timeline in the Water Quality

Fig. 4.12 Basin Land Use 2001

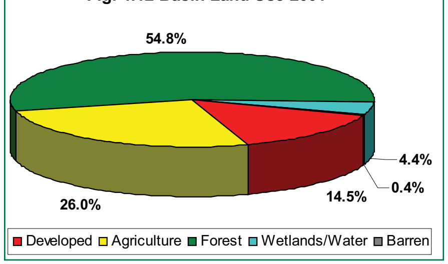
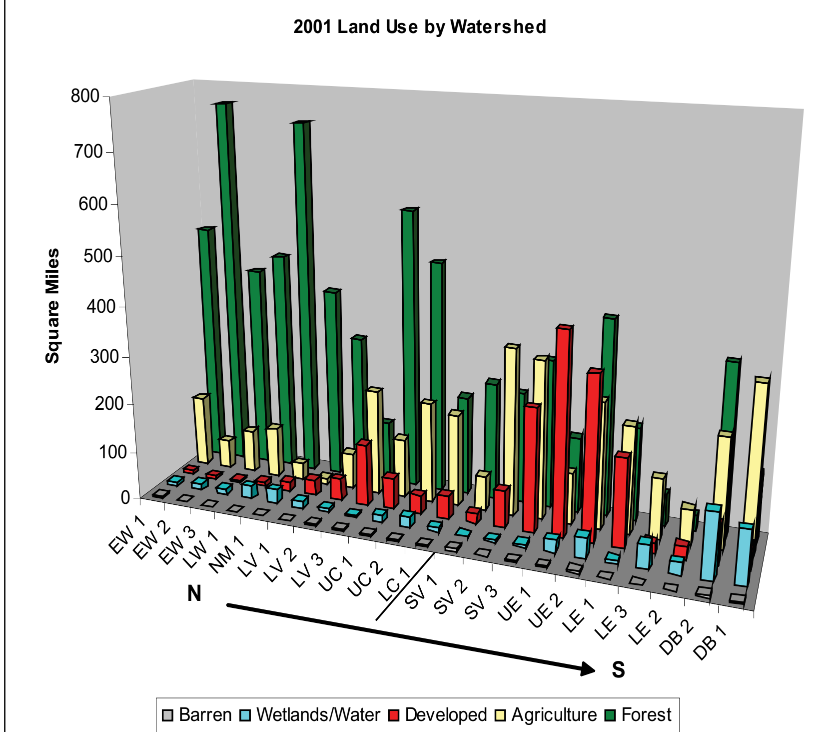


Fig. 4.13 Watershed Land Use 2001



Watersheds

Upper Region	EW•East & West Branch; LW•Lackawaxen; NM•Neversink & Mongaup
Central Region	UC•Upper Central watersheds; LV•Lehigh Valley; LC•Lower Central
Lower Region	SV•Schuylkill Valley; UE•Upper Estuary; LE•Lower Estuary
Bay Region	DB1•Bay watersheds in DE; DB2•Bay watersheds in NJ

Fig. 4.13. There is an obvious land use gradient form upstream to downstream through the watershed. Forested land decreases and agricultural and landscapes generally increase from north to south. Developed land is concentrated in the watersheds of the Lower Region. The relative dominance of the coastal wetlands in the Bay Region is also visible.

section of this report for an historical perspective.

Trends

Based on a land use change analysis from NOAA's Center for Coastal Services, about 70 square miles of basin land was developed between 1996 and 2001. The change analysis also revealed a 48 square mile loss of forested land and 18 square mile loss of agricultural land. The wetlands and water category lost about 3.5 sq mile. Table 4.3 shows the change in acres and square miles.

The conversion of landscapes to development occurred at a rate of 25 to 35 acres per day, or an average of 132 football fields each week. Figure 4.15 illustrates landscape conversion as a daily average.

Naturally, land use change has not occurred uniformly across the basin. Between 1996 an 2001, more development occurred in the watersheds of the Lehigh and Central regions than in other watersheds. The high loss of forested land in the Lehigh is especially noteworthy (Fig. 4.16).

Although forested lands have increased since the 1930s, recent data show a decline in forested landscapes as well as wetlands. A more detailed assessment of changes to these landscape types follows, but improved mapping and assessment of changes to these landscape types follows.

Actions and Needs

- More refined landscape assessments, preferably orthophoto, should be coordinated for the basin on a time frame coincident with the decadal and mid-decade census.

Table 4.3 Landscape Change 1996-2001

Land Use	Change in Sq Mi	Change in Acres
Developed	70.75	45,283
Agriculture	- 18.41	- 11,781
Forest	- 48.29	- 30,909
Wetlands/Water	- 3.48	- 2,230
Barren	- 1.21	- 772

Source: NOAA Center for Coastal Services

Fig. 4.14 Map of Basin Land Use 2001

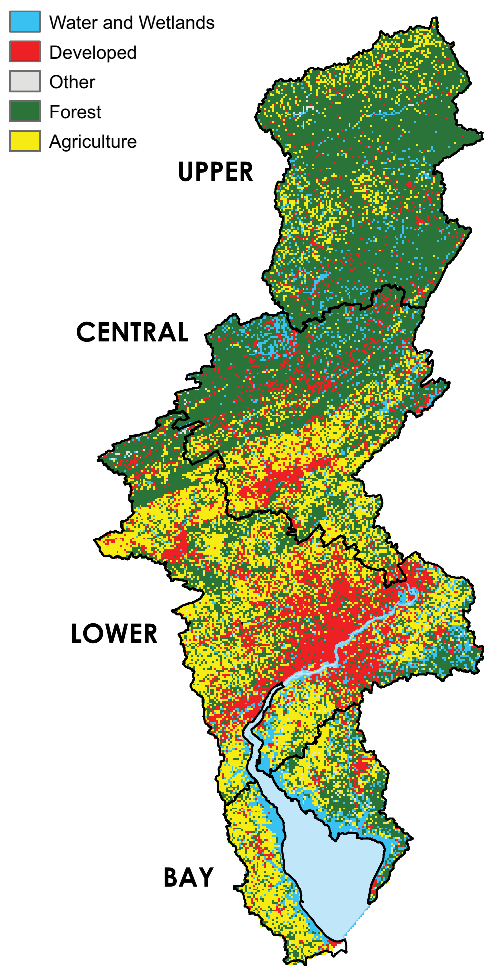


Fig. 4.15 Land Use Change per Day 1996-2001

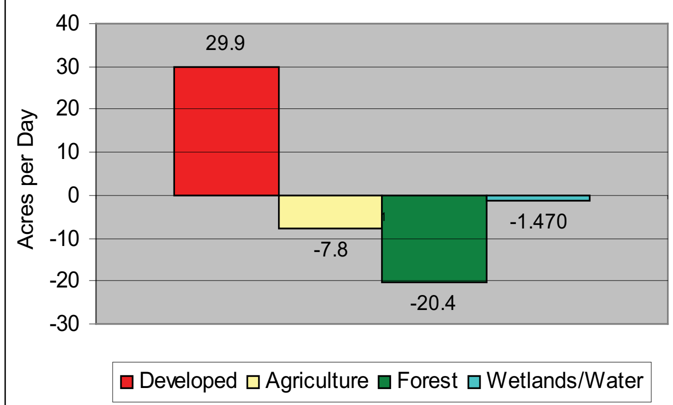
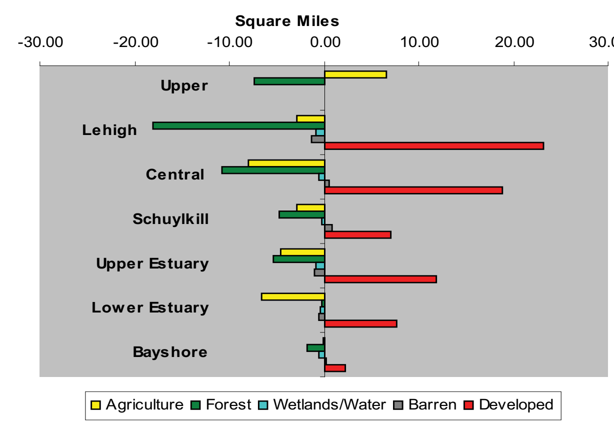


Fig. 4.16 Regional Land Use Change 1996-2001



Indicator • Land Consumption

Land Consumption

The amount of land that is developed per person is a measure of land use efficiency. An increase in land consumption indicates that more acres of land are being developed or altered for each additional person.

Desired Condition

A decreasing or stabilized rate of land developed per capita and protection of landscapes necessary to water resources through efforts to redevelop areas with existing infrastructure (BP Goal 3.4, CCMP Action L16).

Status

Poor: *Per capita* amount of land being developed is increasing.

In 1995, the population of the basin was 7,591,690 and developed land covered approximately 1,790 square miles or 1.44 million acres. On a *per capita* basis, each person represented 0.151 acres of developed land. In 2001, this *per capita* figure had risen to 0.153 acres. Although apparently small, it indicates that the rate of land conversion in relation to changes in population has increased even within a very short 5-year time frame.

In 1995 the cumulative result of historic land development was 0.151 acres of developed land per person. Between 1995 and 2000, the basin's population increased by 166,980 people. Developed land increased by nearly 71 square miles (45,280 acres) in roughly the same time period (1996–2001). The land consumption ratio for this five year period was 0.271 acres per person, nearly double the historic average (Fig. 4.17).

Trend

While coarse, this analysis is revealing: we are developing land at a far greater rate than we have historically. The proliferation of large-lot subdivisions —large homes on several acres—bear witness to this trend.

Rising fuel and construction costs, however, may act as the economic brakes that turn this trend around. Efforts to redevelop housing in urban areas, where social and cultural amenities, utilities and transportation networks are well established, are underway in many cities, fueled by changing demographics and demand.

Actions and Needs

- Analysis of land consumption requires accurate information about land use and population change in representative time periods. Currently, census and land use data are not collected within the same time periods and questions of accuracy in both data sets confound use of the data at smaller scales.
- Understanding how we use land is essential for increasing our efficient use of the landscape and for protecting the landscape functions that support water resources. Additional efforts to link landscape use and change to resource condition and to identify performance standards for land use management are necessary for comprehensive water resource protection.

How big is ...
43,560 square feet = 1 acre
640 acres = 1 square mile
1.32 acres = 1 football field

Between 1996 and 2002, land was developed at an average rate of about 19 football fields per day. Nearly 70% of all land conversion took place on previously forested landscapes.

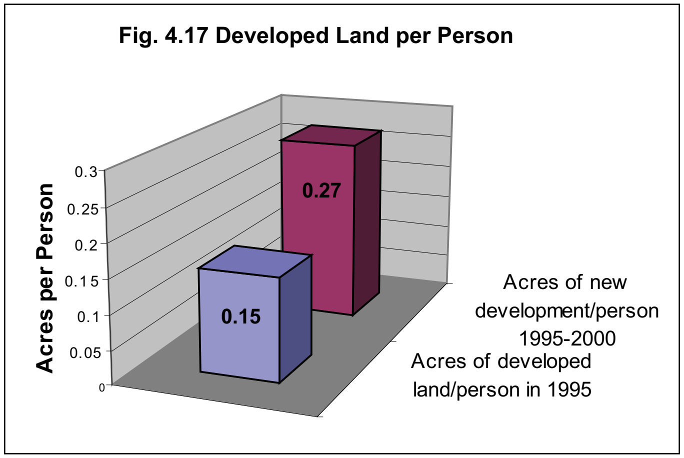


Fig. 4.17 New development of land is occurring at nearly twice the historic ratio.

Indicator • Dams

Indicator Description
Dams are structures built across a water course to impede the flow of water. Historically, dams were built to impound water for irrigation and drinking water supply, for power production, and to create recreational lakes and ponds. These structures pose some harm to ecosystems by causing genetic isolation among sub-populations of resident aquatic life, contributing to anoxic (de-oxygenated) conditions, and inhibiting the migration of spawning fish.

Desired Condition
Restoration of fish access to spawning grounds and ecological connectivity within tributary streams and rivers. Maintaining and enhancing stream flows and ecological health and diversity are primary goals for basin waters (BP Goal 1.2; CCMP Action H5.7)).

Status
Poor: 1550 dams remain on tributaries of the Delaware, blocking fish passage and disrupting the natural hydrology.

The Delaware River is the longest undammed river east of the Mississippi, but approximately 1,550 tributary dams impede stream flow and fish passage. All but a few hundred of these dams were built since 1900. Most are old and many have exceeded their design life, adding concerns about public safety to those of ecosystem health.

It is becoming a common practice to install fish passages to aid the movement of migratory fish up and down stream. Since 1991, the construction of fish ladders has opened up approximately 165 miles of streams in the Lower and Bay Regions to fish migration (PDE 2008). Unfortunately, figures on the total number of stream miles opened to fish passage across the basin are not readily available.

Trend
There is growing interest in dam removal for both ecological and public safety benefits. Several advocacy groups are leading efforts for fish passage construction and dam removal. Pennsylvania reports to be leading the nation in dam removal. The Natural Resources Conservation Service (NRCS) is actively involved in dam evaluation and removal in the basin.

Dam removal is not without controversy. Dams capture sediment which frequently harbors legacy pollutants from upstream farming and industrial activity. Disturbing and disposing of these sediments adds some ecological risk and considerable financial costs to dam removal projects. Re-establishing natural stream corridor conditions—including flow, flood plain function and vegetation—can be a complicated undertaking.

Actions and Needs
- Accurate information about dams and the potential for remediative actions, such as feasibility for dam removal or for the installation of fish ladders, is necessary for continued monitoring and reporting of this indicator.
- Identification and prioritization of restoration projects on a watershed basis could increase efficiency in planning projects and securing resources.
- While the establishment of fish passage is a sound indicator for fish migration, it is only one measure of the health of aquatic communities. Additional indicators for aquatic and riparian community health and for stream corridor integrity and function should be developed.

Anadromous **fish such as shad and sturgeon live in the ocean and return to the fresh water of their birth to spawn.**

Catadromous **fish, notably the American eel, spend most of their lives in fresh water and migrate to the sea to breed.**

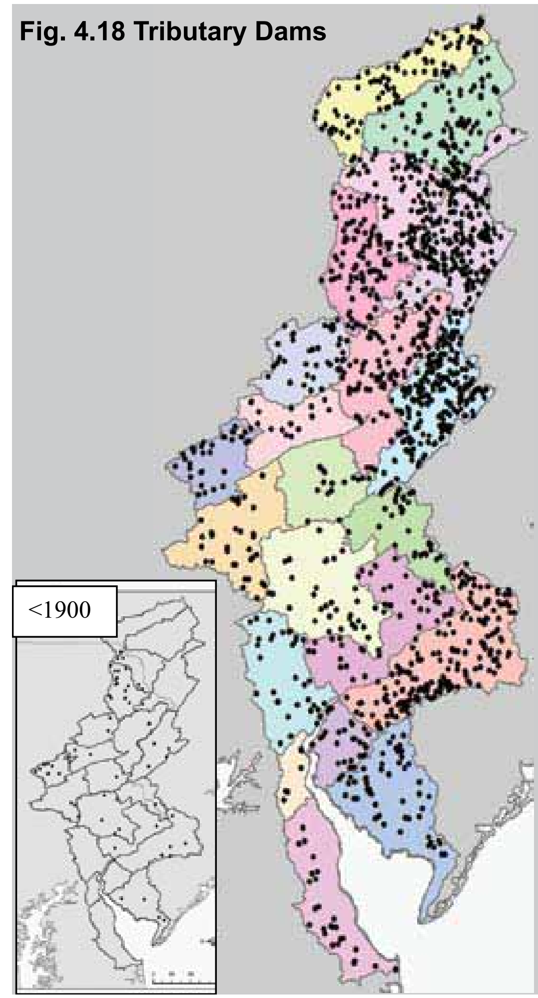
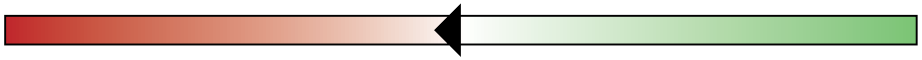


Fig. 4.18. Current location of dams within the basin compared to the location of dams built before 1900 (inset) showing their proliferation in the 20th century.

Indicator • Forests



Indicator Description

Forested landscapes are those with a high percentage of tree canopy and an absence of agriculture and development. Forested land is of prime importance to water resources, playing an important role in temperature moderation, nutrient transfer, oxygen generation, maintenance of soil health, and protection of natural hydrology.

Vegetated riparian corridors, especially forested edges of headwater streams, are important to water resource quality and aquatic ecosystems. For example, forested corridors significantly reduce nitrogen, phosphorus and sediment loadings to streams in proportion to their width; 100 foot stream buffers can reduce loadings by 80%–90%.

Desired Condition

Maintenance of forested landscapes of value to water resources and wildlife (BP 3.2; CCMP Actions L4,L6).

Status

Fair: The basin is losing forested land important to water resources.

The rate of forest loss in the Delaware basin exceeds 12 football fields per day.

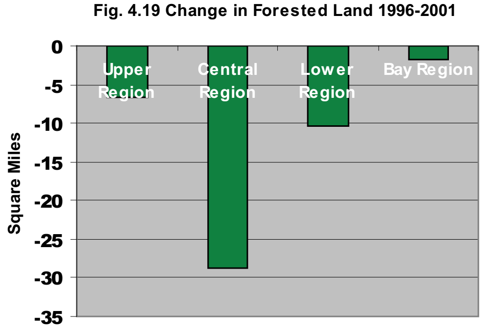
~

One football field-sized swath of forest is cleared every 2 hours.

While still the predominant land cover in the basin, forested land decreased by nearly 50 square miles between 1996 and 2001. Forest was lost in every region of the basin, but the greatest loss was in the Central Region (Fig. 4.19) where the Lehigh Valley and Delaware drainage watersheds of Pennsylvania are undergoing substantial population growth.

Of the 6,263 square miles remaining, approximately 782 (11%) are protected under state or federal ownership, i.e., part of federal and state forests, forest preserves and gamelands (Fig. 4.21). Forested land accounts for 88% of state and federal landholdings in these categories.

Fig. 4.19 Change in Forested Land 1996-2001



Trend

As a result of re-growth following decades of timber harvesting and clearing of land for agriculture, the amount of forested land

Fig. 4.20 Map of Basin Forests

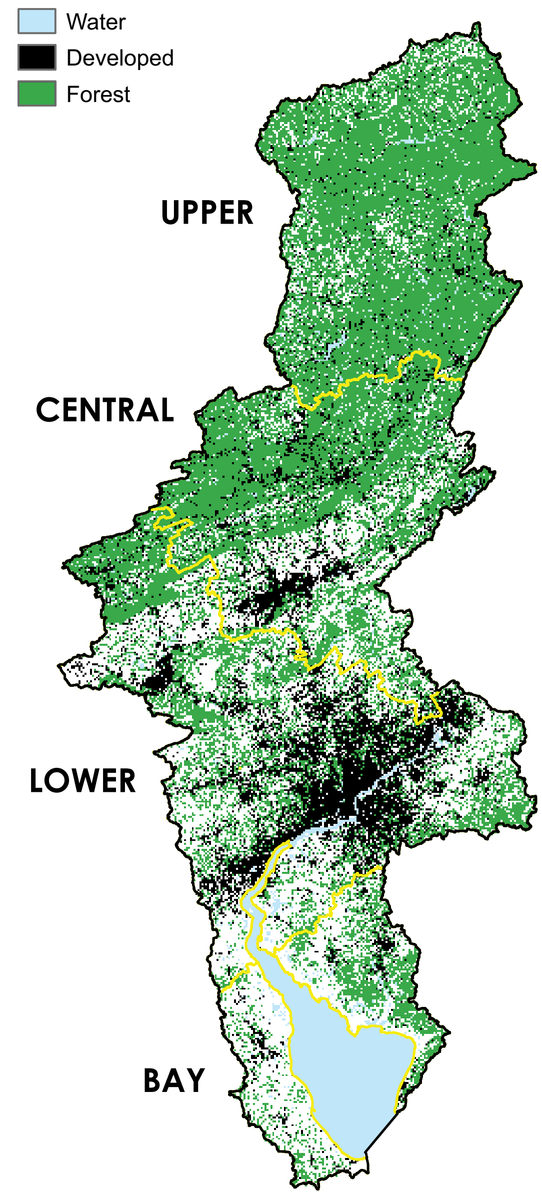


Fig. 4.21 Forested Land 2001

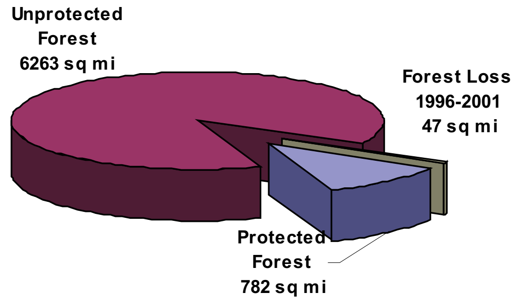
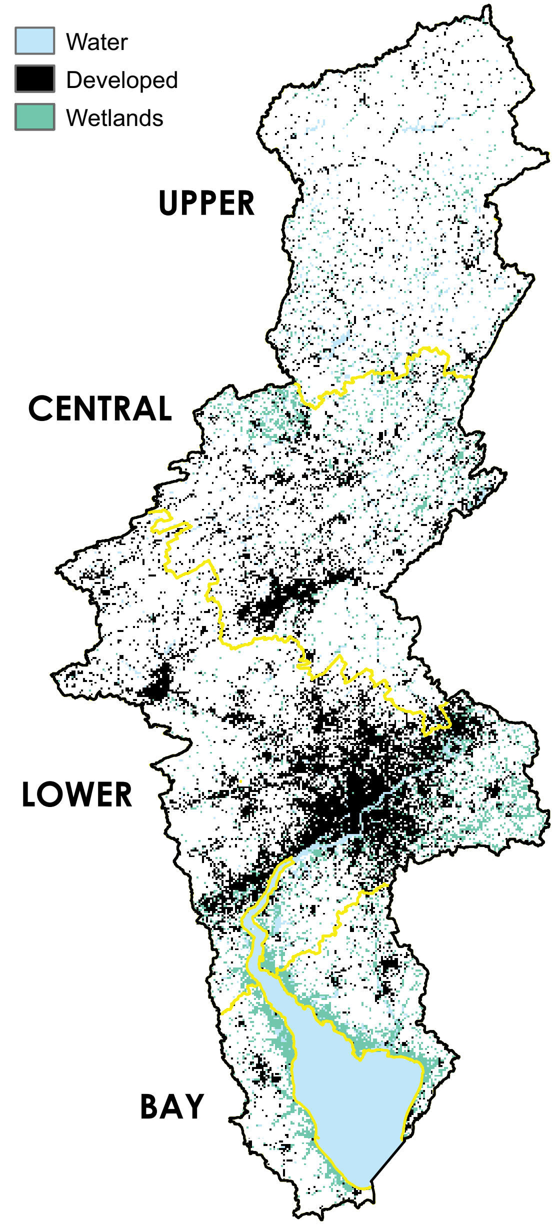


Fig. 4.22. Map of Basin Wetlands



increased between the 1930s and the mid-1990s. More recent information, however, shows that forested landscapes are being lost at the rate of more than 6,000 acres per year. In more graphic terms, that is in excess of 12 football fields per day or about one 1.32 acre football field every 2 hours.

As additional forest is converted for development or cultivation, the percentage of protected land will increase even though no additional land is being preserved. Other methods of protection, such as easements, land trusts and forest management plans, can be effective means of ensuring the landscape function of forested land. The extent of such private efforts is not accounted for in this assessment.

Stroud Water Research Center estimates that full restoration of riparian forest buffers would significantly reduce stream pollution levels even without changes to point and non-point discharges, and the PA Campaign for Clean Water has recommended that all streams be afforded a minimum 100 foot forested buffer. New Jersey recently improved protection of high quality streams by increasing regulatory control of disturbance within 150 feet.

Actions and Needs

- Forest status, including the extent and function of forested land by region, should be assessed and reported on a regular basis, preferably synchronized to census and development information.
- Assessments of riparian buffers should include active river areas—inclusive of all lands within which a river interacts in dynamic processes—and be incorporated into future condition status reports.
- Improve the mapping, assessment and tracking of forested wetlands.

Indicator • Wetlands

Indicator Description

Wetlands are lands that attain a sufficient degree of saturation to affect soil chemistry and maintain a specialized assemblage of wetland-related plant species. The value of wetlands is substantial. Their unique biogeochemical properties filter sediments and pollutants from runoff, and process carbon and nitrogen. During storms, wetlands buffer the effects of wind and precipitation, a function especially important in riparian and coastal areas for flood and erosion protection. Wetlands also furnish essential spawning, foraging, and nesting habitat for finfish and shellfish, birds, and other wildlife, including those important to local economies.

Desired Condition

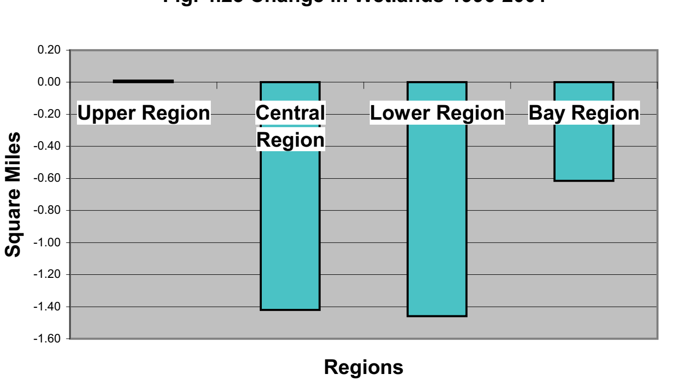
There is a federal policy to attain "no net loss" of wetlands and wetland function. State and federal programs are in place to protect wetlands (BP Goal 3.2, CCMP Actions H4, H7).

Status

Fair: Rate of loss has slowed, but continues. Assessments of functional integrity are needed.

The NOAA assessment of changes to land cover between 1996 and 2001 (NOAA 2008) shows approximately 3.5 square miles (2,300 acres) of wetland loss. While the net change for the basin was small, these changes are concentrated principally in five watersheds: the headwaters of the Lehigh (LV1), the Pennsylvania watersheds of the Central Region (UC1), the New Jersey and Delaware watersheds of the Lower Region (UE2, LE2) and the watersheds of the Bayshore Region (DB1, DB2). Not surprisingly, these same areas also experienced significant population increases in the last decade ranging from 13% to 50%, and all more than twice the basin average of 6%.

Fig. 4.23 Change in Wetlands 1996-2001



All of the watersheds with tidal wetlands showed a loss, except the Lower Estuary watersheds of New Jersey (LE3). Marsh restoration efforts, undertaken in the past decade to offset ecological impacts of power generation, may be responsible for the small increase in that area.

In spite of protection and restoration efforts, *de minimis* changes are accumulating into measurable losses of wetland landscapes.

Trends

The extent and integrity of wetlands in the Delaware River basin and estuary has been under human assault for over 300 years. In the estuary perhaps 50 percent of the natural marshes have been lost to development, conversion, or degradation. Losses have been most severe in the urban corridor where perhaps only five percent of pre-settlement of freshwater tidal marsh remains.

In 2005 New Jersey reported that the annual rate of wetland conversion appears to have slowed since the state Freshwater Wetlands laws went into effect in 1988; the loss between 1995 and 2000, based on satellite imagery and aerial photography, is half of that seen from 1986 to 1995 (New Jersey's Environment 2005: Trends, NJDEP). Too little information on wetlands conversion is available to determine definitively how the rate of change is progressing across the basin, and less is known about the degree of impairment to wetland functions. Wetlands remain vulnerable to both human landscape conversion and, in the case of tidal wetlands, to changes in sea level.

R. LIMBECK, DRBC

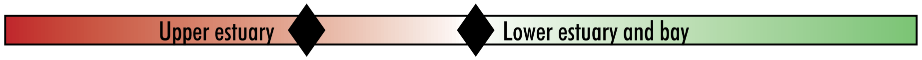
Tannersville Bog located along Cranberry Creek, Monroe County PA, is the southernmost low-altitude boreal bog in the eastern US.

Actions and Needs

- Coordinated monitoring and assessment programs are needed to track the extent and condition of fresh water and tidal wetlands on a regular basis.
- Additional attention should be paid to freshwater wetlands in forested areas, which are poorly mapped since they are often hidden under forest canopy.

New Jersey's Environment 2005: Trends is available at http://www.state.nj.us/dep/dsr/trends2005/.

Indicator • Tidal Wetland Buffers



Indicator Description

A wetland buffer refers to the area immediately landward of a tidal wetland. Buffers that remain in a natural, undeveloped state provide the opportunity for wetland migration in response to changing hydrologic conditions. This is especially important for tidal wetlands where the inability to migrate can mean a loss of this vital landscape feature.

Buffers are an important indicator of the future conditions of tidal wetlands, which play a unique role in the reproductive cycle of many aquatic and avian species, and in the recycling of nutrients, especially carbon.

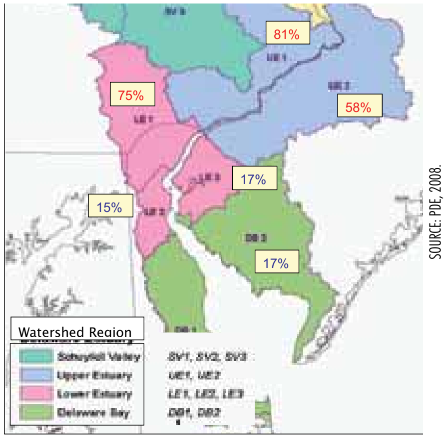


Fig. 4.24. Wetland Buffers. The percentages in each watershed region denote the proportion of land that is unavailable for marsh encroachment due to development in the one-kilometer buffer just inland of tidal marshes. Based in 1992 NLCD.

Desired Condition

Protection of tidal wetlands and their ability to migrate in response to changing conditions (BP Goal 3.2 ; CCMP Actions H4, H7).

Status

Poor: Upper estuary
Fair: Lower estuary and bay.

The Delaware River has one of the largest freshwater tidal prisms in the world extending approximately from Trenton NJ to Wilmington DE. The gradual transition from fresh to salt water allows for freshwater tidal wetlands in the upper estuary, brackish marshes in the middle estuary, and salt marshes surrounding Delaware Bay. Together, these wetland types form a nearly continuous perimeter fringing the tidal system.

Land use within 1,000 meters of tidal wetlands was analyzed using 2001 land use (PDE 2008). The results indicate that the majority of buffer land in the Upper Estuary watersheds (UE1, UE2) is developed and unavailable for the development and migration of the freshwater wetlands characteristic of this portion of the tidal river.

In the Lower Estuary Region, more land is available to accommodate landward advancement of wetlands, except in LE1. Land also remains available in the Bayshore watersheds, although recent population and development trends indicate that much of this land may be in jeopardy from conversion for cultivation or development.

Trends

The good news is that land remains available along the bayshore for the migration of tidal wetlands (Fig. 4.24). Historically, the production of salt hay and the development of dikes to keep out the tides were common practice in these areas. Recent restoration efforts, especially on the eastern bayshore, have restored these lands to the tidal regime of the Bay and enabled wetland migration and survival. The more problematic news is that most buffer area is unavailable to the establishment and migration of freshwater and brackish wetlands in the Lower and Upper Estuary Region.

Human population continues to expand into coastal watersheds. According to a New Jersey report, new development encroaches within 50 feet of 1000 acres of wetlands each year, and within 300 feet of more than 6000 acres of wetland each year (New Jersey's Environment 2005: Trends, NJDEP 2005). This leaves little room for wetland adaptation to changing conditions.

An acceleration of sea level rise adds additional stress, as it quickens the pace of migration necessary to ensure tidal wetland survival. There is also evidence that land subsidence may be magnifying the effects of climate-related sea level rise in some coastal areas.

Development is seen encroaching on the tidal wetland buffers at John Heinz National Wildlife Refuge, PA's largest remaining freshwater tidal marsh. Freshwater tidal wetlands are one of the most diverse types of marsh in the Delaware estuary, and they are nationally rare.

Actions and Needs

- An analysis of wetland buffers should be completed often enough to be useful for targeting areas for preservation.
- Policies discouraging development and redevelopment in wetland buffer areas, and restoration strategies to facilitate the landward transgression of marshes should be developed.

LANDSCAPE

Feature • Landscape

Valuing Natural Landscapes

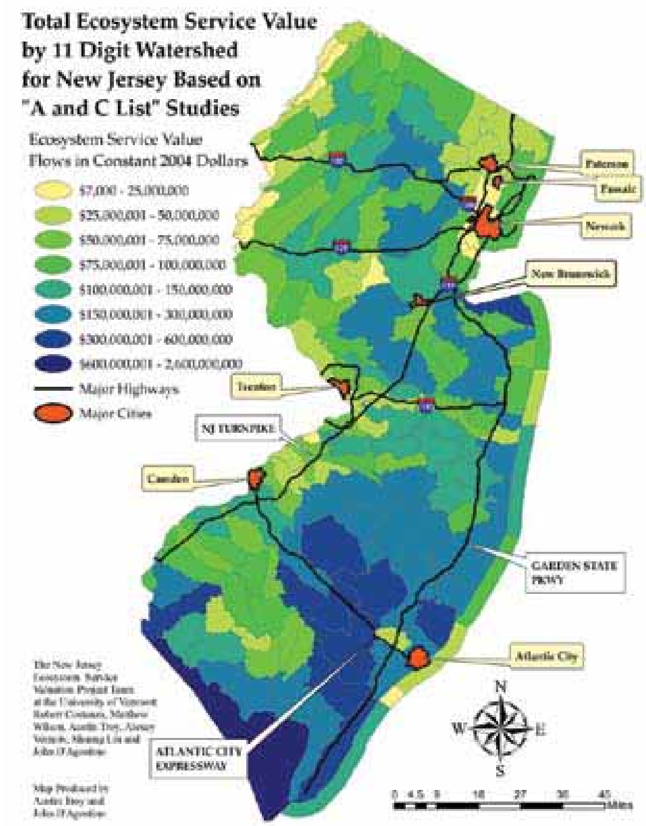


Fig. 4.25. NJ Watershed Ecosystem Service Value.

Natural Capital Project

In 2002, the New Jersey Department of Environmental Protection (NJDEP) began a multi-year study of the economic value of the state's "natural capital." The project is based on the recognition that the various components of the natural environment provide long-term streams of benefits to individuals and to society as a whole and can therefore be viewed as capital assets or, in the aggregate, as "natural capital".

Many of the benefits provided by natural capital come from ecological systems (ecosystems) such as forests, wetlands, and lakes, and include both goods (products) and services provided by both biotic (living) systems, and abiotic (non-living) systems. Goods are tangible commodities such as mineral deposits, fish and timber. Services are process-related outcomes, such as climate regulation, nutrient cycling and crop pollination. See tables for examples of the types of ecosystem goods and services that the New Jersey team considered during the valuation process.

The goods and services of natural capital provide economic value to us as individuals and as a society. The on-going benefits are usually expressed in terms of dollars per year; as with any capital asset, the value of natural capital equals the present value of the related benefit stream. In deriving estimates for those values, the study used several approaches, including value transfer, hedonic analysis, spatial modeling, and market value analysis. The full reports is available from NJDEP at www. state.nj.us/dep/dsr/naturalcap/.

Results

As economic assets, ecosystems provide substantial benefits over time. Values are reported in 2004 dollars.

- New Jersey's ecosystem assets are worth at least $26 Billion per year in goods and services.
- Present value of these New Jersey resources is estimated to be at least $850 billion.
- In general, areas containing wetlands, estuaries, tidal bays, and beaches have the highest ecosystem service values on a per acre basis.
- Different spatial patterns of land use affect ecosystem service levels; Landscape modeling shows that the size and location of ecosystems relative to each other significantly affects their level of ecoservice production. For example, forests located close to an estuary zone contribute more to estuary water quality than forests located further away. For the water quality index, the difference can be as large as 40%.
- Within the overall total, natural goods in the aggregate have an economic value of over $1 billion annually and a present value in the tens of billions of dollars.
- Estimating sustainable harvest or extraction levels for goods is a major challenge,

Table 4.4 Present Value 2004 of New Jersey's Natural Capital (excluding ecotourism)

Ecosystem	Area	NATURAL GOODS & SERVICES			
	(Acres)	$MM/yr	$/ac/yr	PV $Bn	PV $/ac
Freshwater wetland[1]	814,479	$9,612	$11,802	$320.4	$393,394
Marine[2]	755,535	$6,550	$8,670	$218.3	$288,987
Farmland	673,464	$4,242	$6,229	$141.4	$209,982
Forest land[3]	1,465,668	$2,512	$1,714	$83.7	$57,136
Saltwater wetland	190,520	$1,194	$6,269	$39.8	$208,973
Barren land	51,796	$587	$11,337	$19.6	$377,893
Urban[4]	1,483,496	$439	$296	$14.6	$9,869
Beach/dune	7,837	$330	$42,149	$11.0	$1,404,969
Open fresh water	86,232	$145	$1,686	$4.8	$56,208
Riparian buffer	15,146	$53	$3,500	$1.8	$116,681
Total or Avg.	**5,544,173**	**$25,664**	**$4,630**	**$855.4**	**$154,317**

[1] Forested & unforested freshwater wetlands
[2] Estuary/tidal bay and coastal shelf
[3] includes wooded farmland
[4] Urban impervious and green space

and the amount of natural goods provided is subject to change as land use patterns, climate, and other factors change in response to societal land use decisions and wider environmental trends such as global warming.

Actions and Needs

With the release of the natural capital report in April of 2007, the NJ project entered a second phase focusing on disseminating the report's findings as widely as possible and developing ways to help state and local officials, planners, and citizen groups use the study's findings when making decisions on master plans, zoning, and permitting. Economic analyses such as those described above should not be the sole criterion for environmental protection, but such analyses can shed light on the trade-offs we face in making land use decisions and can suggest which land use alternatives will result in the most favorable outcomes for society as a whole.

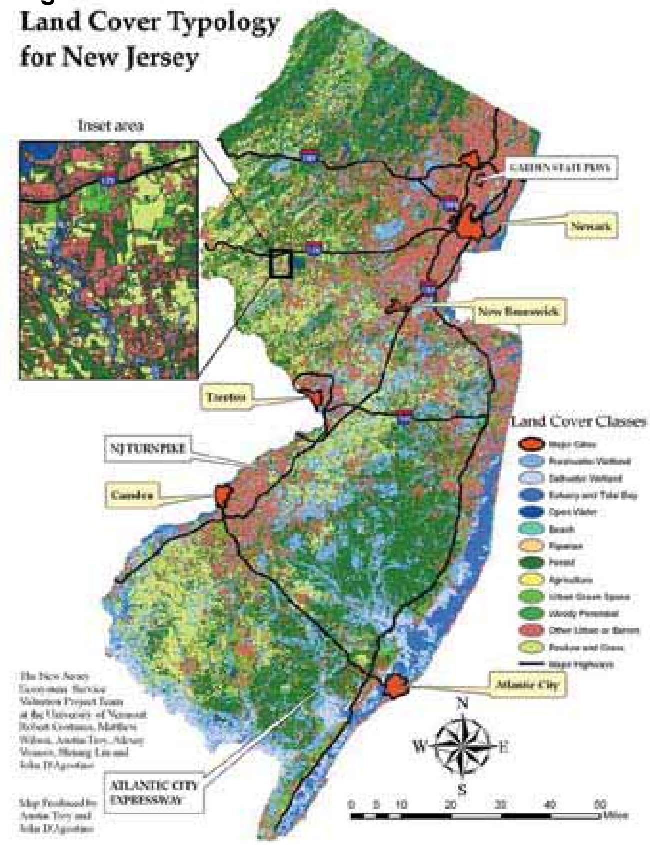
Delaware River Basin ~ Forest Capital
Present Value of Forests: $258 B
Lost Forest Capital (1995–2001): $ 1.7 B

The Delaware River Basin is blessed with visually breathtaking and functionally valuable natural resources. While significant gaps exist in the valuation literature, it is clear that natural systems have substantial economic value and maintenance of these systems in a healthy functioning state can help avoid costly expenditures on artificial replacements such as water treatment plants and flood control infrastructure.

Applying the present value of goods and services derived from the NJ study to the landscapes of the basin yields a coarse estimate of the value of its goods and services. For example, in 2001 forests covered over 7,000 square miles of the basin and, at a present value of $57,136 per acre, were worth nearly $258 billion. Between 1995 and 2001, the basin lost 47 square miles of forest with a natural capital value of $1.7 billion in goods and services. This is a very conservative estimate since it does not include an economic valuation of several services that forests provide, including long-term carbon storage, dampening of stormwater runoff and peak stream flows, and the removal of pollutants such as carbon monoxide, sulfur and nitrogen dioxides, ozone, and particulates from the air. Including such services could conservatively add more than $6,000 to the value of an acre or an additional $36.9 billion to the value of the basin's forests.

More detailed analyses to fully cover the services of landscapes found in the basin, especially those that are shared by the basin at large, such as the Delaware River and Bay, would give a fuller picture of the economic value of the basin's natural capital. Valuing our natural resource base is a necessary step to improving decisions that impact ecosystem function, and to preserving those functions for their long-term value to society.

Fig. 4.26 NJ Land Cover



Examples of Ecosystem Goods and Services

Ecosystem Goods

- Farm products, fiber and food
- Commercial fish
- Raw water
- Saw timber
- Fuel wood
- Game animals, fur
- Minerals

Ecosystem Services

- Climate regulation
- Soil creation
- Habitat
- Flood mitigation
- Pollination
- Air quality
- Water quality
- Nutrient cycling
- Recreational and aesthetic experiences
- Other functions that would require money to replace