CHAPTER 2 MEASURING RECENT URBAN GROWTH IN NEW JERSEY

Introduction:

New Jersey's Landscape at the end of the 20th Century

The current landscape of New Jersey is a reflection of physical geography (geology, climate, ecology) and cultural geography (i.e. how people live in a particular area, their customs, history, legal systems, economics and technologies, etc.). Geology has had a major influence on New Jersey's cultural and physical landscape. The soils along the western flank of the state are highly productive for many types of agriculture. The pine-oak forests of the Pine Barrens are largely confined to the porous, sandy soils of the outer coastal plain. Rocky, glacially carved hills in the highlands provide a rugged landscape of lakes and wetlands among forested ridges. New Jersey is uniquely situated between the major metropolitan areas of New York and Philadelphia, which has had a tremendous influence on how the landscape has developed. All of these geographic conditions result in the current land use/land cover pattern of New Jersey (Figure 2-1).

The State of New Jersey occupies approximately 5 million acres. The land can be categorized into five major categories. Nearly 1.35 million acres of urban land (cities, towns & suburbs) exists in the State largely in the metro regions of Philadelphia and New York. 740,000 acres of agricultural lands can be found in New Jersey's farming belt. 1.6 million acres of forest exists largely in the Pine Barrens and the Highlands region. 917,000 acres of wetlands exists throughout the Pine Barrens, the Great Swamp, along the coastal and riparian estuaries and in thousands of smaller pockets throughout the state. Together these land use/land cover types describe the landscape of the Garden State.

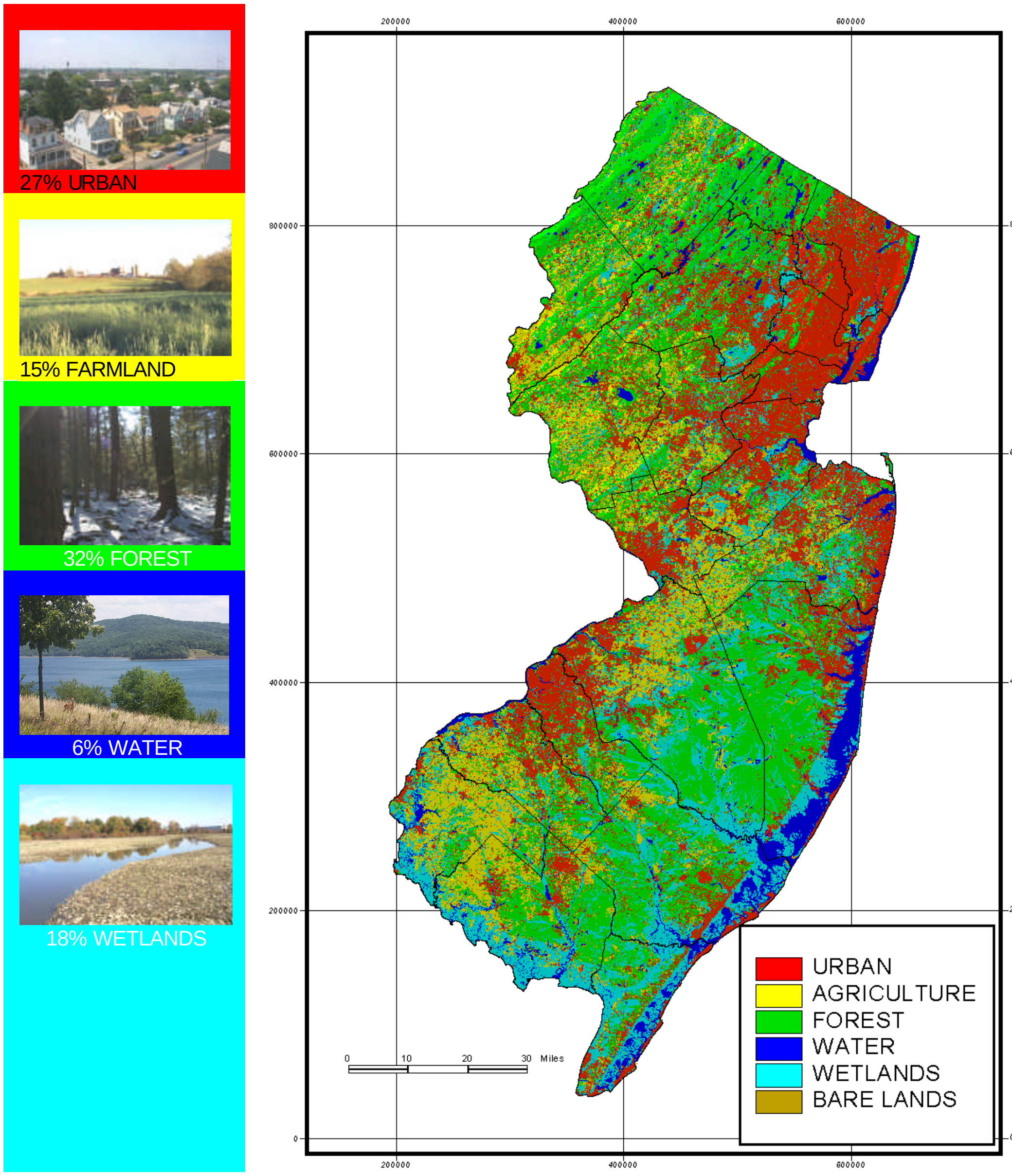

Figure 2-1 *New Jersey Land Use 1995. This map portrays the land use pattern of New Jersey illustrating the urban/suburban regions adjacent to New York and Philadelphia, the Pine Barrens in the Southern core, the agricultural regions flanking the western part of the state and the coastal, palustrian, and forested wetlands which occupy nearly a fifth of the state's territory.*

Measuring Recent Landscape Change in the Garden State

Like all landscapes, New Jersey's unique land use/land cover pattern is constantly changing. These changes are evident in satellite imagery (Lathrop 2000) and aerial photography taken at different time periods (Figure 2-2). The New Jersey Department of Environmental Protection (NJDEP) utilized multi-date aerial photography to produce detailed land use/land cover data for the entire state (NJDEP 2001). To facilitate the burgeoning movement toward watershed-based environmental management, the NJDEP produced the dataset in sections which coincide with each of New Jersey's 20 watershed management areas (WMA's). This statewide dataset contains land use/land cover information from 1986 and 1995 as well as estimates of impervious surface coverage for each land use map unit (i.e., polygon). Figure 2-3 demonstrates a portion of the *Lower Delaware* (WMA18) dataset for the Mullica Hill, Gloucester County area. This report utilizes this and additional geodata sets for the entire state.

(a) Mullica Hill *1977* (b) Mullica Hill 1995

Figure 2-2a, 2-2b *Multidate aerial photography of Mullica Hill, Gloucester County. The multi-date aerial photography above demonstrates landscape change over time. The panchromatic photograph on the left was taken in 1977. The color infrared photograph on the right was taken in 1995. Areas of new urban growth that occurred from 1986 to 1995 as delineated from the NJDEP dataset are outlined in yellow.*

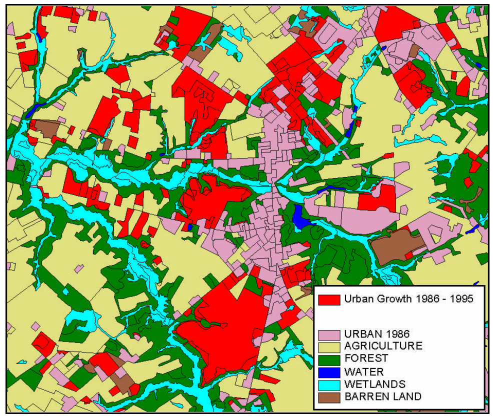

Figure 2-2c *The NJDEP 1995 Land Use/Land Cover dataset for the Mullica Hill, Gloucester County area. Each map unit area (polygon) contains land use information for 1986 and 1995 as well as impervious surface estimates.*

Method of Analysis

The NJDEP land use/land cover dataset was produced as 20 separate Arcview ™ Shapefiles corresponding to the NJDEP Watershed Management Areas (WMA's) (NJDEP 2001). The NJDEP developed the dataset at the watershed management area basis due to the sizable file size required by the detailed nature of the data and the policy shift of the DEP toward watershed-based management.

To analyze state-wide trends this research combined the 20 WMA datasets into one statewide shapefile. The resulting state-wide land use shapefile contained an unwieldy 594,558 polygons. The shapefile was then converted into a state-wide grid to facilitate analysis. The grid cell size chosen was 208.71 feet which is the equivalent of 1 acre per grid cell. A one-acre cell size was chosen to assist efficiency of summarizing land use as the count of cells would correspond to exact acreage amounts. The conversion of the shapefiles to grid resulted in some reduced accuracy in summation of land acreage, however, a check of original shapefile acreage summations versus grid acreage summaries for WMA's 02, 10, and 18 (a rural, mixed and urbanized selection of WMA's) resulted in summation differences of less than ½ of 1 percent for all land use categories except water which had summation inaccuracies of approximately 1 percent. The land acreage summaries within this analysis should therefore be accurate within 1 percent. However, summary statistics for units of measure smaller than a watershed may have slightly larger inaccuracies due to the 1-acre rasterization.

The NJDEP land use dataset contains land use classification codes for each land use polygon for 1986 and 1995 adapted from the Anderson land use/land cover classification system (Anderson, et. al. 1976). There is also a detailed label and general land category label for 1986 and 1995. However, the dataset's general label (*Type 86* and *Type 95*) have a different labeling criteria for land types than the Anderson label (*LU86* and *LU95*). In order to keep the analysis consistent between levels of detail, only the Anderson land use codes were used in this analysis. For example urban land use totals were summed by all polygons with a *LU* code in the *1000*'s rather than the general label *TYPE* code of "URBAN". Use of the dataset's general label code would result in different land use summations. (See the datasets metadata available at www.state.nj.us/dep/gis for an explanation of the differences in label methodology for the LU versus the TYPE labels). The various geographic summaries of land use and land use change were then calculated by tabulating areas for different geographic datasets (for example municipal boundaries or State Planning Areas) against the statewide grided land use/land cover dataset.

Impervious surface statistics were also analyzed by conversion to grided data format. The impervious surface estimates included as an attribute field in the original DEP dataset were coded to a grid coverage at one acre cell size. The percentage of impervious surface then represented the portion of the cell estimated to be impervious. A summary of the total impervious surface areas for various geographic datasets was then calculated by summarizing zones.

A dataset describing estimated land available for development was produced by first overlaying data for lands which are not available for future development. This included State, Federal and other preserved open space layers; steep slopes above 15% grade (derived from a statewide seamless thirty meter Digital Elevation Model), lands already developed and delineated wetlands and water. The resulting grid was then summarized by various datasets to provide an estimate of available lands remaining.

Results – Characterizing New Jersey's Changing Land Use

Analysis of the NJDEP dataset captures the remarkable degree of landscape change that occurred in New Jersey at the end of the 20^{th} century (Figure 2-3 and Table 2-1). The analysis reveals that the net new land developed in New Jersey during the nine-year period of 1986 to 1995 was 135,764 acres, an area equal to the total land area of Union and Essex counties combined. Farmlands experience a net loss of 86,884 acres or an area 27% larger than all the remaining farmland in Cumberland County. Forest land was reduced by 38,240 acres or an area slightly larger than New Jersey's portion of the Delaware Water Gap National Recreation Area. The net wetlands lost during the analysis was 23,781 acres or an area of wetlands 1/3 larger than the Hackensack Meadowlands. The statewide changes represent an 11.1% net increase in developed land area with a corresponding 10.5 % net loss in agricultural lands, 2.5 % net loss of wetlands and a 2.3 % net loss of forested lands.

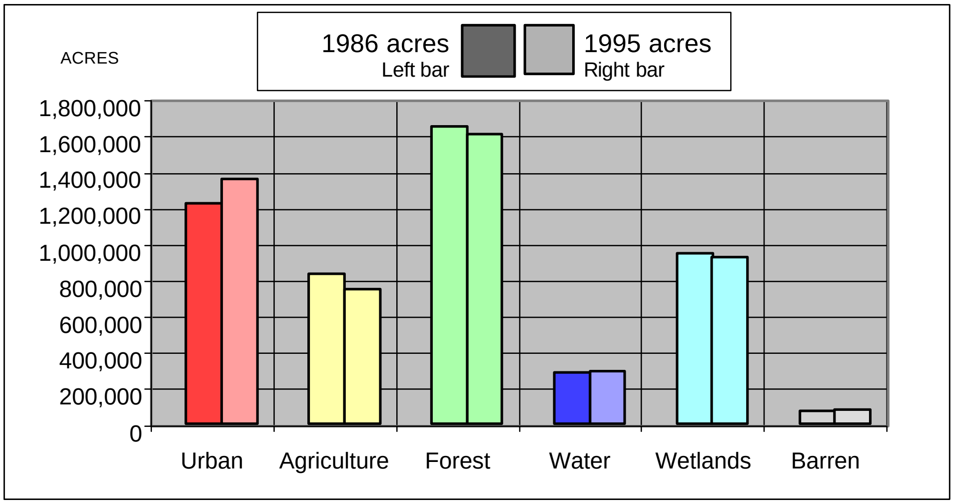

Figure 2-3 *1986 to 1995 Landscape Change in Acres in New Jersey*

Table 2-1 *Net change in acres for New Jersey's 6 major land categories between 1986 and 1995. Annual and daily landscape change statistics (averaged over the 9 year period of analysis) help to make the changes more comprehensible. An acre of land is 43,560 square feet or slightly smaller than a football field*

	1986 acres	*1995 aCREs*	*86-95 change in acres*	*86-95 percent change*	*Annual change in acres*	*Daily change in acres*
Urban	*1,219,748*	*1,355,512*	*135,764*	*11.1%*	*15,085*	*41.3*
Agriculture	*829,598*	*742,714*	*-86,884*	*-10.5%*	*-9,654*	*-26.4*
Forest	*1,641,129*	*1,602,889*	*-38,240*	*-2.3%*	*-4,249*	*-11.6*
Water	*283,874*	*289,014*	*5,140*	*1.8%*	*571*	*1.6*
Wetlands	*941,149*	*917,368*	*-23,781*	*-2.5%*	*-2,642*	*-7.2*
Barren	*69,145*	*77,146*	*8,001*	*11.6%*	*889*	*2.4*
Total	*4,984,643*	*4,984,643*				

Land Use Change Dynamics

The previous description of annual and daily change shows only the net total amounts of land remaining in each land category. This is only part of the story; the landscape change process is actually more complex with some lands being added and lost for each land use category. During the 1986 to 1995 period of analysis, 254,955 acres of land changed in a discernible fashion throughout the state (Table 2-2). Some of this change is real and some is an artifact of the interpretation and mapping methods used to create the dataset.

***Table 2-2** - Land Change Table. All categories of land gain and lose acres over time throughout the state. Net change for each category is calculated by subtracting the acreage of land loss from acreage of land gained.*

	aCRES LAND INCREASE	ACRES LAND DECREASE	net change
Urban	149,904	14,140	135,764
Agriculture	12,443	99,327	-86,884
Forest	48,903	87,143	-38,240
Water	8,586	3,446	5,140
Wetlands	1,901	25,682	-23,781
Barren	33,785	25,784	8,001

While urban growth was responsible for the lion's-share (58.6%) of changed land use type increase, other types of land use increase also occurred (Figure 2-4). New forested areas were responsible for 19 % of land gained, 13.2% of land gained was barren and 4.9 % of land gained was agriculture.

Land use decreases show the other side of the land change equation (Figure 2-5). Forty percent of the quarter million acres of changed land change was attributed to agricultural land use decrease. Forestland expressed 34 % of land use decrease while wetlands and barren lands each contributed 10% of the decreased land use.

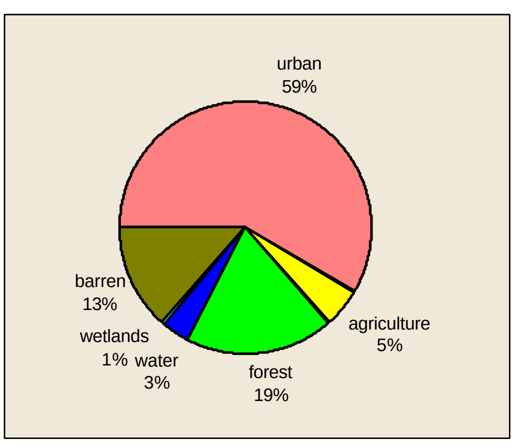

***Figure 2-4** Changed Land Use Increases.*

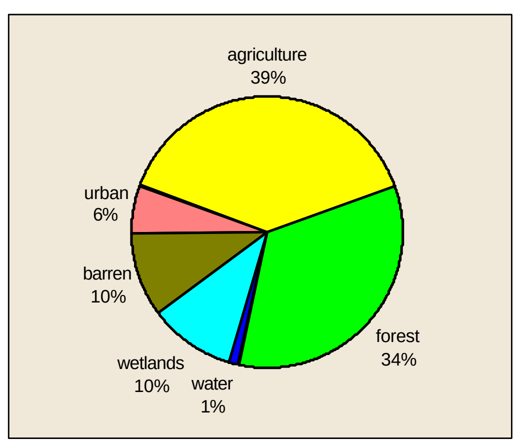

***Figure 2-5** Changed Land Use Decreases.*

Land Use Change Matrix

Even as the majority of landscape change can be attributed to urbanization, all categories of land can potentially change to all other types. A ranked land use change matrix (Table 2-3) shows the types of change as they occurred in decreasing amounts. Four of the top five greatest categories of landscape change were due to urbanization. However the third most significant change (31,551 acres) was due to the conversion of agricultural land to forestland. This is likely attributed to regeneration of forest from fallow fields as a result of agricultural abandonment, often a precursor to future development.

***Table 2-3** - **Ranked Land Use Change Table**. This table shows the acreage of land that changed from each land category for the top 21 categories of change. While the majority of the land change can be attributed to urban growth, the third largest category of change was agricultural land conversion to forestland indicating the difficulty of agricultural viability in modern day New Jersey.*

Rank	*1986 - From land type*	*1995 - to land type*	*Acres converted*
1	*Forest* Þ	*Urban*	*67,108*
2	*Agriculture* Þ	*Urban*	*57,552*
3	*Agriculture* Þ	*Forest*	*31,551*
4	*Barren* Þ	*Urban*	*14,112*
5	*Wetlands* Þ	*Urban*	*10,979*
6	*Forest* Þ	*Barren*	*10,536*
7	*Agriculture* Þ	*Barren*	*9,637*
8	*Urban* Þ	*Forest*	*9,075*
9	*Wetlands* Þ	*Barren*	*8,222*
10	*Barren* Þ	*Forest*	*8,130*
11	*Forest* Þ	*Agriculture*	*7,721*
12	*Wetlands* Þ	*Water*	*4,083*
13	*Urban* Þ	*Barren*	*3,152*
14	*Wetlands* Þ	*Agriculture*	*2,289*
15	*Water* Þ	*Barren*	*2,238*
16	*Barren* Þ	*Water*	*2,218*
17	*Urban* Þ	*Agriculture*	*1,683*
18	*Forest* Þ	*Water*	*1,563*
19	*Water* Þ	*Wetlands*	*926*
20	*Barren* Þ	*Wetlands*	*665*
21	*Barren* Þ	*Agriculture*	*659*

Detailed Urban Growth Patterns

A more detailed examination of the land use data shows the types of changes occurring in the development process (Table 2-4). Residential development was responsible for 65.6% of urban growth whereas commercial industrial and mixed urban land uses combined constituted only 24.9% of new growth. Transportation/utility and recreational lands comprised 3.3% and 4.1% of urban growth respectively.

Table 2-4 - *Ranked detailed urban growth. For a detailed explanation of land use types and method of delineation see the NJDEP metadata for the 1995 land use/land cover dataset available at www.state.nj.us/dep/gis.*

NJ DEP Land Use Code	*Urban Land Use Label*	*Acres Developed*	*Pct Total*
1140	*Residential, Rural, Single Unit*	*45,448ac*	*30.32%*
1700	*Other Urban or Built-Up Land*	*22,696ac*	*15.14%*
1130	*Residential, Single Unit, Low Density*	*21,434ac*	*14.30%*
1120	*Residential, Single Unit, Medium Density*	*20,194ac*	*13.47%*
1110	*Residential, High Density, Multiple Dwelling*	*11,099ac*	*7.40%*
1200	*Commercial / Services*	*9,137ac*	*6.10%*
1800	*Recreational Land*	*6,146ac*	*4.10%*
1300	*Industrial*	*5,352ac*	*3.57%*
1400	*Transportation/Communication*	*4,977ac*	*3.32%*
1750	*Managed Wetland in Maintained Lawn Greenspace*	*1,003ac*	*0.67%*
1850	*Managed Wetland in Built-Up Maintained Rec Area*	*767ac*	*0.51%*
1804	*Athletic Fields (Schools)*	*747ac*	*0.50%*
1211	*Military Reservations*	*429ac*	*0.29%*
1461	*Wetland Rights-of-Way (Modified)*	*208ac*	*0.14%*
1150	*Mixed Residential*	*123ac*	*0.08%*
1500	*Industrial / Commercial Complexes*	*113ac*	*0.08%*
1214	*No Longer Military, Use To Be Determined*	*8ac*	*0.01%*
1600	*Mixed Urban or Built-Up Land*	*4ac*	*0.00%*

The majority of urban growth that occurred during the period of analysis was attributed to residential development. One particular type of residential development stands out as the most land consumptive particularly in the rural countryside. Rural single unit residential growth added nearly 46,800 acres to the New Jersey landscape occurring at twice the amount as the land consumption of the next category of residential development. This development is typified by large lot single residential homes with septic and private wells (Figure 2-6).

Figure 2-6 Rural single unit residences *consumed the majority of land for development in New Jersey accounting for 45,448 acres or 30% of the urban growth.*

Landscape Impacts of Urban Growth

New Jersey's robust urban growth is a result of many factors including population growth and a vigorous economy. Indeed, many economic indicators designed to show the health of the local economy, such as new housing starts, are based on land development growth. However, unchecked urban growth can also have significant undesirable impacts on the health of the local landscape. Some of the most significant undesirable landscape impacts of unrestrained urban growth include farmland loss, habitat loss, wetlands loss, increased impervious surface and loss of open space. The following section explores these impacts.

Farmland Conversion to Urban Growth

Agriculture is a major activity in the Garden State. Cash sales of agriculture are estimated at $829.5 million. When all farming and food related activity is considered, agriculture is the third largest segment of the New Jersey economy contributing $56 billion annually (NJDA 2001). Despite the fact that in some ways New Jersey farmers benefit from close proximity to a large and wealthy population, the conflicts cause by encroaching urban development make it difficult to continue farming over the long term. Soaring land values and operating costs coupled with multiple conflicts stemming from the incompatibility of farming with new residences make it difficult to farm successfully in New Jersey (Adelaja and Schilling 1999). The result is that many farms discontinue farming activities and are eventually sold for development.

During the 1986 to 1995 study period, 99,327 acres of farmland were converted to non-agricultural land uses. To put this in context, this amount of farmland lost over 9 years is a greater number of acres than all the farmland currently remaining in Cumberland County. 58% of the farmland loss was attributed directly to new urban growth (Figure 2-7), 31% of the loss was attributed to reforestation, and 10% of the loss was attributed to farmland which became barren likely indicating transition to development. However, there were some new agricultural lands created during the study period. A sum of 12,443 acres of new farmland were created mostly from lands formerly classified as forested.

What is perhaps more significant is the loss of prime farmland. While prime farmland accounted for 53% of all farmland under the plow in 1986, it received 60% of the development that occurred on farmland. This suggests that prime farmland is more vulnerable to urbanization than non-prime farmland. The continued decrease of prime farmland will accelerate the decline of agricultural viability in New Jersey.

Figure 2-7 *A former peach orchard in Gloucester County makes way for a new housing subdivision. Urban development was responsible for 58% of farmland loss from 1986 to 1995.*

Forest Loss to Urban Growth

The largest single type of landscape change that occurred in New Jersey over the last decade was the urbanization of forested lands. 67,108 acres of forested land were converted to urban land uses during the nine-year period of analysis. This is an amount of forest loss equal in size to Stokes State Forest, Worthington State Forest, High Point State Forest and the Delaware Water Gap National Recreation Area combined. Much of the ex-urban growth (single rural units beyond the suburban fringe) occurred in forested lands as forested lots draw a premium price from new homebuyers (Figure 2-9). However, such ex-urban development can lead to forest core area reduction and forest fragmentation, which may have significant implications for wildlife habitat sustainability and forest land management. Forest loss also has implications for soil erosion, flooding and air quality.

Figure 2-9 *This color infrared aerial photograph of a new subdivision in South Harrison Township, Gloucester County, demonstrates the fragmentation of a patch of forest that can occur when forestland is developed. 67,108 acres of forest land were developed from 1986 to 1995 in New Jersey. Forest was the single largest land category to be developed during this time period.*

While the total amount of forest land lost to urban growth was 67,108 acres the net loss of forest land was only 38,240 acres. This was attributed to the significant amounts of land that became reforested. The majority of reforested land (31,551acres) occurred on former agricultural lands. Areas formerly classified as urban received 9,075 acres of reforestation. Formerly barren lands contributed 8,130 acres of new forest land.

Wetlands Loss To Urban Growth

With one fifth of the state's land area as wetland, wetlands are a vital component of the New Jersey landscape. Wetlands are important for wildlife habitat, flood mitigation, and water purification. Coastal wetlands have been protected since 1970. Disturbance of fresh water wetlands has been regulated since the 1987 New Jersey Freshwater Protection Act. While this regulation has been successful at reducing the magnitude of wetlands loss compared to pre-regulatory days, there has still been a significant continual loss of wetlands. 25,781 acres of wetlands were lost from 1986 to 1995 (Figure 2-10) an area 1/3 larger than the Hackensack Meadowlands. 43% of the loss was attributed to direct urbanization, 32 % was due to wetlands becoming barren (likely in transition to development), 16% of wetland loss was due to water inundation (such as new reservoir creation) and 9% was attributed to wetlands being utilized for agricultural lands.

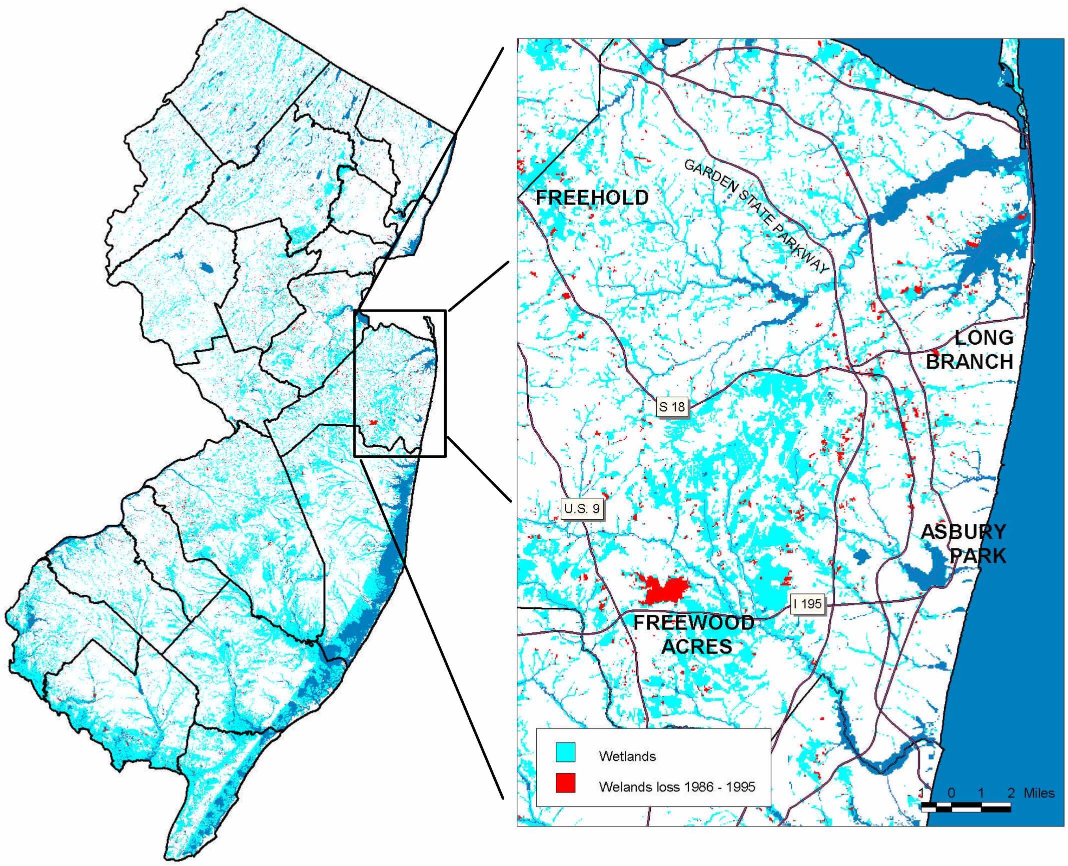

Figure 2-10 *Wetlands Loss. New Jersey has over 917,000 acres of wetlands (cyan color). Even with wetlands regulations in place New Jersey lost 23,781 acres or 2.5% of its wetlands from 1986 to 1995 (red color). The inset map shows an example of the scattered pattern of wetlands loss in Monmouth County, a hot spot for wetlands loss during the study.*

Tidal salt marshes (i.e. coastal wetlands) comprise 20% of NJ's wetlands but were subjected to less loss and urbanization than non-coastal wetlands. Coastal wetlands lost 2,207 out of 192,051 total acres (a loss of 1.2%) where as non-coastal wetlands lost 22,809 out of 748,483 total acres (a 3.1% loss).

There was also a significant difference in the urbanization of coastal versus non-coastal wetlands. Of the wetlands there were lost in each category, urbanization was responsible for 5.8% of coastal loss while urbanization was responsible for 45.5% of non-coastal wetlands loss. New Jersey's Coastal Wetlands Law of 1970 appears to have been largely successful in halting the loss of tidal salt marshes due to human development.

Habitat Implications of Urban Growth

New Jersey's diverse landscape is habitat for hundreds wildlife species (figure 2-10). The loss of farmland, forests and wetlands has profound implications for the diminishment of wildlife habitat. At a daily rate of 11.6 aces of forest loss, 7.2 acres of wetlands loss and 26.4 acres of agricultural lands loss New Jersey's wildlife is rapidly loosing its ground. The complexities of ecological processes make it difficult to map and comprehensively quantify the loss of wildlife habitat. Any change in landscape might be detrimental to some species while beneficial to others. Nonetheless, it is arguable that unchecked urban growth is, on balance, detrimental to the habitat of most wildlife species.

Figure 2-11 *The loss of wildlife habitat is one of the most significant impacts of unchecked urban growth yet one of the more difficult impacts to measure due to its amorphous nature. An example of this amorphous quality is the habitat of this spring peeper, which relies on vernal ponds in the spring for mating and then disperses into the forest throughout the rest of the year becoming nearly impossible to find.*

Particularly important is the habitat of threatened and endangered species. The New Jersey Department of Environmental Protection Division of Fish, Game and Wildlife created a wildlife habitat ranking system for New Jersey. The "Landscape Project" provides delineation for three categories of habitat; 1) forest, 2) wetland and 3) grasslands (Niles & Valent 1999). Each of these categories is designated for habitat priority based on a rigorously researched and peer-reviewed methodology. As New Jersey continues to urbanize, wildlife habitat will continue to be irreversibly fragmented and lost. The Landscape Project provides invaluable data for prioritizing which lands are most important for wildlife habitat conservation for threatened and endangered species.

Impervious Surface Increase From Urban Growth

In nature water is continually flowing between the atmosphere, ground water aquifers, lakes and rivers. When open land becomes developed, a portion of the parcel is necessarily covered with impervious surface such as asphalt and concrete (Figure 2-11). The creation of impervious surface changes the natural hydrologic cycle with significant environmental implications. When impervious surface is created, precipitation can no longer adequately infiltrate into aquifers, streams experience increased flooding, non-point source pollutant levels increase and biological activity is degraded.

Figure 2-11 *Impervious Surface is created with new urban growth. Impervious surface carries significant implications for water quality and flooding as non-point source pollution and runoff are greatly increased.*

Research has shown that the water quality and environmental condition of a watershed is related to the amount of impervious surface within the watershed (Arnold & Gibbons 1996). Watersheds with less than 10% impervious surface cover are generally unimpacted. Greater than 10% impervious surface and watersheds show signs of impact. As impervious surface reaches 30% and greater, water quality is usually seriously degraded.

Impervious surface also has important implications for flooding and ground water recharge. The natural hydrologic regime of a watershed is significantly changed when impervious surface is created as ground water infiltration is reduced and surface runoff is increased. Storm peaks are amplified in magnitude and speed within a stream channel changing the load carrying and erosion characteristics. The increase in impervious surface that has been occurring with urban expansion is changing the flooding characteristics of New Jersey's streams and rivers. A recent example of flooding in the Raritan River during Hurricane Floyd in 1999 (Figure 2-13) suggests significant implication for the role of impervious surface in intensifying the flooding event. The North and South Branch of the Raritan River watershed had expanded its impervious surface by 2,723 acres (an increase of 18.8 %) between 1986 and 1995. While the 11 inches of precipitation that fell in parts of the basin clearly was an exceptional event, the Raritan flood was potentially exacerbated by increased impervious surface within the watershed (Robinson 2001).

As of 1995, the New Jersey landscape is covered with 458,610 acres of impervious surface or 9.2% of the state's total land area (Figure 2-12). This is equivalent to a wall to wall slab of concrete the size of Camden, Gloucester and Hudson counties combined. During 1986 to 1995 more than 38,200 acres of new impervious surface were added to the New Jersey landscape or an area roughly equivalent to a parking lot with 6 million parking spaces. Impervious surface is being created at the rate of 4,244 acres per year or approximately 8.8 football fields of impenetrable ground cover per day. Growth trends of the 1980 and 90's added one acre of impervious surface for every 4 acres of development. In other words newly developed land is, on average, 25% impervious surface.

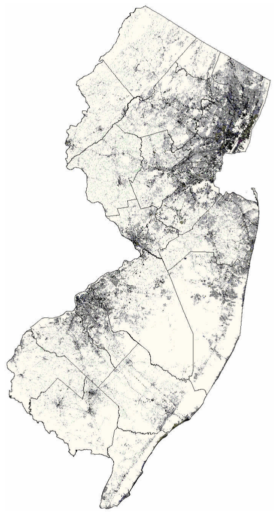

Figure 2-12 *Impervious surface. This map depicts the pattern of impervious surface in NJ. Darker shades of gray represent higher percentage of impervious cover.*

Figure 2-13 *Flooding of the Raritan River at New Brunswick in 1999 after hurricane Floyd dropped more than 11 inches of rain in some parts of the Raritan basin. The North and South Branch of the Raritan River watershed had increased its impervious surface by 2,723 acres (an increase of 18.8 %) between 1986 and 1995 exacerbating the magnitude of the flooding.*

Figure 2-14 illustrates the impervious surface conditions for New Jersey's watersheds. 13 watersheds representing 6.4% of New Jersey's watershed land area are currently 30% or greater impervious surface indicating that the stream has become degraded. 37 watersheds representing 22.3 % of New Jersey's watershed land area are between 10 and 29.9 percent impervious surface indicating that the stream has been impacted. 27 watersheds representing 21% of New Jersey's land area are between 5 and 9.9 percent impervious suggesting impending water quality impacts. The remaining 71 watersheds representing 51% of New Jersey's land area are less than 5 percent impervious surface indicating relatively non-impacted quality.

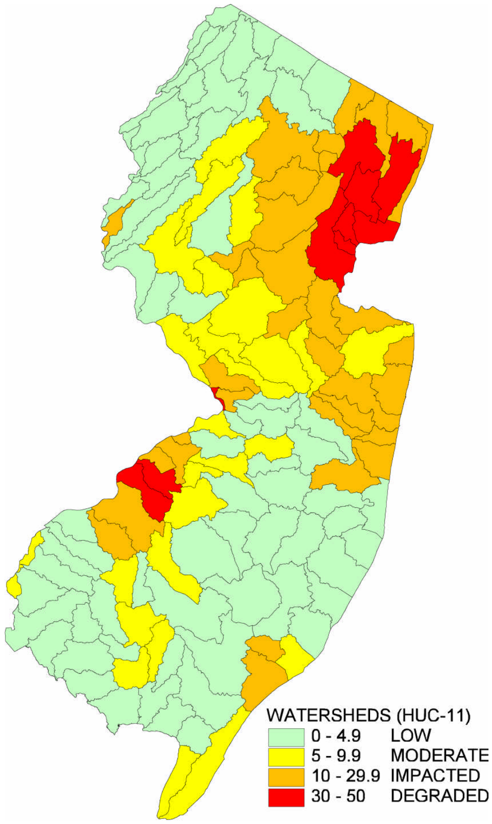

Figure 2-14 *Impacted and degraded watersheds as indicated by impervious surface cover. Watersheds with over 30% impervious surface coverage (colored red) are considered degraded. Watersheds with between 10 and 30% impervious surface coverage (orange) can be considered impacted. Watersheds with 5 – 10% impervious surface (yellow) have impending water quality issues.*

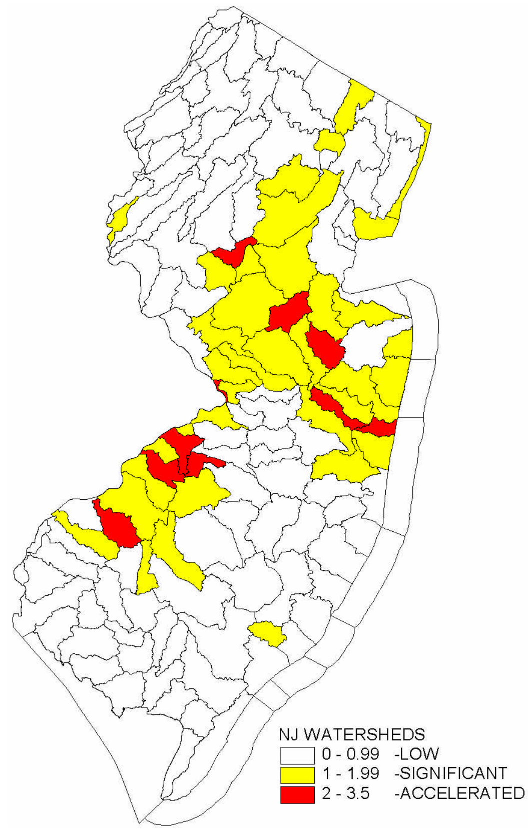

Figure 2-15 *Impervious surface increase. Many watersheds experienced a significant increase in impervious surface from 1986 to 1995. Watersheds that increased their total impervious surface coverage by 1 to 2 percent are colored yellow. Watersheds that have experienced greater than 2 percent increase in total impervious surface coverage are colored red.*

The amount of impervious surface has been increasing in step with urban growth. During the 1986 to 1995 study period 36 watersheds increased their total impervious surface coverage by one to two percent and 10 watersheds increased their total impervious surface coverage by more than 2 percent (Figure 2-15). These rapidly growing watersheds are at greatest risk for experiencing degradation of water quality. Impervious surface will likely become one of the fundamental factors for sound land management practice in the future. While the 10 and 30 percent thresholds have become generally accepted rules of thumb for correlating water quality with impervious surface, further research is needed to elucidate the unique relationship of impervious surface to water quality particular to the various physiographic regions of New Jersey.

Regional Analysis of Landscape Change

The preceding statewide analysis of landscape change provides an interesting overview of New Jersey's landscape trajectory. However, the changes to the landscape are not occurring in the same pattern throughout the state. The following section provides a look at New Jersey's landscape change as it differs between physiographic provinces, counties, watershed management areas and municipalities.

Physiographic Region-Level Analysis

New Jersey consists of five vastly different physiographic regions which are largely defined by the underlying geology. Each region has widely diverging natural and human landscape characteristics and it is helpful to analyze and compare landscape conditions and processes separately across the five regions.

Ridge & Valley

The Ridge and Valley province is the most northern of New Jersey's five regions. Dominated by the forested Kittatinny Ridge and the great limestone valley, the Ridge and Valley province is still comparatively undeveloped. This can be attributed in part to the large amount of federal and state public lands protecting the Kittatinny Ridge, its comparative distance from the New York City and substantial grassroots land preservation efforts. The Ridge and Valley region occupies 7% of NJ's land area but contains less than 1 percent of NJ's population. While total developed land as well as absolute urban growth remains the lowest of the five regions, the Ridge and Valley province is experiencing a significant percentage increase in urban growth.

RIDGE & VALLEY	
Land area	*335,113 ac*
Percent land area of NJ	*6.7%*
1990 Population	*66,604*
Percent of NJ pop	*0.9%*
Urban Density (persons per acre of urbanized land)	*1.93*

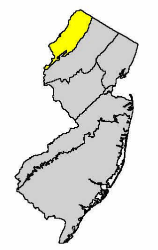

Figure 2-16A Land statistics in the Valley & Ridge Province

	URBAN	*AGRICULTURE*	*FOREST*	*WATER*	*WETLANDS*	*BARREN*
1986	*28,188*	*80,422*	*177,692*	*10,179*	*3,7311*	*1,300*
1995	*34,593*	*73,263*	*178,423*	*10,198*	*36,535*	*2,080*
Change	*6,405*	*-7,159*	*731*	*19*	*-776*	*780*
% Change	*22.7%*	*-8.9%*	*0.4%*	*0.2%*	*-2.1%*	*60.0%*

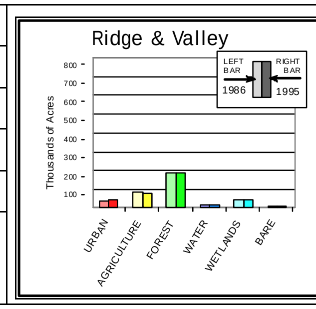

Figure 2-16B Landscape change in the Valley & Ridge Province

Highlands

The Highlands province is a rugged terrain of forested ridges bisected by long narrow valleys. While the northern half is largely forested, the unglaciated valleys of the southern Highlands are important for agriculture. Numerous lakes occur in the glaciated northern half of the province and a number of these water bodies and the watersheds that drain into them are managed as drinking water supplies for northern New Jersey communities. The diverse landscape of the Highlands is recognized as ecologically significant and in need of a comprehensive management strategy. 18,568 acres of new urban growth occurred in the Highlands during the study period. The Highlands occupy 13% of New Jersey's land area and house 6% of its population.

HIGHLANDS	
Land area	*641,348*
Percent land area of NJ	*12.9%*
1990 Population	*484,466*
Percent of NJ pop	*6.3%*
Urban Density (persons per acre of urbanized land)	*3.50*

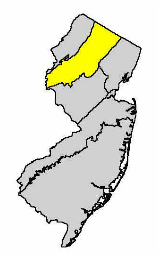

Figure 2-17A Land statistics in the Highlands Province

	URBAN	*AGRICULTURE*	*FOREST*	*WATER*	*WETLANDS*	*BARREN*
1986	*120,026*	*86,470*	*350,417*	*23,941*	*55,079*	*5,403*
1995	*138,594*	*75,674*	*340,833*	*25,342*	*53,578*	*7,315*
Change	*18,568*	*-10,796*	*-9,584*	*1,401*	*-1,501*	*1,912*
% Change	*15.5%*	*-12.5%*	*-2.7%*	*5.9%*	*-2.7%*	*35.4%*

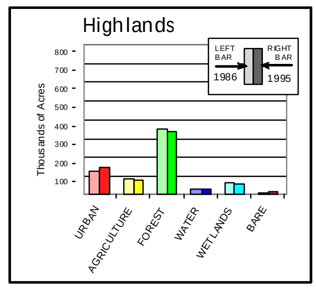

Figure 2-17B Landscape change in the Highlands Province

Piedmont

New Jersey's Piedmont province consists of stretches of rolling shale hills interspersed with Triassic igneous formations such as the Watchung and Sourland mountains. The Piedmont region is often divided into two subsections; the northern glaciated section with associated glacial features such as the Hackensack Meadowlands and the Great Swamp Refuge; and the non-glaciated rolling lands of the southern piedmont. Soils are widely variable for agriculture. The Piedmont is home to the majority of New Jersey's population, housing 51 % of New Jersey's residents on 20 % of its land area. The Piedmont continues to grow adding 33,128 acres of new urban land.

Piedmont	
Land area	*1,011,212 ac*
Percent land area of NJ	*20.3%*
1990 Population	*3,909,755*
Percent of NJ pop	*50.6%*
Urban Density (persons per acre of urbanized land)	*7.46*

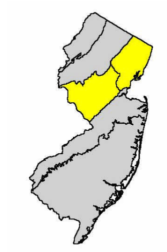

Figure 2-18A Land statistics in the Piedmont Province

	URBAN	*AGRICULTURE*	*FOREST*	*WATER*	*WETLANDS*	*BARREN*
1986	*490,706*	*162,610*	*207,244*	*36,879*	*102,155*	*11,619*
1995	*523,834*	*139,912*	*201,381*	*37,122*	*96,520*	*12,445*
Change	*33,128*	*-22,698*	*-5,863*	*243*	*-5,635*	*826*
% Change	*6.8%*	*-14.0%*	*-2.8%*	*0.7%*	*-5.5%*	*7.1%*

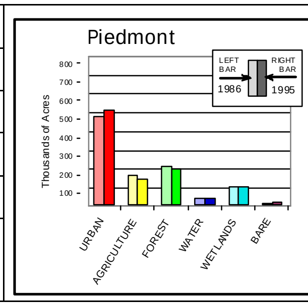

Figure 2-18B Landscape change in the Piedmont Province

Inner Coastal Plain

The Inner Coastal Plain boasts New Jersey's most agriculturally fertile land. It also boasts the greatest amount of farmland loss losing 29,647 acres during the 1986 to 1995 period. The Inner Coastal Plain houses 22 percent of New Jersey's population on 16% of its land area. The urban growth of the Inner Coastal Plain is due in large part to the fact that it lies in close proximity to the transportation corridor between metropolitan Philadelphia and New York City.

Inner Coastal	
Land area	*816,463 ac*
Percent area of NJ	*16.4%*
1990 Population	*1,721,110*
Percent of NJ pop	*22.3%*
Urban Density (persons per acre of urbanized land)	*5.55*

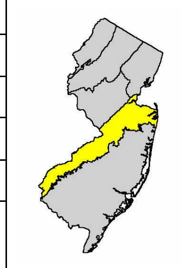

Figure 2-19A Land statistics in the Inner Coastal Province

	URBAN	*AGRICULTURE*	*FOREST*	*WATER*	*WETLANDS*	*BARREN*
1986	*275,232*	*229,660*	*108,752*	*39,767*	*144,999*	*17,461*
1995	*310,356*	*200,013*	*107,143*	*40,348*	*138,802*	*19,209*
Change	*35,124*	*-29,647*	*-1,609*	*581*	*-6,197*	*1,748*
% Change	*12.8%*	*-12.9%*	*-1.5%*	*1.5%*	*-4.3%*	*10.0%*

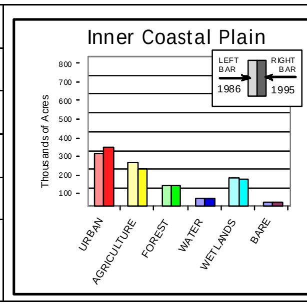

Figure 2-19B Landscape change in the Inner Coastal Province

Outer Coastal Plain

The Outer Coastal Plain consists of largely flat sandy terrain. While some soils in the Outer Coastal Plain can be highly productive for agriculture, the majority are nutrient-poor. This province is dominated by the nationally significant Pine Barrens and extensive coastal wetlands. Urban growth increased in the Outer Coastal Plain by 42,533 acres largely at the expense of both agricultural and forested lands. This was the largest amount of urban growth of any province, however, that should be gauged against the fact that the Outer Coastal Plain occupies 44% of NJ's land area and houses 20% of the state's population.

Outer Coastal	
Land area	*2,180,170 ac*
Percent area of NJ	*43.7%*
1990 Population	*1,548,003*
Percent of NJ pop	*20.0%*
Urban Density (persons per acre of urbanized land)	*4.45*

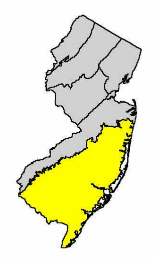

Figure 2-20A Land statistics in the Outer Coastal Province

	URBAN	*AGRICULTURE*	*FOREST*	*WATER*	*WETLANDS*	*BARREN*
1986	*305,565*	*270,433*	*797,019*	*172,141*	*601,589*	*33,345*
1995	*348,098*	*253,850*	*775,102*	*175,958*	*591,847*	*35,237*
Change	*42,533*	*-16,583*	*-21,917*	*3,817*	*-9,742*	*1,892*
% Change	*13.9%*	*-6.1%*	*-2.7%*	*2.2%*	*-1.6%*	*5.7%*

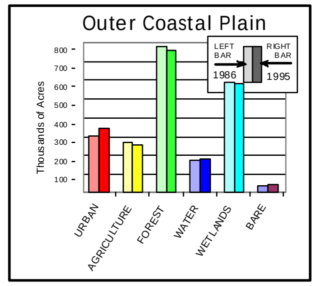

Figure 2-20B Landscape change in the Outer Coastal Province

County Level Land Use Change Analysis

New Jersey's county-level land management activities vary widely, reflecting differences in political atmosphere, financial resources, demographics, and the particular needs of each county. While most land development activities such as zoning are managed at the local municipal level, many other land use related activities such as farmland preservation and open space acquisition are facilitated by county offices. Some counties such as Hunterdon, Monmouth, and Burlington have invested millions in land management infrastructure including Geographic Information Systems (GIS) and digital parcel mapping.

The unique circumstance of each county is also evident in the dissimilar patterns of landscape change demonstrated from county to county. The most rapidly urbanizing counties (Figure 2-21) included Burlington, Monmouth, Hunterdon, Somerset Ocean and Morris. The greatest farmland loss (Figure 2-22) occurred in Hunterdon, Burlington, Monmouth, Gloucester, and Mercer Counties. The greatest forest loss (Figure 2-23) occurred in Morris, Ocean and Atlantic counties. The greatest wetlands losses (Figure 2-24) occurred in Monmouth, Middlesex and Burlington counties.

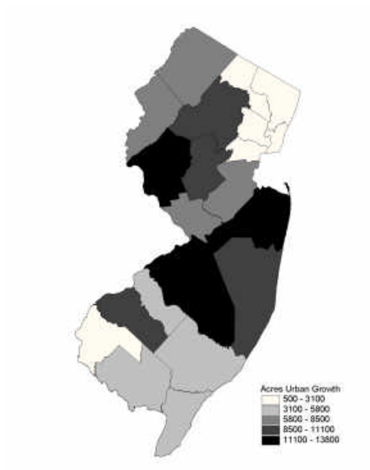

Figure 2-21 Urban Growth by County

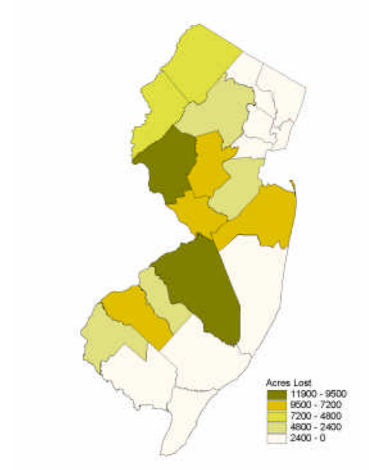

Figure 2-22 Farmland Loss by County

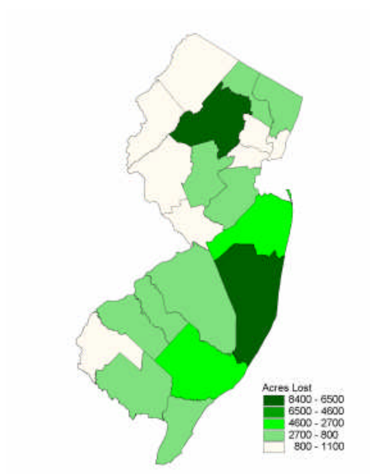

Figure 2-23 Forest Loss by County

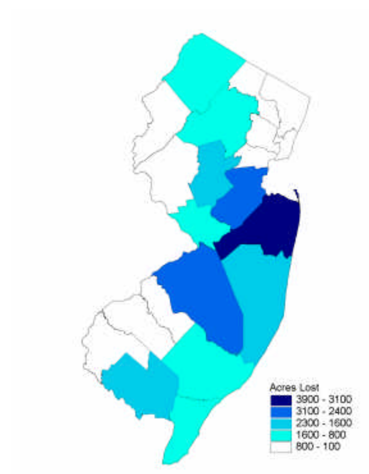

Figure 2-24 Wetlands Loss by County

Watershed Management Area-Level Analysis

New Jersey's 21 counties have held official regional political jurisdiction for a few hundred years. However, the geometric political borders have proven inadequate for sound environmental land management. A new approach to environmental management in New Jersey was initiated in the 1990's to manage environmental issues on a watershed-by-watershed basis. Watershed-based management is beneficial because any activity within a watershed can affect the environment of the entire watershed.

According to delineations made by the US Geological Survey, New Jersey has 152 watersheds (HUC11). The New Jersey Department of Environmental Protection (NJDEP) has aggregated these watersheds into 20 watershed management areas (WMA). Each of the 20 WMA's has unique natural and cultural characteristics as well as different land use patterns.

The WMA's were classified into five categories depending on the amount of developed land within each watershed (figure 2-25). The map categories range from *mostly rural* (less than 15 % urbanized) to *largely urbanized* (greater than 45% urbanized). Each class will likely have different priorities of land management as they are in different stages of urbanization.

Figure 2-26 depicts the percentage urban growth in each WMA. The lowest growth WMA's have already been largely developed whereas some of the more rural WMA's such as WMA1 and WMA2 have, until recently, been sparsely developed and are now rapidly growing in relative terms. The moderate growth WMA's are largely in southern New Jersey and contain a mixture of largely urbanized WMA's such as WMA18 which are beginning to exhaust available land and more rural and mixed WMA's that are growing at a steady clip but relatively less dramatically than their northern counterparts. Both the proportion of developed lands and the rate of urban growth should be considered in determining the land management strategy of each WMA.

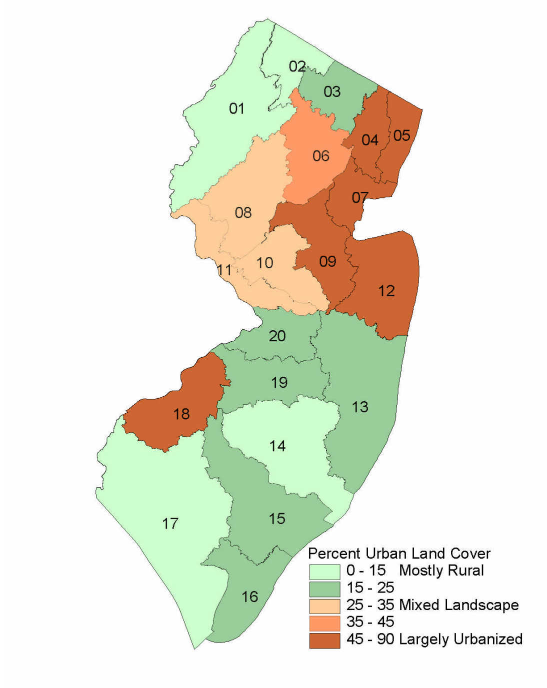

Figure 2-25 Watershed Management Areas Percent Total Urbanized Land Use 1995. The numbers on the map are the WMA labels assigned by the NJ DEP.

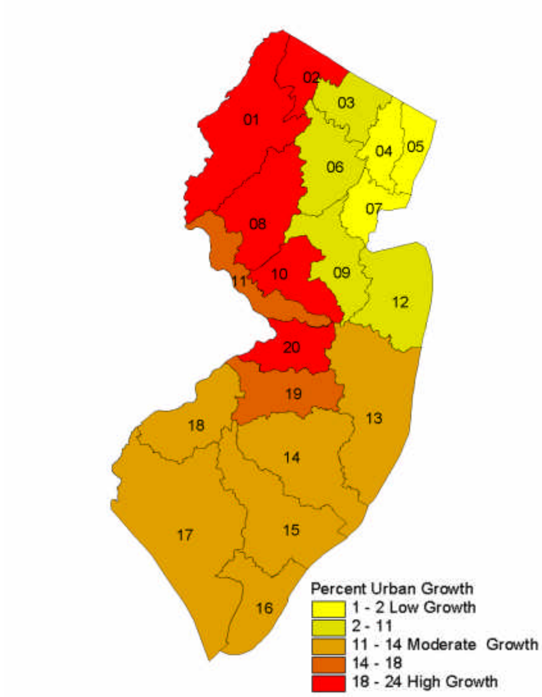

Figure 2-26 Watershed Management Areas Percent Urban Growth from 1986 to 1995.

Municipal Report Card on Landscape Change

New Jersey is a strong *home-rule* state. Land use regulation is largely determined on the local municipal level. Municipalities must compete with one another for limited financial resources and rely heavily on local land taxation to fund schools and municipal services. Balancing land resource protection against the pressures of continued urban growth and the fiscal realities of modern society make local land use planning a formidable challenge. Still many municipalities have made significant progress in addressing the onslaught of urban sprawl while others have been overwhelmed by rampant urban growth.

The following lists provide the top ten municipalities for each land use change total acres of new growth (Figure 2-27); acres of farmland loss (Figure 2-28); acres of forest loss (Figure 2-29); and top ten municipalities for acres of wetlands loss (Figure 2-30).

URBAN GROWTH		
Rank	*Municipality*	*Acres Urbanized 1986 - 1995*
1	*West Windsor Twp. (Mercer)*	*2,717 ac*
2	*Raritan Twp. (Hunterdon)*	*2,266 ac*
3	*Readington Twp. (Hunterdon)*	*2,176 ac*
4	*Washington Twp. (Gloucester)*	*2,071 ac*
5	*Mount Laurel Twp. (Burlington)*	*2,032 ac*
6	*Jackson Twp. (Ocean)*	*1,975 ac*
7	*Franklin Twp. (Somerset)*	*1,905 ac*
8	*Manalapan Twp. (Monmouth)*	*1,878 ac*
9	*Dover Twp. (Ocean)*	*1,782 ac*
10	*Millstone Twp. (Monmouth)*	*1,782 ac*

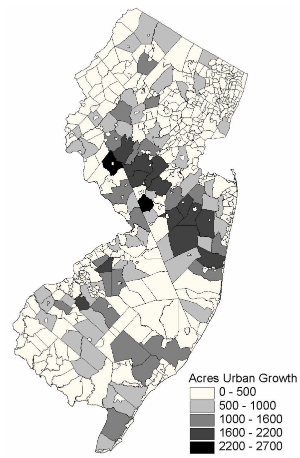

Figure 2-27 Top ten municipalities for urban growth.

Urban Growth by Municipality

FARMLAND LOSS		
Rank	*Municipality*	*Acres Farmland Loss 1986 - 1995*
1	*West Windsor Twp. (Mercer)*	*2,539 ac*
2	*Hopewell Twp. (Mercer)*	*2,392 ac*
3	*Montgomery Twp. (Somerset)*	*2,090 ac*
4	*Raritan Twp. (Hunterdon)*	*2,054 ac*
5	*Readington Twp. (Hunterdon)*	*1,810 ac*
6	*Franklin Twp. (Somerset)*	*1,722 ac*
7	*Mount Laurel Twp. (Burlington)*	*1,558 ac*
8	*Washington Twp. (Gloucester)*	*1,534 ac*
9	*Millstone Twp. (Monmouth)*	*1,528 ac*
10	*Freehold Twp. (Monmouth)*	*1,427 ac*

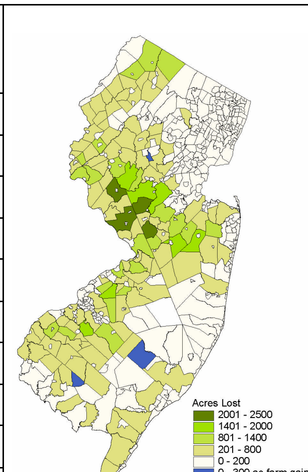

Figure 2-28 Top ten municipalities for farmland loss 1986 - 1995.

Farmland Loss by Municipality

FOREST LOSS

Rank	*Municipality*	*Acres Forest Loss 1986 - 1995*
1	*Dover Twp. (Ocean)*	*1,369 ac*
2	*Galloway Twp. (Atlantic)*	*1,327 ac*
3	*Jackson Twp. (Ocean)*	*1,187 ac*
4	*Randolph Twp. (Morris)*	*1,070 ac*
5	*Egg Harbor Twp. (Atlantic)*	*995 ac*
6	*Berkeley Twp. (Ocean)*	*950 ac*
7	*Hamilton Twp. (Atlantic)*	*923 ac*
8	*Lakewood Twp. (Ocean)*	*851 ac*
9	*Rockaway Twp. (Morris)*	*829 ac*
10	*Brick Twp. (Ocean)*	*790 ac*

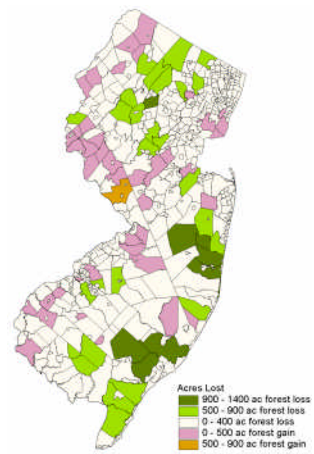

Figure 2-29 Top ten municipalities for forest loss 1986 - 1995.

Forest Loss by Municipality

WETLANDS LOSS

Rank	*Municipality*	*Acres Wetlands Loss 1986 - 1995*
1	*Howell Twp. (Monmouth)*	*1,227 ac*
2	*Downe Twp. (Cumberland)*	*469 ac*
3	*Franklin Twp. (Somerset)*	*461 ac*
4	*South Brunswick Twp. (Middlesex)*	*427 ac*
5	*Manalapan Twp. (Monmouth)*	*417 ac*
6	*Old Bridge Twp. (Middlesex)*	*402 ac*
7	*Mount Laurel Twp. (Burlington)*	*399 ac*
8	*Edison Twp. (Middlesex)*	*342 ac*
9	*Monroe Twp. (Middlesex)*	*319 ac*
10	*Warren Twp. (Somerset)*	*316 ac*

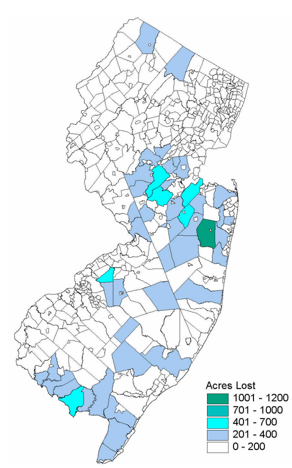

Figure 2-30 Top ten municipalities for wetlands loss 1986 – 1995

Wetlands Loss by Municipality

Urban Growth, Planning & Infrastructure

Urban Growth Patterns and the New Jersey State Plan

Sprawl is not a new phenomenon in the Garden State. New Jersey has been struggling with problems associated with large-scale development for decades. In an effort to limit the negative consequences of poorly planned and implemented development, the New Jersey Office of State Planning has been developing a statewide management plan (NJOSP 2001). The New Jersey State Development and Redevelopment Plan (NJSDRP) has been under development since the 1980's evolving through a number of iterations through a process called *cross acceptance*. The plan delineates five zones of land use; 1) PA1 Metropolitan Planning Area, 2) PA2 Suburban Planning Area, 3) PA3 Rural Planning Area, 4) PA4 Rural Planning Area, 5) PA4B Rural/Environmentally Sensitive Planning Areas, 6) PA5 Environmentally Sensitive Planning Area (Figure 2-31). The planning areas prescribe the type of development and land preservation that is most appropriate for each zone.

Studies focusing on implementation of the state plan indicate its potential for curbing the fiscal, social and environmental costs of sprawl in New Jersey (Burchell 2000). Analyzing the actual urban growth for the State Development and Redevelopment Plan reveals patterns of new development in environmentally sensitive and rural lands during the last decade (Table 2-5). Of the 135,000 acres of new development that occurred from 1986 to 1995, 13.6% occurred in the environmentally sensitive planning PA5, 14.5 % of growth occurred in rural planning area PA4 and 10.2% occurred in the environmentally sensitive rural planning area PA4B. Although the goals and objectives envisioned in the state plan of channeling growth toward centers and away from sensitive lands have been hailed by both researchers and planners, this analysis demonstrates that the non-regulatory status of the SDRP has had limited success in meeting those goals.

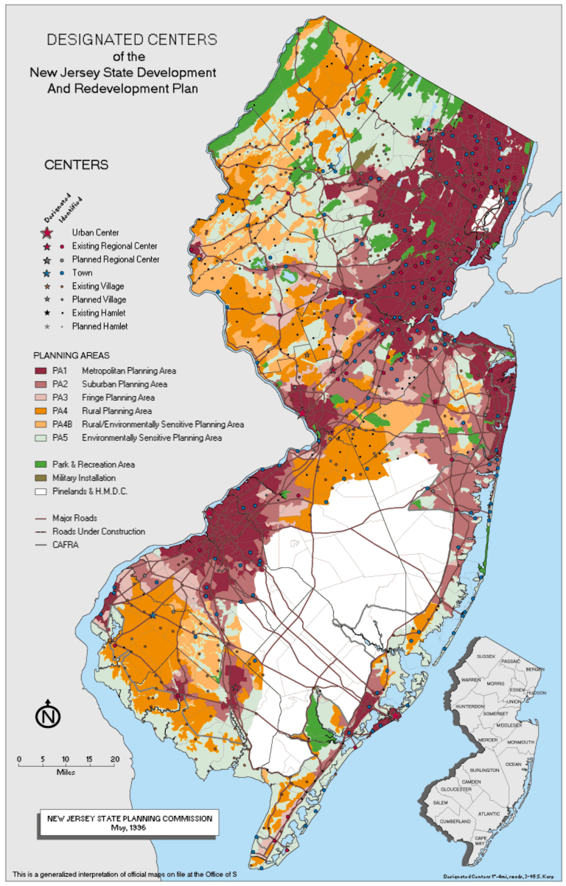

Figure 2-31 The New Jersey State Development and Redevelopment Map (source: NJ Office of State Planning)

Table 2-5 Land development in the NJ SDRP planning areas.

PLANNING AREA	*AVAILABLE ACRES IN 1986*	*URBAN ACRES IN 1986*	*URBAN GROWTH 1986-1995*	*PCT OF TOTAL GROWTH*
01.PA1 Metropolitan Planning Area	*131,662*	*624,914*	*20,053*	*15.5%*
02.PA2 Suburban Planning Area	*251,620*	*196,456*	*40,431*	*29.8%*
03.PA3 Fringe Planning Area	*112,579*	*41,522*	*12,020*	*8.9%*
04.PA4 Rural Planning Area	*419,758*	*74,599*	*19,688*	*14.5%*
06.PA5 Environmentally Sensitive Planning	*317,494*	*137,580*	*18,497*	*13.6%*
07.Park and Recreation Area	*12,581*	*10,057*	*842*	*0.6%*
08.Water	*80*	*267*	*-2*	*0.0%*
09.Pinelands and H.M.D.C.	*371,308*	*86,825*	*9,436*	*7.0%*
10.Military	*11*	*1,071*	*-*	*0.0%*
05.PA4B Rural/Environmentally Sensitive	*241,131*	*46,155*	*13,780*	*10.2%*

Urban Growth Patterns and Sewered Areas

Water and sewer infrastructure play a great role in how the New Jersey landscape develops. Residential development in regions serviced by public wastewater treatment can develop at much higher densities than in regions that rely on individual private septic systems. Higher density growth leaves more open space intact. The growth patterns show a significant amount of growth in both sewered and nonsewered areas. However the types of growth were substantially different.

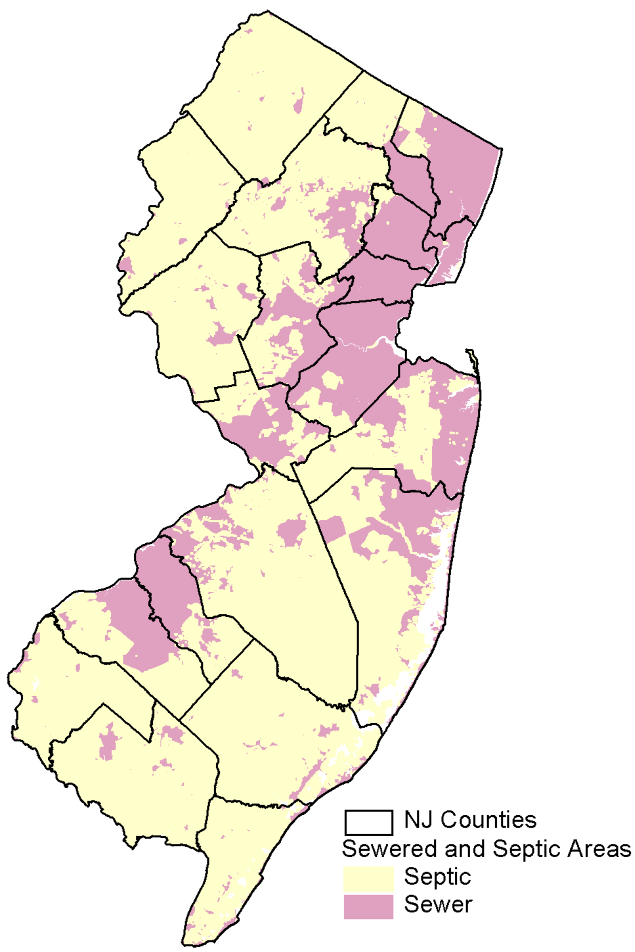

Figure 2-32 Existing Sewered Areas in New Jersey

Table 2-6 illustrates the difference in development type between sewered and non-sewered areas. A similar amount of urban growth occurred within sewered areas (73,055 acres) as occurred in non-sewered areas (76,803 acres). However, growth in sewered areas included the full spectrum of urban land use types whereas growth in nonsewered areas was predominantly residential. Non-sewered areas urbanized at a far lower density than sewered areas, effectually using up more land per capita.

Table 2-6 Detailed urban growth in sewered and nonsewered areas*. The majority of growth in non-sewered areas was attributed to low density residential development*

DEP LU95	*urban land use type*	*SEPTIC ac grth*	*SEWER ac grth*	*total acres*	*pct in septIC*	*pct in sewer*
1110	*Residential, High Density, Multiple Dwelling*	*1,370*	*9,728*	*11,098*	*12.3%*	*87.7%*
1120	*Residential, Single Unit, Medium Density*	*3,263*	*16,931*	*20,194*	*16.2%*	*83.8%*
1130	*Residential, Single Unit, Low Density*	*11,710*	*9,724*	*21,434*	*54.6%*	*45.4%*
1140	*Residential, Rural, Single Unit*	*39,581*	*5,867*	*45,448*	*87.1%*	*12.9%*
1150	*Mixed Residential*	*-*	*123*	*123*	*0.0%*	*100.0%*
1200	*Commercial / Services*	*2,348*	*6,786*	*9,134*	*25.7%*	*74.3%*
1211	*Military Reservations*	*217*	*209*	*426*	*50.9%*	*49.1%*
1214	*No Longer Military, Use To Be Determined*	*-*	*8*	*8*	*0.0%*	*100.0%*
1300	*Industrial*	*1,410*	*3,942*	*5,352*	*26.3%*	*73.7%*
1400	*Transportation/Communication*	*2,211*	*2,754*	*4,965*	*44.5%*	*55.5%*
1461	*Wetland Rights-of-Way (Modified)*	*158*	*50*	*208*	*76.0%*	*24.0%*
1500	*Industrial / Commercial Complexes*	*51*	*62*	*113*	*45.1%*	*54.9%*
1600	*Mixed Urban or Built-Up Land*	*-*	*4*	*4*	*0.0%*	*100.0%*
1700	*Other Urban or Built-Up Land*	*10,852*	*11,840*	*22,692*	*47.8%*	*52.2%*
1750	*Managed Wetland in Maintained Lawn Greenspace*	*272*	*731*	*1,003*	*27.1%*	*72.9%*
1800	*Recreational Land*	*2,899*	*3,243*	*6,142*	*47.2%*	*52.8%*
1804	*Athletic Fields (Schools)*	*247*	*500*	*747*	*33.1%*	*66.9%*
1850	*Managed Wetland in Built-Up Maintained Rec Area*	*214*	*553*	*767*	*27.9%*	*72.1%*

Urban Growth in the Pinelands Management Area

The New Jersey Pine Barrens is a unique pine and oak forest located in the region of sandy soils of southern New Jersey's Outer Coastal Plain. Occupying 1.1 million acres of relatively undeveloped forest, the Pine Barrens is internationally recognized as an exceptional and valuable ecosystem. It is also located above the Kirkwood-Cohansey aquifer, one of the most significant and pristine ground water aquifers in the northeast. In recognition of the significance of this environmentally sensitive resource, the area was protected as part of the Pinelands National Reserve.

The Pinelands are a unique experiment in land management in New Jersey. Parts or all of 56 municipalities and 7 counties fall under the jurisdiction of the Pinelands Commission. Studies have indicated that the Pinelands Comprehensive Management Plan has been somewhat effective at controlling urban growth (Soleki & Walker 1999, Luque et. al. 1995). Analysis of recent growth within the Pineland Management Area (Figure 2-33) provides corroborating evidence for the effectiveness of the Pinelands management strategy.

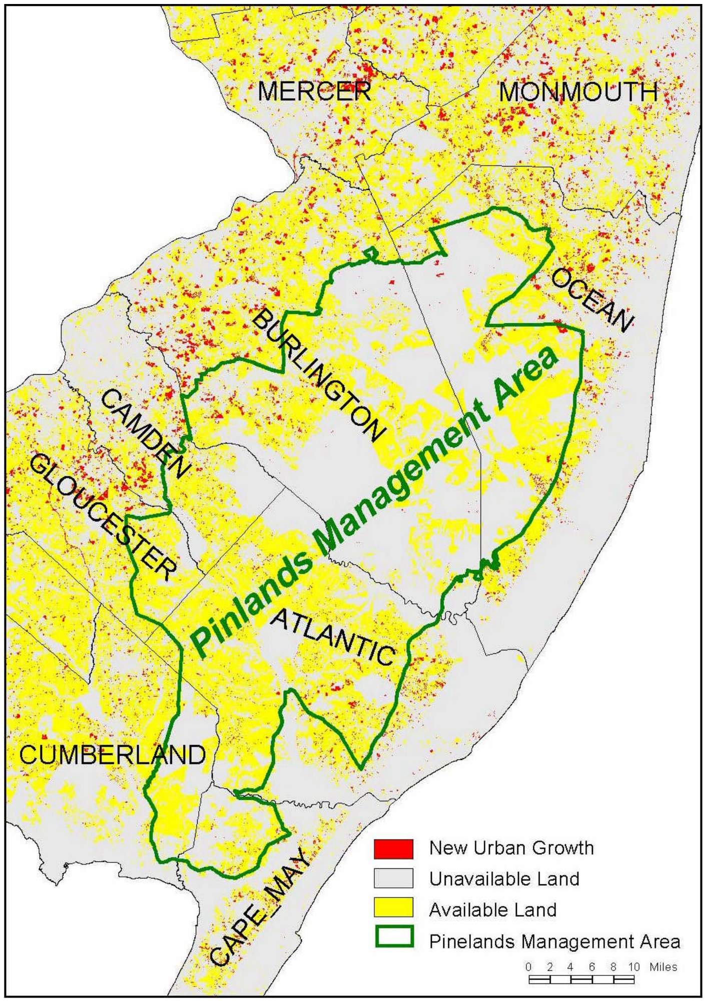

Figure 2-33 Development in Pinelands Management Area.

Analyzing the rates of development of available land for portions of counties within the Pinelands versus portions outside the management area illustrates the propensity for urban growth to occur on lands not under the jurisdiction of the Pinelands Commission. Each of the counties which have land controlled by the PCMP had proportionately less of their available land within the Pinelands developed as compared to lands outside of the Pinelands (Table 2-7). This suggests an overall growth controlling effect of the PCMP.

Table 2-7 Development in counties regulated by the Pinelands Comprehensive Management Plan. The white rows show development in parts of the counties unregulated by the PMCP.

PINE_COUNTY	URB86	URB95	urban growth	available land 1986	% GROWTH of available
ATLANTIC-NON PCMP	22,262	24,763	2,501	28,210	8.9%
ATLANTIC-PINELANDS	25,786	28,962	3,176	135,748	2.3%
BURLINGTON-NON PCMP	51,533	62,549	11,016	88,856	12.4%
BURLINGTON-PINELANDS	26,239	29,016	2,777	94,825	2.9%
CAMDEN-NON PCMP	57,178	60,657	3,479	21,800	16.0%
CAMDEN-PINELANDS	8,111	9,017	906	22,385	4.0%
CAPE_MAY-NON PCMP	24,288	27,412	3,124	26,914	11.6%
CAPE_MAY-PINELANDS	1,994	2,374	380	13,288	2.9%
CUMBERLAND-NON PCMP	31,520	35,509	3,989	120,104	3.3%
CUMBERLAND-PINELAND	1,133	1,264	131	17,838	0.7%
GLOUCESTER-NON PCMP	45,410	53,896	8,486	96,356	8.8%
GLOUCESTER-PINELANDS	5,044	5,317	273	19,608	1.4%
OCEAN-NON PCMP	67,584	76,993	9,409	74,507	12.6%
OCEAN-PINELANDS	10,410	11,991	1,581	64,522	2.5%

The Pinelands Management Plan, however, did not simply stop all urban growth within the Pinelands. 15,667 acres of urban growth occurred between 1986 and 1995. What is significant about the urban growth within the Pinelands is where it occurred. Analyzing the location of the growth within the various Pinelands Management Planning Areas (Figure 2-34) provides evidence that PCMP has been effective at channeling urban growth away from sensitive lands and into designated growth areas.

The majority of growth occurred in the *Regional Growth* and *Rural Development Areas* of the PCMP, whereas the Preservation Area, Agricultural Production Area and Special Ag Production Area combined received less than 5% of the total growth (Table 2-8). Within the Pinelands Management Area sensitive lands remain reasonably intact while planned growth areas and existing towns and villages received the majority of new development growth.

Table 2-8 Urban growth in the various Pinelands Planning Management Zones

PINELANDS MANAGEMENT ZONE	%OF TOTAL AVAILABLE LAND	1986-1995 GROWTH IN ACRES	PERCENT OF TOTAL GROWTH RECEIVED
Agricultural Production Area	11.2%	522	3.3%
Federal or Military Facility	N/A	356	2.3%
Forest Management Area	31.0%	2,131	13.6%
Pinelands Town	2.9%	833	5.3%
Pinelands Village	4.0%	784	5.0%
Preservation Area	10.7%	220	1.4%
Regional Growth Area	15.5%	6,788	43.3%
Rural Development Area	20.1%	4,019	25.7%
Special AG Production Area	4.7%	14	0.1%

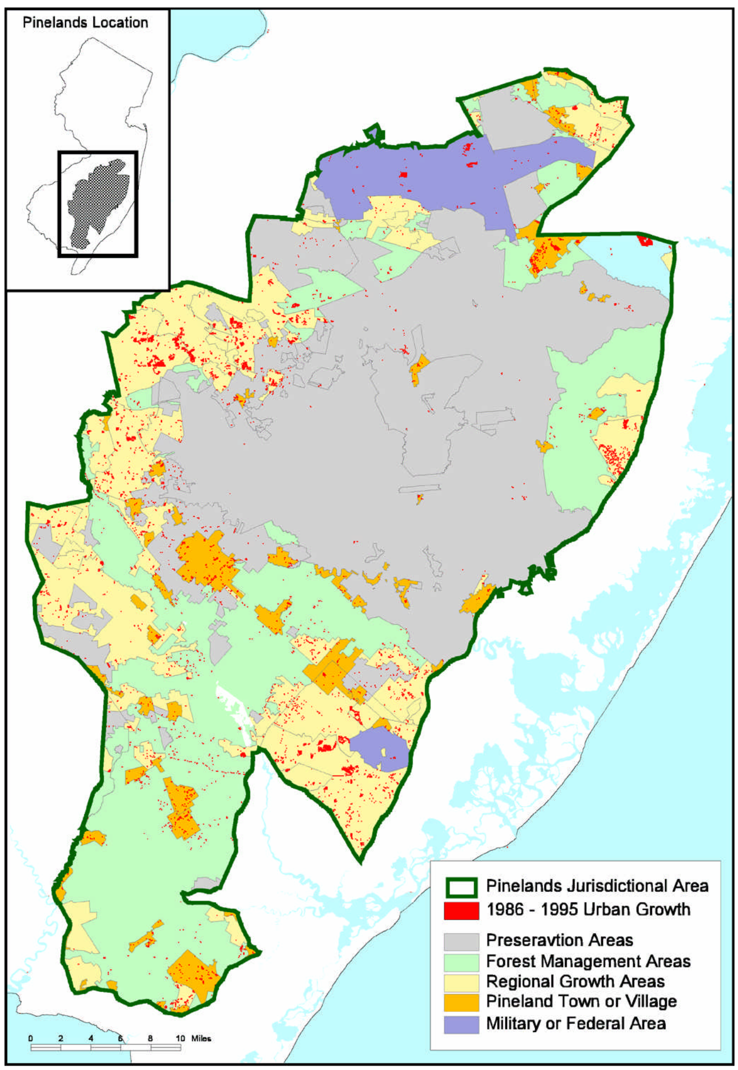

***Figure 2-34 Urban Growth in the Pinelands planning regions**. Areas of new growth (red) by and large occurred in the planned growth areas (yellow and orange) leaving preservation areas (gray) largely undisturbed.*

Remaining Available Lands

An open space coverage was produced by combining the NJDEP federal and state preserved open space layers (Figure 2-35) and additional open space data developed at CRSSA. The coverage also includes farmland preservation parcels as of March 2000 acquired from the NJ Department of Agriculture. The total lands estimated as preserved or protected in New Jersey as of 2000 was 1,056,171 acres.

The available lands coverage (Figure 2-36) was created by overlaying all non-developable lands including the preserved open space layer (mentioned above), steep slopes above 15%, water, wetlands and already developed lands. The total land estimated by this method was 1,765,436 acres. While this is a reasonable estimate of remaining available lands it is likely that there is actually somewhat less land available due to underestimates of open space due to data availability and other constraints on a given property's developability such as lot configuration and road access.

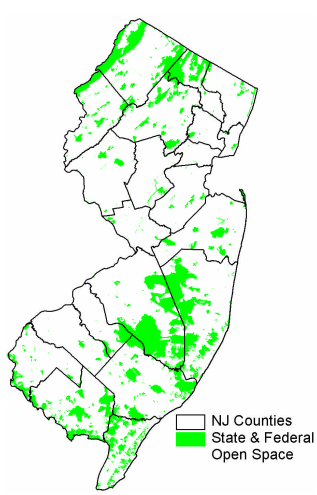

Figure 2-3 State and Federal Open Space

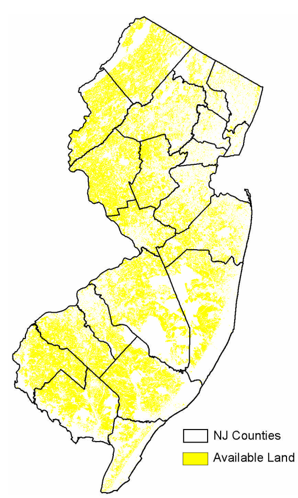

Figure 2-36. Remaining Available Lands

Running Out of Land

New Jersey's urban growth pressure is likely to make it the first state in the nation to reach build-out. The geospatial technologies utilized in this research provide a powerful method for analyzing how landscapes have changed in the recent past, however, predicting future landscape change is a much more tenuous endeavor. Urban growth is affected by multiple factors not withstanding economic conditions, political trends, cultural values and changes in technology. Nonetheless, a projection of current rates of growth help to put the land management circumstances facing New Jersey into perspective. Any projection must consider multiple factors. Some factors will have the effect of making build-out occur sooner and some will delay the date of build-out. The following discussion explores some of the factors that should be considered in projecting build-out. The reader is left to decide which factors and to what degree they will affect the actual build-out date.

New Jersey's growth trajectory – The previous section described that there are an estimated 1.76 million acres of available undeveloped land in New Jersey. If the state is successful at preserving 1 million acres of additional open space then at the current 16,600 annual acres rates of growth the remaining 0.76 million acres of available land will be entirely urbanized within 41 years. This 41-year figure is the time at which if the growth rate were to remain at 16,600 acres per year, every acre of available land not preserved as open space will be converted to urban land use. However, total urbanization of all available land is not a realistic scenario and many of the following additional factors will also influence New Jersey's build out scenario.

Will NJ really preserve 1 million acres? – New Jersey's total land area is almost 5 million acres. There are currently just less than 1 million acres of protected open space. If New Jersey is successful at preserving an additional million acres, then nearly 40% of New Jersey's land will be protected open space. This amount of preservation is unprecedented and represents the most ambitious land preservation effort anywhere in the United States. But is it realistic that 1 million acres can and will be preserved? Ultimately it will come down to economics. As land becomes scarcer through development and open space purchase, property prices will increase. The increase in property value will result in New Jersey's open space dollars diminishing in preservation power. Unless additional future funding sources are found to supplement New Jersey's Open Space Trust Fund, it is questionable whether the full 1 million acre goal will be met. For example if New Jersey successfully preserves only 75% of its million acre goal then build-out of the remaining 1,014,169 available acres would be reached in 56 years (all other factors held constant).

Build-out not 100% urban – Parcels do not become 100% urbanized at build-out, especially in rural areas. For example, in Hunterdon County (a county with available county-wide parcel mapping) we estimated that build-out in 1 acre, 3 acre and 5 acre zoning resulted in urban coverage of 88%, 64%, and 55% respectively. If New Jersey's entire remaining available land was urbanized in a similar pattern at 1, 3, or 5 acre zoning then build-out would occur in 36, 25 and 20 years respectively (all other factors held constant).

Sewered versus non-sewered areas – Land outside of sewered areas builds-out at lower densities than within sewered areas. Analysis of Hunterdon County build-out in sewered areas versus non-sewered areas suggests a build-out of approximately 89% total urban land cover within sewered areas versus approximately 61% total urban land cover in non-sewered areas. If New Jersey follows this same pattern for proposed statewide future sewered areas and non-sewered areas (NJ OSP) then build-out will be reached in 28 years (all other factors held constant).

Open space, wetlands and steep slopes – 1 million acres of additional open space is likely to include some wetlands and steep slopes. This overlap of protected land would result in more land being available for development, which would prolong build-out. For example approximately 36% of New Jersey's current open space is wetlands or steep slopes. If the future million acres of open space will include the same proportion of wetlands and steep slopes as current open space, then the million acres of open space would protect 64% or 640,000 acres of available buildable land. This would leave 1.125 million acres of available land and build-out would occur in 62 years at current growth rates (all other factors held constant).

Some development occurs on wetlands – While coastal wetlands have been regulated since 1970 and fresh water wetlands since 1987, there is still a significant amount of development that occurs on wetlands. From 1986 to 1995 there was an annual loss of 1,220 acres or wetlands. If the current amount of wetlands continues to be lost every year then build-out would occur be prolonged to 45 years as more land will be developed at build-out (all other factors held constant).

Method of urban growth delineation – There are various approaches for delineating urban growth within a region. The 16,600 acres per year figure 2-used in this report was derived from the 1995 NJ DEP land use/land cover dataset, which delineated land use change from aerial orthographic photography. The delineation relied on expert photo interpretation and contains a high measure of precision. However, as with all methods of land analysis, there are limitations and potential inaccuracies. Other recent urban growth studies of New Jersey that utilized different methodologies concluded with different rates of urban growth. The New Jersey Office of State Planning estimated 18,000 acres of urban growth per year (NJOSP 2000), a rate that would reach total build-out of the 0.7 million acres of available land in 34 years. A previous satellite-based CRSSA landscape change analysis (Lathrop 2000) estimated a growth rate of

20,217 acres per year, which would result in a build-out condition in 30 years. The US Department of Agriculture conducts a nation-wide natural resource inventory every 5 years. Their most recent estimate of development in New Jersey was 42,720 acres per year, which would result in build-out in 17 years (note: the methods utilized in the USDA analysis are based on a sampling methodology that is widely divergent to the other remote sensing-based methods mentioned and therefore problematic to directly compare). These differences are due to both the limitations of each technology as well as differences in classification scheme. For example land uses labeled "urban" in one method may not be considered "urban" in another method.

Non-linear rate of development – The rate of development in New Jersey is not likely to be linear. The analysis presented in this research only compares urban growth between two dates and then extrapolates that forward. Three or more consecutive periods of urban growth would present a more complete picture of the trajectory of urban development. One of the urban growth delineation methods mentioned above does contain multi-temporal data. The USDA Natural Resource Inventory is conducted every five years and shows dramatic variability over each period. In New Jersey, the USDA development rate went from 44,780 acres per year during 1982 to 1985 to 15,400 acres per year during 1987 to 1992 to 42,720 acres per year from 1992 to 1997. When averaged out over 15 years, the development rate is 34,180 acres per year. This illustrates that development will not occur in a linear fashion into the future but will significantly fluctuate year to year. However, the overall trend is likely to increase for a while and then level off and decrease as remaining land becomes less available and therefore more expensive. This will undoubtedly affect build-out. For example, if the current 16,600 acres increased by 1% annually for 15 years and then remained constant for 10 years and then decreased by 1% annually, build-would be reached in 36 years (all other factors held constant).

Adjusting for the Pinelands and Hackensack Meadowlands – The New Jersey Pinelands and the Hackensack Meadowlands are two special regions for land management in New Jersey. Regional regulatory authority for land management within Pinelands and Meadowlands has resulted in a significantly slower pattern of urban growth within these areas than rest of New Jersey. During the 1986 to 1995 analysis, the Pinelands and the Hackensack Meadowlands developed 2.5% of their available land whereas the rest of the state developed 8.4% of its available lands. If the Pinelands and the Meadowlands are removed from the analysis then the amount of available land remaining in the rest of the state would be 1,361,600 acres and the rate of growth for this area was 13,923 acres per year. Lands outside of the Pinelands and Meadowlands account for 79% of New Jersey's total available land area. If a proportionate amount of the million acres of open space (790,000 acres) are preserved in the lands outside the Pinelands and Meadowlands then the remaining available lands (571,596 acres) being developed at the rate of 13,923 acres per year will reach build-out in 36 years (all other factors held constant).

Variable geography of build-out – Some places in New Jersey will reach build-out sooner than others. The most remote counties will likely be the last ones to run out of land. At current county by county growth rates Salem, Cumberland, Atlantic and Sussex Counties will not reach build-out until well into the next century. As land becomes scarcer in the more urbanized counties, however, these rural counties can expect to see an increase in growth effectively accelerating the arrival of build-out. Nonetheless, some remote areas of these counties may be unlikely to reach total build-out in the foreseeable future.

Other socioeconomic factors – Many other socioeconomic factors will significantly affect the actual date at which New Jersey runs out of land. Some of these include economic and employment trends. For example, the continued suburbanization of corporate enterprises along with the increasing popularity of telecommuting will lead to higher demand for ex-urban development putting greater pressures on the rural landscape. Alternately, the growing popularity for the redevelopment of some of New Jersey's urban areas such as Jersey City and New Brunswick may indicate a growing trend for urban redevelopment and a lessening of the pressure for development of rural open spaces. Infrastructural improvements such as new roadways and sewer service areas will also have an important effect on where and when build-out will occur. On the other hand, more than half the development that occurred in New Jersey during this analysis occurred on non-sewered lands suggesting that sewer infrastructure may be less of a factor influencing build-out than previously thought.

Demography – Demographic changes will also affect New Jersey's future build-out as population is projected to increase by 1.6 million by 2025 and immigration is expected to increase by 1.2 million significantly diversifying the population (US Census Bureau 2000). Cultural trends will also influence future development. For example, growing anti-sprawl sentiment is leading to many smart growth initiatives throughout the state while at the same time the popularity for large homes on expansive rural lots seems to be increasing. The adoption of the New Jersey State Development and Redevelopment Plan will have an important influence on the rate and pattern of future urban growth (Burchell 2000). These and potentially other socioeconomic and demographic factors will all influence New Jersey's final build-out date. The fluctuating nature of socioeconomic factors makes incorporating them in a build-out projection extremely difficult. However, these ancillary variables may prove to be the most significant factors in determining New Jersey's actual build-out.

New Jersey is on course to run out of land sometime within the middle of this century. Exploring the various factors that will affect how and when that might occur is not intended to be a comprehensive model to predict the exact build-out scenario that will occur, but rather a conceptual exercise to help put the magnitude of New Jersey's current growth patterns into perspective. Even if the exact date cannot be foreseen with certainty from this vantage point, it is important to comprehend the degree to which development is changing the landscape and the significance that land management practices currently employed will have on the final condition of New Jersey's landscape.

Conclusion

In this chapter I have attempted to illustrate the magnitude of urban growth occurring in New Jersey and the implications of this rate of growth to impact the landscape as New Jersey steadily marches towards urban build-out. While the question of when New Jersey will actually reach build-out is dependent on many dynamic variables and therefore impossible to predict with confidence, the more important question to be asked is not when build-out will be reached but what New Jersey's built-out landscape will look like and how well will it function for both New Jersey's human and ecological community? How viable will the agriculture, habitat, water quality and wetlands be for that final landscape? What will be the quality of life in the communities of the future? These questions focus on the nature, quality and impact that continued urban growth that will have on that future landscape. If continued urban growth will continue to impact the landscape, the question then arises as to whether all development will have the same impact or whether certain patterns of urban growth are more damaging than others. The remaining chapters of this dissertation attempt to explore this question by developing a means of measuring the sprawling characteristics of new urban growth and impacts of sprawl to the functional integrity of a landscape.