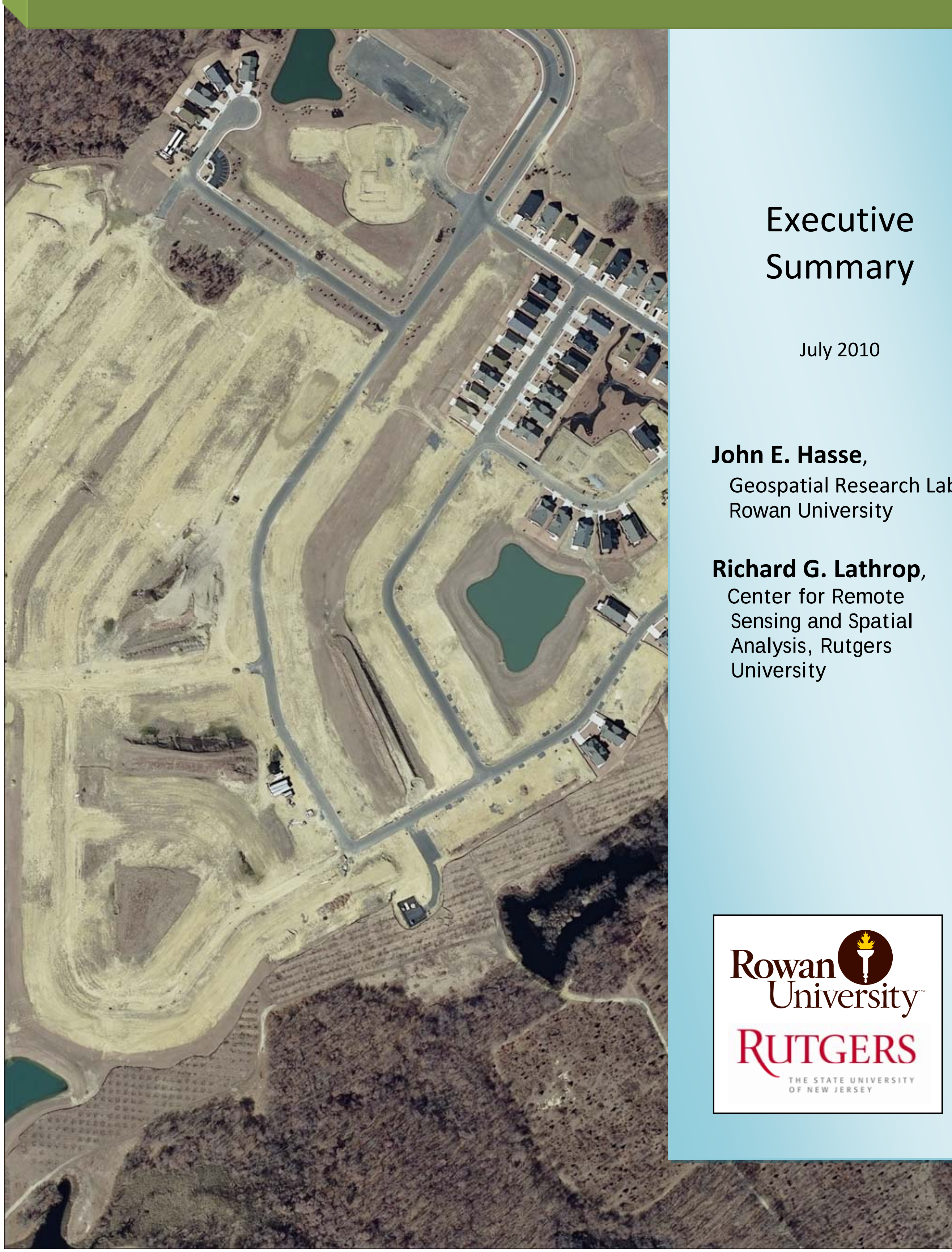
Changing Landscapes in the Garden State:

Urban Growth and Open Space Loss in NJ 1986 thru 2007



Executive Summary

July 2010

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1 Introduction

The numbers are in for New Jersey's most recent statewide digital mapping dataset. Using high-precision aerial photography, the state has created one of the most comprehensive inventories of land composition of any state. The land use mapping initially developed by the NJ DEP in 1986 has just been updated to give a picture of land use patterns and changes in the Garden State up through 2007.

This report is part of an ongoing series of collaborative studies between Rowan and Rutgers Universities examining New Jersey's urban growth and land use change. The DEP data set utilized for the analysis represents a detailed mapping of the land use and land cover as depicted in high resolution aerial photography that was acquired in the spring of 2007. The imagery was then classified and mapped (Figure 1.1) providing a window into how the Garden State has developed over the past several decades (from 1986 through 2007) and the subsequent consequences to its land base. It views land development patterns from several different angles providing a "report card" on urban growth and open space loss.

What the data show is that is that urban development in the nation's most densely populated state has continued unabated and in fact gained momentum up through 2007. The data reveals a 7% increase in development rate to 16,061 acres of urbanization per year by 2007, up from the previous rate of 15,123 acres per year during the 1995 through 2002 time period. During the 21 year period since the datasets were first compiled, New Jersey urbanized a massive

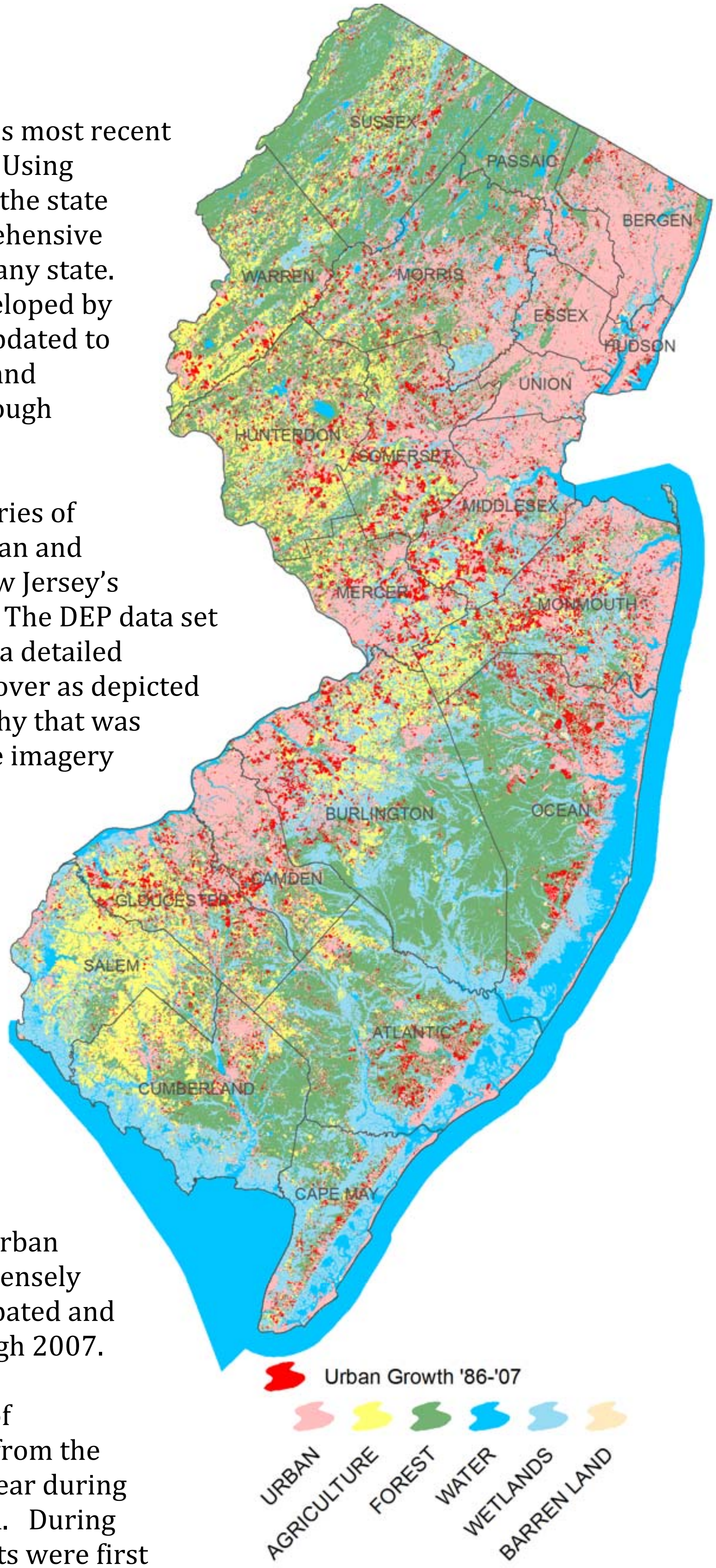


Figure 1.1 Land use and urbanization in New Jersey 1986 through 2007

323,256 acres (507 sq mi) of land adding 26.8% to the state's pre 1986 urban footprint. At the same time, New Jersey added about 1 million residents to reach a population of 8.5 million, an increase of only 14% during the same 1986 to 2007 time period. In other words, NJ's urban growth rate was nearly twice as fast as its population growth rate during the two decades of the study.

Looking at the last 5 years of the study, population growth slowed from an estimated 97,000 additional people per year T2 to 21,000 additional people per year T3. The change in population from 8.5 million in 2002 to 8.6 million in 2007 represents a 1.2% population increase. In contrast, during the same time the rate of urban land increase went from 15 to 16 thousand acres per year for a total of 80,306 acres representing a 5.3% urban growth rate. That is to say that the five year period from 2002 to 2007 saw urbanization occurring at over 4 times the growth rate of population.

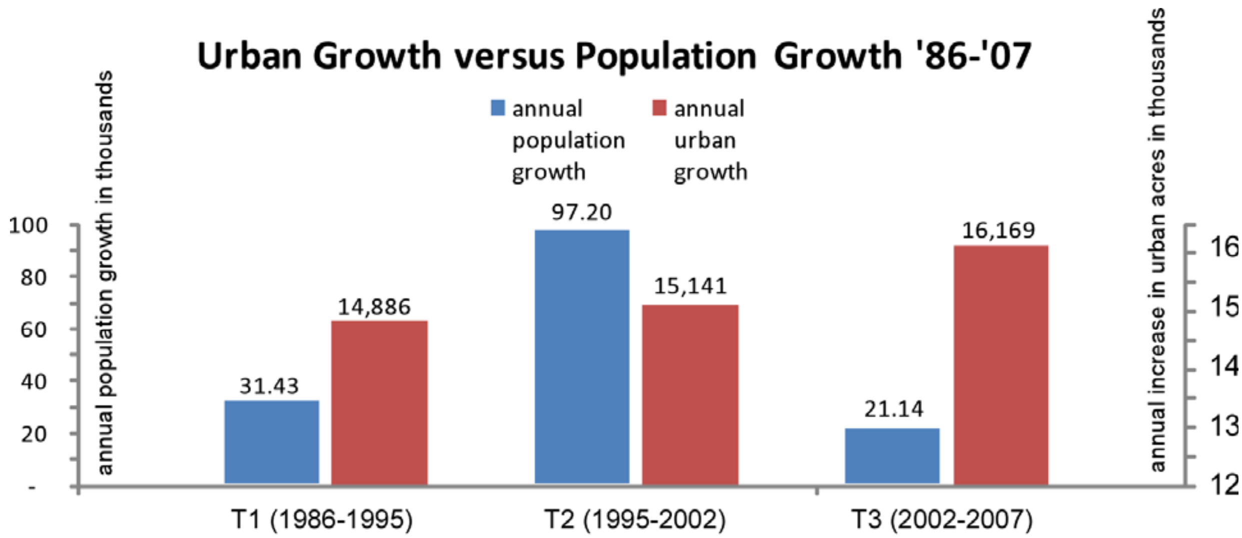
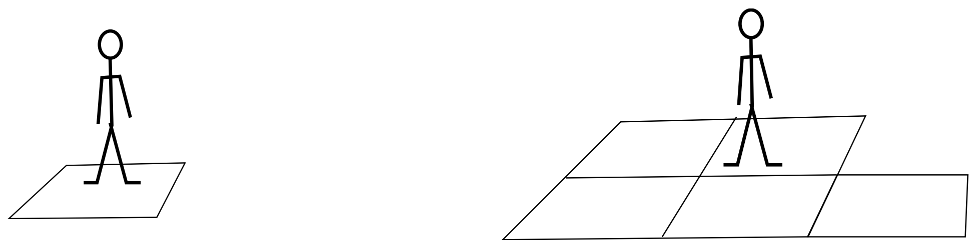


Figure 1.2 Population growth rates versus urban growth 1986 – 2007

On a per-capita basis, the land occupied by NJ's population in 1986 was 0.16 acres (6,941 sq ft) per person. In the 2002-2007 time period, the per capita consumption of land for each new person added to the population was 4.8 times the 1986 rate at 0.76 acres (33,311 sq ft) per person. Some researchers have generalized "urban sprawl" as development growth that significantly exceeds population growth (Peiser, 1989; Ewing, 1994; Ewing, 1997, Gordon and Richardson, 1997; Burchell and Shad, 1999; Galster et al, 2001; Hess, 2001;). By this measure, considering the density of urban development pre 1986, the Garden State has just completed its two most sprawling decades in history.

One of the consequences of sprawling development patterns is the loss of important land resources to urbanization. During the 2 decade analysis the Garden State loss substantial amounts of agricultural lands, wetlands and forest lands. Forest loss has been so significant during this time period that by 2007 urban land had surpassed forest land as the most prominent land type covering the state. As of 2007 the Garden State has more acres of subdivisions and shopping centers than it has of upland forests including forests in the Pinelands and all New Jersey's parks and reserves combined. And the pace of deforestation is increasing. During the early 1986-1995period of the data (which we label T1) forest loss occurred at 4,300 acres per year. During the middle period of the study (T2 1995-2002) the rate of deforestation had risen to 5,901 acres per year. The most recent time period of data (T3 2002-2007) shows that loss jumping to 8,490 acres per year, a 97% increase in deforestation rate from the T1 1986-1995 period.



1986 land urbanized per capita (0.14 acres)

2002 – 2007 urban growth per capita population growth (0.76 acres)

Figure 1.3 Per capita urban footprint

Clearly, the changes occurring to the state's land use pattern are remarkable but they are also complex. The patterns of development experienced during these two decades vary throughout different regions of the state. An in-depth analysis requires a deeper probing of the data than simple population to land consumption ratios. The landscape change research conducted at Rowan and Rutgers takes a more nuanced approach to characterizing sprawl in New Jersey looking at urban growth and open space loss from many different angles. In subsequent reports to be released throughout the coming year, we will describe in detail the character, context, and consequences of urban growth during the 1986 to 2007 time period. The following is a summary of our initial major findings to date.

Geographic Context - New Jersey has a long history as having the highest population density, as well as having the highest percentage of its land area in urban land uses of any state in the United States. New Jersey's population pressure stems from its geographic location, wedged between the nation's largest and 6th largest cities, New York and Philadelphia. These factors have resulted in New Jersey maintaining its status as one of the most rapidly urbanizing states in the nation throughout the past several decades. Even while the population growth has slowed over the past decade, urban development has continued to increase pace and dispersion. By the year 2007, over 30% of the states 5 million acre territory had become urbanized, surpassing any other land use type in total number of acres.

2 Basic Level I Land Use Changes

This report relies on the 2007 New Jersey Land Use/Land Cover (LU/LC) dataset released by the New Jersey Department of Environmental Protection (NJDEP) in June of 2010 (NJDEP, 2010). Employing the 2007 LU/LC dataset, a Level 1 analysis looks at the broadest categories of landscape change that have occurred statewide over time. A Level 1 analysis groups all land into six broad categories of land use/land cover: *urban*, *agriculture*, *forest*, *water*, *wetlands*, and *barren*. Since the LU/LC datasets utilized in this study were produced for the years 1986, 1995, 2002, and 2007 an accounting of the number of acres within each of the Level 1 category reveals the changes over this 21 year time period (Table 2.1). Since the time spans between dates in the datasets are different, annualizing the rates of change allows for more direct comparison. Given that the total territory of the state hasn't changed over the time period of interest, when development increases there must also be a corresponding decrease in other categories of land. Figure 2.1 depicts the change in each Level 1 category over the 1986, 1995, 2002 and 2007 time period.

Table 2.1 Level 1 land use/land cover for 1986, 1995, 2002 and 2007 time periods.

Two Decades of New Jersey's Land Use Change

	1986 (acres)	**1995 (acres)**	**2002 (acres)**	**2007 (acres)**	**21 year Change**	**21 yr % Change**
Urban	1,208,553	1,334,542	1,452,503	1,532,809	324,256	**26.8%**
Agriculture	744,382	652,335	594,696	566,044	-178,338	**-24.0%**
Forest	1,641,279	1,616,522	1,568,809	1,526,358	-114,921	**-7.0%**
Water	783,260	800,610	803,185	810,095	26,835	**3.4%**
Wetlands	1,049,269	1,022,253	1,005,636	996,984	-52,285	**-5.0%**
Barren	57,223	56,698	59,138	51,678	-5,545	**-9.7%**

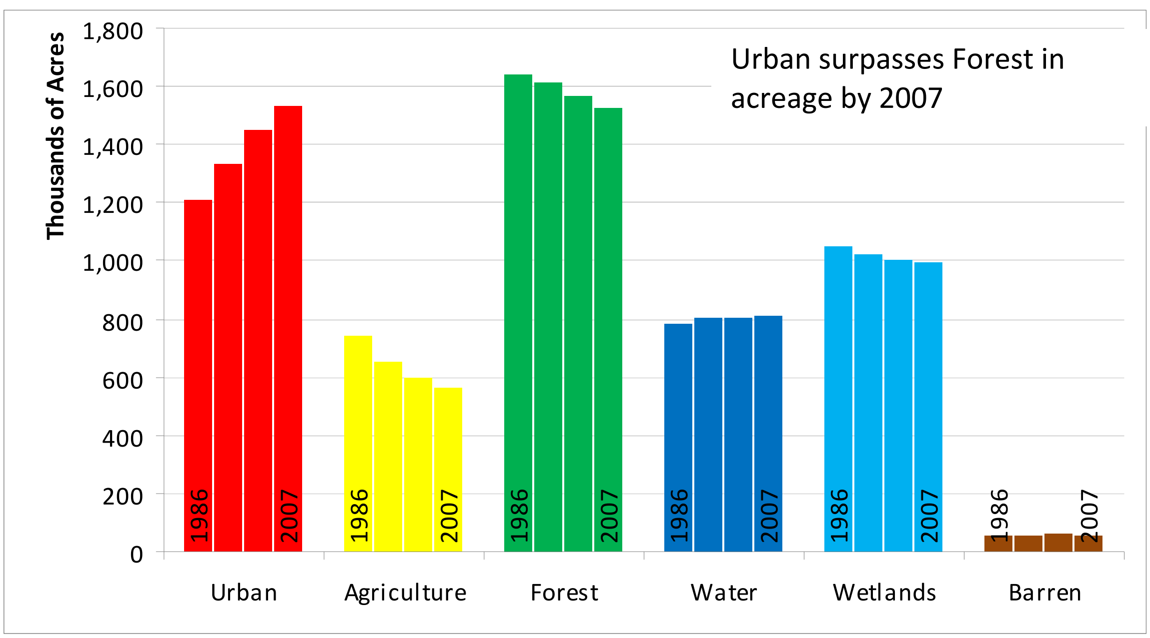


Figure 2.1. Change in each Level 1 category over the 1986, 1995, 2002 and 2007 time periods.

Looking first at *urban (i.e. developed)* land, the analysis reveals that New Jersey's pace of development appears to have been surprisingly steady over the past two decades. Between the year 2002 and 2007 (T3) New Jersey expanded the amount of urban land by

80,306 acres to a statewide total of 1,532,809 acres total urban land. Normalizing the number of new acres of development by the 5 year time period provides a rate of 16,061 acres of new development per year (Figure 1.2). This represents a 7% increase in the rate of development from the previous land use mapping periods of T1 (1986 to 1995) and T2 (1995 to 2002) when urban development grew at a pace of 14,886 and 15,123 acres per year, respectively (Figure 2.2).

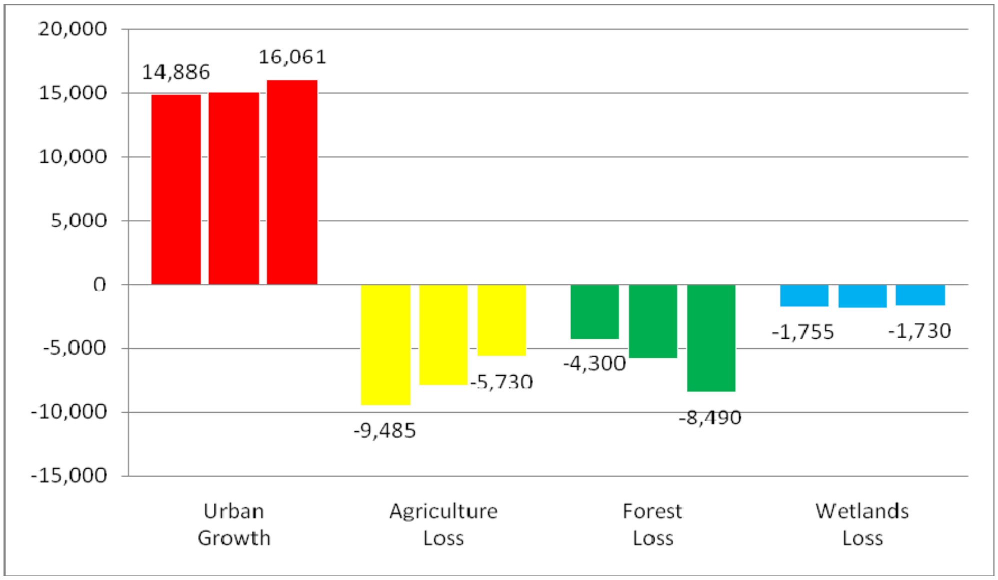


Figure 2.2 Annualized rates of land use change for the T1('86 – '95), T2('95 – '02) and T3('02 – '07) time periods.

Land Use Change Matrix – Over time, land use types change in many possible directions. While many acres of open space become urbanized, some urban lands can possibly change back into a non urban category. Farmlands can convert to forest and visa versa and so on. In order to give a complete picture of the multiple directions of change occurring in New Jersey's dynamic landscape a land use change matrix is provided. Since wetlands can have overlap with other level 1 land use types (for examples, *agricultural wetlands*), the authors recast the wetlands categories depending on their Level III Anderson land use codes (Table 2.2). The labels remain unchanged for: URBAN, AGRICULTURE, FOREST, WATER and BARREN. The following tables (Tables 2.3a and 2.3b) provide the net and annualized land use change matrix for changes that occurred in the 2002 – 2007 dataset. These tables can be studied and compared with the land use change matrix tables for the T1 and T2 datasets. For a more complete discussion of the recasting of the wetlands categories and the T1 and T2 matrix tables, see Hasse and Lathrop 2008 p. 9-14.

Table 2.2 H-L wetlands categories.

H-L wetlands name	Anderson Codes
Coastal Wetlands WETCOAST	6110, 6111, 6112, 6120, 6130, 6141
Emergent Wetlands WETEMERG	6230, 6231, 6232, 6233, 6234, 6240, 6241, 6290
Forested Wetlands WETFOREST	6210, 6220, 6221, 6250, 6251, 6252
Urban Wetlands WETURB	1461, 1711, 1750, 1850
Agricultural Wetlands WETAGR	2140, 2150,
Disturbed Wetlands WETDIST	6500, 7430, 8000

Table 2.3a,b H-L class land use/land cover total and annual acres change matrix for T3('02-'07). These tables allow for the examination of all possible transitions between different land classes. Not only can the total acreage of a particular class be read at the final columns and bottom rows of the tables, the number of acres of change for each possible transition can also be traced.

Table 2.3a T3('02-'07) total acres transition matrix.

2002					2007							
	AGRICULTUR	BARREN	FOREST	URBAN	WATER	WETAGR	WETCOAST	WETDIST	WETEMERG	WETFOR	WETURB	total 2002
AGRICULTUR	558,623	5,759	7,510	22,415	314	21	13	4	19	8	10	594,696
BARREN	637	29,899	2,238	22,024	3,467	1	783	44	35	3	7	59,138
FOREST	5,169	9,835	1,513,653	38,823	870	16	58	35	195	151	5	1,568,809
URBAN	1,407	3,915	2,772	1,443,831	478	7	32	5	37	10	9	1,452,503
WATER	4	753	27	124	800,743	15	830	33	629	18	8	803,185
WETAGR	95	259	59	1,075	138	74,691	8	417	2,717	36	410	79,905
WETCOAST	1	234	3	62	1,766	1	196,358	992	61	9	5	199,492
WETDIST	16	207	29	941	463	302	527	5,482	2,436	425	353	11,181
WETEMERG	17	219	26	494	1,437	376	82	1,729	98,562	3,835	174	106,950
WETFOR	73	561	37	2,741	381	302	80	1,692	687	587,329	280	594,162
WETURB	3	35	4	279	38	29	1	45	144	8	13,359	13,947
total 2007	566,044	51,678	1,526,358	1,532,809	810,095	75,762	198,772	10,478	105,521	591,831	14,619	5,483,968
Net Change '02-'07	-28,652	-7,460	-42,452	80,306	6,910	-4,142	-720	-703	-1,429	-2,331	673	

Table .2.3b T1('02-'07) annualized acres transition matrix.

2002					2007							
	AGRICULTUR	BARREN	FOREST	URBAN	WATER	WETAGR	WETCOAST	WETDIST	WETEMERG	WETFOR	WETURB	Annual loss
AGRICULTUR	-	1,152	1,502	4,483	63	4	3	1	4	2	2	7,215
BARREN	127	-	448	4,405	693	0	157	9	7	1	1	5,848
FOREST	1,034	1,967	-	7,765	174	3	12	7	39	30	1	11,031
URBAN	281	783	554	-	96	1	6	1	7	2	2	1,734
WATER	1	151	5	25	-	3	166	7	126	4	2	488
WETAGR	19	52	12	215	28	-	2	83	543	7	82	1,043
WETCOAST	0	47	1	12	353	0	-	198	12	2	1	627
WETDIST	3	41	6	188	93	60	105	-	487	85	71	1,140
WETEMERG	3	44	5	99	287	75	16	346	-	767	35	1,678
WETFOR	15	112	7	548	76	60	16	338	137	-	56	1,367
WETURB	1	7	1	56	8	6	0	9	29	2	-	117
Annual gain	1,484	4,356	2,541	17,796	1,870	214	483	999	1,392	900	252	-
Net Change annualized	-5,730	-1,492	-8,490	16,061	1,382	-828	-144	-141	-286	-466	135	-

3 Land Resource Impacts

Deforestation: The land category to lose the greatest number of acres was *forest* which lost 42,452 net acres (66.3 sq miles) statewide during T3 (‘02 - ‘07). This represents a substantial increase in the net rate of forest loss to 8,490 per year in T3 up from 5,923 acres per year in T2, a 43% increase, and a 97% increase in rate of deforestation when compared to T1 net rate of 4,300 acres forest loss per year. While the numbers are staggering, the data needs some clarification. In T2 the rate of forest loss specifically to urbanization was 8,356 acres per year but this amount was overshadowed by the significant number of acres of other land uses that changed back into forest during T2 for the net change of 5,923 acres of loss. During T3 the net loss of forest due specifically to urbanization was 38,823 acres or 7,765 acres per year of forest urbanized an actual drop from T2 rate but there were far fewer lands that changed back into forest during T3 compared to T2.

Looking across the entire 21 year study period, New Jersey lost a net of 114,921 acres (180 sq mi) of upland forest between 1986 and 2007 representing a 7% loss (figure 3.1). During the majority of New Jersey’s history, upland forest was the predominant land category. However, at the T3 rates of upland forest loss and simultaneous urban growth, the total amount of urban land in New Jersey surpassed the total amount of upland forest land by 2007.

The net effect of landscape changes experience over the past two decades is that New Jersey’s forested lands experienced significant losses including fragmentation and forest core loss which have significant ecological implications (Franklin 1993; Robinson et al., 1995). Habitat

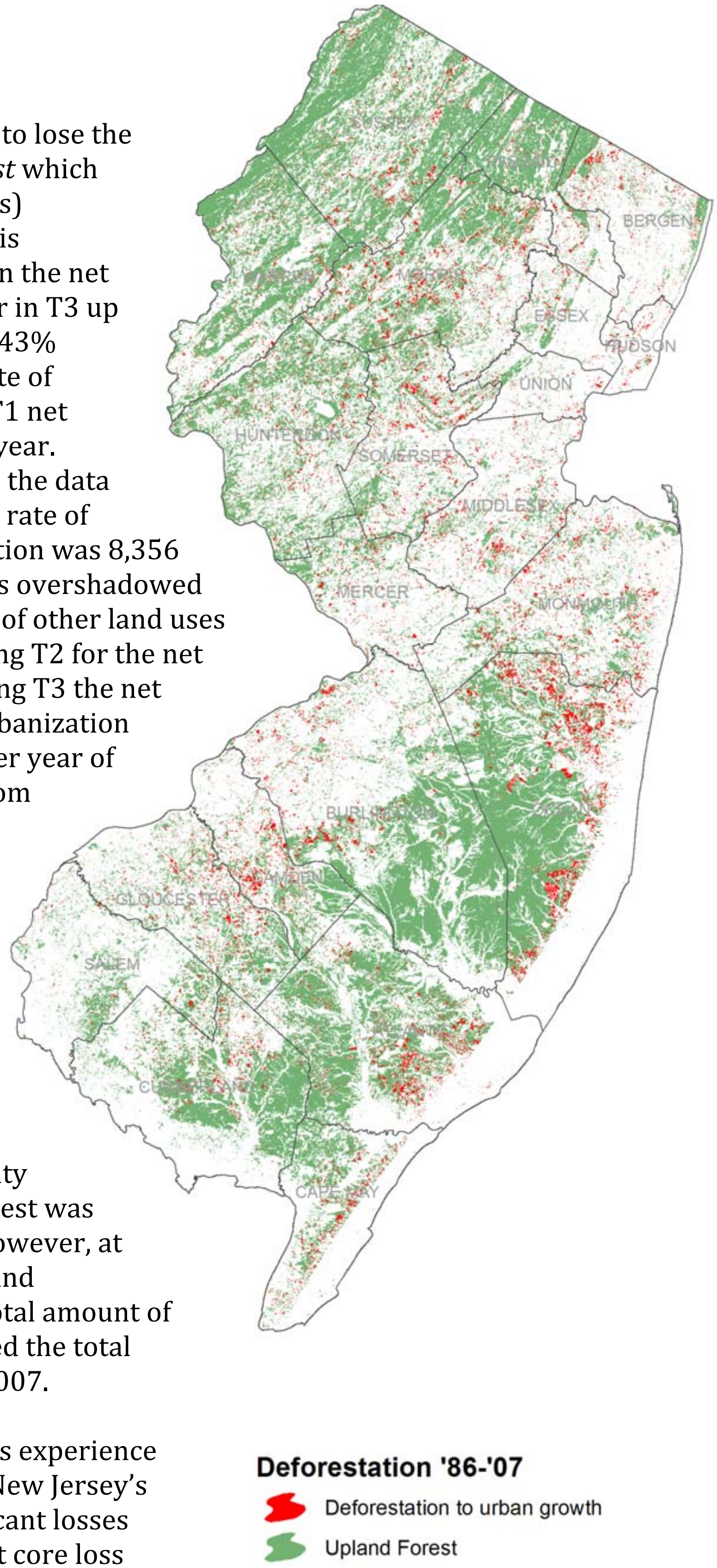


Figure 3.1 Deforestation in New Jersey due to urban growth 1986 - 2007

areas and movement corridors are diminished and disrupted when forest stands are broken into smaller and non-connecting sections. Many species that rely on large blocks of uninterrupted forest core for habitat may be adversely affected by its reduction (NJDEP 2008). Forest core in NJ (measured 100 meters inward from forest edge including forested wetlands) also was diminished throughout the study period. During the 1986 to 2007 study period, the state lost an estimated 79,489 acres of forest core for an 8.1% loss. The impacts to forest lands revealed in the data suggest that addressing forest loss has become an increasingly important issue for the Garden State.

Farmland Loss - The rate of *agricultural land* loss has consistently declined over the same period from an annualized rate of 9,485 acres per year in T1('86- '95) to 7,933 acres per year in T2('95- '02) to the most recent 5,730 acres per year in T3('02 - '07) (Figure 3.2). This trend is closely related to two factors: 1) there is less farmland consumed by urbanization (6,114 acres per year in T1 vs. 5,149 in T2 vs. 4,483 acres per year in T3); and, 2) less farmland is being abandoned and allowed to regenerate to forest. Likewise, over this time period farmland preservation has made significant gains in protecting farmlands. While the slowing of farmland loss is certainly a positive trend, it must be gauged against the bleak reality of the magnitude of 178,337 acres or 279 square miles agricultural land loss over the 21 year period of the study (Figure 3.2) In only 21 years, ¼ of the states total farmland that existed in 1986 has disappeared.

Wetlands Loss - *Wetlands* also continued to be lost to urban growth with the net acreage of wetlands loss totaled 8,652 acres statewide during T3(02'- '07). To put this rate of wetlands loss into

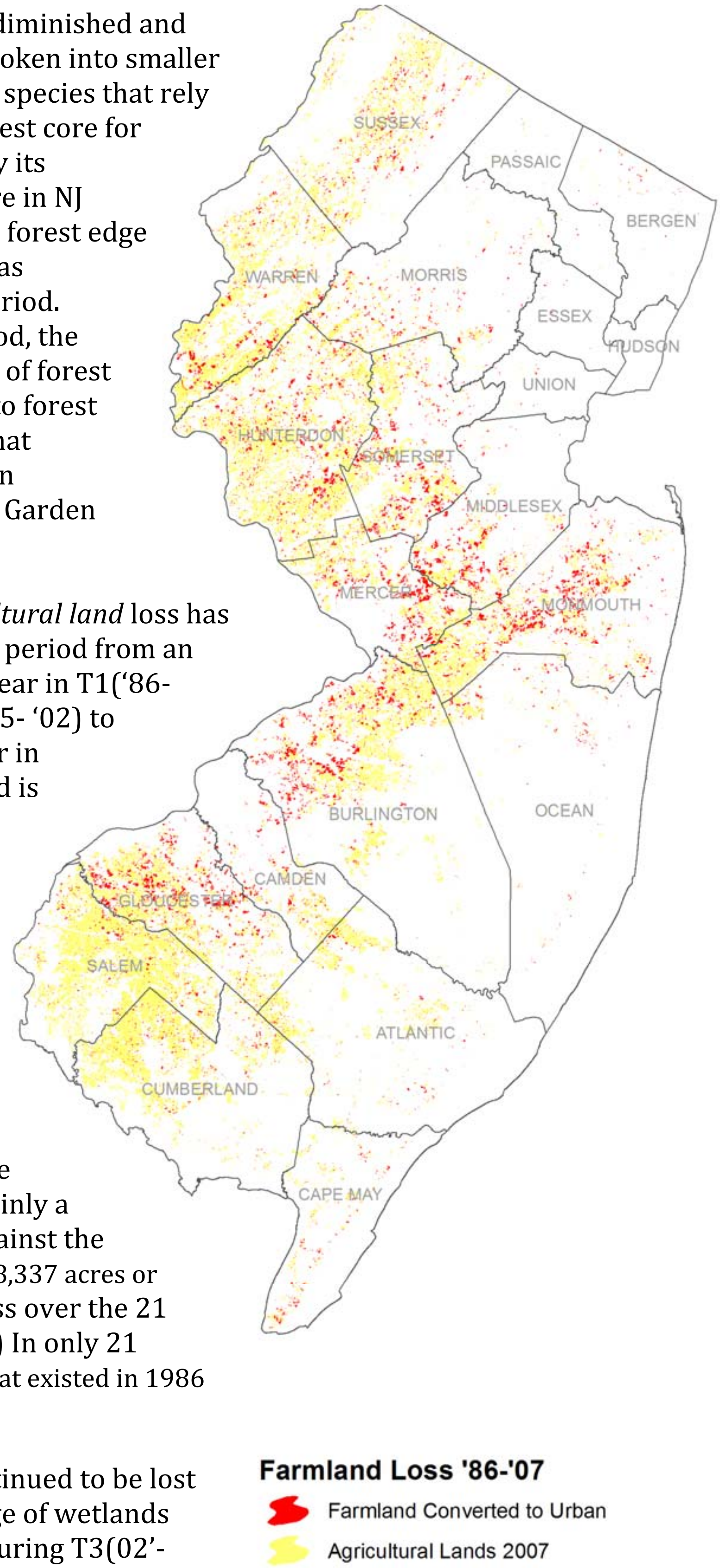


Figure 3.2 Farmland Loss to urbanization in New Jersey 1986 through 2007

perspective, the New Jersey Hackensack Meadowlands has a total of 8,400 acres of wetlands. At the annual rate of loss experienced during T3, New Jersey disposed of more than a Hackensack Meadowlands worth of wetlands over the last 5 years. The annualized loss rate has remained relatively consistent over the past two decades with annualized rate of 1,730 acres per year in T3('02 - '07) down slightly from 1,842 acres in T2('95 – '02) which was an increase from 1,755 acres in T1('86- '95).

However, the net numbers of wetlands loss mask some of the positive trends that have occurred in wetlands change in T3 compared to T2. Namely there has been a significant drop in rate of wetlands changing into urban classes, from 1,601 acres per year urbanized in T2 to 1,118 acres per year in T3, a 30% drop. So, while wetland losses continue, and are certainly of major concern, the fact that the conversion rates to urban land have dropped significantly is certainly a positive trend that shouldn't be over looked.

The Level 1 net land use/land cover changes revealed in the T3 ('02- '07) dataset confirm that overall trends of urban development have remained robust while open space and important land resources continue to be lost at an equally rapid pace. While the Level 1 analysis provides the basic outline, digging deeper into the data reveals more details of exactly how New Jersey's landscape has been changing.

4 Level III Analysis of Urbanization

The net acres of urban growth are an important measure to track given that development comes at the loss of a limited amount of open space. However, equally important to the question of 'how much' urban growth has occurred are the questions of 'where' and 'what kind' of development has occurred. Level III analysis of the data facilitates a detailed look as the specific types of development that occurred and from what types of land they changed from.

A more in-depth urban analysis can be conducted by utilizing the Level III Anderson land use codes that are contained within the datasets. By analyzing the polygons within each dataset that changed from a non-URBAN to URBAN land, significant details of this change can be revealed. Table 3.1 provides a statistical breakdown of all twenty-eight Level III urban classes included in the datasets (note: classes have changed over the multiple datasets)

The majority of land developed during theses time periods was attributable to residential housing development (Figure 4.1). Combined categories of residential growth represented 56.9% of the total amount of land developed during T3('02 – '07) time period Breaking residential down further into the different categories of residential reveals that the largest consumers of land were the large lot units that have become prevalent during the last couple of decades. LU type1130 Residential (Single Unit, Low Density) represents about 11% of the land that was developed during the T3 time period and consists of single unit residential neighborhoods with areas greater than ½ acre up to and including 1-acre lots. LU type 1140 Residential (Rural, Single Unit) represents over 27% of the land developed during T3 and consists of single unit residential neighborhoods with areas between 1 acre and up to and including 2-acre lots. These two low density residential categories combined represent 67% of the land developed into residential land uses during T3. In spite of many mechanisms put in place in New Jersey to encourage more efficient compact development over the last two decades, two thirds of the acres developed into residential housing were the large-lot land consumptive units that have encroached on rural landscapes throughout the state.

Overall, there appears to be a slight decline in the percentage of residential land (as a % of the total amount of urban land) for T3 as compared to the earlier time periods; from 63.3%, 65.6%, and 62.1% of the total development in T0, T1, and T2 to 56.9% in T3. This decline in residential land is made up for an increase in the OTHER URBAN OR BUILT-UP LAND category (LU 1700) which went from 11.6% of the urban growth in 2002 to 18.6% of the urban growth in 2007. This category of land is for areas not clearly definable by other categories such as small strips of land between properties. This increase in the "other" urban land is likely more of a classification methodology issue than a true change in land development pattern.

Figure 4.1 Low density large lot residential units consumed about 67% of the open land developed into housing in New Jersey but housed only about 24% of the residents that occupied newly developed units. This pattern has remained consistent throughout the 21 period of the study.

Table 4.1 Summary of acres within urban Level III land use category for T0(pre '86) through T3('02-'07).

Land Use Code	Land Use LABEL	T0(pre '86) Total Urban Acres	T0(pre '86) % of Total Urban	T1('86-'95) Acres of Urban Growth	T1('86-'95) % of total Urban Growth	T2('95-'02) Acres of Urban Growth	T2('95-'02) % of total Urban Growth	T3('02-'07) Acres of Urban Growth	T3('02-'07) % of total Urban Growth
1110	RESIDENTIAL, HIGH-DENSITY OR MULTIPLE DWELLING	115,032	9.4%	11,170	7.4%	7,018	5.6%	4,652	5.2%
1120	RESIDENTIAL, SINGLE UNIT, MEDIUM-DENSITY	330,489	27.1%	20,258	13.5%	18,556	14.8%	12,197	13.6%
1130	RESIDENTIAL, SINGLE UNIT, LOW-DENSITY	143,095	11.7%	21,440	14.3%	16,550	13.2%	9,836	11.0%
1140	RESIDENTIAL, RURAL, SINGLE UNIT	183,297	15.0%	45,415	30.3%	35,675	28.5%	24292	27.1%
1150	MIXED RESIDENTIAL	884	0.1%	125	0.1%	11	0.0%	3	0.0%
1200	COMMERCIAL/SERVICES	110,288	9.0%	9,179	6.1%	7,173	5.7%	6,548	7.3%
1211	MILITARY INSTALLATIONS	8,125	0.7%	429	0.3%	197	0.2%	221	0.2%
1214	FORMER MILITARY, INDETERMINATE USE	33	0.0%	9	0.0%	2	0.0%	1	0.0%
1300	INDUSTRIAL	63,525	5.2%	5,384	3.6%	4,943	4.0%	3,110	3.5%
1400	TRANSPORTATION/COMMUNICATION/ UTILITIES	65,606	5.4%	5,030	3.4%	1,553	1.2%	1,064	1.2%
1410	MAJOR ROADWAY	NA	NA	NA	NA	475	0.4%	372	0.4%
1419	BRIDGE OVER WATER	NA	NA	NA	NA	10	0.0%	0	0.0%
1440	AIRPORT FACILITIES	NA	NA	NA	NA	150	0.1%	161	0.2%
1461	WETLAND RIGHTS-OF-WAY	4,150	0.3%	197	0.1%	108	0.1%	131	0.1%
1462	UPLAND RIGHTS-OF-WAY DEVELOPED	NA	NA	NA	NA	109	0.1%	73	0.1%
1463	UPLAND RIGHTS-OF-WAY UNDEVELOPED	NA	NA	NA	NA	297	0.2%	512	0.6%
1499	STORMWATER BASIN	NA	NA	NA	NA	4,148	3.3%	3,528	3.9%
1500	INDUSTRIAL/COMMERCIAL COMPLEXES	378	0.0%	118	0.1%	50	0.0%	53	0.1%
1600	MIXED URBAN OR BUILT-UP LAND	1,444	0.1%	4	0.0%	3	0.0%	4	0.0%
1700	OTHER URBAN OR BUILT-UP	103,542	8.5%	22,617	15.1%	14,468	11.6%	16,693	18.6%
1710	CEMETERY	NA	NA	NA	NA	220	0.2%	120	0.1%
1711	CEMETERY ON WETLAND	NA	NA	NA	NA	34	0.0%	0	0.0 %
1741	PHRAGMITES DOMINATE URBAN AREA	NA	NA	NA	NA	87	0.1%	9	0.0%
1750	MANAGED WETLAND IN MAINTAINED LAWN GREENSPACE	4,727	0.4%	999	0.7%	1,464	1.2%	0	0.0%
1800	RECREATIONAL LAND	60,877	5.0%	6,127	4.1%	10,115	8.1%	4,994	5.6%
1804	ATHLETIC FIELDS (SCHOOLS)	14,252	1.2%	754	0.5%	845	0.7%	897	1.0%
1810	STADIUM THEATERS CULTURAL CENTERS AND ZOOS	NA	NA	NA	NA	155	0.1%	39	0.0%
1850	MANAGED WETLAND IN BUILT-UP MAINTAINED REC AREA	2,409	0.2%	770	0.5%	595	0.5%	0	0.0 %

Photo: J. Hasse

Figure 4.2 The majority of land developed in New Jersey (about 57 %) went to residential housing.

5 Impervious Surface

One of the more significant landscape impacts attributable to urbanization is the creation of impervious surface. In nature water is continually moving between the atmosphere, ground water aquifers, lakes and rivers. When land becomes developed, a portion of the parcel is necessarily covered with impervious surface such as asphalt and concrete. The creation of impervious surface changes the natural hydrologic cycle by impeding precipitation infiltration to groundwater while increasing the amount of surface runoff. Storm peaks are amplified in velocity and magnitude changing the load carrying and erosion characteristics of stream channels. These changes have significant environmental consequences including impacts to ground water recharge, frequency and magnitude of flooding, elevated non-point source pollutant levels and degraded biological activity (Kennen, 1998; Brabec et al., 2002).

Research has shown that the water quality and environmental condition of a watershed is demonstrably related to the amount of impervious surface within the watershed. A landmark paper by Arnold & Gibbons (1996) described the relationship. Watersheds with less than ten percent impervious surface cover are generally considered un-impacted. At levels greater than ten percent impervious surface watersheds show signs of impact. As impervious surface reaches thirty percent and beyond, water quality has typically become seriously degraded.

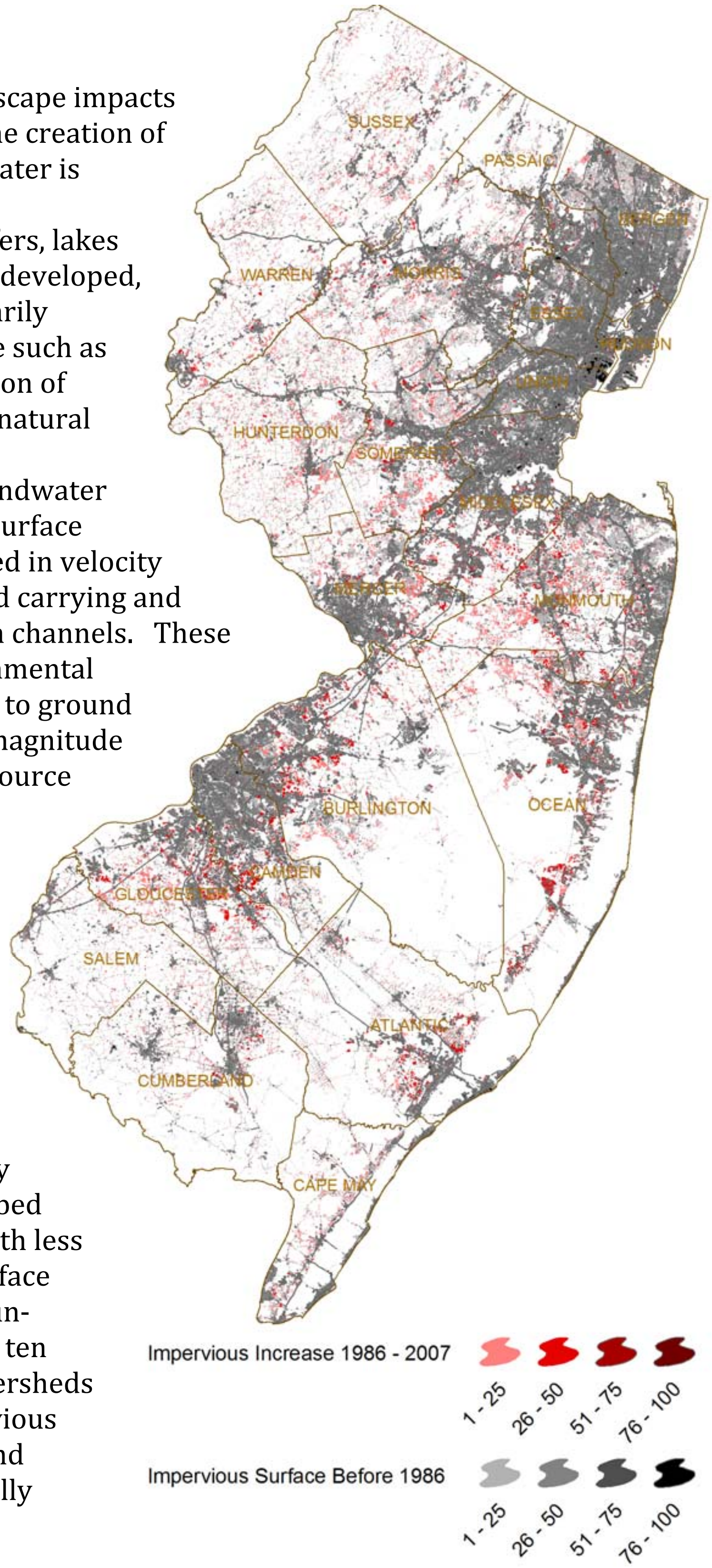


Figure 5.1 Percentage impervious surface cover throughout the state.

Urbanized lands can vary in the percentage of impervious coverage.

Single unit residential housing can have relatively low percentages of impervious cover such as 15 percent whereas commercial land uses can have impervious coverage of over 90%. New Jersey's total impervious footprint as of 2007 was 508,681 acres or nearly 800 square miles of concrete and asphalt (Figure 5.1). During the T3 (2002-2007) period, New Jersey generated 21,348 acres (33.4 square miles) of additional impervious surface representing an annual rate of 4,270 acres of impervious surface increase per year or 9 football American fields per day (including end zones) (Figure 5.2). Growth trends of the past 21 years added one acre of impervious surface for every 4.2 acres of development. In other words, newly developed land is, on average, 23.8% impervious surface. While impervious surface creation is perhaps the most direct indicator of environmental impact representing not only impacts to water quality, it is also a proxy for other land resource impact such as forest loss, farmland loss and wetlands loss. Regulation of impervious surface may be the key to reigning in sprawl. But first we must identify which growth is smart and which is sprawl.

Photo J. Hasse

Figure 5.2 - New Jersey increased impervious surface by nearly 9 football fields per day during 2002 – 2007.

6 How Much of New Jersey's Urban Growth is Sprawl?

The NJ Office of Smart Growth (OSG) has delineated "Smart Growth areas" within the New Jersey State Plan and the Pineland Comprehensive Management Plan. In the State Plan the smart growth areas are represented by Planning Areas 1 & 2 and by designated centers. In the Pinelands the smart growth areas are the Regional Growth areas, Pinelands Towns and Villages. Interestingly, the 1986 initial year of the land use data set corresponds to the year in which the NJ state plan was initiated. During the 21 years of the study approximately 171,000 acres of development actually occurred outside of the designated smart growth areas while 187,600 acres of growth occurred within a smart growth zone. In other words, nearly half (48%) of land developed did not occur in a Smart Growth designated area.

However, not all growth within a smart growth zone is necessarily "smart". Since sprawl is more than simply *where* development occurs but also *how* it occurs and since sprawl is not necessarily a binary factor, we have created a third category for this quick look at urban sprawl. We grouped residential growth into *high density* and *low density* to constitute a third class that we label "mediocre growth", not really sprawl but not really smart growth. Mediocre growth is when low density development occurs in a smart growth zone or when high-density development occurs in an area outside of the smart growth zone. We also grouped all "recreational land" (classified as Urban in the dataset) as smart growth no matter in which smart growth or non-smart growth area it was located. Following this categorization, during the 21 year period of the study, 147,703 acres of growth (41%) was sprawl (low density growth outside of smart growth zone), 53,480 acres of growth (15%) was "mediocre" (low-density residential within a smart growth zone or

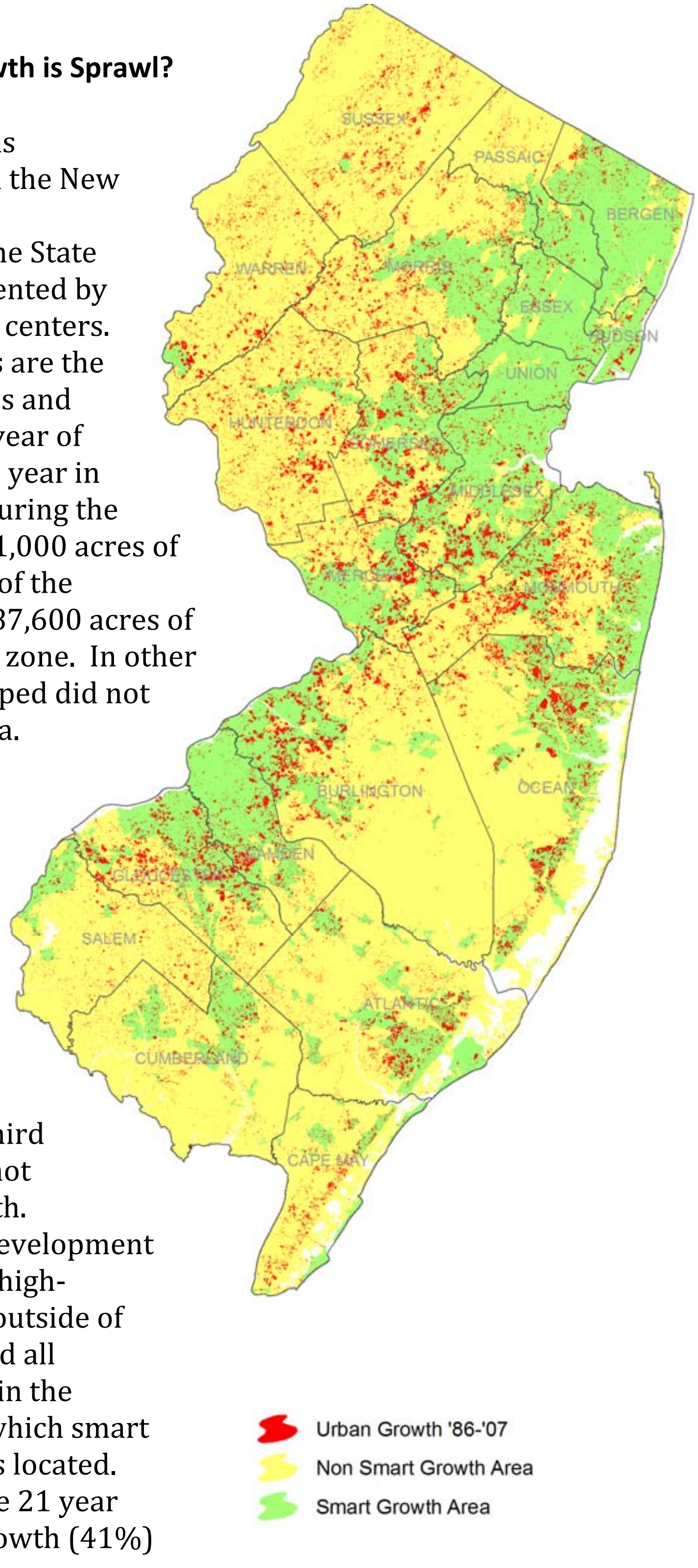


Figure 6.1 Urban growth in Smart Growth versus non-smart growth areas in New Jersey 1986 through 2007

high density outside of smart growth zone), and 157,426 acres of growth (44%) was consistent with smart growth occurring within the designated growth areas.

It should be noted that these figures are only for newly urbanized land. The dataset does not provide a measure of how much previously urbanized land has been redeveloped, which is a major component of smart growth. It should also be noted that the values represent acres of land developed which does not necessarily reflect the number of building units built. Smart growth has a denser footprint and so it accommodates a significantly greater proportion of development units for the land occupied than the growth outside of the smart growth zones. Notwithstanding, these caveats, this quick look at sprawl indicates that a significant proportion of the land that became urbanized over the two decades of the study was significantly sprawling in nature. We plan more in-depth evaluation of sprawl versus smart growth in subsequent studies.

7 County Level 1 Analysis

At the county level, the geographic distribution of urban growth hot spots has remained consistent across the state. The annualized change in ac/yr across the four categories of Level 1 land use categories are outlined in Table 7.1. Several counties standing out as urban growth and open space loss hotspots include the coastal counties of Atlantic, Monmouth, and Ocean, the south Jersey counties of Burlington and Gloucester and the central Jersey county of Middlesex. All these counties experienced urban growth rates of > 1000 acres/yr. Rounding out the top ten urban growth counties are Hunterdon, Morris, Somerset and Sussex.

Major hotspots of agricultural land loss (> 400 acres/year) are Burlington, Gloucester, Hunterdon, Middlesex, and Monmouth counties. While most counties have shown a decline in the annual rate of farmland loss, Gloucester County experienced an increase from 697 acres/year to 1,225 acres/year (an increase of over

Table 7.1 Acre/yr change in Level 1 land use during T3 by county. Highlighted in red are the top 5 and in yellow are the next 5 ranked counties in each category of land use change.

	T3 Acres per Year Change			
County	Urban	Ag	forest	wetland
Atlantic	1,104	-117	-856	-114
Bergen	284	-17	-319	-43
Burlington	1,412	-598	-600	-230
Camden	575	-139	-417	-50
Cape May	351	-130	-218	-27
Cumberland	524	-246	-376	-13
Essex	167	-3	-134	-22
Gloucester	1,531	-1,225	-422	-138
Hudson	90	0	-94	-19
Hunterdon	960	-470	-368	-43
Mercer	693	-444	-96	-71
Middlesex	1,128	-483	-398	-221
Monmouth	1,754	-583	-642	-244
Morris	930	-124	-685	-70
Ocean	1,565	-99	-1,414	-110
Passaic	191	0	-158	-17
Salem	327	-212	-60	-105
Somerset	909	-344	-311	-114
Sussex	875	-262	-582	-78
Union	59	-3	-47	-6
Warren	631	-233	-291	-28

75%). The major hotspots of upland forest loss (> 600 acres/year) include the counties of Atlantic, Burlington, Monmouth, Morris and Ocean. The major hotspots of wetland loss (> 125 acres/year) include the counties of Atlantic, Burlington, Gloucester, Middlesex and Monmouth.

Table 7.2 compares the annualized urban growth rates (ac/yr) for New Jersey's 21 counties across the T1, T2 and T3 time periods. Examination of Table 1.3 reveals that 6 counties experienced a greater than 10% increase in urban growth rate while 8 counties experienced a greater than 10% decrease in urban growth rate in T3 vs. T2 time periods. Atlantic and Gloucester counties stand out as have increasing growth rates across all three change time periods (Table 7.2).

Table 7.2 Annualized rates of urban growth by county. Counties highlighted in red represent a greater than 10% increase in urban growth rate and counties highlighted in cyan represent a greater than 10% decrease in urban growth rate.

County	T1 (ac.yr)	T2 (ac/yr)	T3 (ac/yr)
Atlantic	683	838	1,104
Bergen	-26	325	284
Burlington	1,411	1,455	1,412
Camden	516	449	575
Cape May	448	325	351
Cumberland	574	376	524
Essex	-33	119	167
Gloucester	959	1,027	1,531
Hudson	60	42	90
Hunterdon	1,130	1,132	960
Mercer	866	863	693
Middlesex	848	1,131	1,128
Monmouth	1,373	1,934	1,754
Morris	903	1,219	930
Ocean	1,229	1,826	1,565
Passaic	94	230	191
Salem	425	278	327
Somerset	1,091	1,447	909
Sussex	782	928	875
Union	34	102	59
Warren	631	654	631

8 The final million acres of available land

In a state with limited land supply and such intense growth pressures it becomes evident that land will at some point run out. In order to examine build-out, a statewide open space coverage was produced by combining available open space GIS datasets. The open space datasets included the NJDEP, federal and state preserved open space layers and additional open space data developed at CRSSA. The coverage also includes farmland preservation parcels as of 2009 acquired from the NJ Department of Agriculture (NJSADC 2010). The total land estimated as preserved in New Jersey as of 2009 was approximately 1.5 million acres. This is almost 1/3 of the state's territory in preservation of one type or another, a remarkable accomplishment to date considering that New Jersey did not begin with vast tracks of public land as in many western states.

In addition to preserved open space, other land categories are restricted from development either because they are already developed or have constraints to development such as wetlands. The restricted lands coverage was created by overlaying all non-developable lands which were defined as preserved open space (as mentioned above), steep slopes above fifteen percent, streams, water and wetlands buffered to 50 feet, category 1 streams buffered to 300 feet and already developed lands. The layers were combined in gridded overlay at a 50 foot cell sized and then filtered to remove all single pixel gaps. Following this methodology the total available open land still remaining was estimated as 991,649 acres. While this model provides a reasonable estimate of remaining available lands, it has limitations and

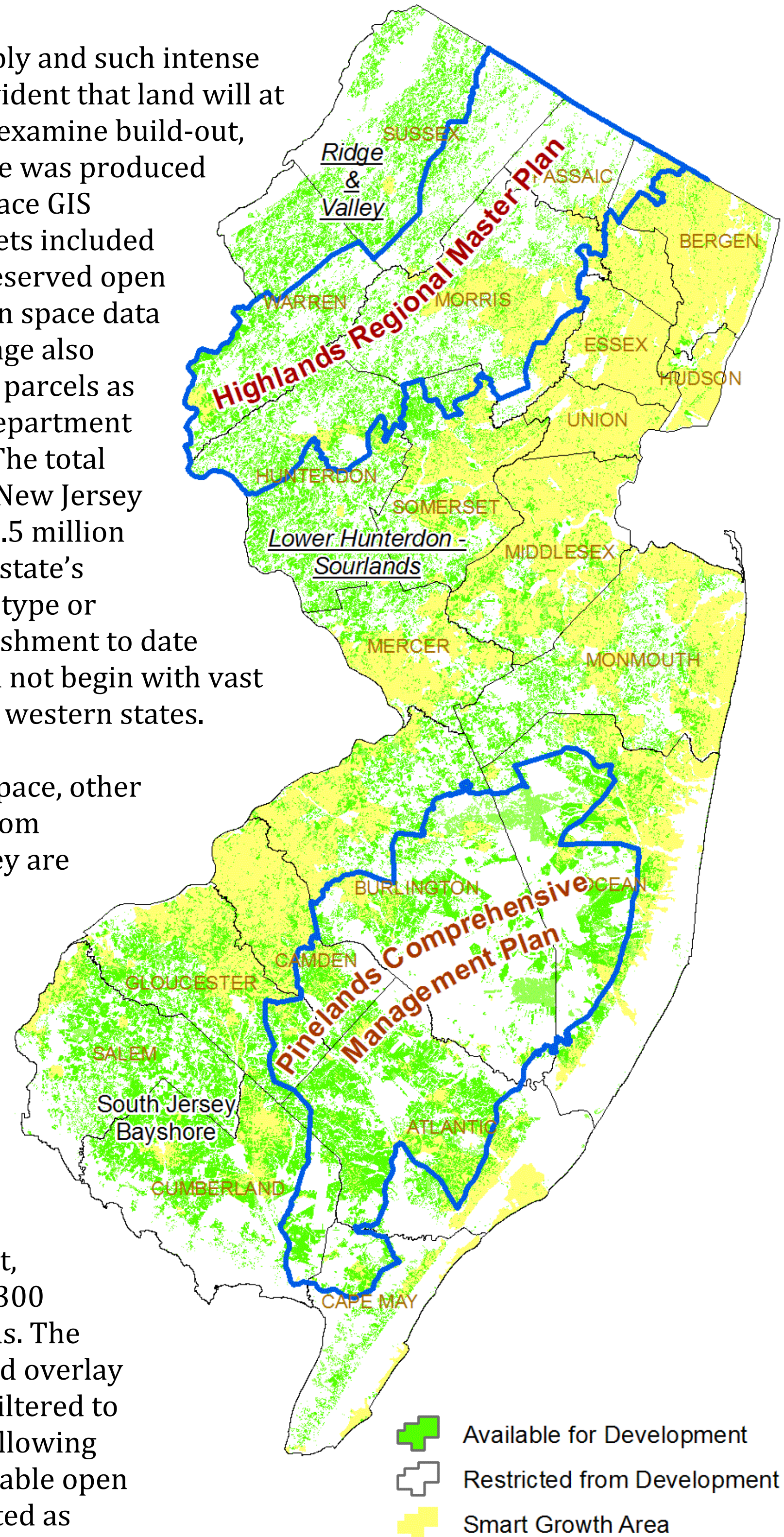


Figure 8.1 . Remaining available land. The remaining available lands (light green) will become either preserved or developed as New Jersey approaches build-out in the coming decades.

should only be taken as approximate. It is likely that there is actually somewhat less land available due to incomplete open space inventories, privately held land trusts and other constraints on a given property's developability such as zoning, lot configuration and road access in addition to larger buffers around wetlands and habitat of significant value.

Figure 8.1 depicts the remaining lands available for development overlain with the boundaries for the Highlands and Pinelands management regions. There is a strong measure of land management in areas controlled by the Pinelands Comprehensive Management Area which contains 25 % of the available lands. The recently established Highlands Regional Management Plan contains about 16% of the state's remaining available lands. These two planning areas are likely to have development occur in a more prudent manner than the rest of the state.

Table 8.1 Estimated available lands by NJ Smart Growth Planning Areas

Planning Area	Acres Avail Land in Smart Growth Zone		Acres Avail Land not in Smart Growth Zone	
Pinelands	48,002	5%	198,759	20%
Highlands	14,015	1%	147,302	15%
State Plan	174,243	18%	409,328	41%

The remaining available lands map (Figure 8.1) also indicates regions that are particularly vulnerable rapid urbanization outside of the Pinelands and Highlands management areas. The remaining regions of the state, constituting 59% of the available remaining land, are covered by the non-regulatory State Development and Redevelopment Plan and are more susceptible to impending impacts of rapid urbanization. The areas with significant available unprotected land most at risk include the Ridge and Valley, lower Hunterdon County-Sour lands and the South Jersey Bayshore regions. These are the areas where there is still significant viable agricultural activity and where large tracts of rural lands are still intact. These are also areas that have begun to see an increase in development activity as other parts of the state run out of available land.

As the remaining available lands are consumed for development or preserved, ultimately New Jersey will run out of "raw" undeveloped land. Urban growth pressure is likely to make it the first state in the nation to reach build-out. Predicting the exact date of when build-out will occur is not precisely possible since variables will certainly change such as the current economic recession. Urban growth is affected by multiple factors, not withstanding, economic conditions, political trends, cultural values and changes in technology. Total urbanization of all available land is not a realistic scenario and many additional factors will also influence New Jersey's journey towards build-out. Our previous report, (Hasse and Lathrop, 2001) explores some of the factors that should be considered when projecting build-out at greater length. Exploring the multiple factors that will likely play into NJ's build-out trajectory is not intended to be a prediction of the exact build-out scenario that will occur, but rather a conceptual exercise to help put the magnitude of New

Jersey's current growth rate into perspective. Even if the exact date cannot be foreseen with certainty from this vantage point, it is efficacious to approach land management by keeping in mind that near total build-out will likely be approached in New Jersey sometime within the middle of this century.

At this point in time New Jersey's final landscape pattern is being set for centuries to come. This final landscape is being determined by the collective actions of all the development and land preservation stakeholders in the race for the remaining open space. The important questions to be asked are not about when build-out will be reached, but should focus on what New Jersey's built-out landscape will look like, after build out happens. How will it function for both New Jersey's human and nonhuman communities? Will we be able to maintain the value of the state's ecosystem services and natural capital? How viable will our agriculture, forests, watersheds, wetlands and wildlife habitat be in that final landscape? At current trends future generations will likely be disappointed by the result of how today's policies shaped their landscape.

What steps need to be taken now to ensure the healthiest possible landscape in the future? Planning from the perspective of impending build-out can help to guide prudent land management decisions in the present.

9 Conclusions

This report presents one segment of ongoing research on landscape changes in New Jersey that is being conducted at the Grant F. Walton Center for Remote Sensing & Spatial Analysis, Rutgers University and the Department of Geography at Rowan University. The objective of this research program is to monitor trends in land use/land cover change, analyze the implications of these changes and make this information available to a wide audience of interested stakeholders. Our analysis of the NJDEP 2007 Update land use/land cover data shows that New Jersey continues to experience rapid and extensive land use changes during the beginning of the 21^{st} century. By the year 2007, over 30% of the state's 5 million acre territory had become urbanized. The Level 1 net land use/land cover changes revealed in the T3 ('02- '07) dataset confirm that overall trends of urban development have remained robust while open space and important land resources continue to be lost at an equally rapid pace.

The 2007 Update provides that welcome news that the annual rate of loss of agricultural land in the Garden State continues to decline. More troubling is the fact that loss of wetlands remains steady and the rate of forest loss continues to increase. Wetlands and forests play a fundamental role in maintaining air and surface water quality, ground water aquifer recharge, flood control, micro and macro climate change, carbon sequestration, abatement of soil erosion among and critical wildlife habitat many others. While wetlands receive regulatory protection by the state, upland forests do not. For many decades, forest land has been the most prevalent landscape category in the state occupying more acres than any other land use category. Recent decades, however, have seen deforestation in New

Jersey accelerate largely due to sprawling residential development. In 2007, New Jersey crossed a critical juncture with urban developed land surpassing upland forest in total acres.

The 2007 Update shows urban development trends maintained the status quo of sprawling residential development that was highly consumptive of open space resources. However since 2007, New Jersey and the United State have been hit by spiking gasoline prices, a major recession and a housing bust. While there are some indications that there has been increase in urban redevelopment and a stronger push towards smart growth, it is too soon to tell whether the urban sprawl that New Jersey experienced in the late 20th and early 21st century is a thing of the past or only in temporary abeyance. If past is prologue, we expect that New Jersey's highly consumptive land use development patterns will reemerge once the economy has improved (as it did after the last housing bust of the early 1990's). The land development and open space decisions that we make now will determine the shape of our future landscape, affecting the quality of life for generations of citizens to come.

10 Background Notes on the 2007 Land Use/Land Cover Data

The 2007 NJDEP Land Use/Land Cover (LULC) data set was produced by the visual interpretation of leaf off color infrared digital ortho-imagery with a spatial resolution of approximately 1 foot. Detailed metadata is available from the NJ DEP which documents the creation of each dataset (www.state.nj.us/dep/gis). Using the 2007 imagery along with the polygonal boundaries of the 2002 NJDEP, LULC changes that took place between 2002 and 2007 were interpreted and polygonal boundaries digitized. In the process, some earlier (i.e., 2002 –era) interpretations and boundaries were refined with the higher resolution imagery and a slight change in interpretation/mapping protocols, leading to two sets of 2002 LULC boundaries, one from the T2 data set and one from the T3 data set. Thus there are discrepancies if one compares the area totals for the year 2002 from the T2 and T3 data sets. For example, the T3 2002 total for Forest = 1,568,793acres (Table 2a) while the T2 2002 total is 1,575,210 acres, a difference of 6,417 acres or less than 0.5%. Thus to help control for these discrepancies, for the T3 analysis we are only comparing the "new" 2002 LULC boundaries with the 2007 data and for the T2 analysis we are comparing the "old" 2002 boundaries with the 1995 data.. Similar differences occur in comparing the 2002,1995 and 1986 data sets and similar methods are used to control for these differences. While it can be assumed that the T3 ('02 – '95) dataset is more accurate than the T2 ('95 – '02) dataset, errors and inconsistencies are inherent in all datasets and must be properly understood by the user.

The 2002-2007, 1995-2002 and 1986-1995 LULC data sets were analyzed using ArcGIS software in a vector polygonal format. For the purposes of this report, the area totals are reported in acres out to the ones place. We recognize that there are errors of both omission and commission in this data set (as with any photo-interpretation and LULC mapping exercise) and thus the reported acreages should be treated as estimates and not "absolute" amounts. As the metadata does not include a quantitative assessment of error, nor have we undertaken an independent assessment, it is difficult to determine what the error bars around any LULC acreage figure or change amount should be. To be conservative, only LULC changes more than 5% should be treated as significant.

The majority of statewide values in this report were created by creating summary pivot tables from the original merged polygon dataset. Acreage values for land use/land cover change by other geographic extents such as the smart growth zones and remaining available lands, was accomplished by rasterizing the data to a 50 foot cell size. The rasterization of vector data can also lead to summation differences compared with straight vector areal summations. However, these differences are minimal and of little significance at a state wide scale.

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