Land Use and Land Cover

Background

The conversion of land from a natural to a developed or disturbed condition is well documented as causing significant, direct, as well as secondary and cumulative, environmental impacts. Environmental impacts associated with land conversion and alteration include habitat loss, fragmentation, and the introduction of invasive species. Such impacts have led to a loss of biodiversity and reduction of habitat quality within several of the state's ecosystems.[1] Indirect negative impacts of land use change also include traffic congestion and air pollution.

All types of water resources are vulnerable to direct and/or indirect impacts resulting from land use change. Impervious cover is a useful indicator of impacts of land development on water resources. Over twenty years of scientific evidence have related increased impervious cover to specific changes in hydrology, habitat structure, water quality, and biodiversity of aquatic systems.[2,3,4,5,6] It is clear that water quality usually declines as the intensity of developed and agricultural land increases.

NJ's current water quality assessment identifies hydrologic areas that either support, do not support, or have insufficient information to report on various designated uses. The spatial extent and cause of use impairments varies across the state. However, both short and long-term data show correlations between use impairment, particularly aquatic life uses, and density of development. The largest concentrations of high-quality waters are located in the least developed regions of the State, specifically the upper northwest and the Pinelands region.[7] Some water-quality impacts of land use change are transitory, including road or building construction that increases the release of sediments into nearby waterways. Other conditions are more permanent, such as the impacts of increased impervious cover and the loss of natural vegetation and riparian corridors caused by land development.

New Jersey's dense population makes accommodating the state's economic development and protecting land, air, and water resources a major challenge. Much of the State's ecological diversity depends on the maintenance of critical habitat, especially wetlands. Wetlands provide breeding grounds and nesting sites for a variety of fish and wildlife species and offer unique habitat for many threatened and endangered plants and animals.[8]

One sign of stress to the state's ecological diversity is the increasing number of species listed as rare or endangered. More than 40 percent of the native vascular plant species in the State are considered rare, and approximately 17 percent of New Jersey's plant species are listed as endangered (see the *Endangered Plants* chapter of this Environmental Trends series https://www.nj.gov/dep/dsr/trends/endangered-plant.pdf). Like plant species, about one-third of the known vertebrate animal species in New Jersey are classified as either rare or endangered.

In addition to the traditional on-the-ground surveys and analyses, the State has taken advantage of the recent advancements in the use of aerial photography and satellite imagery to better monitor land use and land cover. Changes which can be readily observed, such as a transition from undeveloped land (e.g., forests or wetlands) to developed land (e.g., residential), are now monitored as new aerial photography and satellite data become available. Other changes, such as type or size of trees in a forest, are more subtle and continue to rely upon routine surveys and inventories for assessment.

Status and Trends

An important parameter of land use and land cover is the amount of developed or urban land in the state. Urban land includes land with houses, buildings and pavement, and other areas that are essentially impervious to infiltration of rainfall. Agriculture is also an important classification that possesses the potential to impair waterways if best management practices are not maintained. In addition, barren land, or land that has been denuded of vegetation or other cover, may represent ongoing construction activities, but may also represent open sandy areas and beaches.

There have been two important studies conducted over the years in New Jersey that both address the change in land use and land cover over time, using two different technologies. Beginning in 1986, the NJ Department of Environmental Protection (NJDEP) began a rigorous, detailed study of the status and trends in land use and land cover (LULC) using aerial images and photo-interpretation. Updates to the 1986 data have been completed using 1995, 2002, 2007, 2012, and 2015 aerial imagery. These data are mapped to a one-acre minimum mapping unit and most recently used one-foot resolution digital imagery. An analysis of trends based on available data is presented.

During the 29-year period of 1986 to 2015, the NJDEP data show an increase of over 360,000 acres of development, nearly 34 acres per day on average. The increase in urban developed land is in large part due to losses of agricultural and forested lands. Recently though, the pace of wetland and forest loss has decreased.

Rutgers University Center for Remote Sensing and Spatial Analysis (CRSSA) has used satellite data from 1972 (LANDSAT 1) to 2001 (various satellite sources) to quantify LULC status and trends.[9] During this 29-year period, CRSSA found that over 600,000 acres of land had been developed in New Jersey. This represented an increase of about 68% in the amount of developed land over that time period. This dataset shows strong agreement with the State's data and provides a snapshot of land-use conditions prior to the State's assessments.

The amount of developed land, termed urban land in the LULC dataset, in New Jersey and population growth in the same period are shown in Figure 1 below. This chart highlights that developed lands have expanded at a greater rate than population growth.

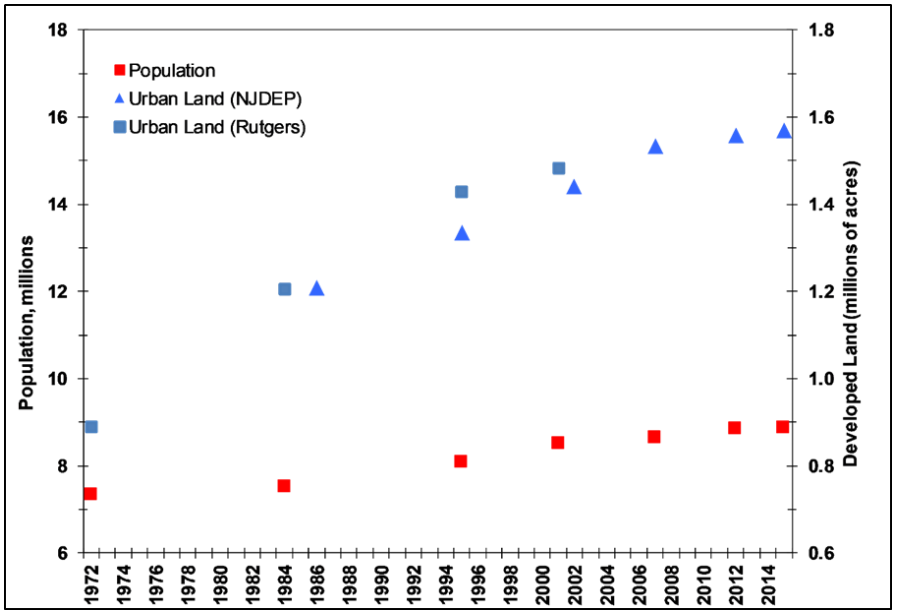

Figure 1. Population growth and the increase in urban lands in New Jersey, 1972 - 2015.

Aerial photography and satellite imagery show changes in the state's overall land use. Figure 2 below summarizes DEP's evaluation of land-use/land-cover (LULC) types based on aerial photography data in 1986 and 2015. These data for 1986 indicate that 49% of the State was either forested or wetlands and 22% was developed. Similar data for 2015 show that 43% of the State was either forested or wetlands and 27% of the State developed, representing a loss in both forests and wetlands and an increase in urban land over time. The same data indicate a decrease in agricultural area from 14% to 10%. The increase in open water is likely an artifact of mapping resolution over time and the timing of when the aerial photography was captured, especially along the coast where tidal exposure will determine the water line.

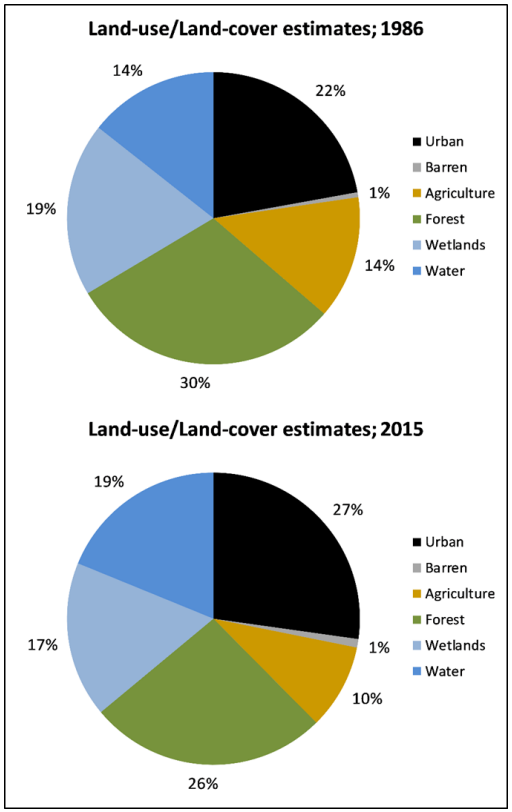

Figure 2. Summary of land-use/land-cover data for 1986 and 2015.

The NJDEP LULC data have also been used to show changes by land use category. The acreage of land in each category for the years 1986, 1995, 2002, 2007, 2012, and 2015 is shown in Figure 3. This figure shows a decrease in acreage of agriculture, forested land, and wetlands with a subsequent increase in acres of urban (i.e., developed) land.

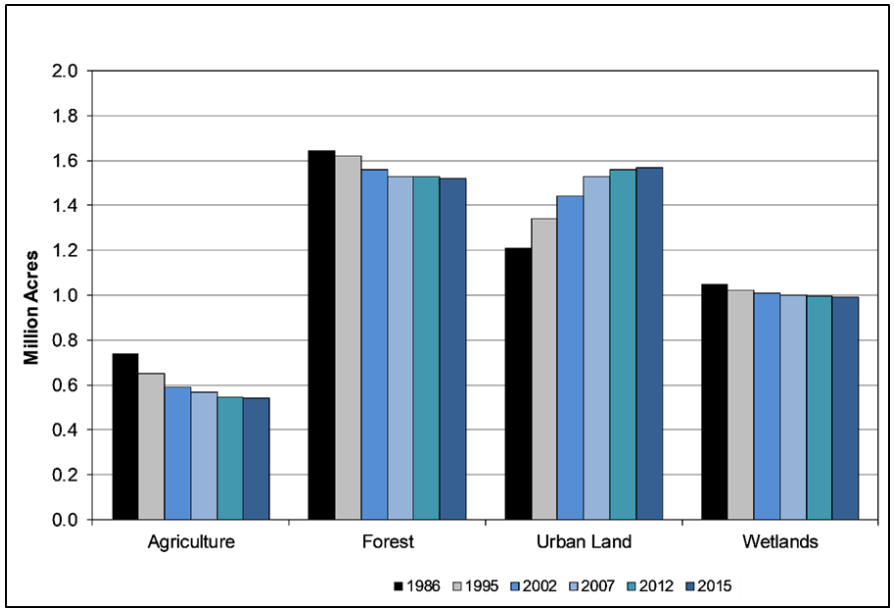

Figure 3. Annual comparison of the total acreage for four land-use/land-cover classes.

A more detailed look at some of the general types of land classifications noted above reveals additional potentially important features and trends.

Forests

The USDA Forest Service, in cooperation with NJDEP, conducts inventories of the State's forested lands using a series of permanent plots and remote sensing techniques. Since 2006, data has been collected annually with the entire state remeasured every five years.[10] The most recent detailed five-year inventory was published in 2017.[11] The data reveal significant details about the State's forests that are not observable via satellite or aerial photos alone. The average size of trees in New Jersey's forests is changing. Forest stand structures today are typically more mature and contain larger trees than they have in the past. Since 1972, areas characterized by poletimber (medium diameter; greater than 5-inches diameter at breast height) and saplings/seedlings have declined (small diameter), while the areas of larger trees (sawtimber; large diameter) have increased and remained stable (Figure 4). This summary incorporates data from a series of previous inventories.[12]

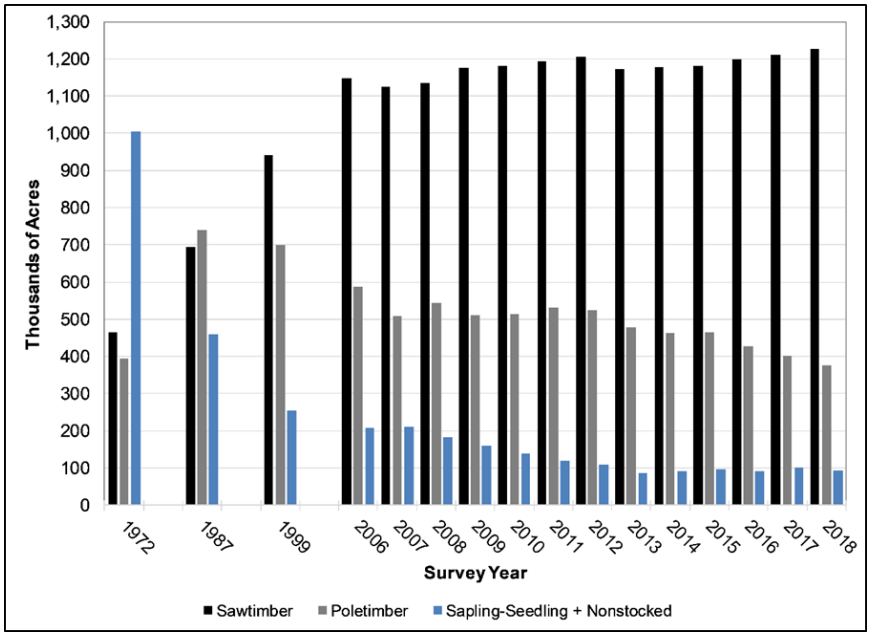

Figure 4. Estimated acreage of timberland by stand size class. Note the uneven breaks in annual stock estimates between 1972 to 1987, 1987 to 1999, and 1999 to 2006. Estimates have been available annually since 2006. The data compiled herein are from various surveys.[12]

Overall, the woody biomass of New Jersey's forests has increased in recent years. The 2015 estimate of the net volume of growing stock trees with a diameter greater than five inches has increased 3.7% from the 2010 estimate.[13] However, there are concerns that forest regeneration has declined so much that there are virtually no young seedlings to be found in some regions.[14] At least some of the

decline in regeneration can be traced to deer. For example, a project to restore acreage of the Atlantic white-cedar has found regeneration is only successful where deer browsing is controlled.[15] Another reason for less regeneration is forest succession, where the thick canopy of mature trees limits establishment and growth of some species of seedlings.

Not only is development consuming forest areas, it is also breaking up existing contiguous forest areas into smaller tracts. This fragmentation degrades watersheds, reduces wildlife habitat, increases site disturbances, and favors invasion by exotic plant species and predators such as feral housecats. Fragmentation is believed to be a contributing factor in the decline of some bird species and other wildlife.

There are also indications that New Jersey's forests are troubled by an increase in insects and disease. Insects that are especially problematic include the emerald ash borer, Asian long-horned beetle, which is currently eradicated in NJ, the gypsy moth, the hemlock woolly adelgid, the southern pine beetle, and spotted lantern fly.[12,16] Tree diseases that require careful monitoring include bacterial leaf scorch and sudden oak death.[17]

Invasive species are also a problem in forested areas in the State. An initial survey of invasive plants by the USDA showed that invasive plants are widely distributed in the state.[18] Currently, multiflora rose (*Rosa multiflora*), Japanese honeysuckle (*Lonicera japonica*), and Japanese barberry (*Berberis thunbergii*) are the most frequently encountered invasive plants statewide, but the abundance is greatest in the northern part of the State.[12] It is not yet clear to what degree these and other invasive species cause harm. However, it is likely that as invasive species spread, the number and abundance of native plant species will decline, resulting in a loss of overall species diversity and a reduction in the value and health of New Jersey's forests. For a discussion of threatened and endangered plants in the State, please see the *Endangered Plants* chapter in this Environmental Trends series (https://www.nj.gov/dep/dsr/trends/endangered-plant.pdf).

Wetlands and other prime wildlife habitat

Certain areas of the state are especially important in maintaining biodiversity. The NJDEP's Division of Fish and Wildlife's Endangered and Nongame Species Program (ENSP) adopted geographic information system (GIS) approaches to imperiled species protection called the Landscape Project[19] (https://www.nj.gov/dep/fgw/ensp/landscape/) and Connecting Habitat Across NJ (CHANJ)[20] (https://www.njfishandwildlife.com/ensp/chanj.htm). These projects use GIS to identify and delineate habitat critical to the long-term survival of New Jersey's wildlife. Comparisons between the satellite imagery used to track changes in land use and land cover between 1995 and 2015, discussed above, reveal that prime wildlife habitat (habitat for listed endangered and threatened species, as well as priority wildlife species) has been lost to development.

Residential and non-residential construction

The change in the amount of developed land in the state can also be tracked through building permits. Information from these permits and certificates provide useful indicators on the level of construction activity in the state; the type of structures that are built; the number of dwelling units authorized for construction and completed; and the square footage of nonresidential space. This information is submitted monthly to the New Jersey Department of Community Affairs by municipal construction officials.[21]

There are two broad categories of construction: residential and nonresidential. Residential construction is measured by unit and divided further into new construction and redevelopment. An increase in the issuance of building permits for residential construction from 1996 to 2000 is evident in Figure 5. After this period, there was an overall decline in permits, with a general increase in permits for redevelopment. Residential permits again began to rise in 2004, with permit issuance at its peak in 2005. After that, a significant decline continued until 2009.

Since then, the number of residential construction permits has generally increased.

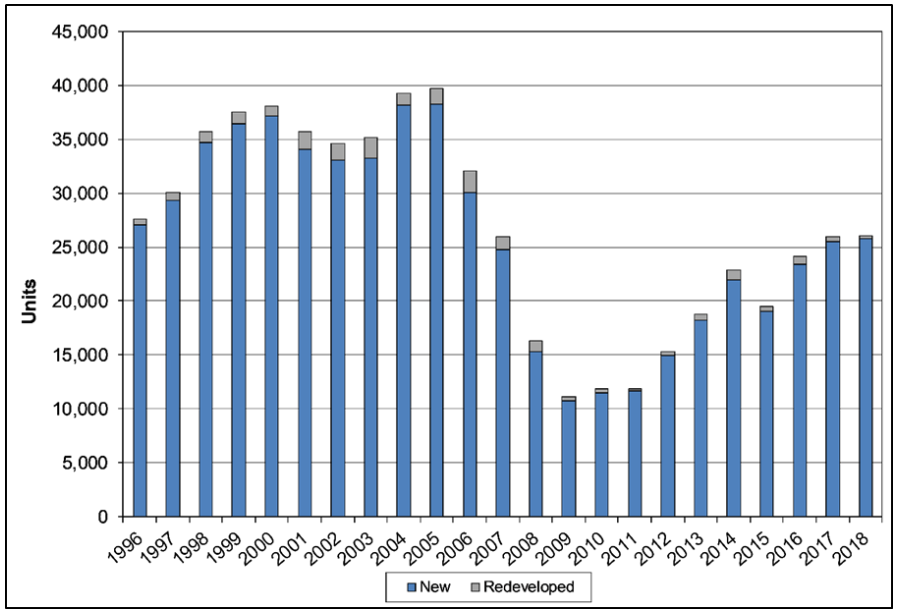

Figure 5: Number of residential construction permits by development type granted between 1996 and 2018.

The geographic distribution of residential construction permits highlights a shift from suburban sprawl to the recentralization of metropolitan areas. This regional transformation to a growing urban core is linked to changes in age demographics and economic changes.[22,23] Specifically, a large portion of the workforce is favoring more sustainable, urban living, and working arrangements. The 2008 economic recession is also suspected to have had an influence on these changing community preferences.[21] As seen in Figure 6, there is a significant increase in the relative percentage of residential construction permits by development type over time, with a shift from single-family houses and duplexes (one and two family permits) to multifamily and mixed-use buildings (Kendall Tau P-value < 0.001). Examples of multifamily and mixed-use buildings can include college dormitories, assisted living facilities, and multi-level buildings with a mix of apartments and commercial use. The shift to more concentrated dwellings is geographically apparent based on a recent five-year snapshot of the state.

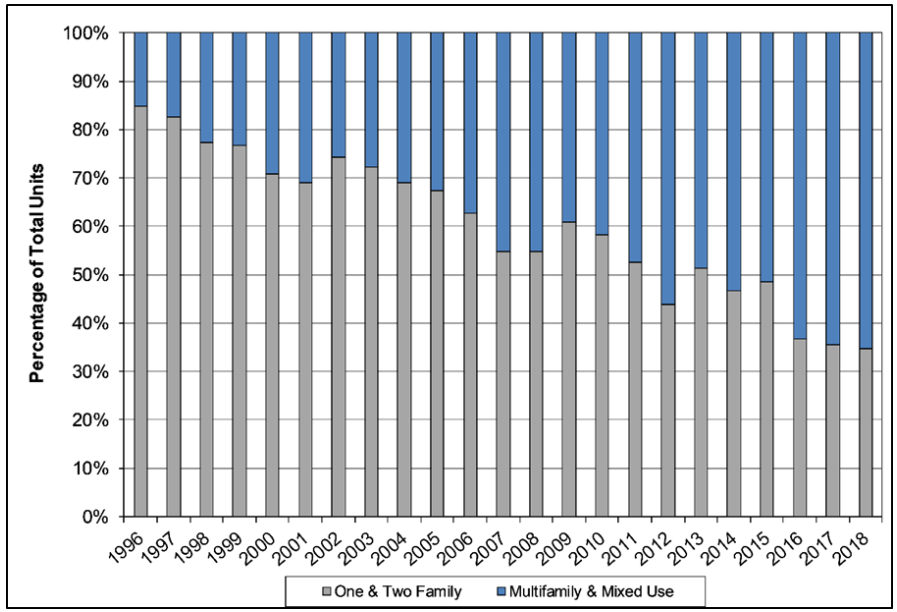

Figure 6: Residential construction permits as a percentage of total units by use category (one & two family versus multifamily and mixed-use) granted between 1996 and 2018.

The map below (Figure 7) highlights that residential construction permits over the period of 2014 to 2018 were issued predominantly for multifamily dwellings in more highly-populated counties (such as Hudson, Essex, and Passaic Counties) relative to less urbanized counties (such as Cumberland, Salem, and Cape May) in the state. Collectively, these data suggest that the rate of conversion of undeveloped land has likely slowed in recent years as urban areas are being revitalized to meet changing needs.

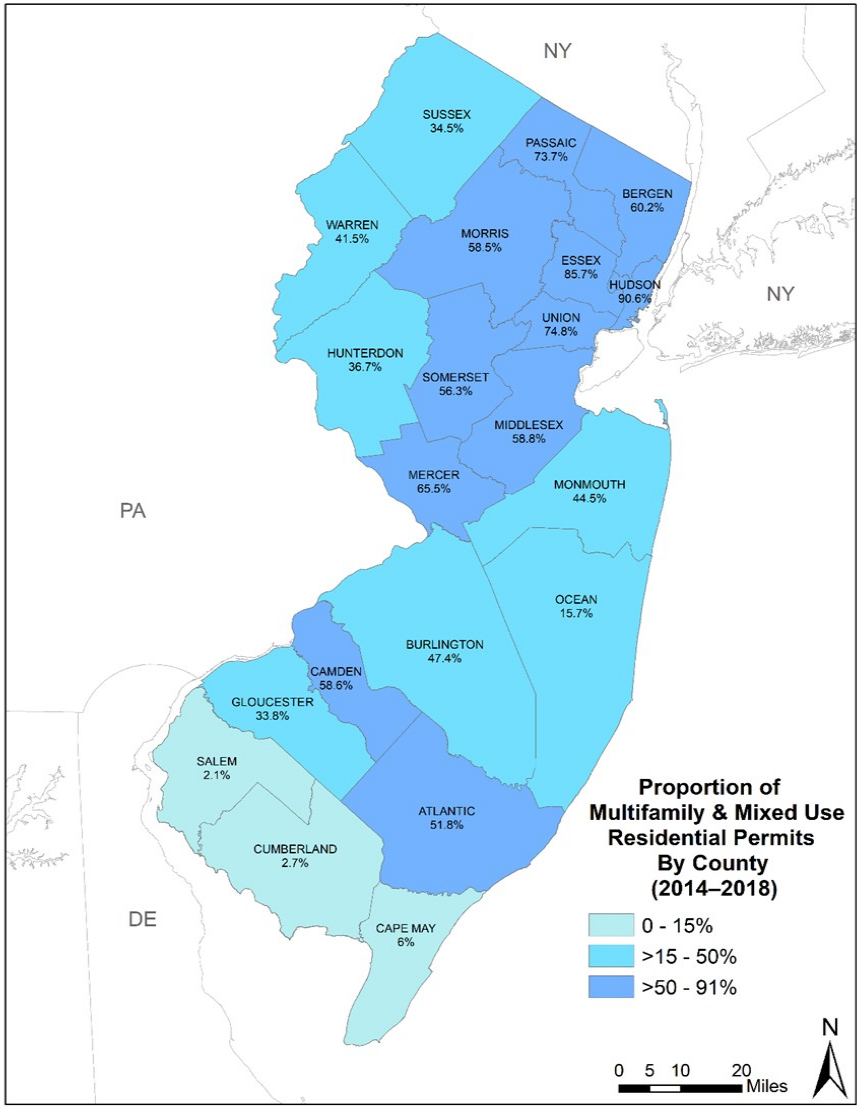

Figure 7: Proportion of multifamily and mixed-use residential permits by county (2014 – 2018).

Nonresidential construction is measured by square footage. The three major categories of nonresidential construction are retail, office, and other. This last category includes such things as hotel/motel, educational institution, and storage facility construction. During the period of 1996 – 2018, nonresidential building permit issuance peaked in 2001 and decreased until 2011 (Figure 8). Nonresidential building permits have generally increased since 2012.

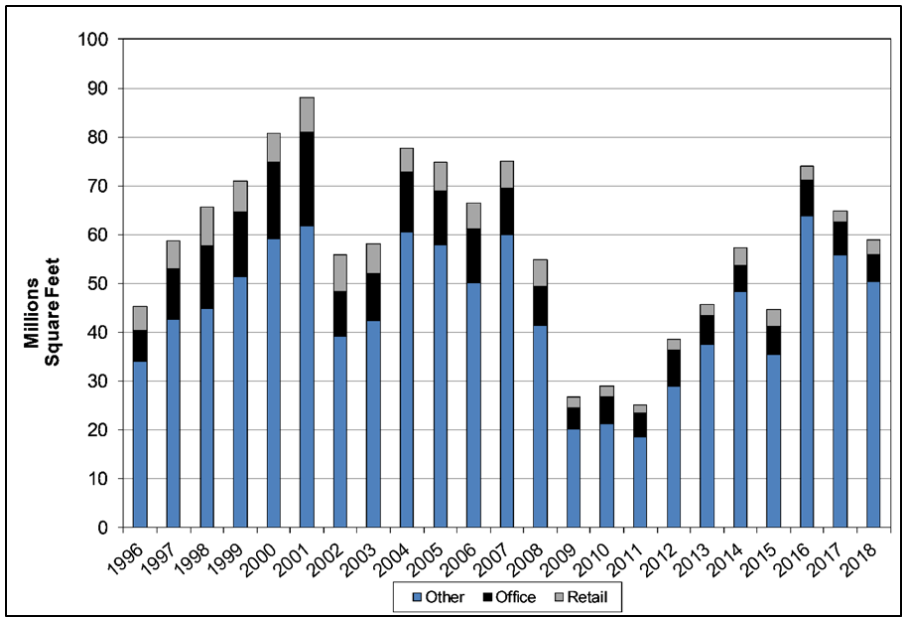

Figure 8: Area of nonresidential building permits granted annually.

Outlook and Implications

The State continues to undertake initiatives to prevent environmentally damaging land-use change and encourage sustainable growth. Specifically, the NJDEP continues to work towards planning that reflects existing water supply and wastewater demands, as these two needs are fast becoming the limiting factor with respect to development. For example, the DEP Water Quality Management Planning (WQMP) rules at N.J.A.C. 7:15[24] give local planners more flexibility regarding wastewater infrastructure decisions. The proposed rules focus new sewer infrastructure projects on areas of targeted growth while remaining

protective of environmentally sensitive areas and cognizant of local zoning efforts. Significant efforts are also directed at managing storm water to reduce runoff and flooding and protecting riparian areas to reduce flood impacts and maintain the health of surface waters. Additions to the state's Category One (C1) waterways will provide additional protections to waterbodies and help prevent water-quality degradation by discouraging development where it would impair or destroy natural resources and environmental quality. The state is also increasing the amount of open space preserved by expanding and improving the state and local park system and restoring and expanding urban forests and open space. For additional trend information please see the individual *Open Space Preservation* (https://www.nj.gov/dep/dsr/trends/Open%20Space.pdf), *State Parks and Forests* (https://www.nj.gov/dep/dsr/trends/parks.pdf), and *Urban and Community Forests* (https://www.nj.gov/dep/dsr/trends/urban.pdf) chapters in this Environmental Trends series.

More Information

The NJDEP Division of Land Use https://www.nj.gov/dep/landuse/

The NJDEP Division of Water Supply and Geoscience https://www.nj.gov/dep/watersupply/

The NJDEP Division of Fish and Wildlife https://www.njfishandwildlife.com/

New Jersey's Landscape Project https://www.nj.gov/dep/fgw/ensp/landscape/index.htm.

Connecting Habitat Across New Jersey https://www.njfishandwildlife.com/ensp/chanj.htm.

The NJDEP Division of Water Quality https://www.nj.gov/dep/dwq/

The NJDEP Division of Parks and Forestry https://www.nj.gov/dep/parksandforests/index.html.

NJ DCA Construction Reporter http://www.nj.gov/dca/divisions/codes/reporter

References

[1]NJ Department of Environmental Protection (DEP), 2004, *New Jersey Comparative Risk Project*, NJDEP, Trenton, NJ. Available at https://www.nj.gov/dep/dsr/njcrp/. Also named as important stressors to the environment in the study were indoor air pollution, invasive species, and outdoor air pollution.

[2]Wieben, C. M, et al. 2010, *Sources and Quantities of Nitrogen Contributing to Eutrophication of Barnegat Bay-Little Egg Harbor Estuary, New Jersey*. American Geophysical Union, Fall Meeting 2010, abstract #H52D-04.

[3]Conway, TM. 2007. *Impervious surface as an indicator of pH and specific conductance in the urbanizing coastal zone of New Jersey, USA.* Journal of Environmental Management 85, 308-316.

[4]Zampella, et al. 2007, *Relationship of land use/ land cover patterns and surface water quality in the Mullica River Basin*. Journal of the American Water Resources Association 43, 594-604.

[5]Beach, Dana, 2002. *Coastal Sprawl: The Effects of Urban Design on Aquatic Ecosystems in the United States.* South Carolina Coastal Conservation League.

[6]Kaplan, Marjorie and Mark Ayes. 2000 *Impervious Surface Cover Concepts and Thresholds.* New Jersey Department of Environmental Protection and United States Geological Survey. 10p.

[7]NJDEP. 2019. Draft 2016 New Jersey Integrated Water Quality Assessment Report. NJDEP Division of Water Monitoring and Standards, Bureau of Environmental Analysis, Restoration and Standards. https://www.nj.gov/dep/wms/bears/assessment.htm. Accessed 05/11/2020.

[8]Welsch et al. 1995. Forested Wetlands: Functions, Benefits and the Use of Best Management Practices U.S. Forest Service NA-PR-01-95. Available at https://www.fs.usda.gov/naspf/publications/forested-wetlands-functions-benefits-and-use-best-management-practices

[9]Research in satellite and related new methods of monitoring changes in the land surface is carried out at the Grant F. Walton Center for Remote Sensing and Spatial Analysis at Rutgers University (CRSSA), which can be found at https://crssa.rutgers.edu/projects/lc/

[10]Refer to the NJ Forest Inventory and Analysis data available at https://www.nrs.fs.fed.us/fia/data-tools/state-reports/NJ/.

[11]Crocker, et al, 2017. New Jersey Forests 2013. Resource Bulletin NRS-109. Newtown Square, PA. Available at https://www.nrs.fs.fed.us/pubs/53471.

[12]Inventories include: Widmann, Richard H. 2005. Forests of the Garden State. Resour. Bull. NE-163. U.S. Department of Agriculture, Forest Service. Northeastern Research Station. 20 p. available at https://www.fs.fed.us/ne/newtown_square/publications/resource_bulletins/pdfs/2005/ne_rb163.pdf; Crocker, Susan J, et al. 2011. *New Jersey's Forests, 2008.* USDA Forest Service Resour. Bull. NRS-59 available at https://www.nrs.fs.fed.us/pubs/39842 , and annual summaries available at https://www.nrs.fs.fed.us/fia/data-tools/state-reports/NJ/.

[13]USDA Forest Service. 2019. Forests of New Jersey, 2018. Core Tables. Table 19. Available at https://www.nrs.fs.fed.us/fia/data-tools/state-reports/NJ/. Accessed 05/11/2020. Northern Research Station. 4 p. available at https://www.nrs.fs.fed.us/pubs/52497.

[14]Lempicki, Edward, NJDEP Bureau of Forest Management, Trenton, personal communication, 12/16/04.

[15]Zimmermann, George, 1995, The Atlantic White-Cedar (*Chamaecyparis thyoides*) Regeneration Experiments: Years Three and Four (Final Reports). Trenton, NJ: New Jersey Department of Environmental Protection.

[16]Spotted Lanternfly. New Jersey Agricultural Experiment Station https://njaes.rutgers.edu/spotted-lanternfly/

[17]NJDEP. Forest Health in New Jersey. See http://www.nj.gov/dep/parksandforests/forest/njfs_forest_health.html.

[18]Crocker et al, 2011, *New Jersey's Forests, 2008*. Available at https://www.nrs.fs.fed.us/pubs/39842 .

[19]NJDEP. New Jersey's Landscape Project. See http://www.nj.gov/dep/fgw/ensp/landscape/index.htm.

[20]NJDEP. Connecting Habitat Across New Jersey (CHANJ). See https://www.njfishandwildlife.com/ensp/chanj.htm

[21]Department of Community Affairs. Building Permits Yearly Summary Data available at https://www.nj.gov/dca/divisions/codes/reporter/building_permits.html.

[22]Hughes, J. & Seneca, J. 2014. *The Receding Metropolitan Perimeter: A New Postsuburban Demographic Normal.* Rutgers University Community Repository. 16 p.

[23]Hughes, J. & Seneca, J. 2012. *Reinventing the New Jersey Economy: New Metropolitan and Regional Employment Dynamics.* Rutgers Regional Report, 331-12.

[24]Please see https://www.nj.gov/dep/wrm/wqmprule.html.