

**Land use Changes in Middlesex County**  
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### **Abstract**

This report focuses on land use and land cover changes within Middlesex County. With the use of ArcMap, and data downloaded from the NJDEP bureau of GIS's online database, six maps were constructed that display land use within Middlesex County. The maps represented data from 1986, 1995, 2002, 2007, 2012, and 2015. This report displays four of these maps, from the years 1986, 1995, 2007, and 2015. The maps also display six different land use criteria, which are water, forest, agriculture, barren land, wetlands, and urban. This report focuses specifically on Urban, Forest, and Agriculture. The total changes for these three land uses are 27,958 acres gained for urban, 3,409 acres lost for forests, and 15,345 acres lost for agriculture. It was concluded that the greatest change in land use and land coverage occurred between 1995 and 2007.

After analyzing total land use and land cover change for Middlesex county, the Township of Monroe, which is in the southern region of Middlesex county, was analyzed using the same six land use criteria that were used for Middlesex county as a whole. Two maps are displayed that show land use change for Monroe between 1995 and 2007. From here, the data from the map were organized into a table and analyzed. The results show that from 1995-2007, urban areas increased by 3,360.804 acres, forests decreased by 1372.918 acres, and agriculture decreased by 2765.871 acres. It was then calculated that urban acreage increase is responsible for 81.223% of the total loss in acreage between both forests and agriculture. Through further research, it was discovered that a portion of this urbanization can be attributed to the development of certain remediation efforts taking place within Monroe Township. Understanding this is essential to the analysis of land use and land cover change because not all urbanization results in a negative impact on the environment.

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## **Introduction**

The study conducted in this report analyzes land use and land cover changes over a period of 29 years within the New Jersey County, Middlesex County. Monitoring land use, and land use change, is a practice that is necessary in the modern world. This can be done in many ways, however the most effective way is by satellite mapping through the use of Geographic Information System (GIS)/geospatial technology. GIS not only uses satellite maps, but one could also create geodatabases with any type of information about the area, and apply it to the maps. This combination of maps and information together allows for analysis to be made on the area of study in many different perspectives and directions. For this report, the study conducted looked at middlesex county's land usage, and looks to draw conclusions on both how land use is changing, as well as what the driving factor of the change in land use is.

Many urban and suburban areas of the world are dealing with increased population, and because of the increase in population, these places are expanding and growing by urbanizing land. Monitoring land use in any urban or suburban areas of the world is a great tool, and when done properly, can provide valuable information on proper urban growth within those areas. Two professors from Mansoura University in Egypt, Hegazy and Kaloop, co-wrote an article that discussed monitoring urban growth and land use change with GIS and remote sensing techniques in Dakahlia Governorate, Egypt. Within the article, they stated, "land use and land cover change are considered one of the central components in current strategies for managing natural resources and monitoring environmental changes"(Hegazy and Kaloop, 2015). The authors emphasize the important role that land use and land cover change has on proper planning for urbanization. Similarly to the study conducted within this report, Hegazy and Kaloop also used GIS to put together all the information and to organize the data collected. Another excerpt from their article reads, " Geospatial technologies and remote sensing methodology provide essential tools which can be applied in the analysis of land use change detection"(Hegazy and Kaloop, 2105). They further expand on the necessity of GIS in the process of monitoring land use and land coverage changes.

Without professional and continuous monitoring of land use and land coverage, improper and dangerous urbanization and growth could take place, and this could be detrimental to a community. Urbanization is directly associated with building, and with an ever increasing population, these buildings for people to live in and for people to work in are destroying other areas of the community. Areas such as forests and agricultural land are being torn down, and built upon. This is a prime example of improper and unplanned urbanization. As population increases, the need to build also increases. However, the need to feed the increasing population also increases and this will not be accomplished by destroying agricultural areas in order to build upon them. It is essential to monitor land use and land cover changes in areas like these to provide proper insight on proper urban planning and to build a healthy community.

## **Objectives**

- Review land use and land cover changes for Middlesex County in the years; 1986, 1995, 2002, 2007, 2012, and 2015 and conclude how land use is changing and what the driving factor of the change in land use is.
- Gather data and information on a town within Middlesex County that exhibits similar land use trends on ones that occur at the county level and conclude how land use is changing and what the driving factor of the change in land use is.
- Discuss certain strategies that have been implemented within a selected municipality to understand how the township is dealing with environmental issues resulting in land use changes

## Methods

All information obtained for this lab was gathered from the New Jersey Department of Environmental Protection, Bureau of Geographic Information Systems (GIS). The first step in this process was downloading shapefiles for land use/ land cover maps for Middlesex County. Files for the years 1986, 1995/97, 2002, 2007, 2012 and 2015 were downloaded and then added into an ArcMap document. Because land use data is compiled by state as opposed to county, the clipping feature of ArcMap had to be utilized in order to trim the relevant information down to simply display Middlesex County. Subsequently, opening up the properties tab of each clipped data frame allowed the type of land use to be displayed on each map of Middlesex county. For this lab, agriculture land is displayed in yellow, barren in olive, forest in green, urban in red, water in dark blue and wetlands in light blue. Just from this simple alteration in symbology, the changes in land use become very apparent over the 29 year period. These changes can be seen in **Image 1- Image 4**.

Although the maps are able to visually show these changes, a deeper understanding of how severe the land cover alteration truly is can be better obtained by evaluating actual data. Therefore, the attribute table for each map was then exported into an excel document and a pivot table was inserted for each year's information. From this pivot table, values and data for each year could ultimately be better summarized. The initial analysis began by studying the total acreage of urban land (**Figure 1**), forest land (**Figure 2**), and agriculture land (**Figure 3**). All three graphs display the trend of overall change in acreage for these three specific land covers. The information displayed in all three figures is further combined and summarized within **Table 1**.

This preliminary analysis gives a strong but broad analysis of the overall change occurring within Middlesex County over the 29 year period. In order to obtain a more in depth understanding, a specific municipality was selected within the county. For this report, Monroe Township was selected because of the large change in land cover that visually appeared to be occurring when assessing **Image 1- Image 4**. Revisiting the ArcMap document, a shapefile containing all municipalities within New Jersey was added into each data frame. This shapefile was then clipped to only display municipalities within Middlesex County. From here, by utilizing the select by attribute feature, Monroe Township was able to be selected within the shapefile. An additional clip allowed the shapefile to be clipped to only Monroe. Subsequently, the land cover shapefile of which currently displayed land use for all of Middlesex County, was now able to be clipped to display land usage in only Monroe Township. These series of clippings were repeated for each year being assessed. A shapefile of roads from 2008 was added into each year's map for additional context. **Image 5** and **Image 6** better display this information. By removing the land use symbology, **Image 7** was created to provide insight as to where Monroe Township is actually located in relation to the entire county. This was achieved

by simply selecting Monroe Township within the attribute table of the Middlesex County Municipality clip.

After obtaining **Image 5** and **Image 6**, a deeper analysis was once again obtained by exporting these new attribute tables to an excel document and summarizing the information through the usage of pivot tables. It appeared that the greatest change in land usage occurred between the years of 1995 and 2007. The total change in acreage for urban, forest and agriculture land cover for just Monroe Township was then summarized within **Table 2**. **Table 3** was subsequently created to further analyze the information. The combined decrease for both forest and agriculture land was calculated and was then mathematically compared to the overall change in land cover for urban land use through a percent change calculation.

### **Results & Discussion**

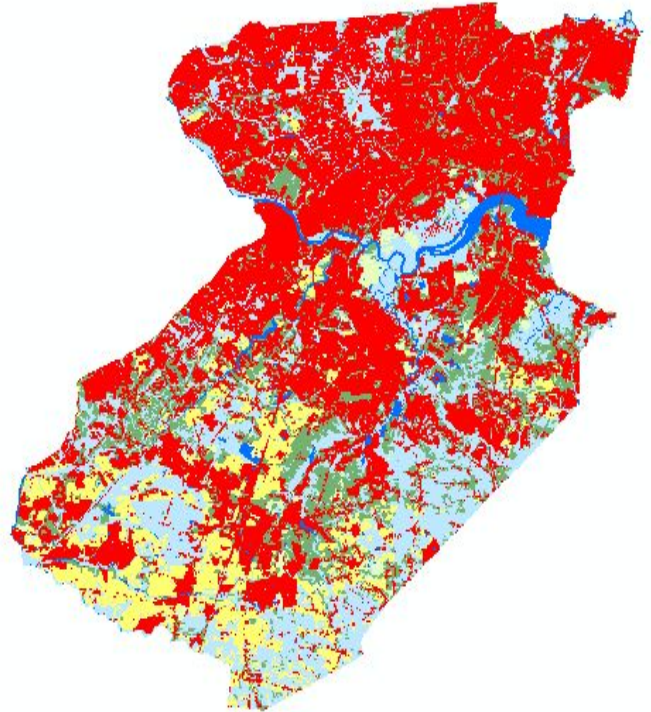
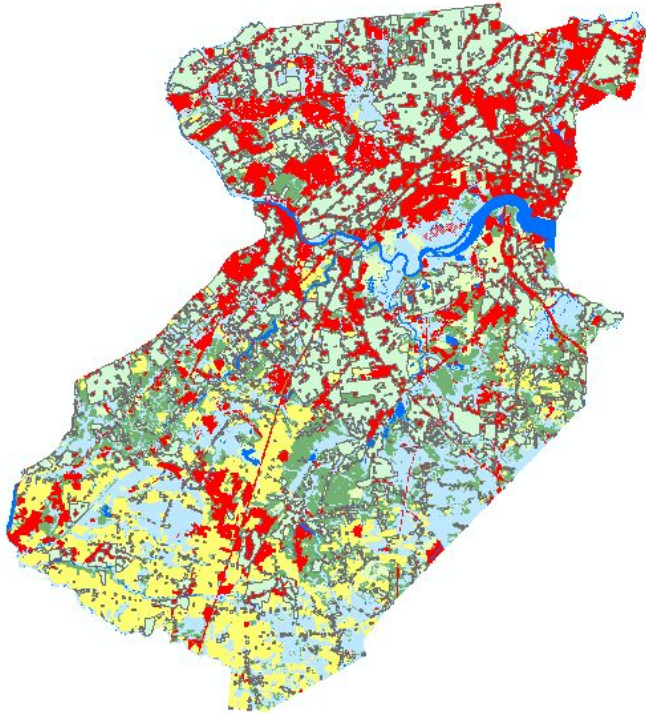
Through analysis of **Image 1- Image 4**, it becomes apparent that a large portion of the land cover change within Middlesex County is attributed to urbanization. Large portions of land that were once categorized as agricultural or forested areas very quickly became overtaken by newly categorized urban land. This large amount of urbanization can be attributed to a variety of different aspects. One leading factor can be linked to the counties large change in population growth. In 1980, the population of Middlesex county was recorded to be approximately 596,000 individuals. By 1990 the population had grown to approximately 672,000 people and by 2010 it was up to almost 811,000 residents (“Middlesex County,” 2020). When the population of an area greatly increases, the township must do their best to accommodate these changes. Urbanization can be classified as the development of residential zones, businesses, offices, etc. It makes sense to see that an increase in people living within Middlesex County would ultimately correlate to an increase in the overall development of land.





**Image 1 - Middlesex Land Use 1986**

**Image 2 - Middlesex Land Use 1995**



**Legend**

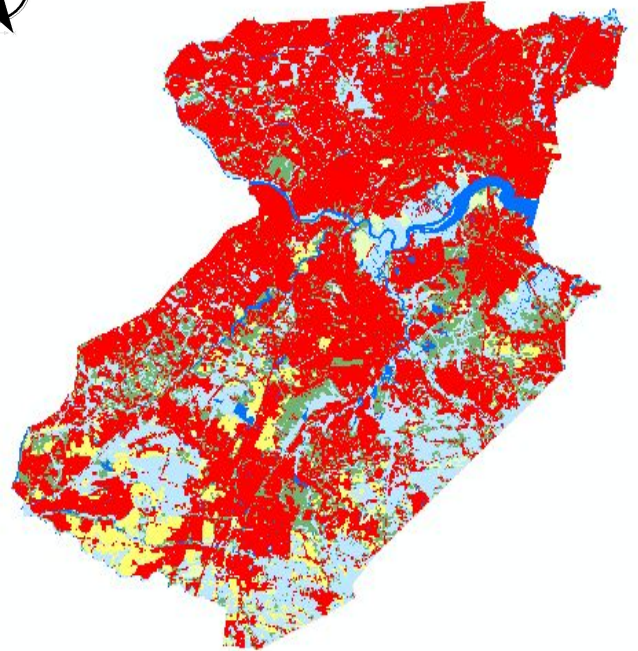
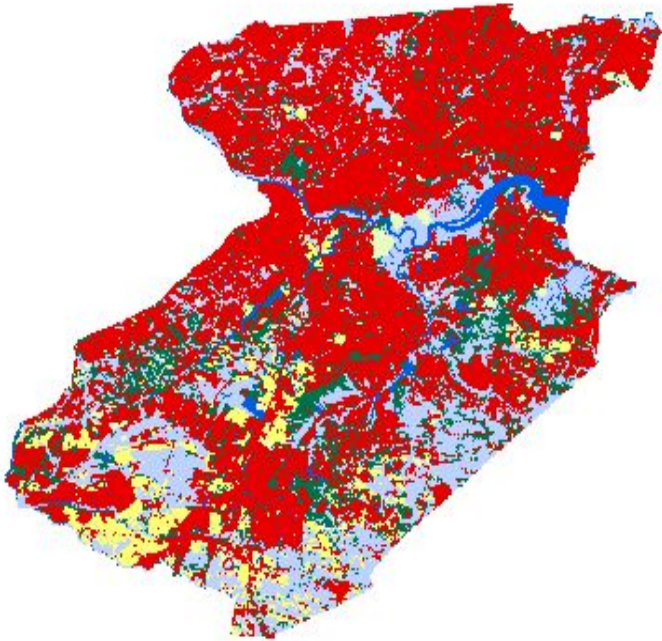
**Land Usage**

**TYPE07**

-  AGRICULTURE
-  BARREN LAND
-  FOREST
-  URBAN
-  WATER
-  WETLANDS

**Image 3 - Middlesex Land Use 2007**

**Image 4 - Middlesex Land Use 2015**



**Legend**

**Land Usage**

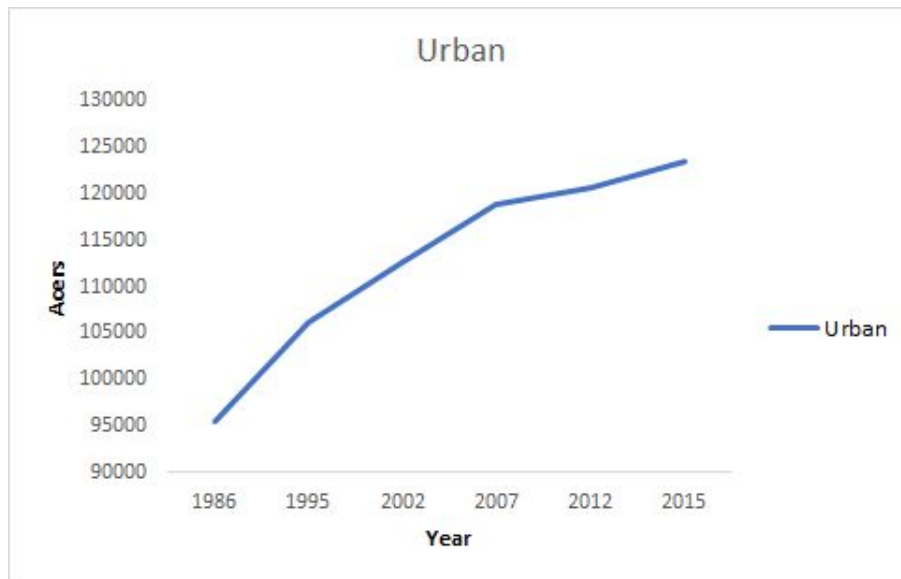
**TYPE07**

-  AGRICULTURE
-  BARREN LAND
-  FOREST
-  URBAN
-  WATER
-  WETLANDS

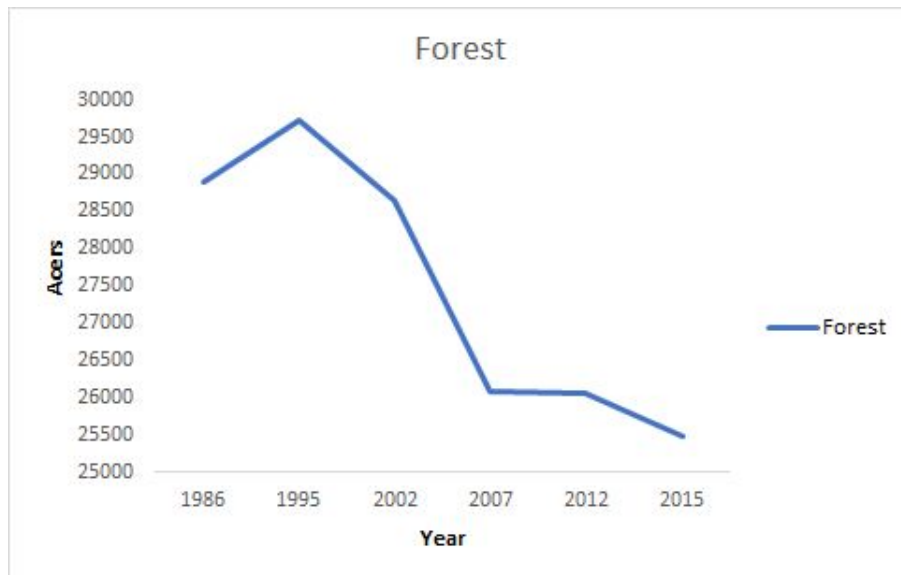
As necessary as this urbanization of land may have been to suit the needs of Middlesex County residents, some aspects of land use within the county had to give in order to allow this development to occur. These give-and-take types of trends can be better visualized within **Figure 1- Figure 3**. **Figure 1** shows a steady increase in urbanization of the land between the years 1986 through and including 2015. **Figures 2 and 3** both show a steady decrease in the amount of forested and agricultural land cover between the years of 1995 and 2015. One abnormal trend that can be seen would include the increase in forested land cover for Middlesex County between the 1986 and 1995. Upon further research, it was discovered that Monroe Township of Middlesex County, NJ sustained a major forest fire in 1985. The fire burned

approximately 700 acres of forested land (Sapia, 2010). Because such a great amount of forested land was destroyed in 1985, it would make sense that the recorded acreage for forest land cover in 1986 is lower than expected. Additionally, despite the fact that urbanization was undoubtedly occurring between 1986 and 1995, all of the forested land that was burned down was also regenerating between these same years. This fire can ultimately be correlated to the abnormal increase in forested land cover between 1986 and 1995.

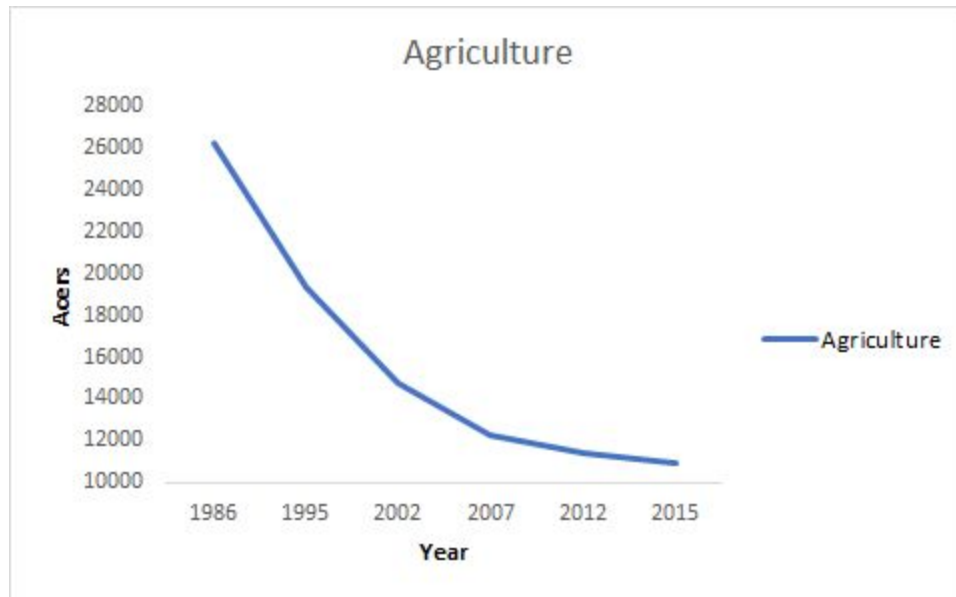
**Figure 1 - Urban Land Acreage for Middlesex County**



**Figure 2 - Forest Land Acreage for Middlesex County**



**Figure 3 - Agriculture Land Acreage for Middlesex County**



After visualizing the altering trends between agriculture, forest and urban land use, a table was then constructed as a method for compiling all trends into one representative feature. **Table 1** numerically displays this compilation.

**Table 1 - Land Use Acreage Totals Throughout All Six Years for Urban, Forested, and Agricultural Areas for Middlesex County**

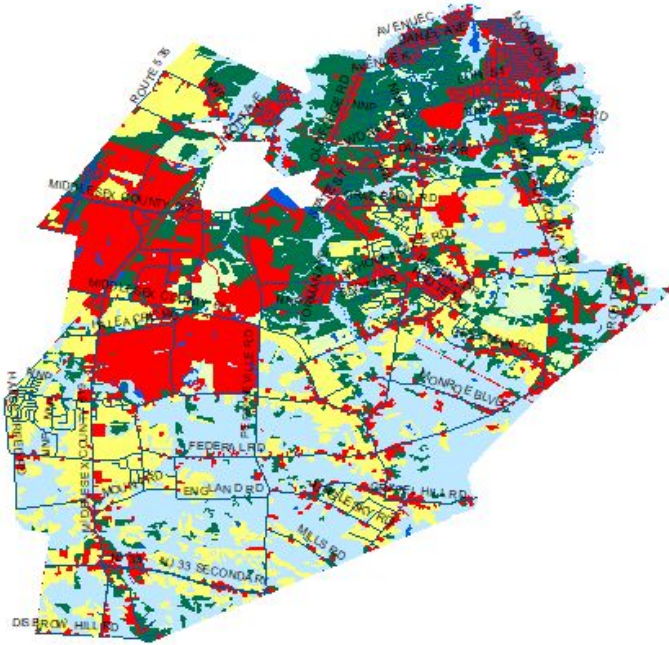
Year	Urban (Acres)	Forest (Acres)	Agriculture (Acres)
1986	95,576	28,895	26,261
1995	106,180	29,724	19,340
2002	112,568	28,645	14,746
2007	118,853	26,076	12,265
2012	120,670	26,066	11,444
2015	123,534	25,486	10,907
<b>Total Change</b>	27,958	-3,409	-15,354

From the analysis of the Middlesex county seen within **Images 1-4**, it becomes apparent that the northern portion of the county was largely affected by urbanization. However, as a whole, the red color of urbanization can be seen encroaching across the entire county at a steady rate. In order to better understand this change in land cover on a smaller scale, one municipality

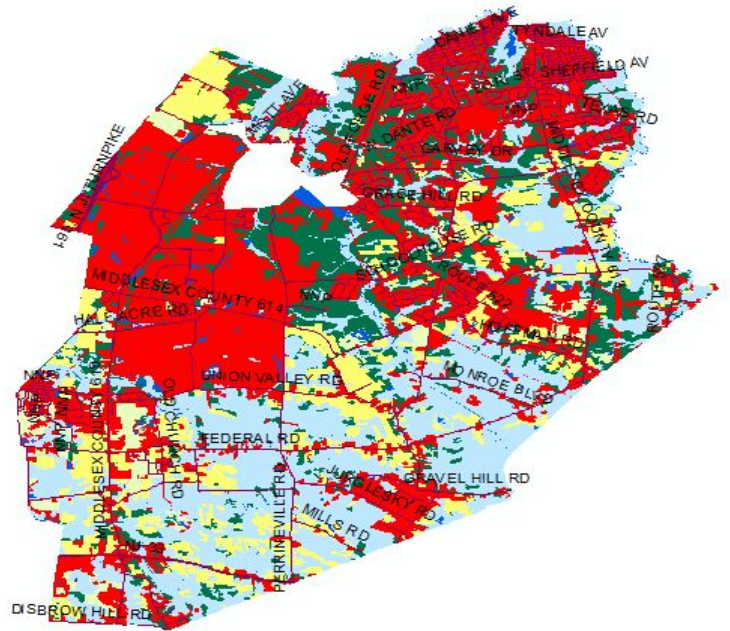
from the county was selected. When observing the trends within the lower portion of Middlesex County, a change in land color can still be observed, even though it is not as drastic as seen within the northern portions. To further the analysis of these trends, Monroe Township in the southern portion of Middlesex County was selected. Land use data was then collected for each of the studied years.

**Images 5** and **Image 6** show the change in land use for Monroe Township, which is located in southern Middlesex county, and this is shown in **Image 7**. **Image 5** is based off of land use in 1995, and when compared to **Image 6**, which is based off of 2007 land use, shows a substantial increase in urban development. In order to truly understand this major change that occurred within the township, a shapefile of roadways from 2008 was added into each map document. When this shapefile was overlaid with the data from 1995, it becomes evident that many present roadways in 2008 are currently sitting in areas of which used to be completely forested zones. When looking at the two images, it can be seen that urban areas increase at the expense of agricultural and forested areas. This is displayed within **Table 2**. This table shows the overall change in land usage between Urban, Agricultural, and Forested areas. The data collected between 1995 and 2007 show that Forested areas lost 1372 total acres, Agricultural areas lost 2766, all while Urban areas gained 3361. This shows that the loss of acreage between agriculture and forested areas is mainly caused by urbanization. This is presented in **Table 3**, which shows the calculations made in order to come to the conclusion that 81.223% of the total land use change between both agriculture and forests is directly attributed to development of urban areas.

**Image 5 - Monroe Twp. Land Use 1995**



**Image 6 - Monroe Twp. Land Use 2007**



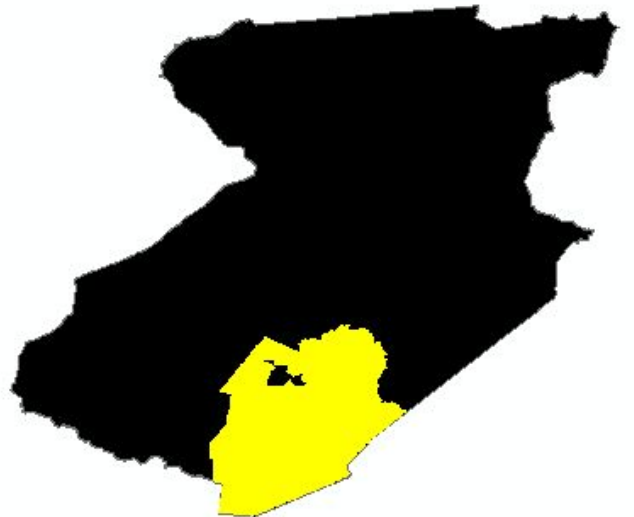
**Legend**

**Land Usage**

**TYPE07**

-  AGRICULTURE
-  BARREN LAND
-  FOREST
-  URBAN
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-  WETLANDS

**Image 7 - Location of Monroe Twp.**



**Table 2 - Total Change in Acres for Urban, Forested, and Agricultural Areas in Monroe Twp.**

Year	Urban Acres	Forested Acres	Agricultural Acres
1995	8133	6056	6439
2007	11494	4684	3673
<b>Total Change</b>	<b>3361</b>	<b>-1372</b>	<b>-2766</b>

**Table 3 - Total Acreage Change Correlation Between Forested/Agricultural Areas, and Urban Areas**

Land Use	Total Change
Forested Acres Total Change	-1372
Agricultural Acres Total Change	-2766
<b>Sum of Total Change Between Forest and Agriculture Areas</b>	-4138
Urban Area Total Change	3361
<b>(ABS (Urban Change / Frst &amp; Agri Change)) *100</b>	81.223% of the sum of the total change between 1995 & 2007 is due to urban acreage increase

Although these maps and tables explain a large portion of land use and land cover changes within both Middlesex County, and specifically Monroe Township, they do not tell the full story. After further analysis, it became evident that Monroe Township was having significant issues with leaching from their township landfill. Because the surrounding area was almost entirely residential zones, the landfill was shut down in 1978 (“Superfund Record,” 1993). It was not until 1979 that remedial actions were taken, and additional measures were added in 1986 (“Superfund Record,” 1993). The landfill itself covers a span of 86 acres. However, actions for remediation forced further urbanization of the area to take place. For instance, a 7,000 foot wall was constructed to enclose the entire site, while an entire leachate collection system was created for storage (Brady, et. al., 2018). Understanding these facts prove to be important when analyzing the overall land cover change of the area. From a glance at the maps, it appears that urbanization is a terrible process because it is destroying valuable forested and agricultural lands. However, in certain cases, such as the Monroe landfill case, urbanization is actually helping to improve the environmental quality of the municipality.

## **Conclusion**

The main objective for this lab was to better understand how land cover across Middlesex County has drastically changed over a 29 year period. More specifically, urbanization has spread across the entire county while forest and agriculture areas have, in return, been slowly diminishing. On a smaller scale, these trends were further analyzed by exploring the change in land cover seen across just Monroe Township. These trends held constant, even when observing them for a single municipality. It is important to further research why these changes are occurring in order to obtain a better understanding of their true environmental impact. Despite the fact that much of the urbanization can be attributed to an increase in residential and public areas because of the increasing population, not all of the increase in urbanization is correlated with negative environmental impacts. More specifically, Monroe's development of land surrounding the landfill is actually proving to be a very beneficial development for both the environment and the surrounding residents. Overall, the land cover for Middlesex county has drastically changed over a 29 year period and these changes can be correlated to a wide variety of different occurrences. Understanding these occurrences and the impact that they have on the surrounding area is an essential aspect to the overall condition of the surrounding environment.



## References

- Brady, P. V., Brady, M. V., & Borns, D. J. (2018). *Natural Attenuation Cercla, RBCAs, and the Future of Environmental Remediation*. Bosa Roca: Chapman and Hall/CRC.
- Hegazy, I. R., & Kaloop, M. R. (2015, February 21). Monitoring urban growth and land use change detection with GIS and remote sensing techniques in Daqahlia governorate Egypt. Retrieved from <https://www.sciencedirect.com/science/article/pii/S2212609015000060>
- Historic Aerials. (n.d.). Retrieved February 18, 2020, from <https://www.historicaerials.com/viewer>
- Middlesex County, New Jersey Population 2020. (n.d.). Retrieved February 18, 2020, from <http://worldpopulationreview.com/us-counties/nj/middlesex-county-population/>
- NJDEP Open Data. (n.d.). Retrieved February 18, 2020, from <https://gisdata-njdep.opendata.arcgis.com/>
- Sapia, J. (2010, April 15). The day Monroe burned. Retrieved February 18, 2020, from <https://archive.centraljersey.com/2010/04/15/the-day-monroe-burned/>
- Superfund Record of Decision: Monroe Township Landfill, NJ. (2020, February 18). Retrieved March 31, 1993, from [https://nepis.epa.gov/Exe/ZyNET.exe/9100SYF6.txt?ZyActionD=ZyDocument&Client=EPA&Index=1991 Thru 1994&Docs=&Query=&Time=&EndTime=&SearchMethod=1&TocRestrict=n&Toc=&TocEntry=&QField=&QFieldYear=&QFieldMonth=&QFieldDay=&UseQField=&IntQFieldOp=0&ExtQFieldOp=0&XmlQuery=&File=D:\ZYFILES\INDEX DATA\91THRU94\TXT\00000025\9100SYF6.txt&User=ANONYMOUS&Password=anonymous&SortMethod=h|-&MaximumDocuments=1&FuzzyDegree=0&ImageQuality=r75g8/r75g8/x150y150g16/i425&Display=hpfr&DefSeekPage=x&SearchBack=ZyActionL&Back=ZyActionS&BackDesc=Results page&MaximumPages=1&ZyEntry=2](https://nepis.epa.gov/Exe/ZyNET.exe/9100SYF6.txt?ZyActionD=ZyDocument&Client=EPA&Index=1991%20Thru%201994&Docs=&Query=&Time=&EndTime=&SearchMethod=1&TocRestrict=n&Toc=&TocEntry=&QField=&QFieldYear=&QFieldMonth=&QFieldDay=&UseQField=&IntQFieldOp=0&ExtQFieldOp=0&XmlQuery=&File=D:\ZYFILES\INDEX DATA\91THRU94\TXT\00000025\9100SYF6.txt&User=ANONYMOUS&Password=anonymous&SortMethod=h|-&MaximumDocuments=1&FuzzyDegree=0&ImageQuality=r75g8/r75g8/x150y150g16/i425&Display=hpfr&DefSeekPage=x&SearchBack=ZyActionL&Back=ZyActionS&BackDesc=Results%20page&MaximumPages=1&ZyEntry=2)

Appendix

*Middlesex Land Use 2002*

*Middlesex Land Use 2012*

