TOOLE DESIGN

2 OLIVER STREET
SUITE 305
BOSTON, MA 02109

617.619.9910
TOOLEDESIGN.COM

MEMORANDUM

August 12, 2022

To: Keith Hamas
Organization: North Jersey Transportation Planning Authority
From: Theja Putta and Michael Blau
Project: North Jersey Transportation Planning Authority Regional Active Transportation Plan

Re: Trip Potential Analysis – FINAL REVISED (6/16/23)

Introduction

Toole Design performed a trip potential analysis to determine where people would be most likely to walk and bike in the NJTPA region, based on factors that are positively associated with pedestrian and bicycle trip attraction or generation. The project team selected a combination of factors related to development patterns and socioeconomic characteristics as the primary elements to estimate a location's trip potential.

Methodology

The trip potential value is calculated using a hexagonal grid. Each hexagonal cell is 500 feet across. A value representing the measure of each input variable is shown in Table 1. The project team scaled raw values using percentile scaling so that inputs of different units can be compared. The total trip potential score is an aggregate of the individual factor scores.

Input Variables

The following inputs are used as variables for the analysis.

Table 1: Trip Potential Analysis Variables

Variable	Measure	Source	Process Description	Pedestrian Weight	Bicycle Weight
Population	Population within a given search distance (1/4 mile for pedestrian and 1 mile for bicycle)	American Community Survey (ACS), 2019	Calculated by proportional allocation of population based on the overlap between Census Block Groups and a buffer of each hex cell	30	30
Employment	Number of jobs within a given search distance	Longitudinal Employer-Household	Calculated by proportional allocation of jobs based on the overlap between	20	20

Variable	Measure	Source	Process Description	Pedestrian Weight	Bicycle Weight
	(1/4 mile for pedestrian and 1 mile for bicycle)	Dynamics (LEHD), 2019	Census Block Groups and a buffer of each hex cell		
Intersection Density	Number of intersections within 1/4 mile	Derived from a street centerline network layer provided by NJTPA which includes off-street trails	Limited access highways and ramps are removed from the analysis and further processing was done to exclude false intersections where line segments are broken.	10	0
Poverty	Number of households below poverty within a given search distance (1/4 mile for pedestrian and 1 mile for bicycle)	American Community Survey (ACS), 2019	Calculated by proportional allocation based on the overlap between Census Block Groups and a buffer of each hex cell	10	15
Vehicle Access	Number of households without access to vehicles a given search distance (1/4 mile for pedestrian and 1 mile for bicycle)	American Community Survey (ACS), 2019	Calculated by proportional allocation based on the overlap between Census Block Groups and a buffer of each hex cell	10	15
Transit Stops	Number of transit stops within a given distance (1/4 mile for pedestrian)	NJTPA	Calculated by counting the number of transit stops within the search distance. Includes bus stops, regional express bus and ferry stops, and train stops	10	10
Land Use Mix	Land Use Mix Score	Multiple (see Land Use Mix Score section below for details)	Land use mix score is calculated on a scale of 0-100 based on whether a location has a combination of land use types.	20	20

Land Use Mix Score

The land use mix factor was included because particular land uses and zoning regulations can encourage active transportation by making it safe, easy, and comfortable to walk or bike for both transportation and recreation. Effective active transportation networks create pedestrian and bicycle connections to important destinations within a reasonable distance (typically a quarter mile for walking and one mile for bicycling) from home. Multiple destination types within the same neighborhood, such as shops, grocery stores, job centers, public services, and schools, allow for more active transportation trips for different purposes. The land use mix score was a combination of factors in itself, including retail locations, large employment centers, community health and welfare locations, residential areas, and park space. Using percentile scaling enabled comparisons between different land-use types.

To measure the likelihood of mixed land uses generating more active transportation trips in the NJTPA region, the project team calculated a land-use mix (LUM) score which aims to identify locations where multiple types of land-uses exist on a comparable scale. The LUM score variable is calculated based on the methodology described by Christian et al.[1] LUM score is expressed in Equation 1:

$$LUM = \frac{-1(\sum_{i=1}^{n} lu_i * \ln(lu_i))}{\ln{(n)}} \tag{1}$$

Where

LUM = Land-use mix score

lu_i = relative measure of land-use type i

n = number of land-use types of interest

The land-use types selected for consideration in this project are explained in Table 2. Since land-use types are in different formats and their corresponding measures use different units, the analysis rescaled them to a percentile value between 0-100 within the region. This process enables comparisons between different land-use types on the same scale regardless of the magnitude and units of the inputs data. The relative land-use measure (lu_i) is described by Equation 2:

$$lu_i = \frac{prc_i}{\sum_{i=1}^{n} prc_i} \tag{2}$$

Where

lu_i = relative measure of land-use type i

prc_i = percentile score of land-use type i compared to the rest of the region

n = number of land-use types of interest

The LUM score is higher for locations which have relatively equal prc_i values compared to rest of the region. For example, a location with equal prc_i non-zero values for all i have a LUM score of 100. Locations with very high or low prc_i value for one-use category compared to others receive a lower LUM score. Locations with only one type of land-use present get a LUM score of 0. In other words, LUM score measures the uniformity of each nearby land-use category.

[1] Christian, H.E., Bull, F.C., Middleton, N.J. *et al.* How important is the land use mix measure in understanding walking behaviour? Results from the RESIDE study. *Int J Behav Nutr Phys Act* **8,** 55 (2011). https://doi.org/10.1186/1479-5868-8-55

Table 2: Land-Uses of Interest for Land-Use Mix Score

Land-Use Type	Raw Measure	Source	Process Description
Retail	Number of retail locations nearby	Open Street Map	Count the number of locations classified as supermarkets, general stores, convenience stores, theaters, or cinemas within a 1/4 mile search distance for pedestrians and 1 mile for bicycles
Office Space	Number of large employment locations nearby	LEHD 2019 employment data at census block level	Count the number of census blocks with at least 100 jobs within a 1/4 mile search distance for pedestrians and 1 mile for bicycles
Community Health and Welfare	Number of locations which promote community health and welfare nearby	Open Street Map	Count the number of locations classified as clinic, hospital, pharmacy, doctor, dentist, community center, library, post office, school, college, or university within a 1/4 mile search distance for pedestrians and 1 mile for bicycles
Residential Area	Area of land use classified as residential nearby	NJTPA land-use polygon data	The total area of overlap between residential land-use polygons (land-use code 1110, 1120, 1130, 1140, or 1150) and polygon buffer of hex cells. A buffer distance of 1/4 mile for pedestrians and 1 mile for bicycles is used.
Recreation (Park Space)	Area of park space nearby	NJTPA parks polygon data	The total area of overlap between park polygons and a polygon buffer of hex cells. A buffer distance of 1/4 mile for pedestrians and 1 mile for bicycles is used

Results

Summary

Overall potential for both pedestrian trips and bicycle trips in the NJTPA region followed a markedly similar pattern, with some exceptions. The intersection density variable was not included in the bicycle Trip Potential Analysis, since it has a negligible impact on biking trips. While large numbers of intersections enhance network connectivity for people walking because it makes the network more permeable, they can be a deterrent to people bicycling (especially for recreational riding) because intersections create more conflict points. The net effect of intersection density on people's willingness to bike is not always positive, as it tends to be for walking.

The influence of transit also varies between walking and biking trips. For bike trip potential, the transit variable only included train stops, regional express bus stops, and ferry stops (and not regular bus stops). While almost every transit trip begins and ends with a walk, first and last mile bike trips to or from local bus stops are less common. The analysis reflects these differences, which led to some expected, and minor, variation in the results. This section discusses composite scores for pedestrian and bicycle trip potential. Composite results show a score that is the weighted average of all variables calculated for each hex cell. For results by variable, refer to Appendix A (pedestrian) and Appendix B (bicycle). Trip potential scores range from 0 to 100, with yellow areas showing the lowest trip potential values (0-10) and black areas representing the highest trip potential values (90-100).

Pedestrian Trip Potential

Low Trip Potential

Overall, Sussex, Warren, and Hunterdon counties have low composite trip potential values, with many areas scoring less than 10. These values are primarily due to low population, employment, and intersection density scores. Some small communities show higher potential for various reasons, such as a greater mix of population and employment density than surrounding areas, greater intersection density, or higher poverty concentration and lack of vehicle access (especially in areas like Hackettstown, Belvidere, and Newton). Communities with higher trip potential than counties overall include:

- Sussex County
  - Town of Newton
  - Boroughs of Sussex, Hamburg, Franklin, Branchville, Stanhope, Hopatcong, and Ogdensburg
  - Byram and Sparta Townships
- Warren County
  - Towns of Belvidere, Phillipsburg, and Hackettstown
  - Boroughs of Alpha and Washington
  - Allamuchy Township
- Hunterdon County
  - City of Lambertville
  - Towns of Clinton
  - Boroughs of High Bridge, Lebanon, Califon, Hampton, Glen Gardner, Frenchtown, Milford, Flemington

The southwestern portions of Ocean and Somerset counties and the northwestern portion of Passaic County also score low. These scores indicate that the variables used in the trip potential analysis (i.e., population, employment, intersection density, etc.) have a low likelihood of generating pedestrian trips in these areas. These values are primarily due to low land use mix and transit scores in southwestern Ocean County; low transit, vehicle access, and employment scores in southwestern Somerset County; and low intersection density and transit scores in northwestern Passaic County.

Medium Trip Potential

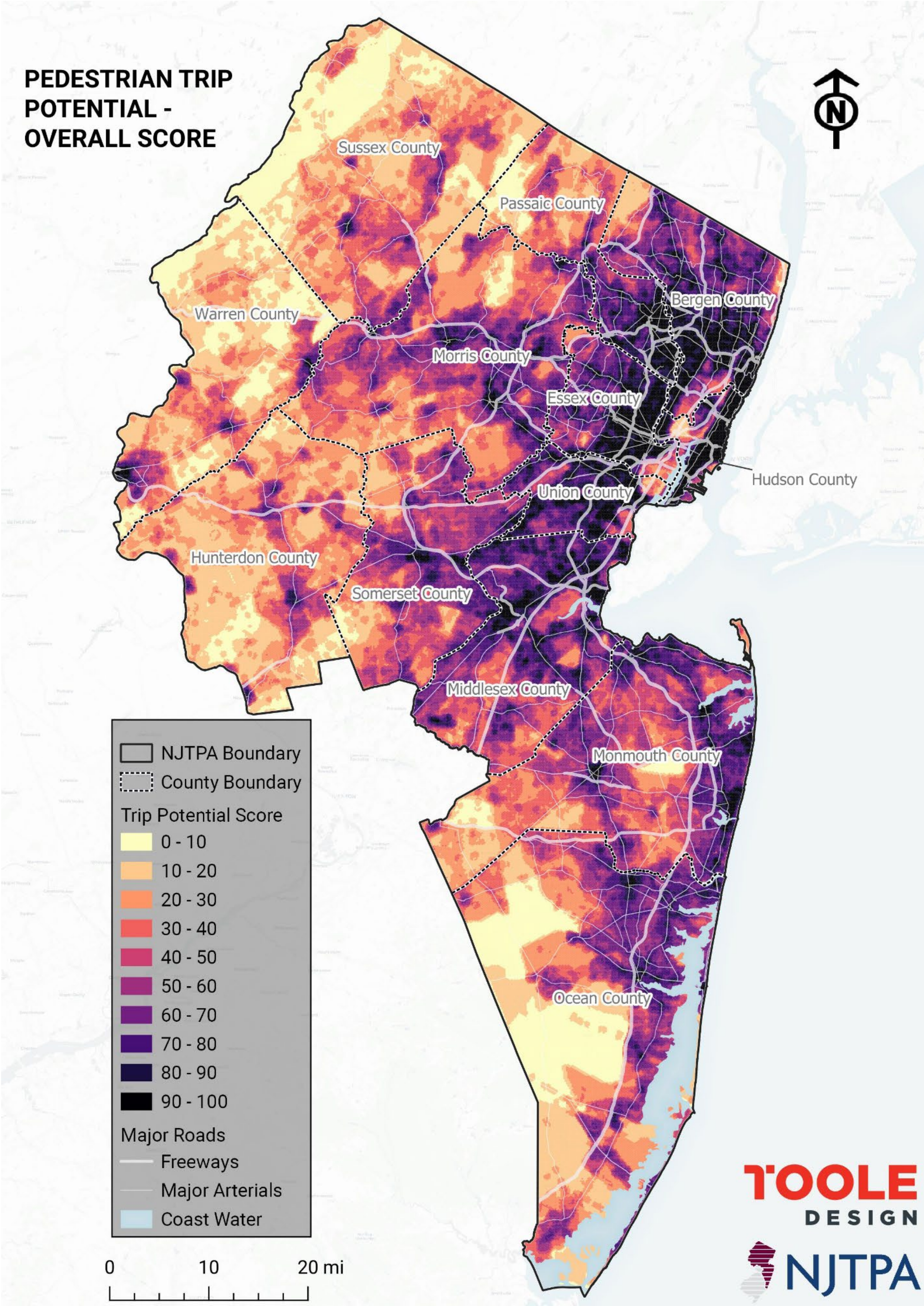
Morris County straddles the urban and rural areas in the NJTPA region; its high trip potential scores are confined primarily to Morristown, Randolph, and Madison, with lower scores in the western, rural parts of the county. Due to its unique shape and geography, Passaic County may be considered as two separate areas in terms of trip potential. The southeastern portion of the county is more akin to the very high trip potential values in neighboring urbanized areas in Essex and Hudson counties, whereas trip potential patterns in the northwestern portion of the county share more similarity with rural Sussex and Morris counties.

High Trip Potential

Monmouth County has high pedestrian trip potential, with the exception of Naval Weapons Station Earle and southwestern portions of the county (Upper Freehold Township). Middlesex, Union, Essex, Hudson, and Bergen counties and southeastern Passaic County all have very high pedestrian trip potential values overall, with the strongest potential in New Brunswick, Perth Amboy, Elizabeth, Bayonne, Newark, East Orange, Passaic, Jersey City, Hoboken, Fort Lee, Paterson, Englewood, Teaneck, Hackensack, and other large and medium-size communities within those counties. With the exception of the transit variable (whose high scores are confined to the heavily urbanized areas of Union, Essex, Hudson, Passaic, and Bergen counties), these counties exhibit high trip potential across all variables included in the analysis.

See Figure 1 for overall results.

Figure 1: Pedestrian Trip Potential – Overall Score



Bicycle Trip Potential

Overall potential for bicycle trips in the NJTPA region follows a markedly similar pattern to pedestrian trip potential values, with some exception. The intersection density variable was not included in the bicycle trip potential analysis. While large numbers of intersections enhance network connectivity, they can also be a deterrent to bicycling (especially recreational riding) by adding more conflict points. The net effect of intersection density on people's willingness to bike is not always positive, as it tends to be for walking. The transit variable was included with only train stops, regional express bus stops, and ferry stops. These changes led to some minor variation in the results.

The other major difference between the two sets of results is attributable to search distances. The search distance for pedestrians was ¼ mile, whereas we used one mile for bicyclists, due to longer trip lengths. This difference means that bicycle trip potential extends over larger areas than pedestrian trip potential, even though both analyses are using the same variables and weights. The change in results is clear in urban areas, such as Bergen, Essex, Union, and Hudson counties, whose bicycle trip potential scores are more broadly distributed, with fewer pockets of low-scoring areas in between. The difference in search distances is also evident in rural communities, such as the Town of Phillipsburg in Warren County. Phillipsburg is in the 90-100 range for both pedestrian and bicycle trip potential scores; however, its impact on bicycle trip potential extends further out into Warren County due to longer search distances. See Figure 2 for a side by side comparison.

See Figure 3 for overall results.

Figure 2: Phillipsburg Area Bike Trip Potential (left) and Pedestrian Trip Potential (right)

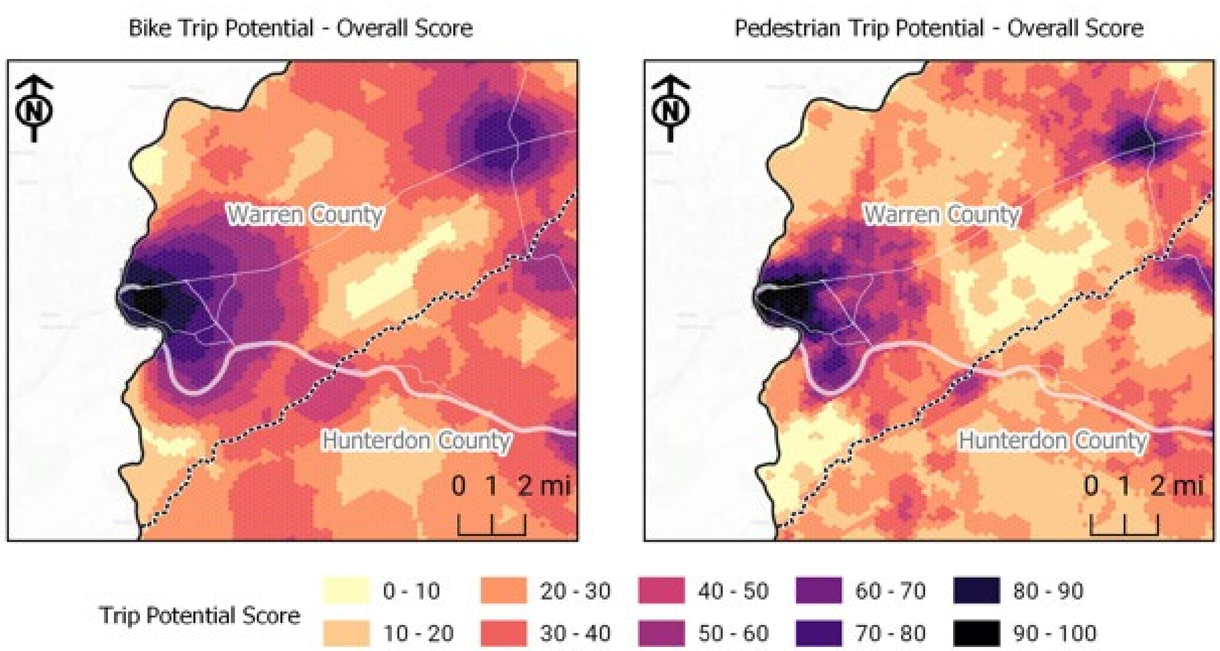
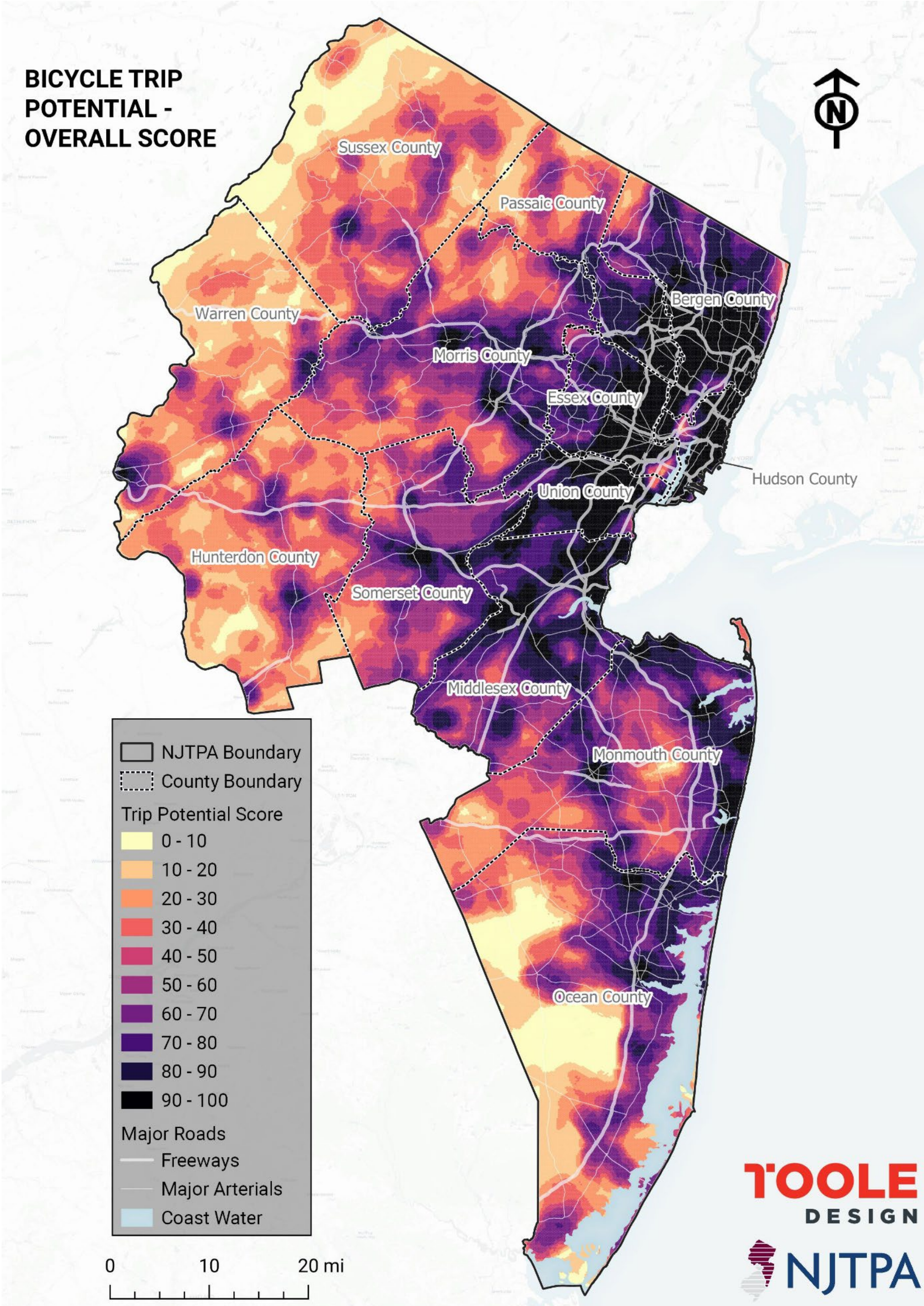


Figure 3: Bicycle Trip Potential – Overall Score



Next Steps

The project team compared the results of the trip potential analysis to the barrier analysis to find areas with high active transportation potential and large barriers to connectivity. The project team also overlaid results with the New Jersey Department of Transportation’s network screening datasets and the New Jersey Department of Environmental Protection’s environmental justice datasets to determine where there is overlap between high active transportation potential and regional safety/equity priorities. These areas served as a starting point to develop a conceptual, regional active transportation network.

APPENDIX A: PEDESTRIAN TRIP POTENTIAL RESULTS BY VARIABLE

Figure 4: Pedestrian Trip Potential – Population Score

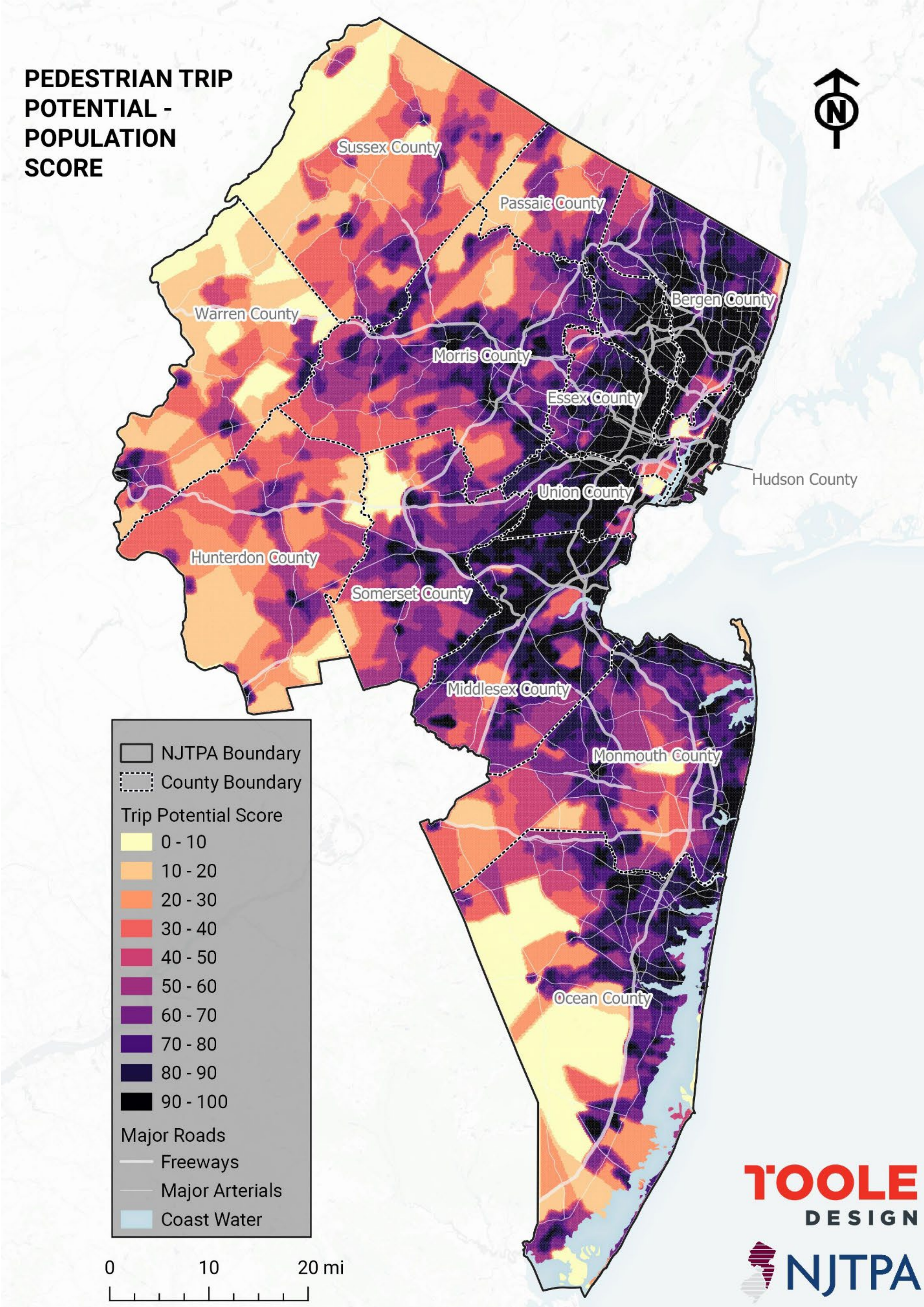


Figure 5: Pedestrian Trip Potential – Employment Score

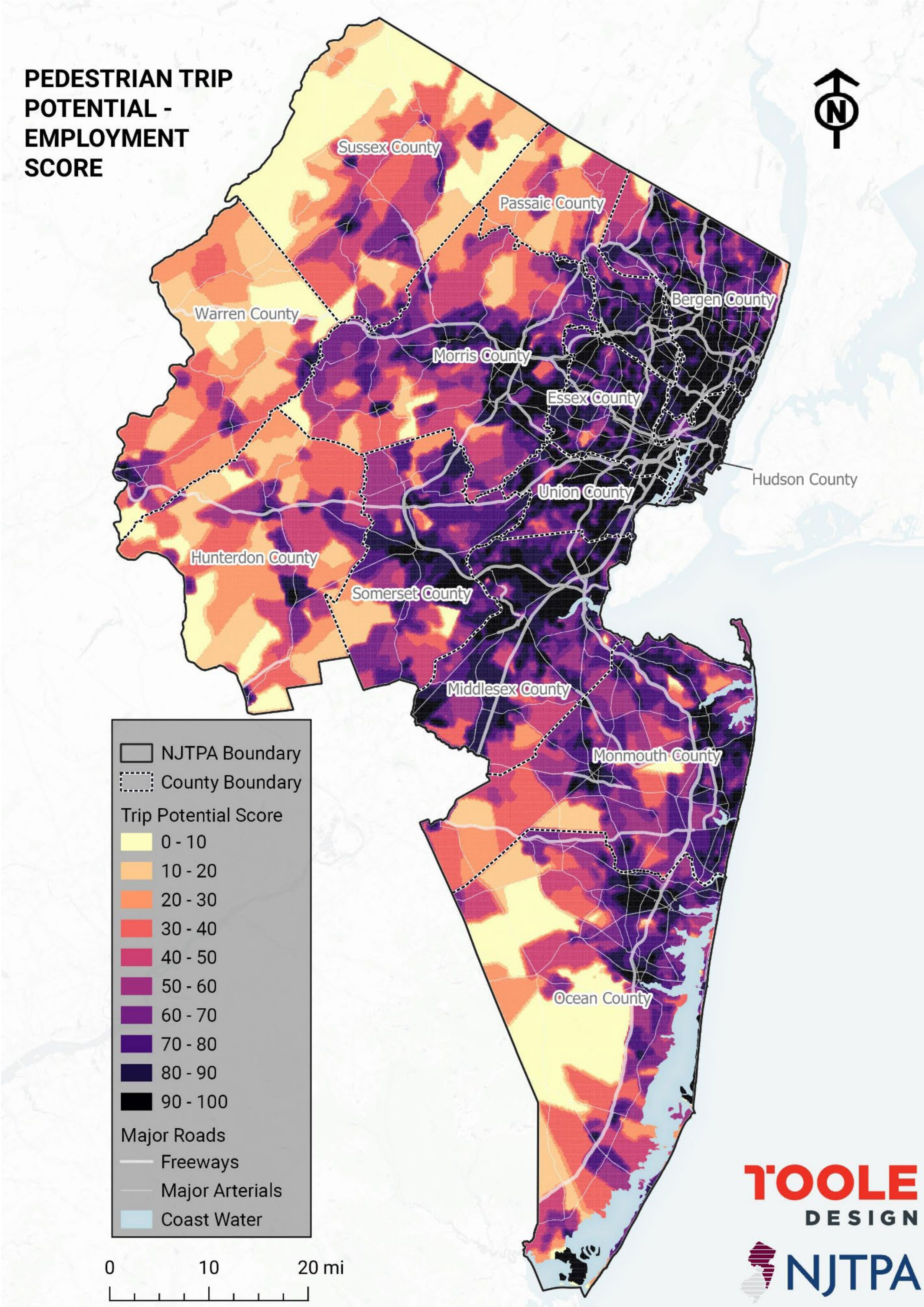


Figure 6: Pedestrian Trip Potential – Intersection Density Score

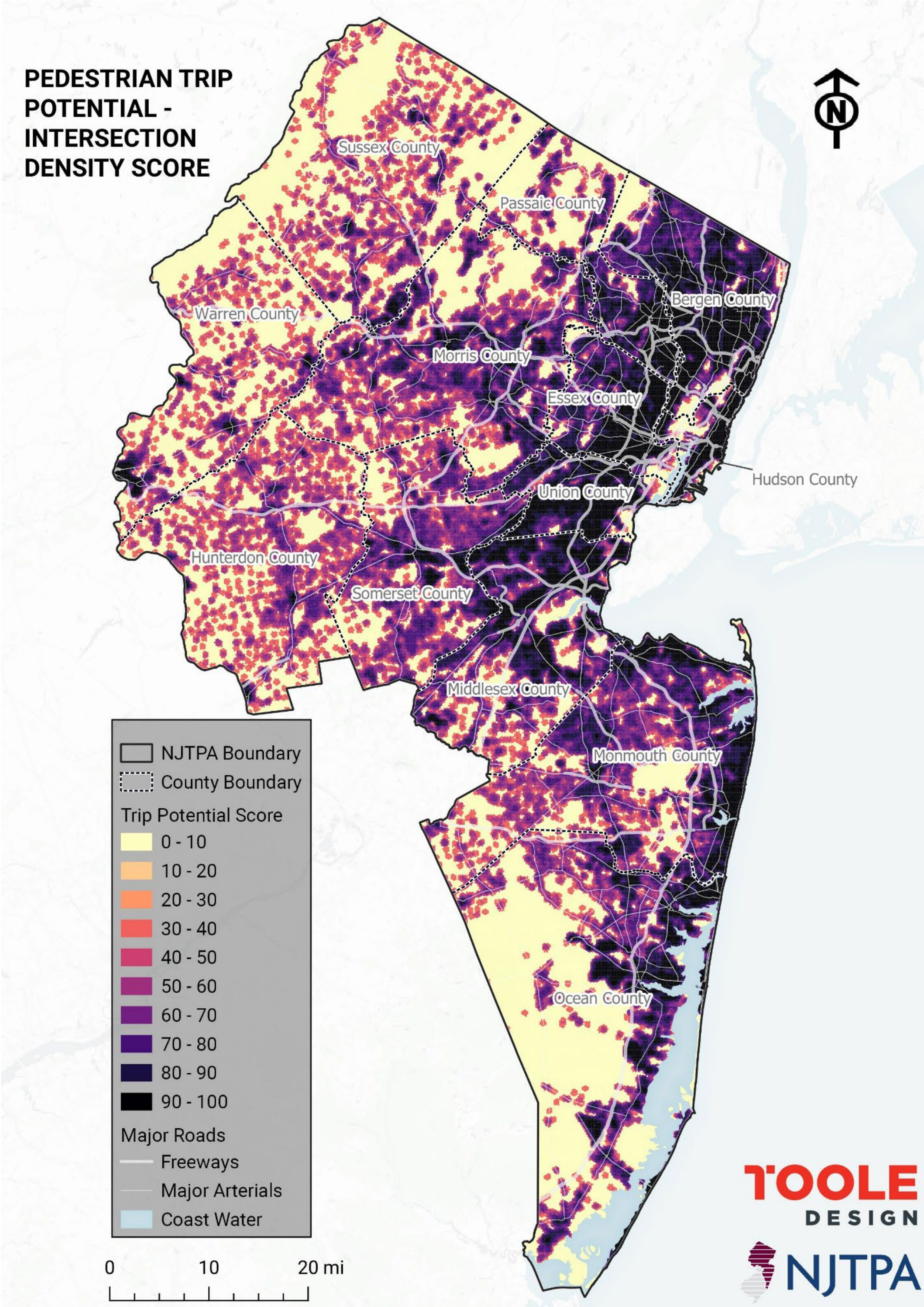


Figure 7: Pedestrian Trip Potential – Poverty Score

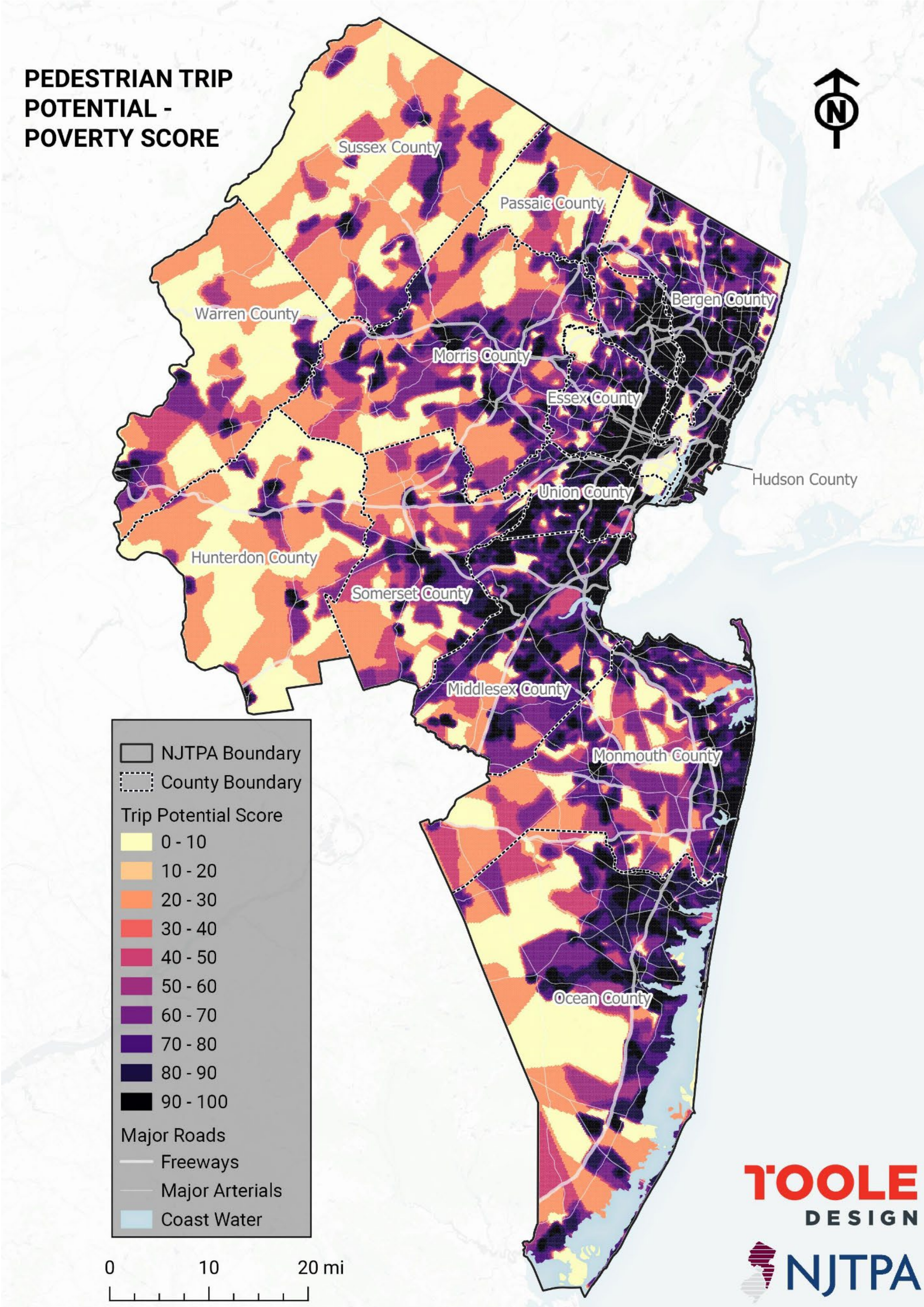


Figure 8: Pedestrian Trip Potential – Vehicle Access Score

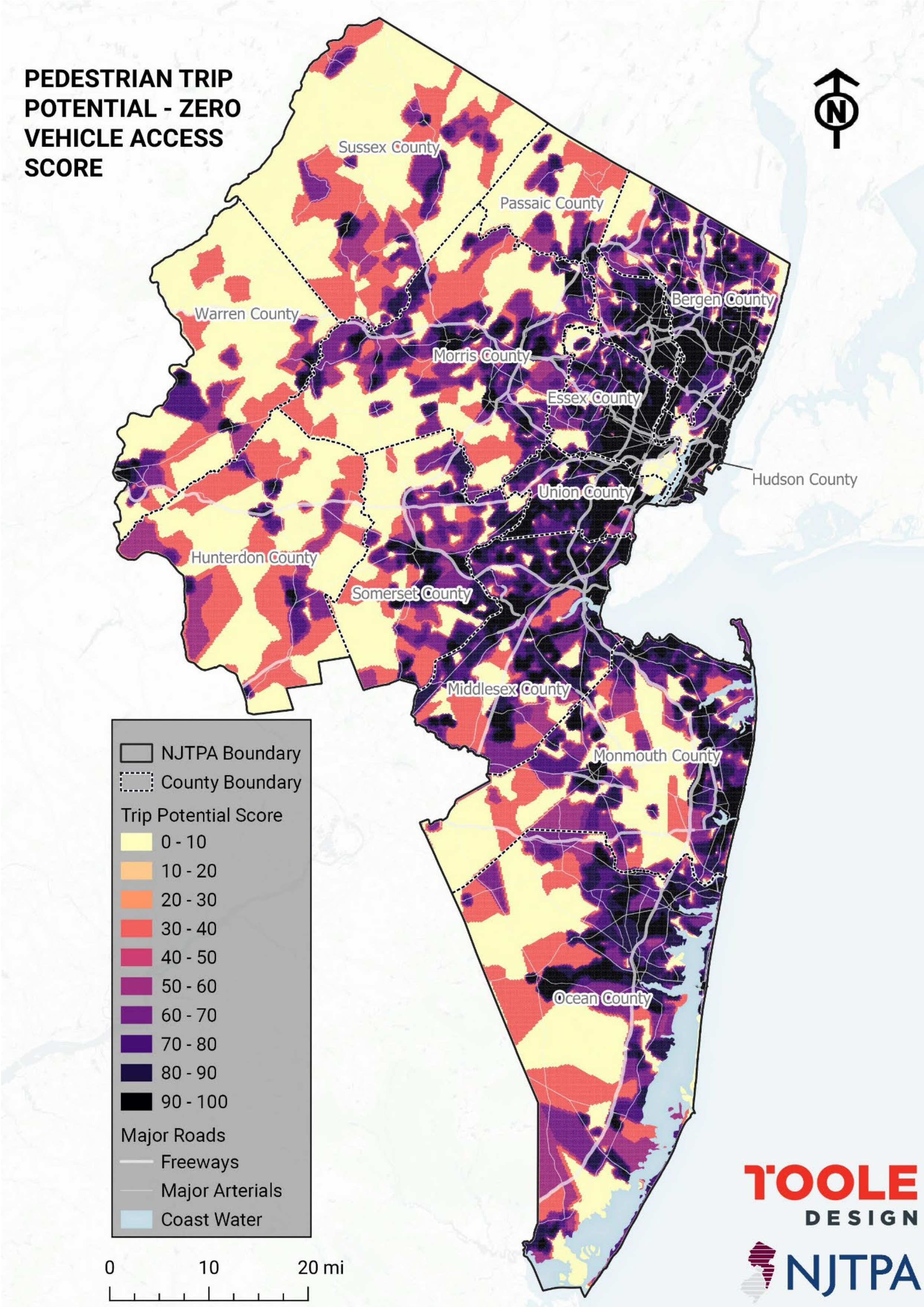


Figure 9: Pedestrian Trip Potential – Transit Proximity Score

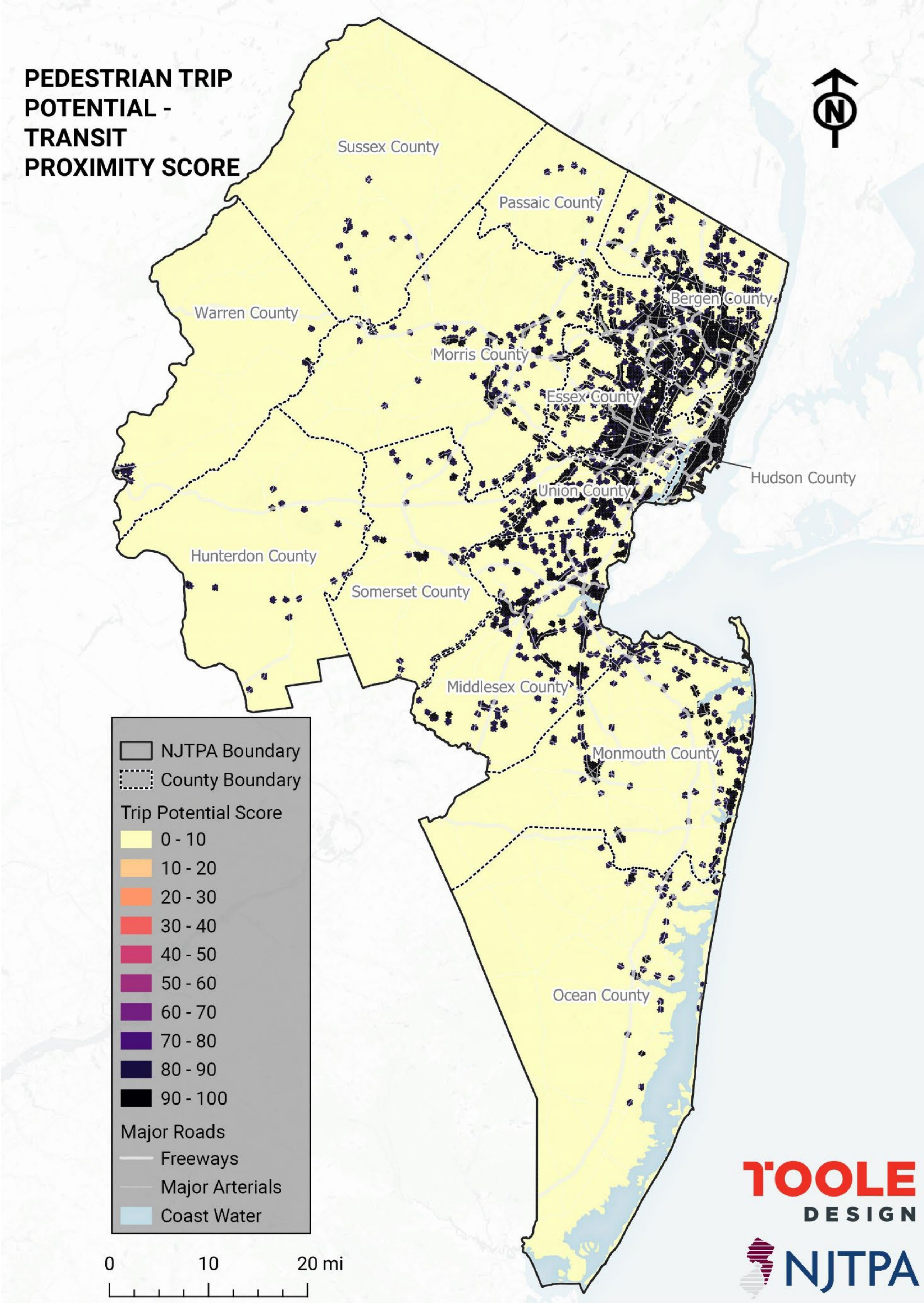
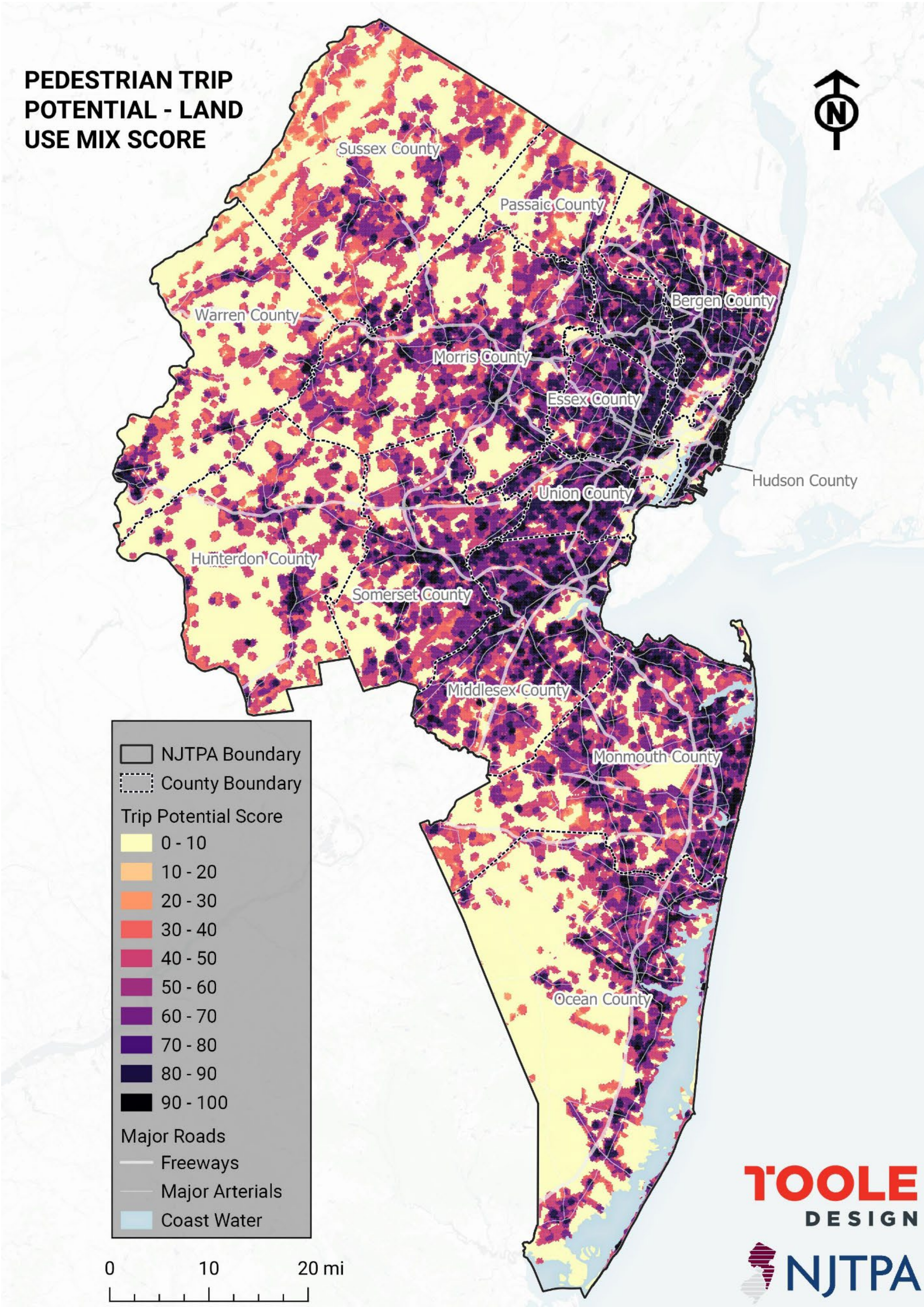


Figure 10: Pedestrian Trip Potential – Land Use Mix Score



APPENDIX B: BICYCLE TRIP POTENTIAL RESULTS BY VARIABLE

Figure 11: Bicycle Trip Potential – Population Score

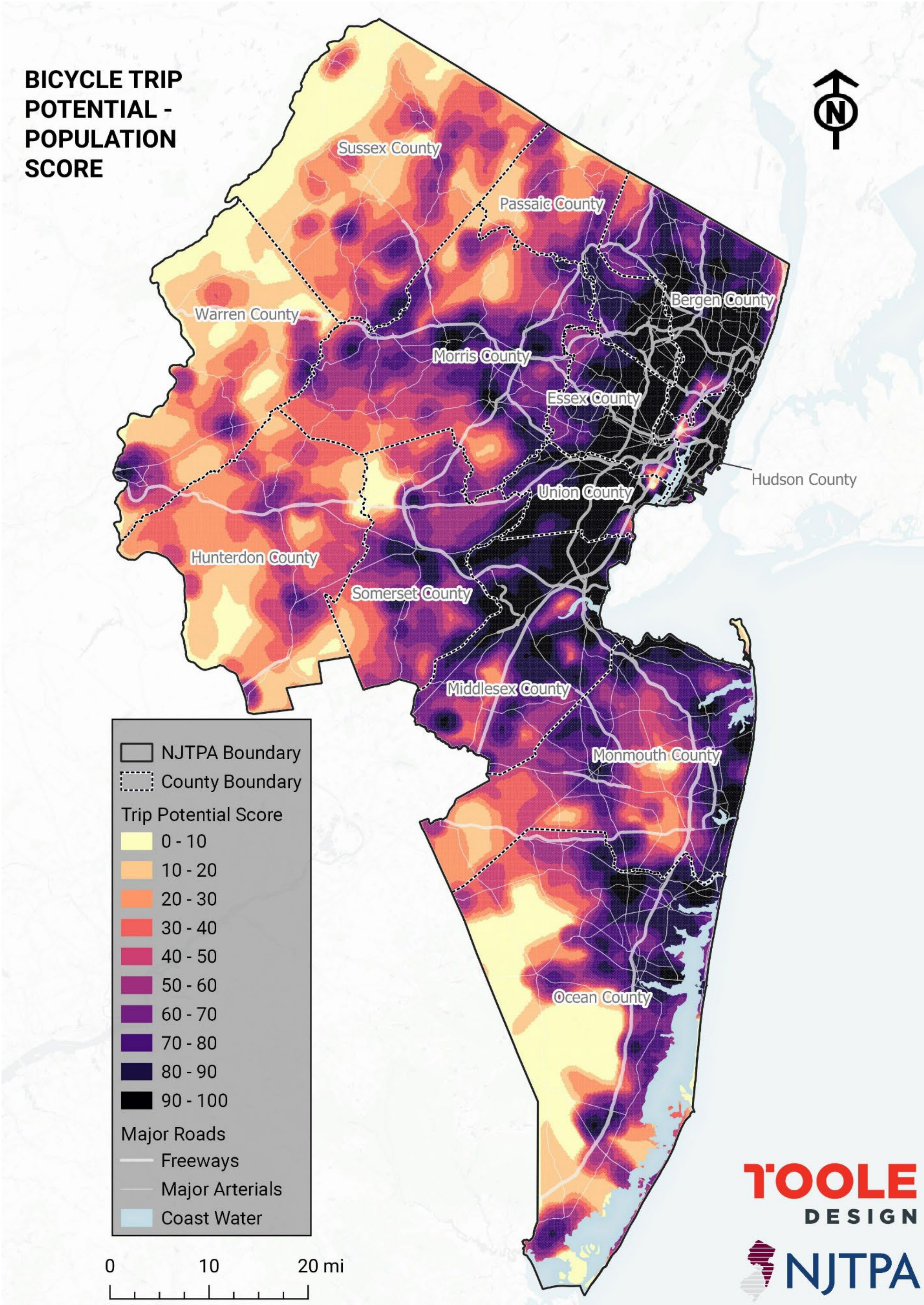


Figure 12: Bicycle Trip Potential – Employment Score

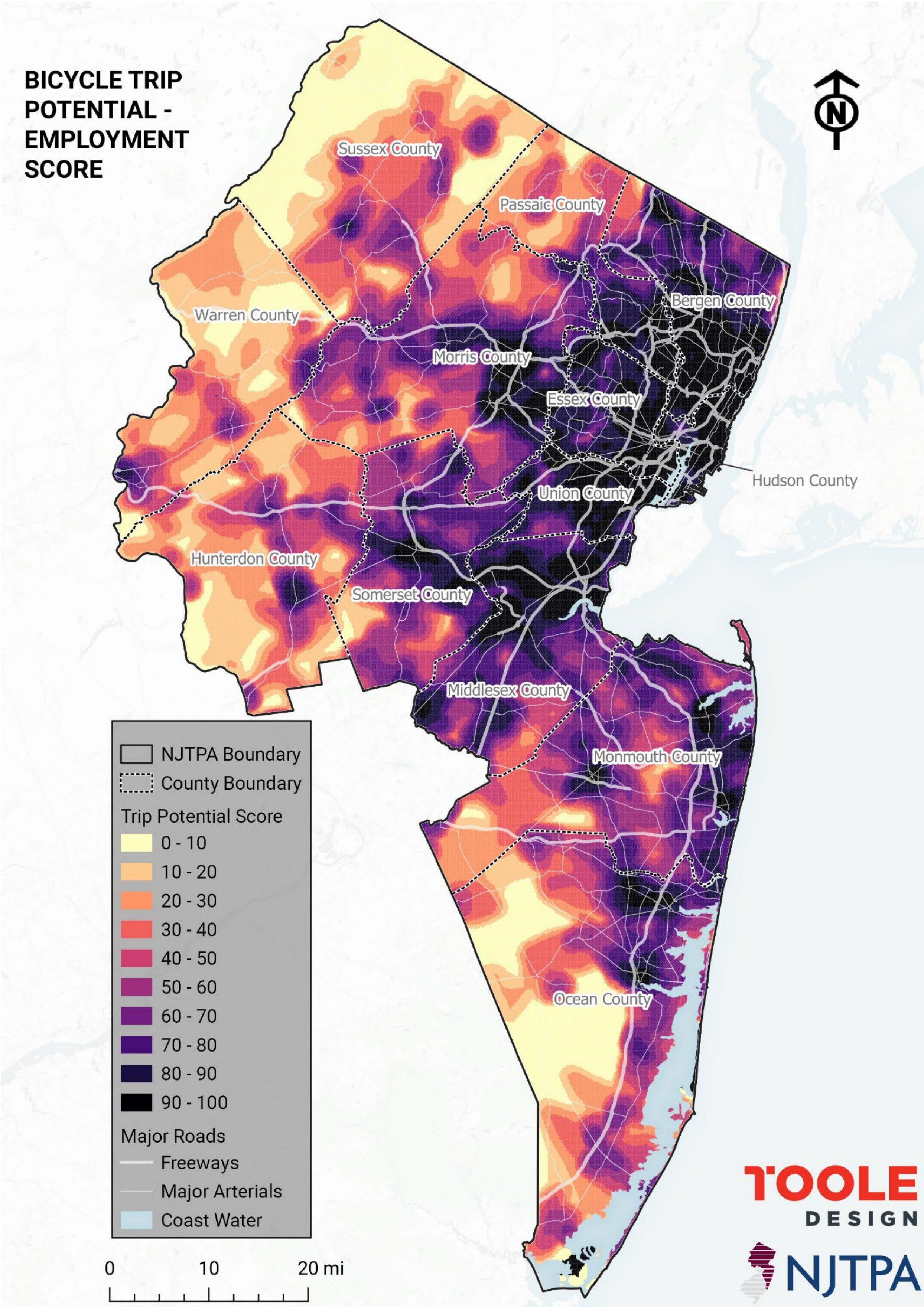


Figure 13: Bicycle Trip Potential – Poverty Score

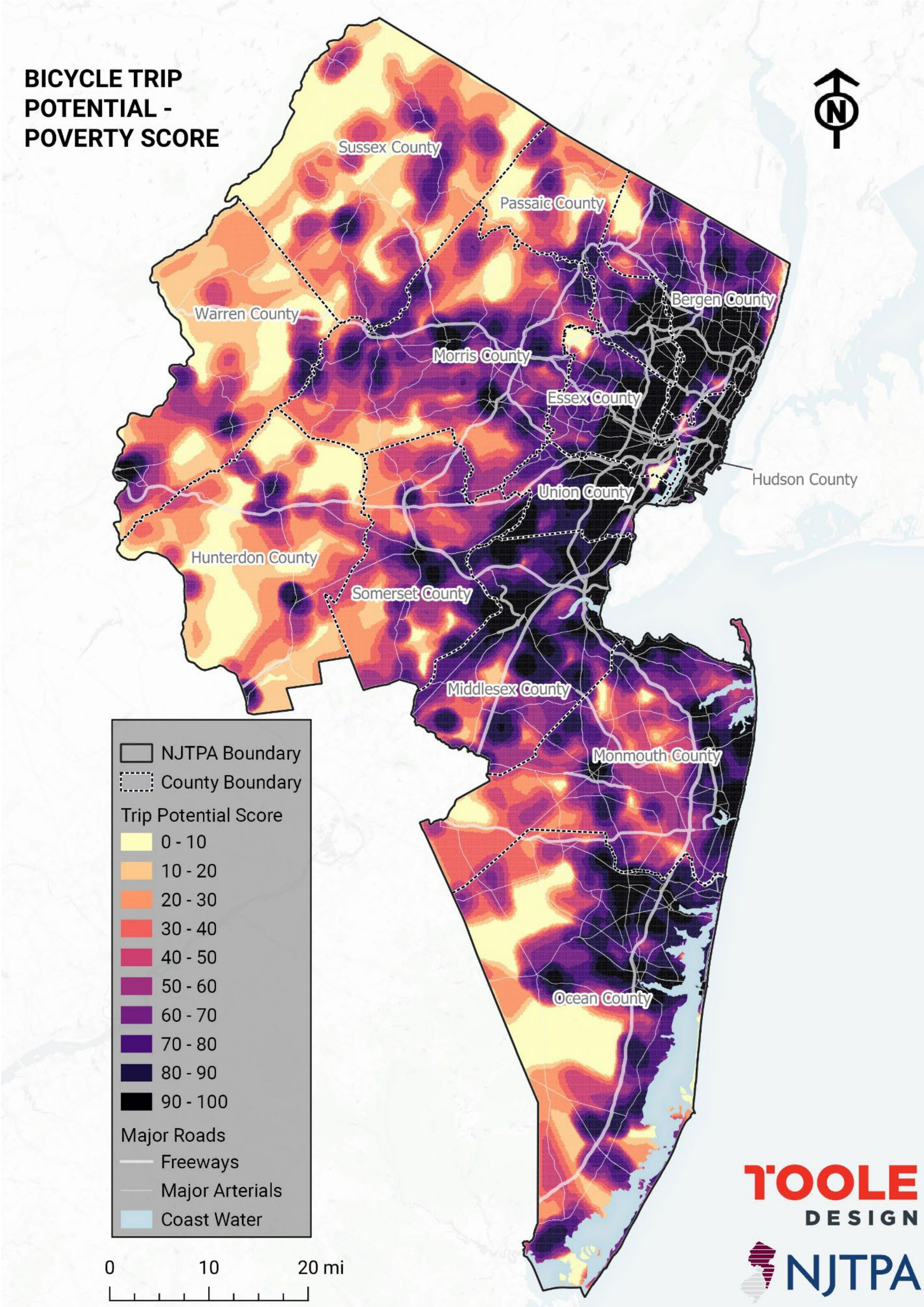


Figure 14: Bicycle Trip Potential – Vehicle Access Score

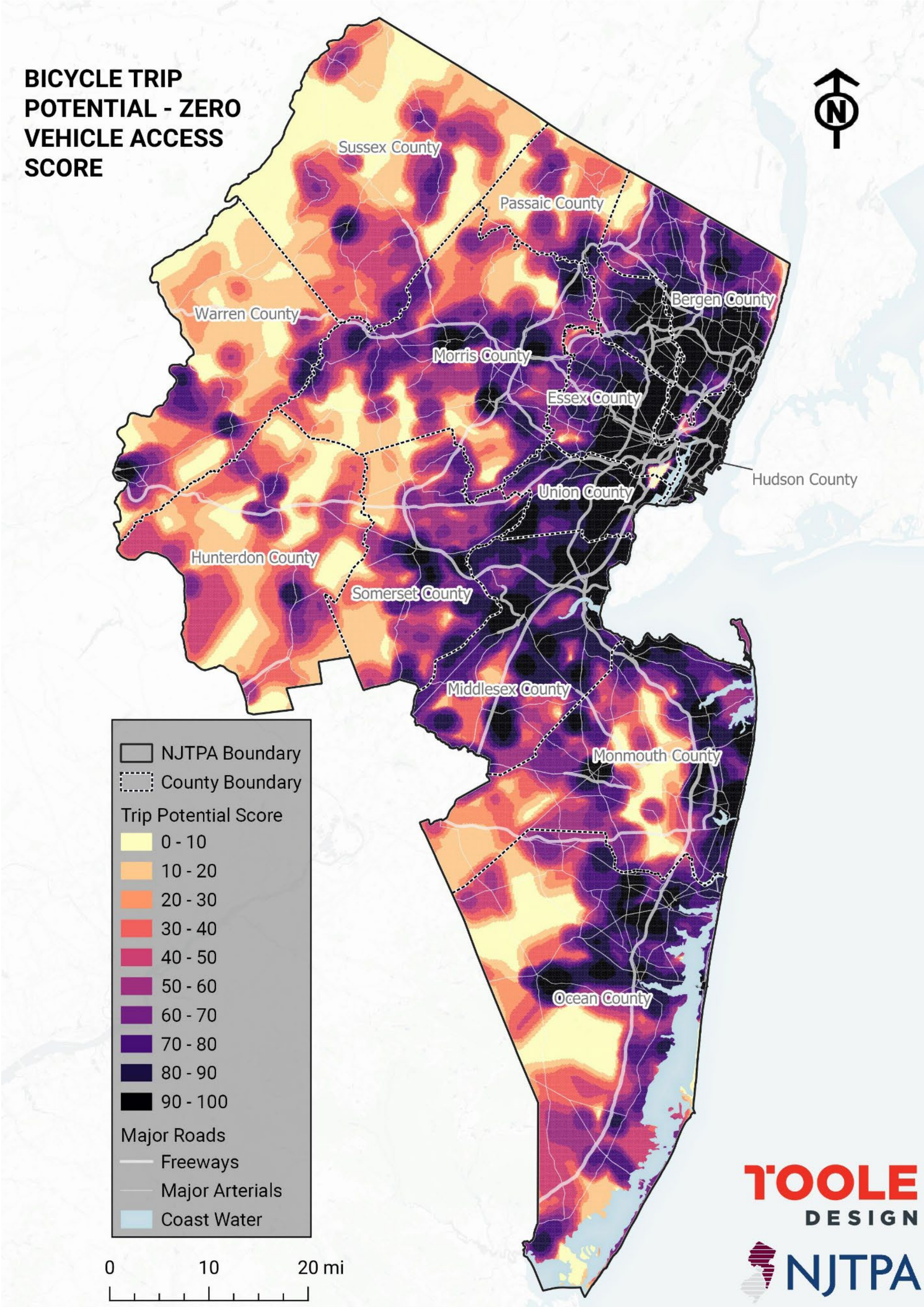


Figure 15: Bicycle Trip Potential – Land Use Mix Score

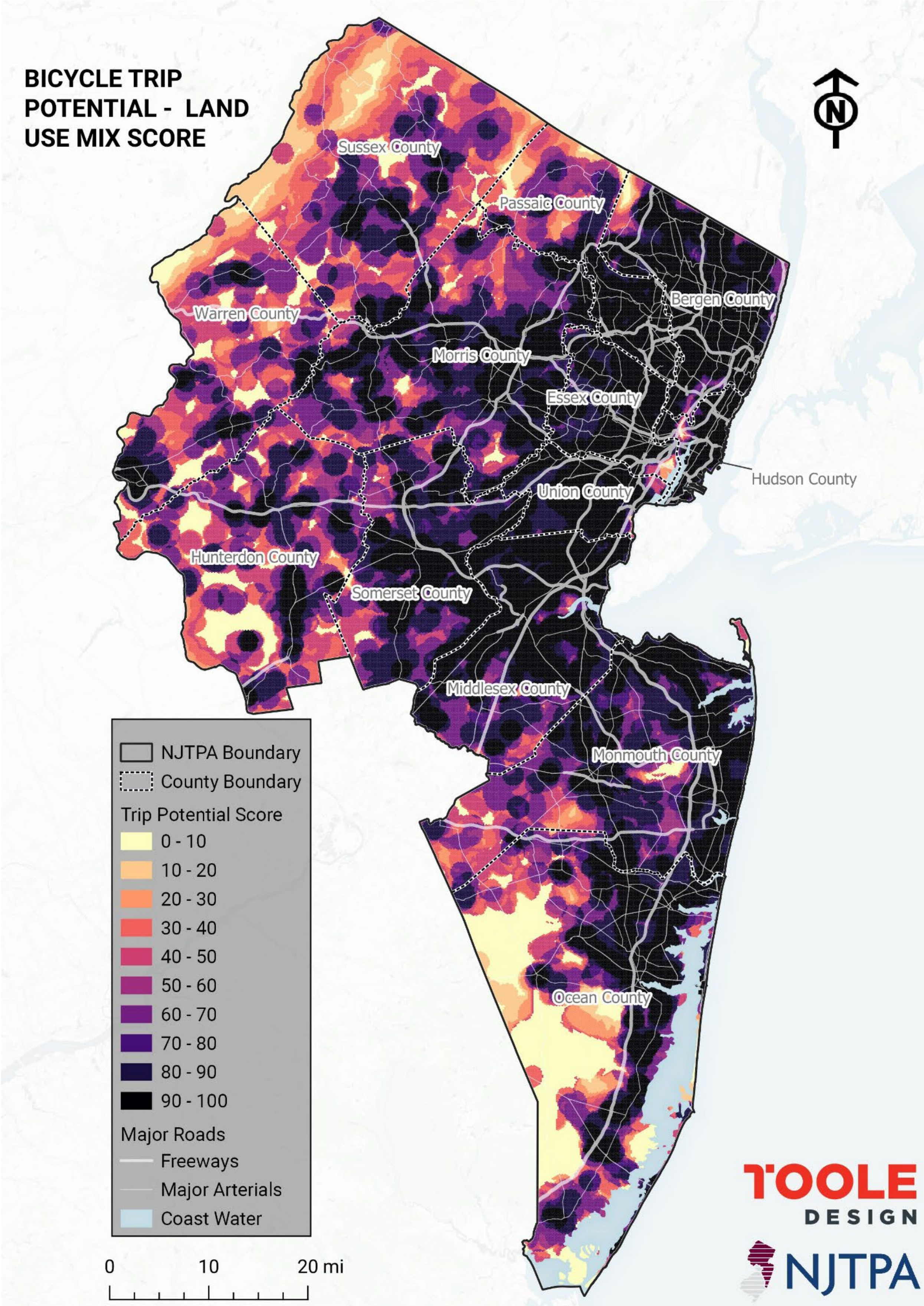


Figure 16: Bicycle Trip Potential – Transit Proximity Score