Anticipating Future Land Use and Land Cover Transformations in Aberdeen Proving Ground, Maryland, via MOLUSCE Plugin Modeling

Research Team (Bruck Lab)

Mojtaba Tahmasebi
MSc Student
University of Florida
Mojtabatahmasebi@ufl.edu

Dr. Jules Bruck
Professor and Director
University of Florida
jbruck@ufl.edu

Martha Ryan
Ph.D. Student
University of Delaware

Dr. Afsheen Sadaf
Post-Doctoral Researcher
University of Florida

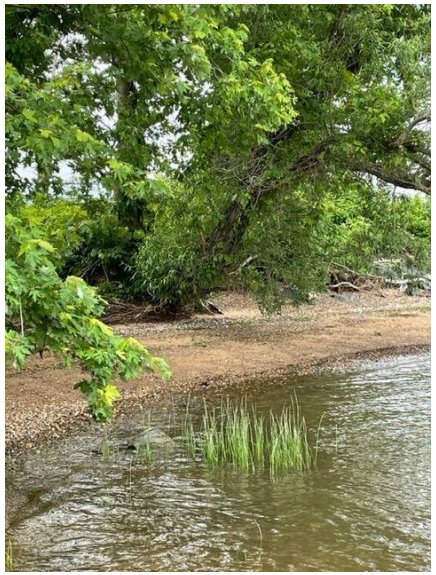
Introduction| Aberdeen Proving Ground

- Land Use and Land Cover (LULC) patterns are significantly shaped by both human activities and natural factors, serving as crucial indicators of environmental change.

- Understanding the contributing factors, encompassing transformative actions such as deforestation, desertification, soil erosion, and agricultural and urban expansion is paramount, given the significance of LULC changes in influencing the environment.

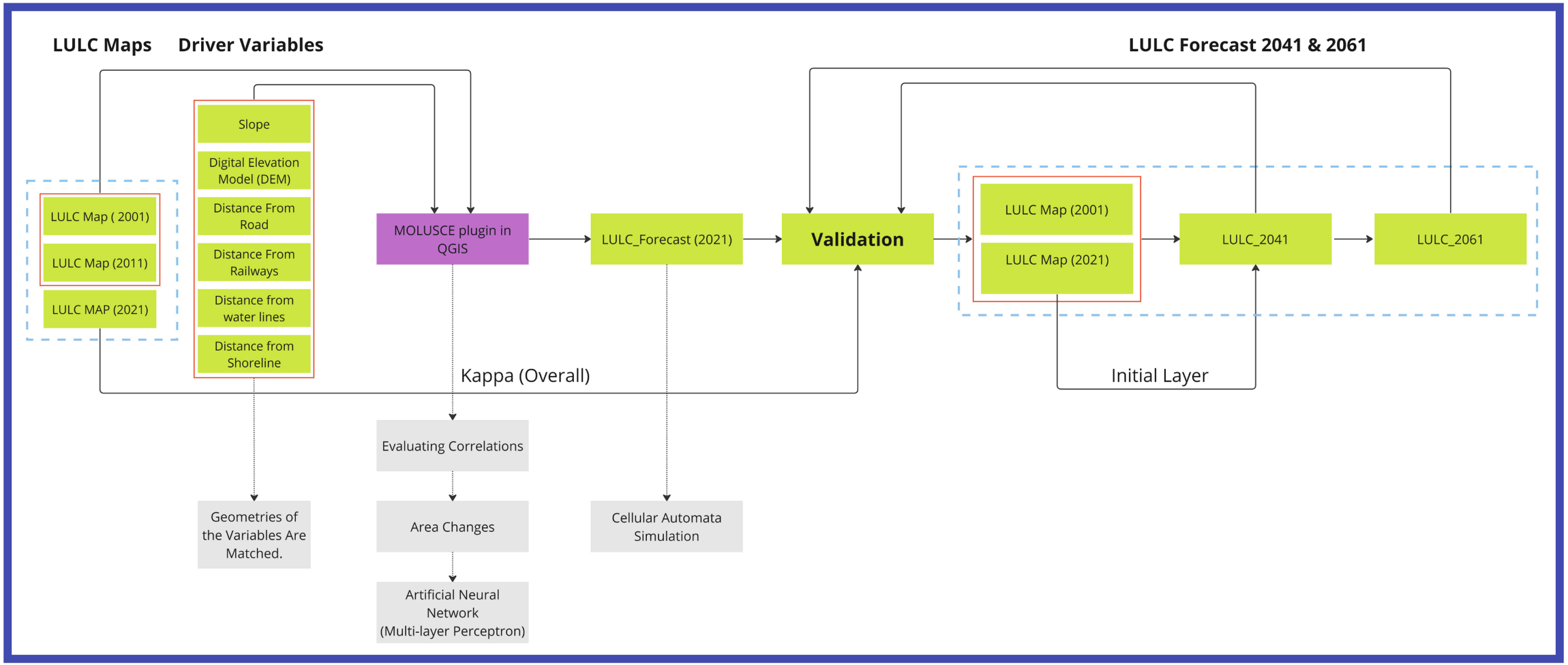
- Prioritizing practical solutions and forecasting future LULC scenarios are vital steps in the ongoing effort to mitigate the impact of climate change.

- We identify LULC changes in the Northern Chesapeake Bay at Aberdeen Proving Ground and the adjacent areas in Harford County, Maryland.



Research Model Overview

1. Predicting future LULC in different scenarios.
2. Emphasizing regions undergoing significant changes.
3. Current: Utilizing the InVEST Carbon Storage and Sequestration Model to forecast ecosystem services values.
4. Future: The Sea Level Affecting Marshes Model (SLAMM) is employed in coastal regions to forecast the dynamics of marsh migration in response to long-term sea level rise (SLR).



Methods and Modifications

MOLUSCE is an open-source plugin that analyzes LULC Data from the past to the future. It also considers variables that have impacted predictions. It trains a model using this historical data and then uses that model to forecast future land use changes based on current conditions and various influencing factors.

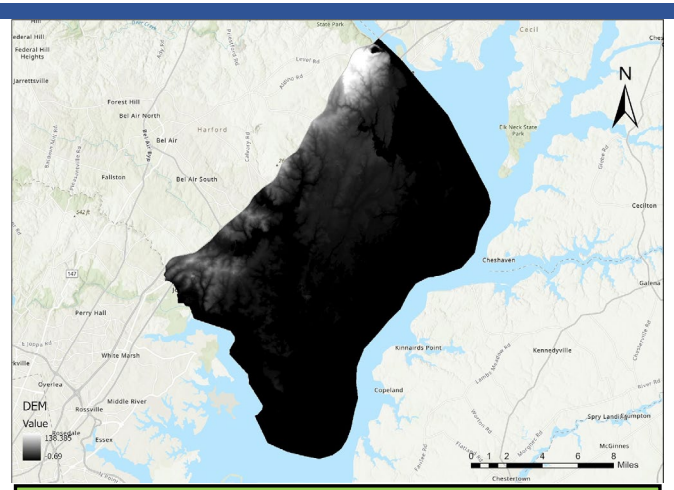
- Land Use and Land Cover Class Legend and Description are according to the National Land Cover Database

- We must categorize into small LULC types for the MOLUSCE Plugin.

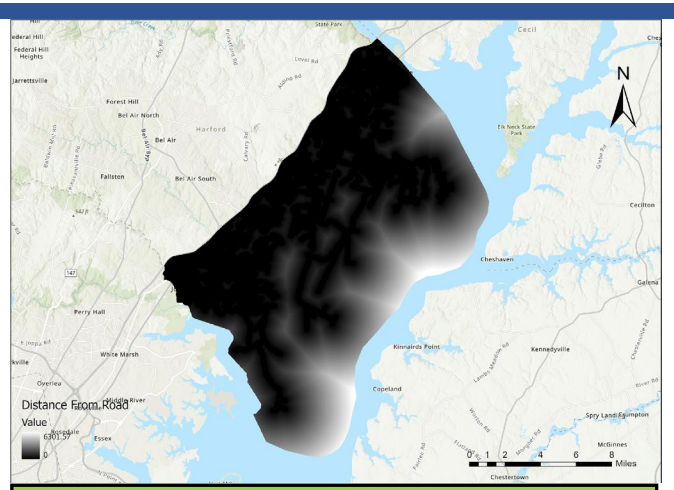
- **Barren land** is characterized by rock, sand, and clay, with minimal vegetation cover (less than 15%).
- The **forest** includes deciduous, evergreen, and mixed forest.
- **Mid-layer vegetation** comprises shrubs, scrub, herbaceous, hay, pasture, and cultivated crops.
- **Woody wetlands** are defined as forested or shrubland areas with over 20% vegetation cover, periodically saturated or covered with water.
- **Emergent herbaceous wetlands** denote areas with over 80% perennial herbaceous vegetation cover, periodically saturated or covered with water.

Class	LULC Types	Previous LULC Classes
1	Waterbodies	Open Water
2	Built-up Land	Developed, Open Space/Developed, Low Intensity/Developed, Medium Intensity/Developed, High Intensity
3	Barren Land	Barren Land
4	Forest	Deciduous Forest/Evergreen Forest/Mixed Forest
5	Mid-Layer Vegetation	Shrub/Scrub/Herbaceous/Hay/Pasture/Cultivated Crops
6	Woody Wetlands	Woody Wetlands
7	Emergent Herbaceous Wetlands	Emergent Herbaceous Wetlands

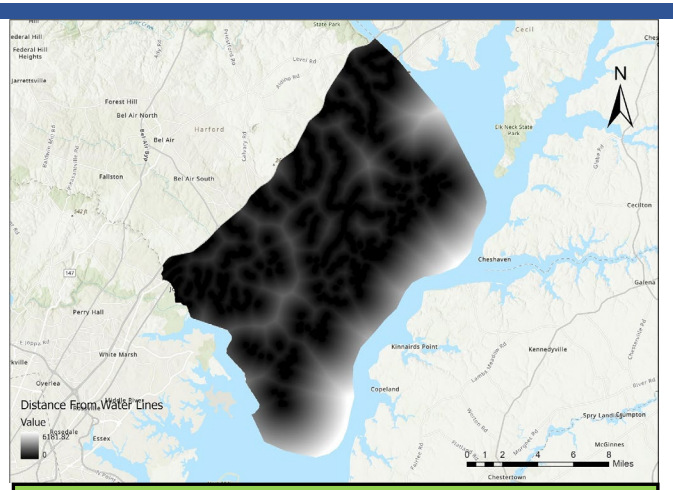
Defining Variables



DEM



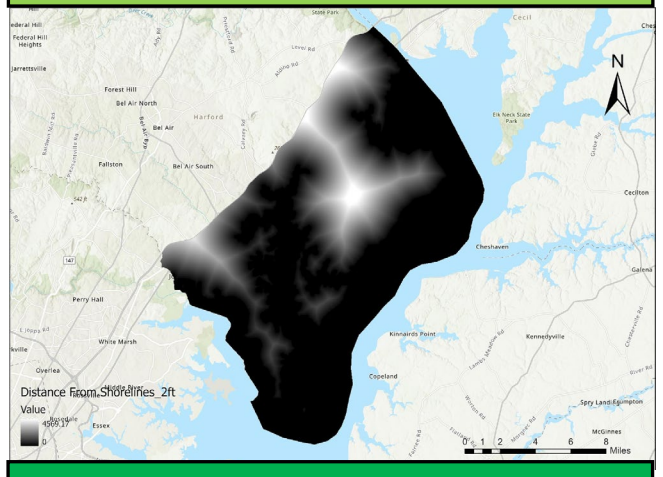
Distance from Roads



Distance from Water Lines

Slope

Distance from Railways



Distance from Shoreline

MOLUSCE Plugins Process

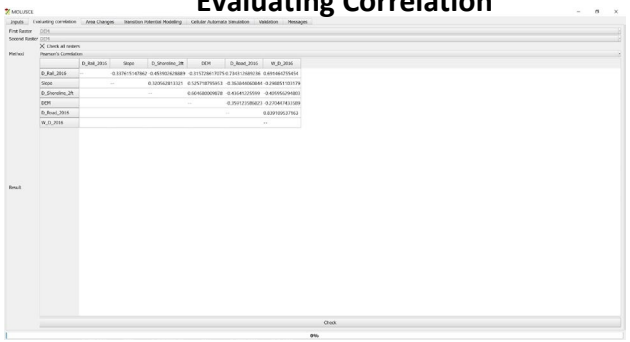
- Utility modules
  - **Data Provider** - provides procedures for reading/writing raster data and similar utility functions
  - **Cross Tabulation** - provides functions for creating contingency tables
  - **Sampler** - provides sampling procedure

- Algorithmic modules:
  - **Area Analysis** - provides procedures to calculate the amount of change between states, create change maps
  - **Modeling** - provides submodules for modeling relation between input-output data
  - **Simulation** - provides the procedure of land change simulation
  - **Validation** - provides statistic functions and procedures for validation of simulation result

Simulation Steps and Process

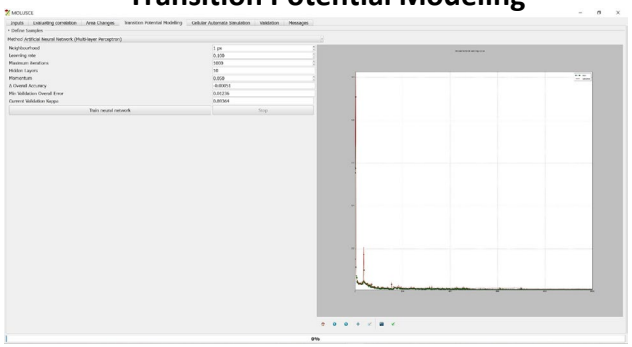
Input

Evaluating Correlation

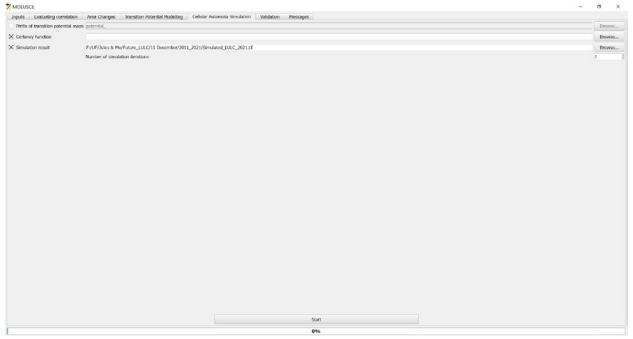


Area Changes

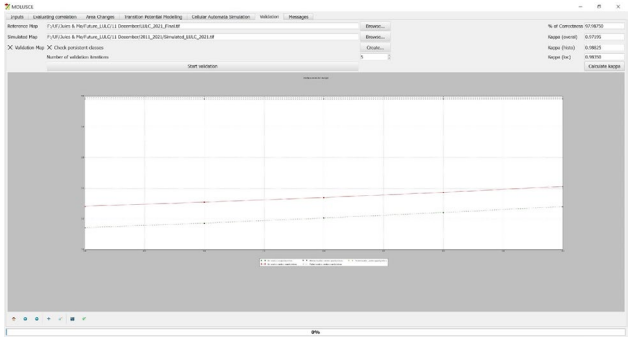
Transition Potential Modeling



Cellular Automata Simulation

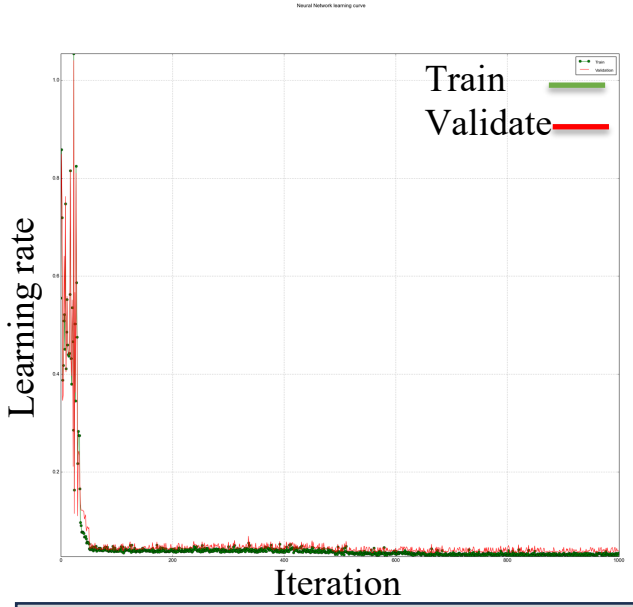


Validation

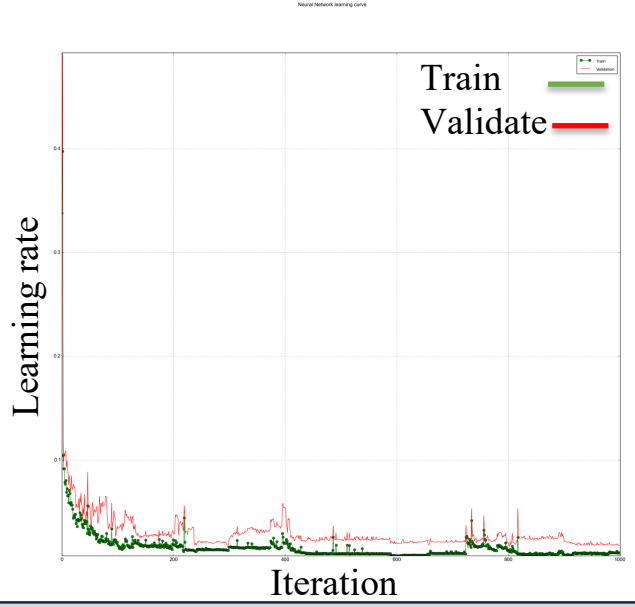


Artificial Neural Network (Multi-layer Perceptron)

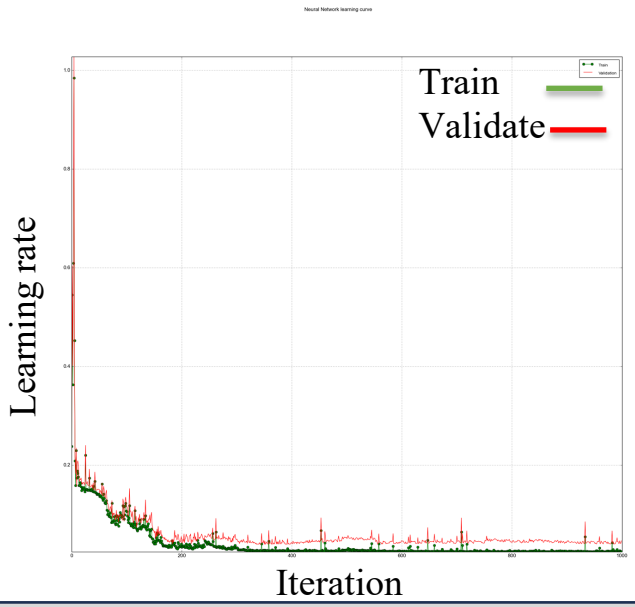
(LULC 2001- LULC 2011)
LULC 2021



(LULC 2001-LULC 2021)
LULC 2041



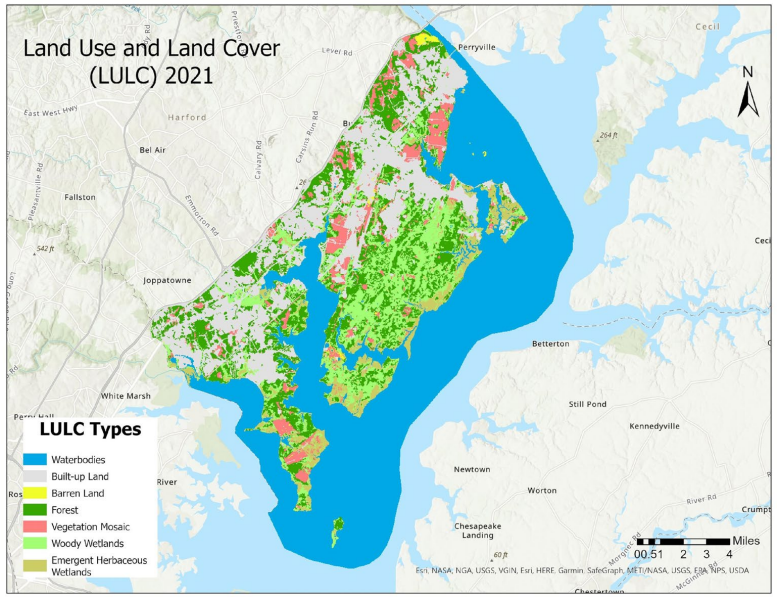
(LULC 2021-LULC 2041)
LULC 2061



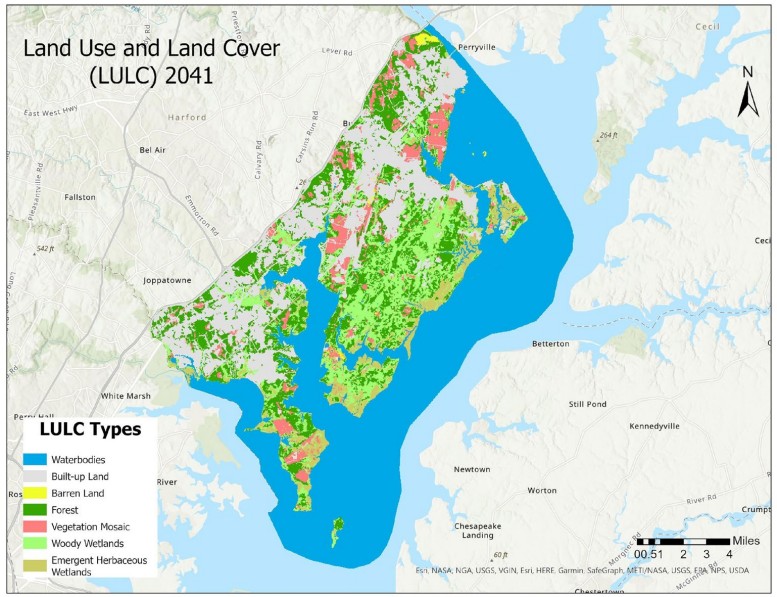
Employing the Multi-layer Perceptron of Artificial Neural Network (MLP_ANN) method, we achieved a current validation accuracy of 0.89. The validation of projected and actual LULC maps for 2021, based on data from 2001 and 2011, demonstrated a high level of accuracy, with an overall Kappa Value of 0.97 and a correctness percentage of 97.98%. Subsequently, MLP-ANN was employed to predict LULC changes for 2041 and 2061, achieving validation accuracies of 0.93 and 0.95, respectively.

Results

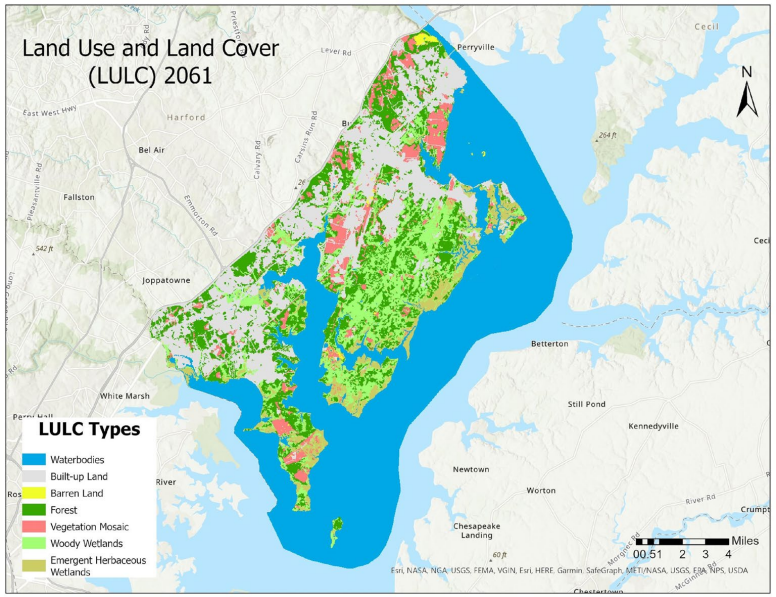
LULC Forecast-2021



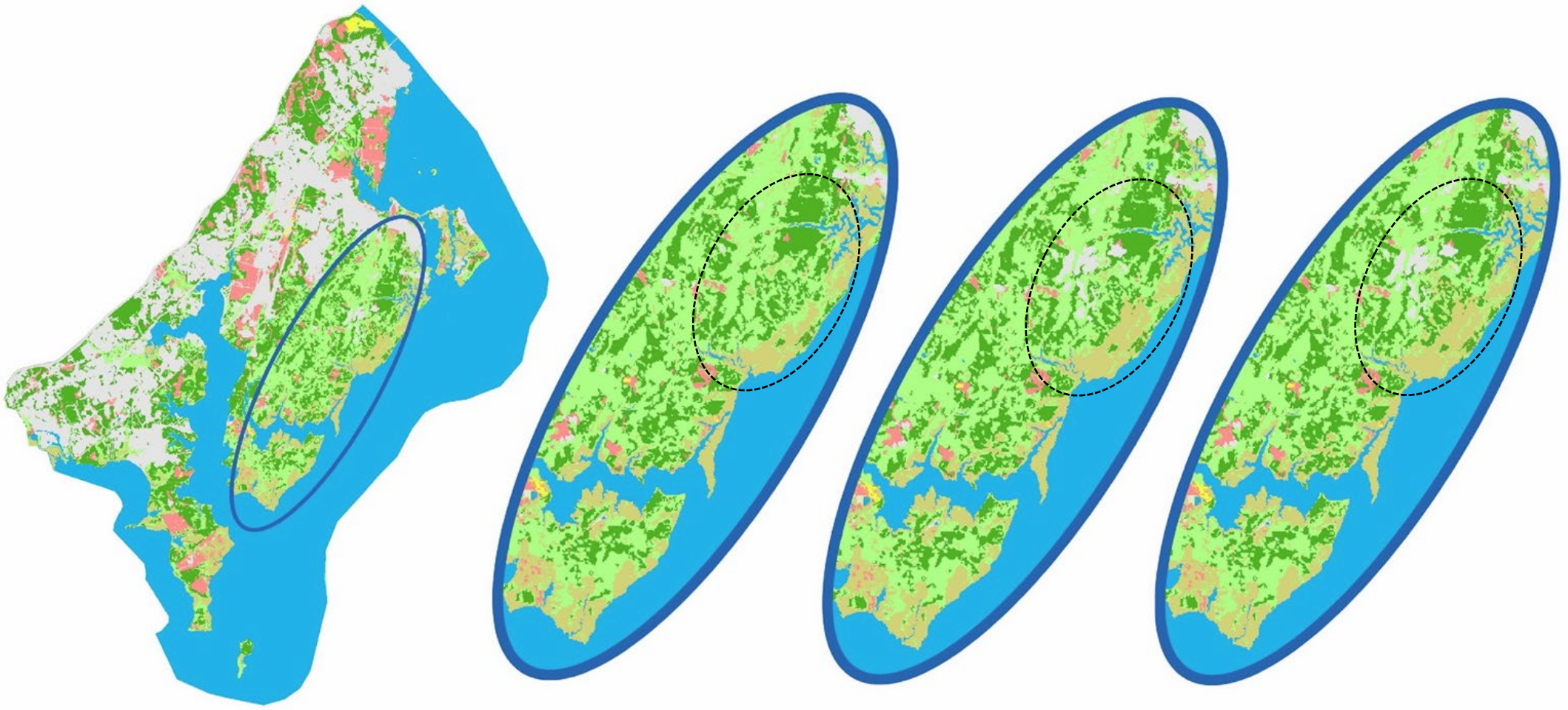
LULC Forecast-2041



LULC Forecast-2061

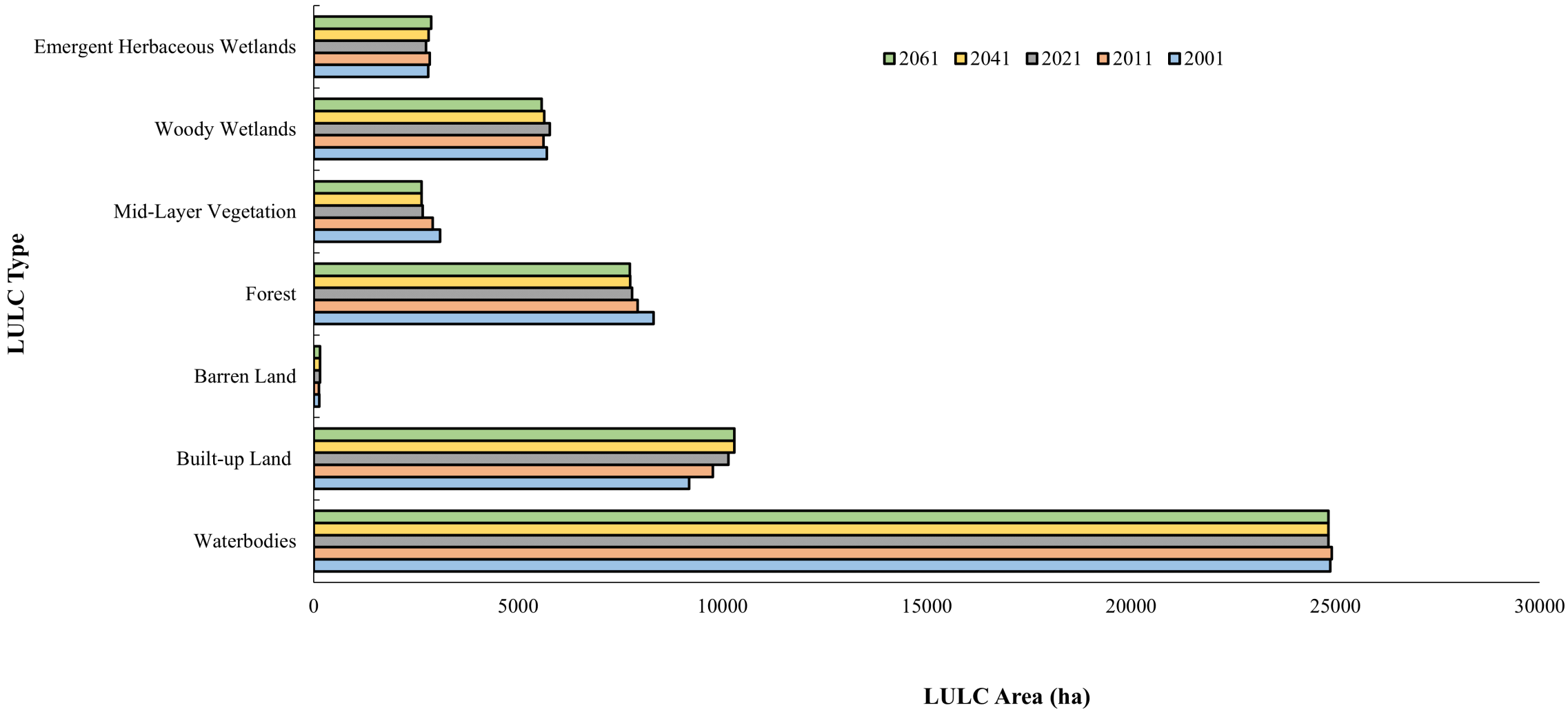


Dynamic LULC Regions Over Time



APG 2061 2021 2041 2061

Results


Emergent Herbaceous Wetlands
Woody Wetlands
Mid-Layer Vegetation
Forest
Barren Land
Built-up Land
Waterbodies
2061
2041
2021
2011
2001
LULC Type
0
5000
10000
15000
20000
25000
30000
LULC Area (ha)

Conclusion

- **2001-2021 Observations:**

Increase in built-up land, barren land, and woody wetlands.

- **2021-2041 Shift in Trends:**

All LULC types exhibit consistent changes, contrasting the preceding periods.
No decline was observed in woody wetlands and barren land.

- **2041-2061 Trends:**

woody wetlands have decreased while emergent herbaceous wetlands have increased.
The built-up category experiences a slight increase.

- **Overall Analysis:**

- We have contradictory correlations between woody and emergent herbaceous wetlands.
- The noteworthy pattern observed in LULC changes over time.
- There are meaningful and impactful changes occurring in how we interact with different landscapes.

Thank you for your attention