National Aeronautics and
Space Administration

NASA

RHODE ISLAND ECOLOGICAL CONSERVATION

Methods for Monitoring Rhode Island Habitats: Contributing to a Framework for Targeted Conservation and Management

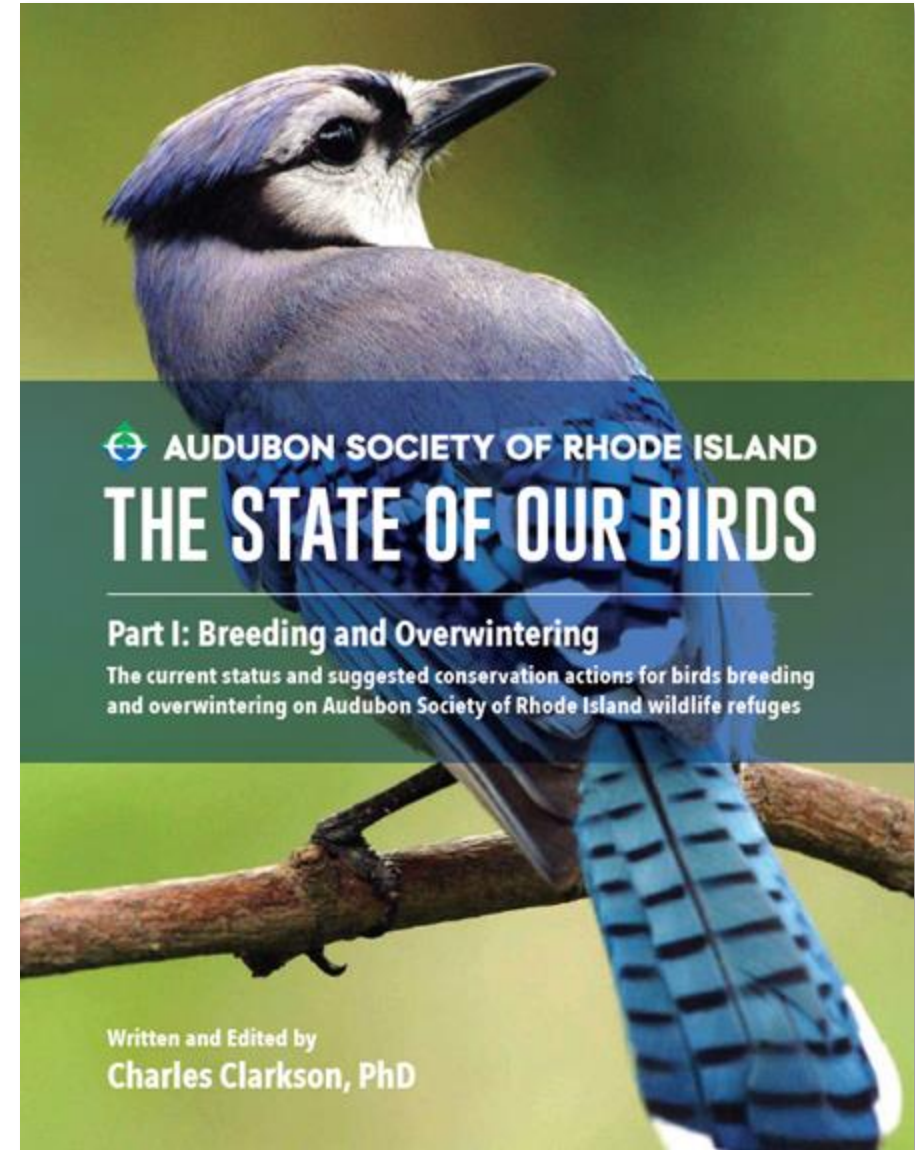Natasha Crater   Nancy Nthiga
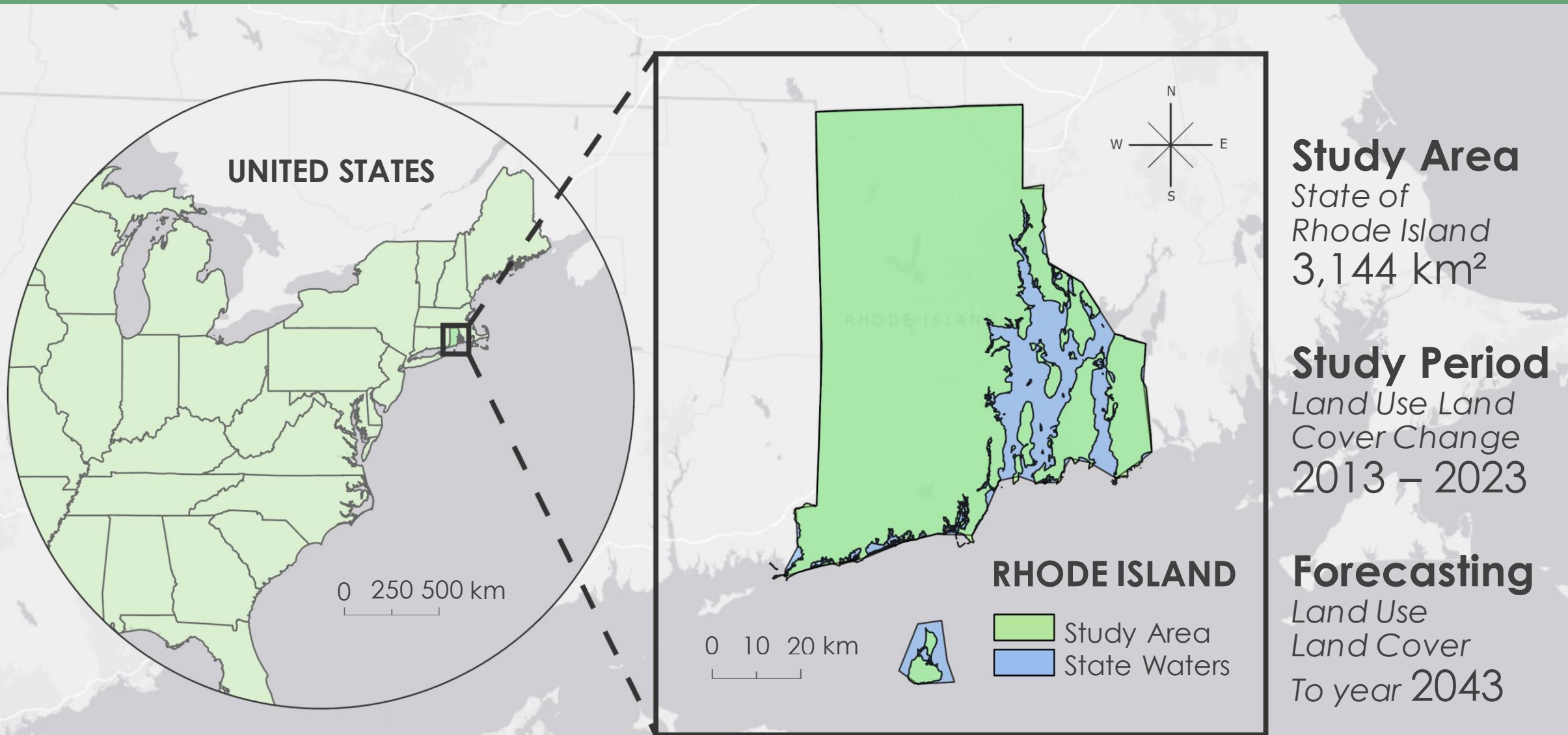
Kristen Mecke   Joseph Barnes

Background

- The Audubon Society of Rhode Island has identified 9 "Responsibility Bird Species" (RBS).

- RBS protection supports the conservation of many other avian species due to habitat overlap.

- Rhode Island experiences climatic and development land use changes.

- Rapidly changing land covers can impact avian shelter, food, and nesting availability.

- Use of NASA Earth imagery to monitor habitat will allow Audubon to highlight and prioritize important conservation areas.

Image credit: Audubon Society of Rhode Island

Study Area and Period

UNITED STATES

0 250 500 km

RHODE ISLAND

- 🟩 Study Area
- 🟦 State Waters

0 10 20 km

Study Area
State of Rhode Island
3,144 km²

Study Period
Land Use Land Cover Change
2013 – 2023

Forecasting
Land Use Land Cover
To year 2043

Projection: WGS 1984

Objectives

Land Use Land Cover (LULC) Mapping

Map landcover for Rhode Island using GIS and Google Earth Engine (GEE)

Image credits: Microsoft

Objectives

Land Use Land Cover (LULC) Mapping

Land Use Land Cover *Change* (LULCC)

Assess Rhode Island LULCC over the last decade

Image credits: Microsoft

Objectives

Land Use Land Cover (LULC) Mapping

Land Use Land Cover *Change* (LULCC)

Forecasted LULCC

Create ecological forecast maps of LULC in 2026, 2032, 2037, and 2043

Image credits: Microsoft

Objectives

Land Use Land Cover (LULC) Mapping

Land Use Land Cover *Change* (LULCC)

Forecasted LULCC

GIS Data & Maps

Provide Audubon with GIS data and maps to aid in strategic land acquisition and management for avian conservation

Image credits: Microsoft

Partner

Audubon Society of Rhode Island (Audubon)

Partner Needs

- Assessing Responsibility Bird Species (RBS) habitat forecasting feasibility

- Data-driven land acquisition for future habitat conservation

Image credits: Rhode Island Audubon Society

Community Concerns

Local Ecosystems

Land Use Land Cover Change (LULCC) analysis may reveal unintended impacts to habitat areas.

Land Acquisition

LULCC-driven habitat acquisition may conflict with existing urban growth planning and trends.

Public Participation

Conservation efforts based on LULCC data may not consider differing perspectives from the community.

Education Initiatives

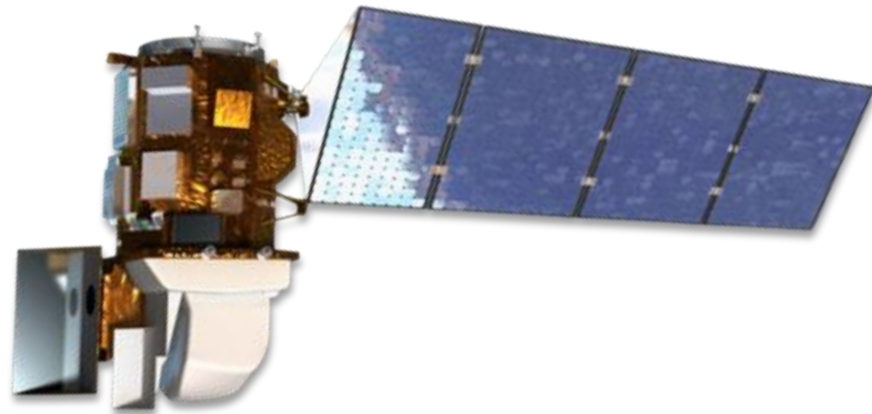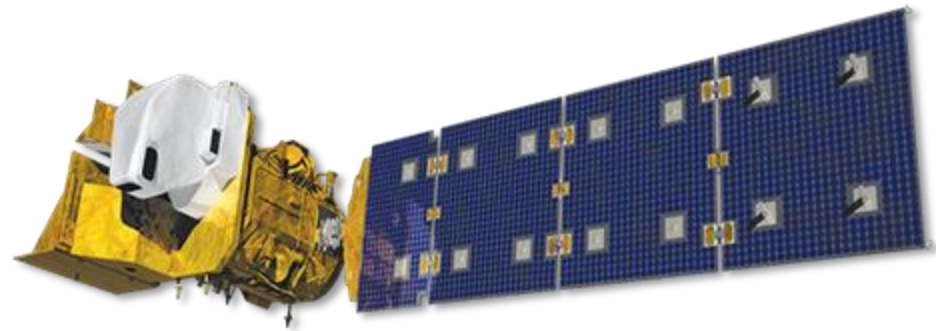LULCC data may not be accessible or understandable to others who could benefit from it without outreach.

Image credits: Microsoft

Earth Observations

February 2013

Landsat 8 OLI

Landsat 9 OLI-2

September 2021

Image credits: NASA

Overview of Methods

Data Acquisition

- **USGS Earth Explorer & Google Earth Engine Catalog**
  Landsat 8 OLI / 9 OLI-2, Collection 2 Level 2, Bands 2–7
- **USGS National Land Cover Database (NLCD)**
  NLCD 2013 & 2021 Land Cover (CONUS)

Data Processing

- **QGIS Prizren 3.3.4**
  Semi-Automatic Classification Plug-In
- **ArcGIS Pro 3.2.2**
  Spatial & Imagery Analyst Toolsets
- **Google Earth Engine**
  JavaScript API

Classification / Change Analysis

- **ArcGIS Pro**
  Isocluster Unsupervised Classification
  Raster Functions Toolset
- **Google Earth Engine**
  Supervised Classification and Change Analysis

Forecasting

- **Idrisi TerrSet Land Cover Modeler**
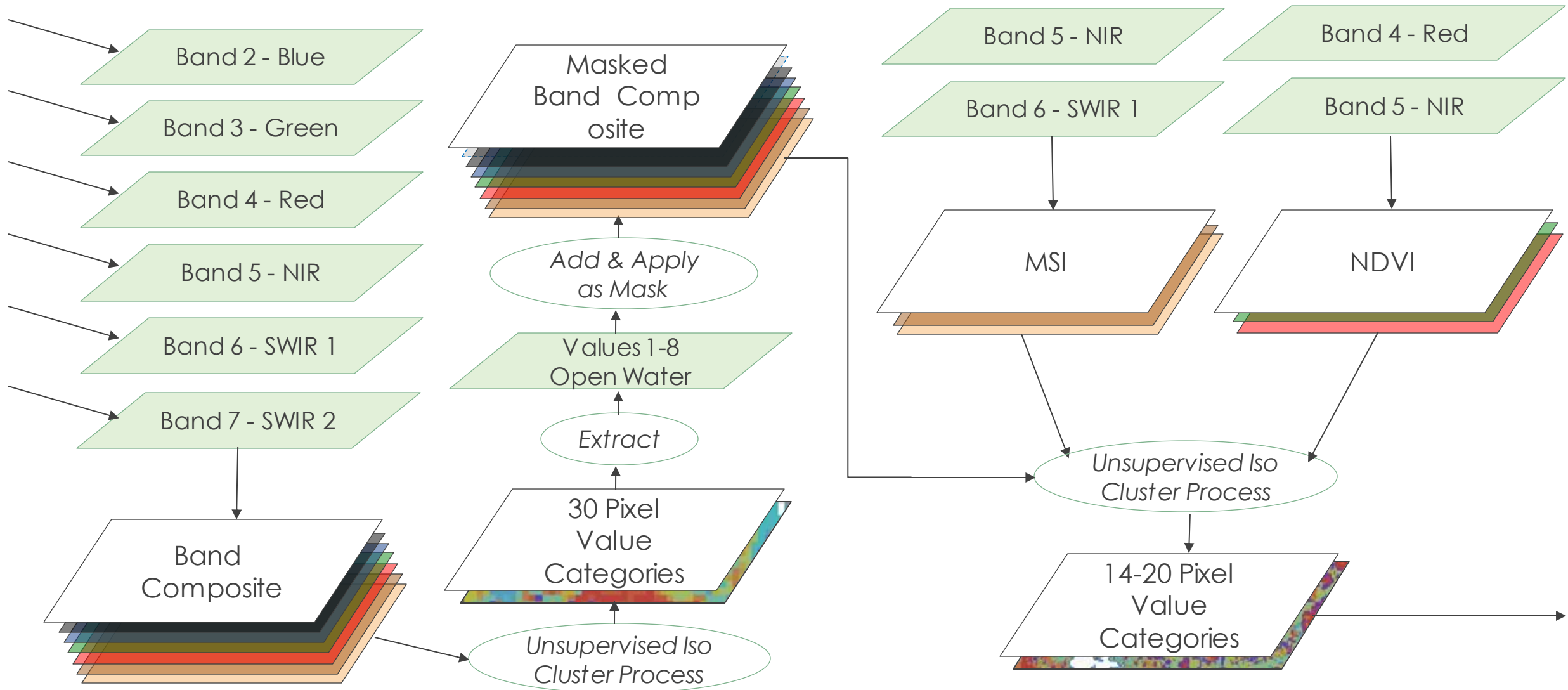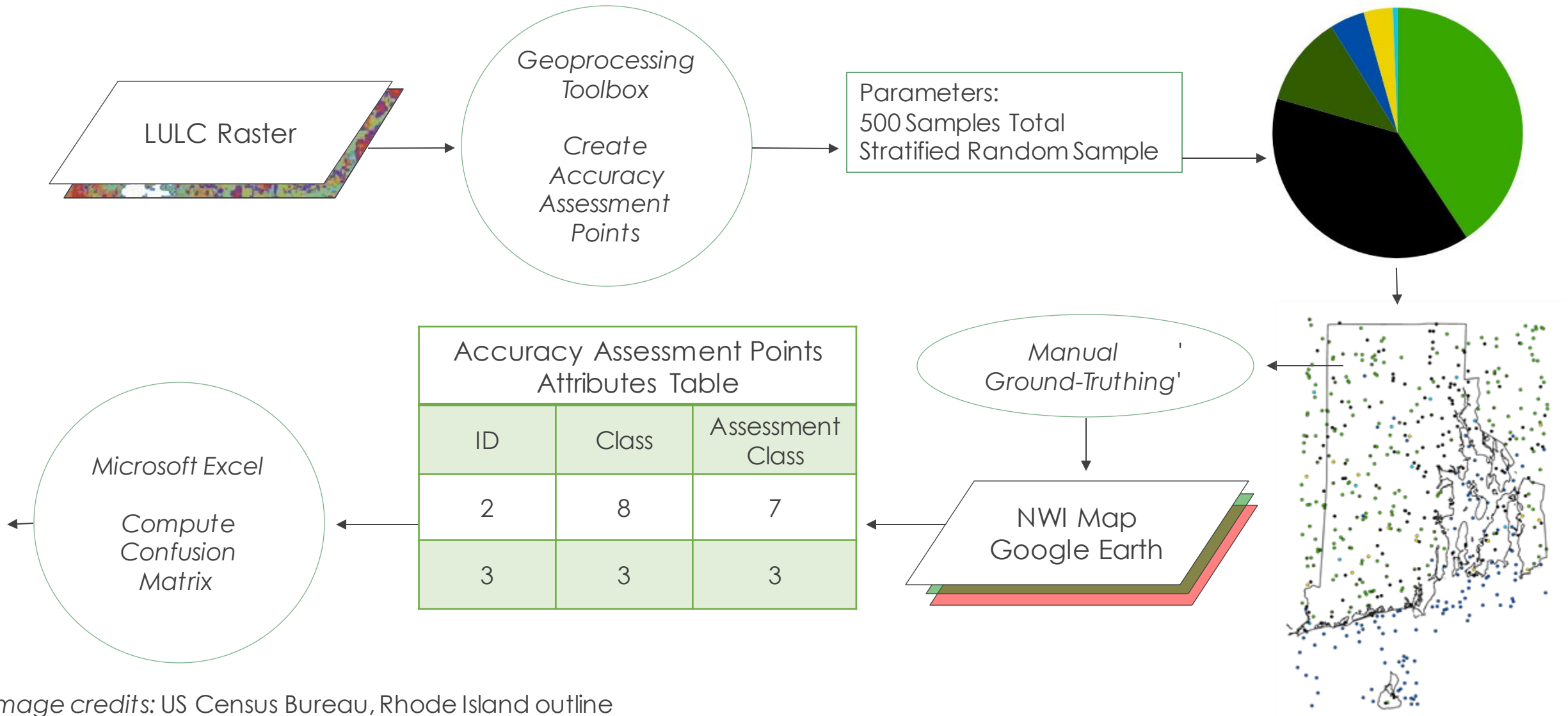
Data Classification – ArcGIS Pro

Clusterbust

14–20 Pixel Value Categories

Remap

Reference Vectors

RIGIS Hydro

RIGIS Roads

RIGIS Buildings

Reference Rasters

NAIP Imagery

USGS NLCD

NOAA C-CAP

LULC Classifications	
1	Open Water
2	Developed, Open Space, & Barren
3	Agricultural
4	Upland Forest, Shrub, & Grassland
5	Woody Wetlands
6	Non-Woody Wetlands

Image credits: RIGIS, USDA NAIP, USGS NLCD, NOAA C-CAP
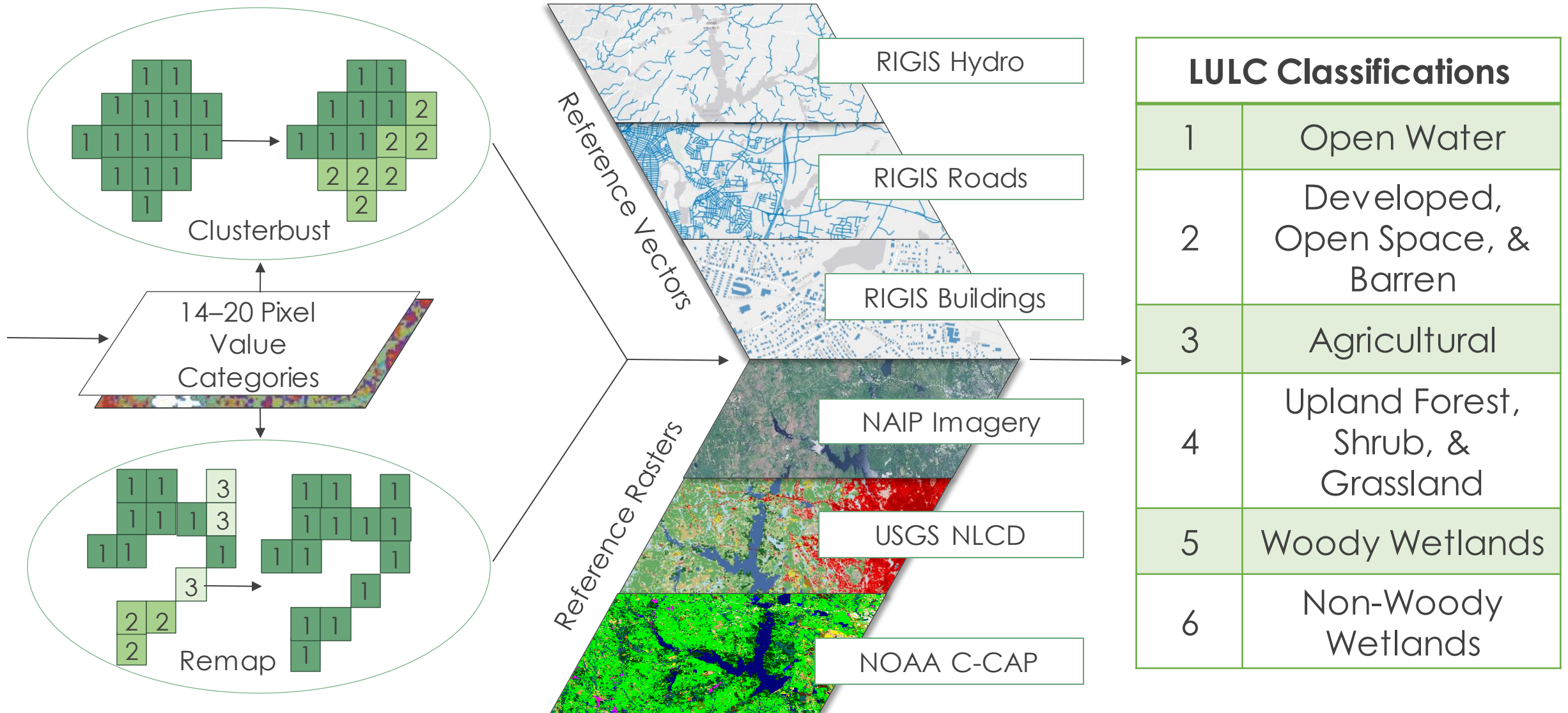
LULC Results 2023 – ArcGIS
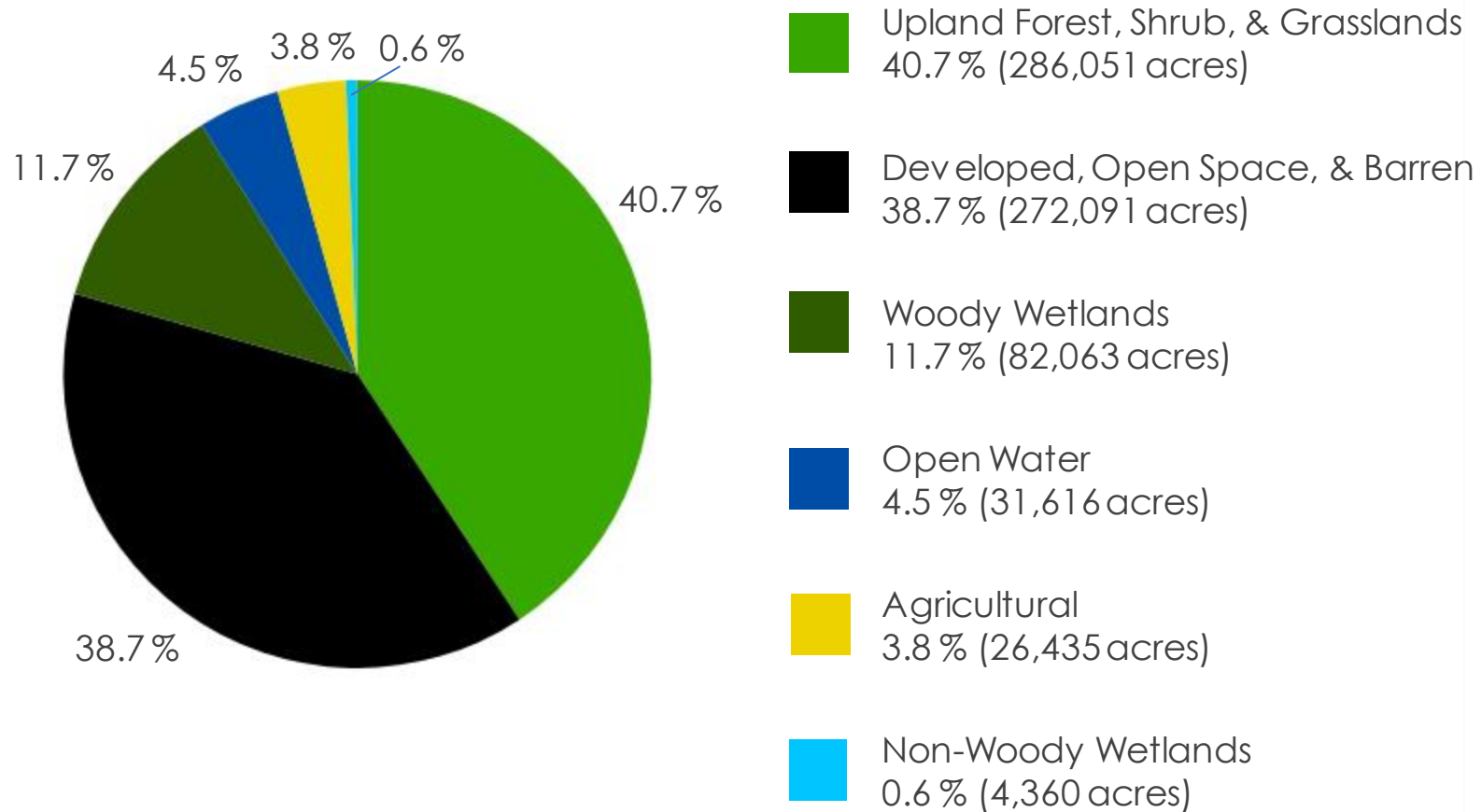
Accuracy Assessment Method

LULC Raster

Geoprocessing Toolbox

Create Accuracy Assessment Points

Parameters:
500 Samples Total
Stratified Random Sample

Manual 'Ground-Truthing'

Accuracy Assessment Points Attributes Table		
ID	Class	Assessment Class
2	8	7
3	3	3

Microsoft Excel

Compute Confusion Matrix

NWI Map
Google Earth

Image credits: US Census Bureau, Rhode Island outline

Accuracy Assessment – 2023 LULC

Land Cover Type	N=	Accuracy
⬛ Open Water	132	95.45%
⬛ Developed, Open Space, & Barren	118	88.98%
⬛ Agricultural	18	83.33%
⬛ Upland Forest, Shrub, & Grassland	193	82.38%
⬛ Woody Wetlands	40	87.50%
⬛ Non-Woody Wetlands	6	50.00%
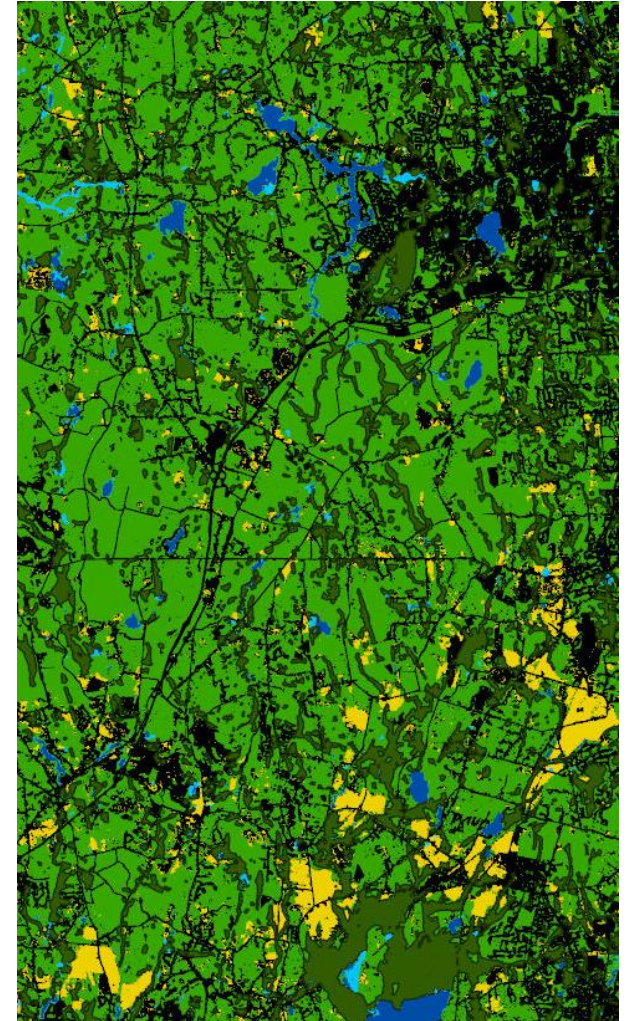
Image credits: RI Eco Team

Google Earth Engine

2021 NLCD Map

Sample
Points

8
Classes

30 Training
Samples /Class

Supervised Classification
Dataset Training

Merge
Training
Data

Supervised Random
Forest Classification

LULC Classifications	
1	Developed
2	Agricultural
3	Grassland
4	Scrub
5	Forest
6	Woody Wetlands
7	Non-Woody Wetlands
8	Open Water
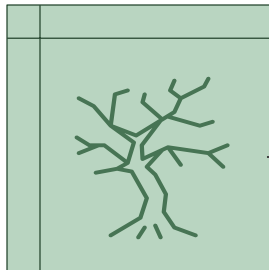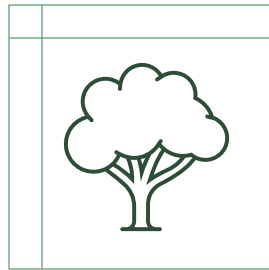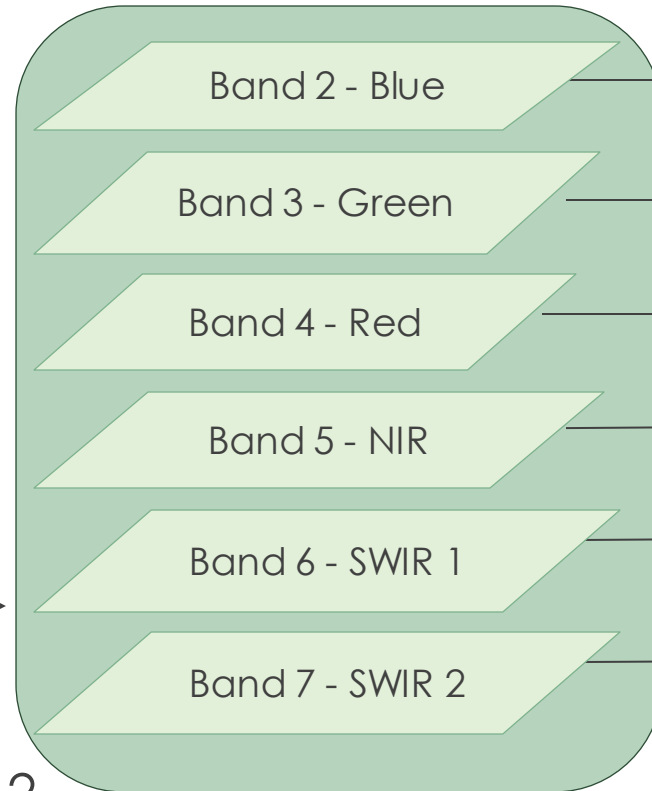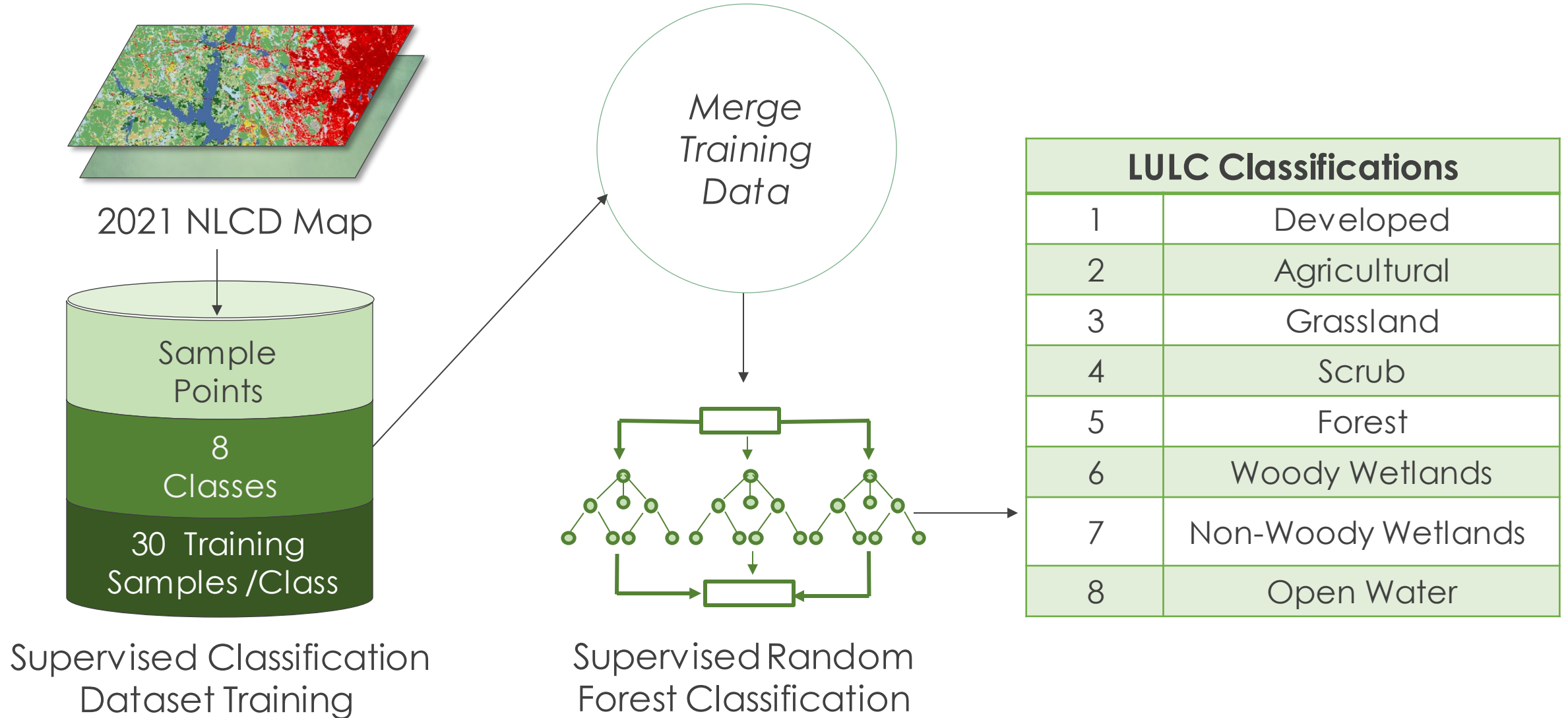
Accuracy Assessment – Google Earth Engine

Manual Sampling of Points

240 Total Samples

2021 NLCD Map

2023 LULC Map

Same Reference Points

Actual Values

		Positive (1)	Negative (0)
Predicted Values	Positive (1)	TP	FP
	Negative (0)	FN	TN

Confusion Matrix

Accuracy Assessment	
Agriculture	80.25%
Developed	92.40%
Forests	84.38%
Grassland	80.64%
Non-woody Wetland	40.47%
Open Water	98.92%
Shrubs	67.73%
Woody Wetland	85.19%
Overall	**81.43%**

Image credits: RI Eco Team

LULC Results 2013 – Google Earth Engine

Developed
30.4% (213,606 acres)

Forest
19.1% (134,317 acres)

Woody Wetlands
15.0% (105,066 acres)

Agricultural
4.9% (34,724 acres)

Open Water
8.1% (56,580 acres)

Shrub
7.2% (68,616 acres)

Grassland
9.8% (50,425 acres)

Non-Woody Wetlands
5.6% (39,283 acres)
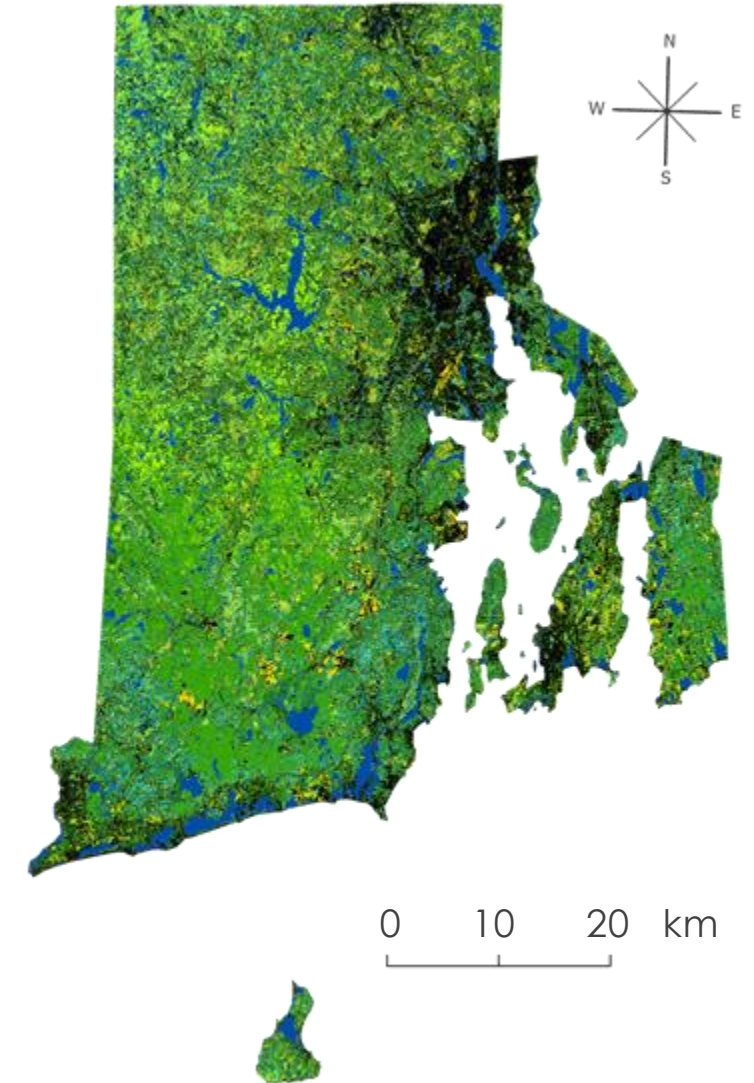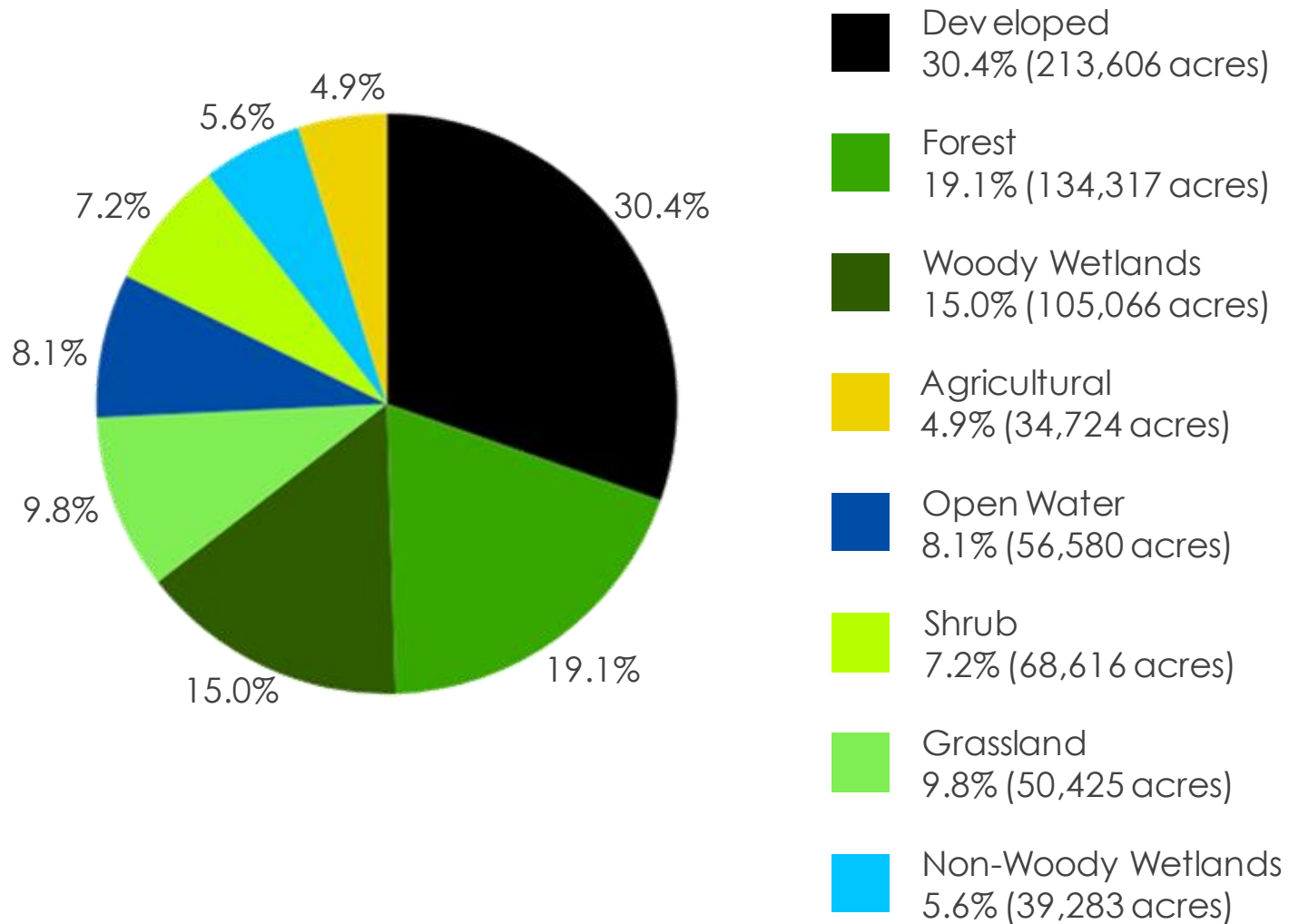
LULC Results 2023 – Google Earth Engine

Developed
31.6% (222,068 acres)

Forest
25.9% (181,926 acres)

Woody Wetlands
11.6% (81,820 acres)

Agricultural
9.4% (65,988 acres)

Open Water
6.7% (46,837 acres)

Shrub
6.3% (44,178 acres)

Grassland
6.4% (45,195 acres)

Non-Woody Wetlands
2.1% (14,605 acres)
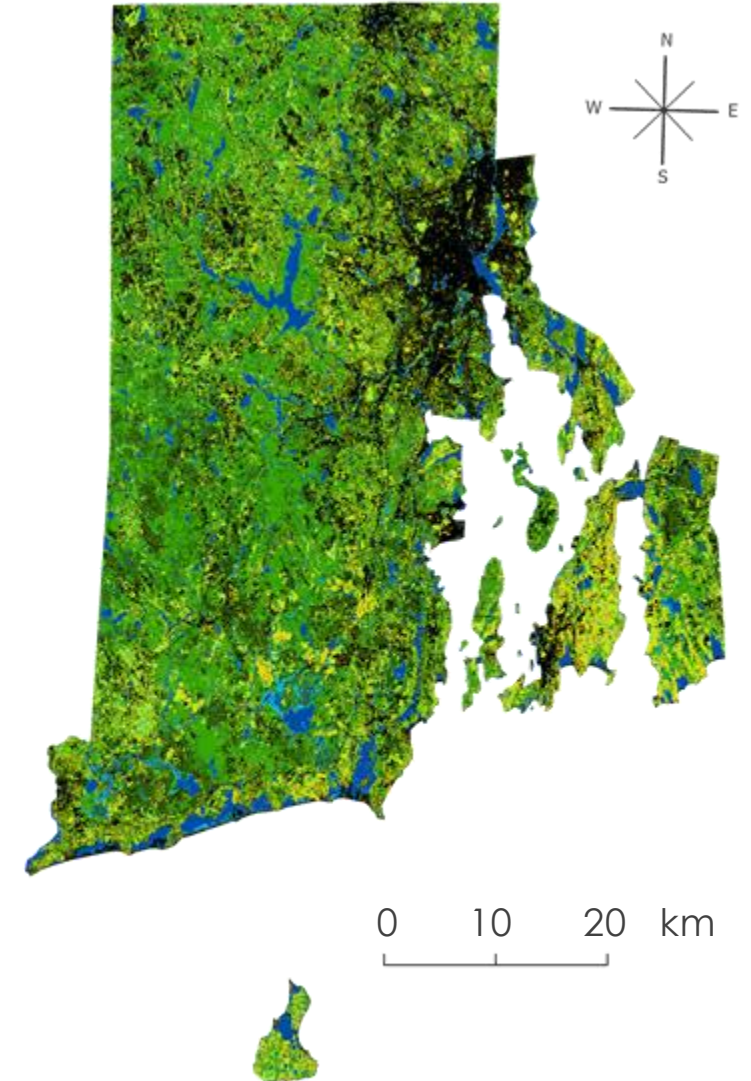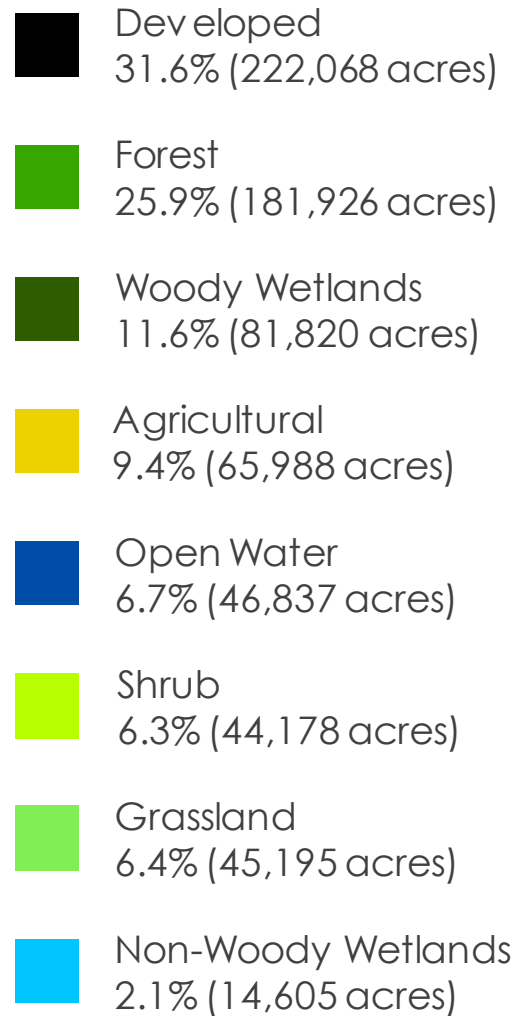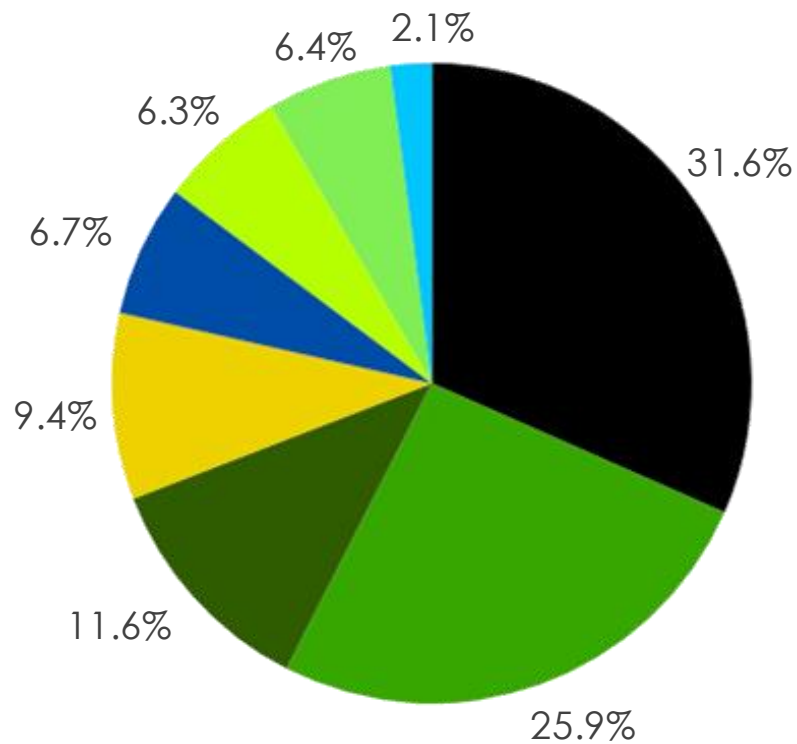
Ecological Forecasting – TerrSet

Driver Variables

RIGIS Hydro

RIGIS Roads

RIGIS Buildings

Reference Maps

USGS NLCD 2011

USGS NLCD 2021

Class to Class Accuracy Assessments

Weighted Normalized Likelihood

Projections

Forecasted LULC Maps	
2023	Current
2026	+ 5.5 years
2032	+ 11 years
2037	+ 16.5 years
2043	+ 22 years

Image credits: RIGIS, USDA NAIP, USGS NLCD, NOAA C-CAP
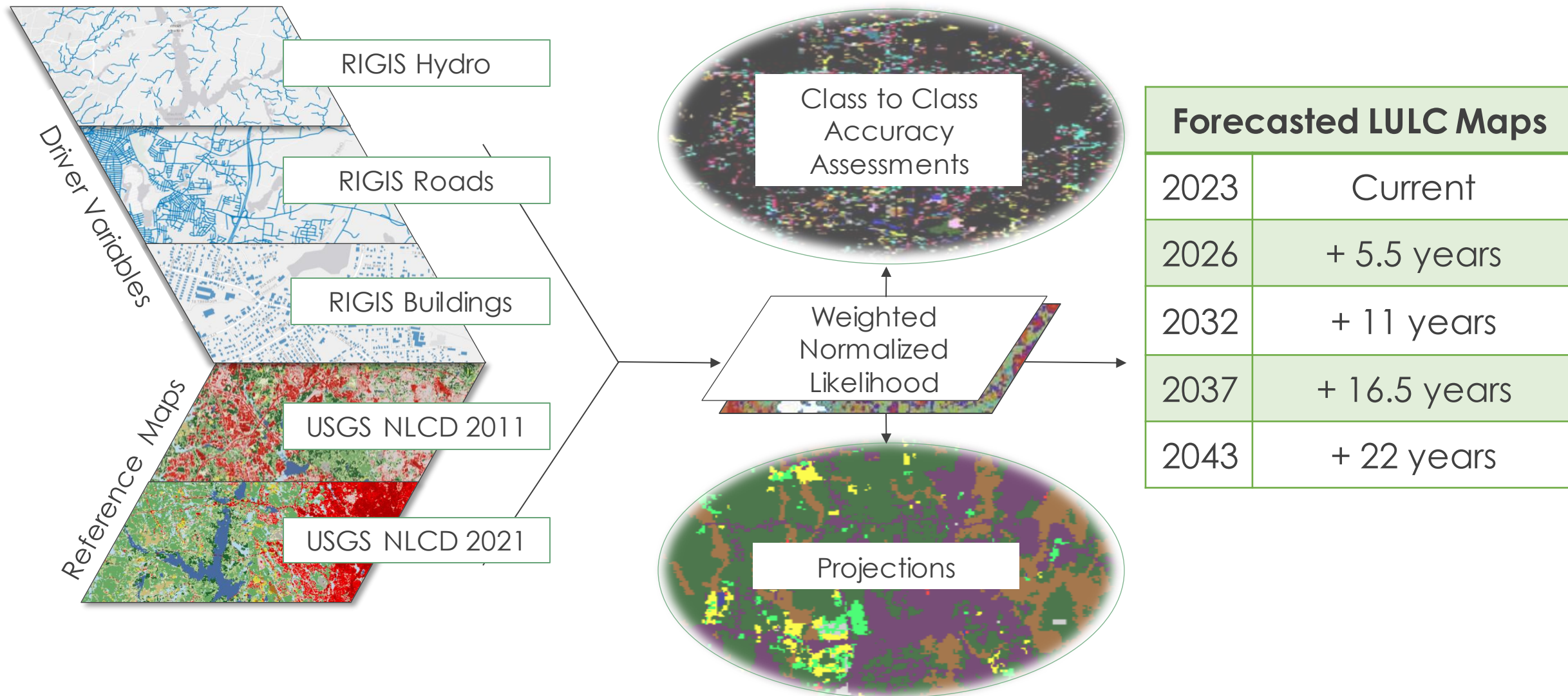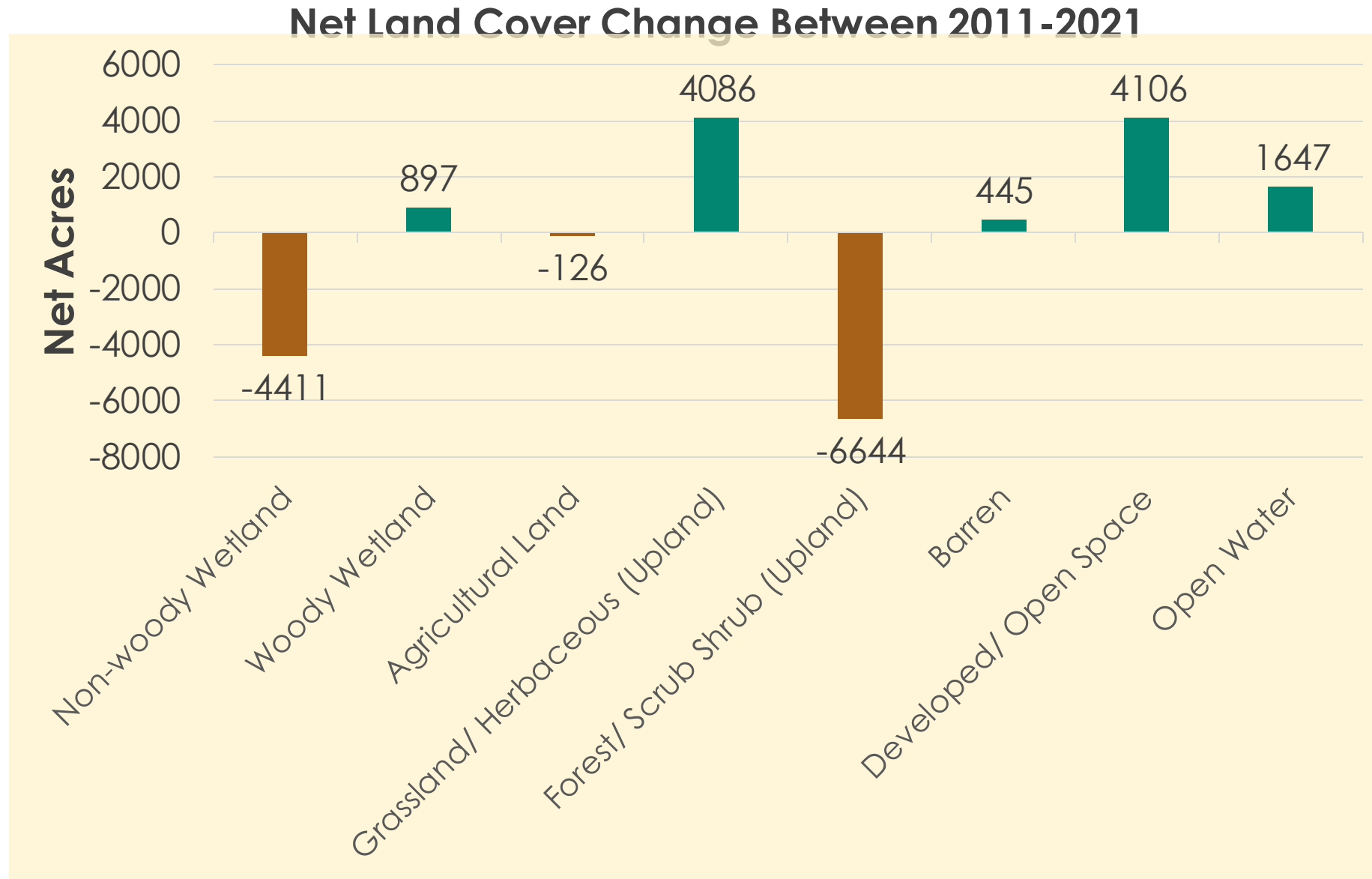
Ecological Forecasting Results - TerrSet

Ecological Forecasting Results – TerrSet 2026
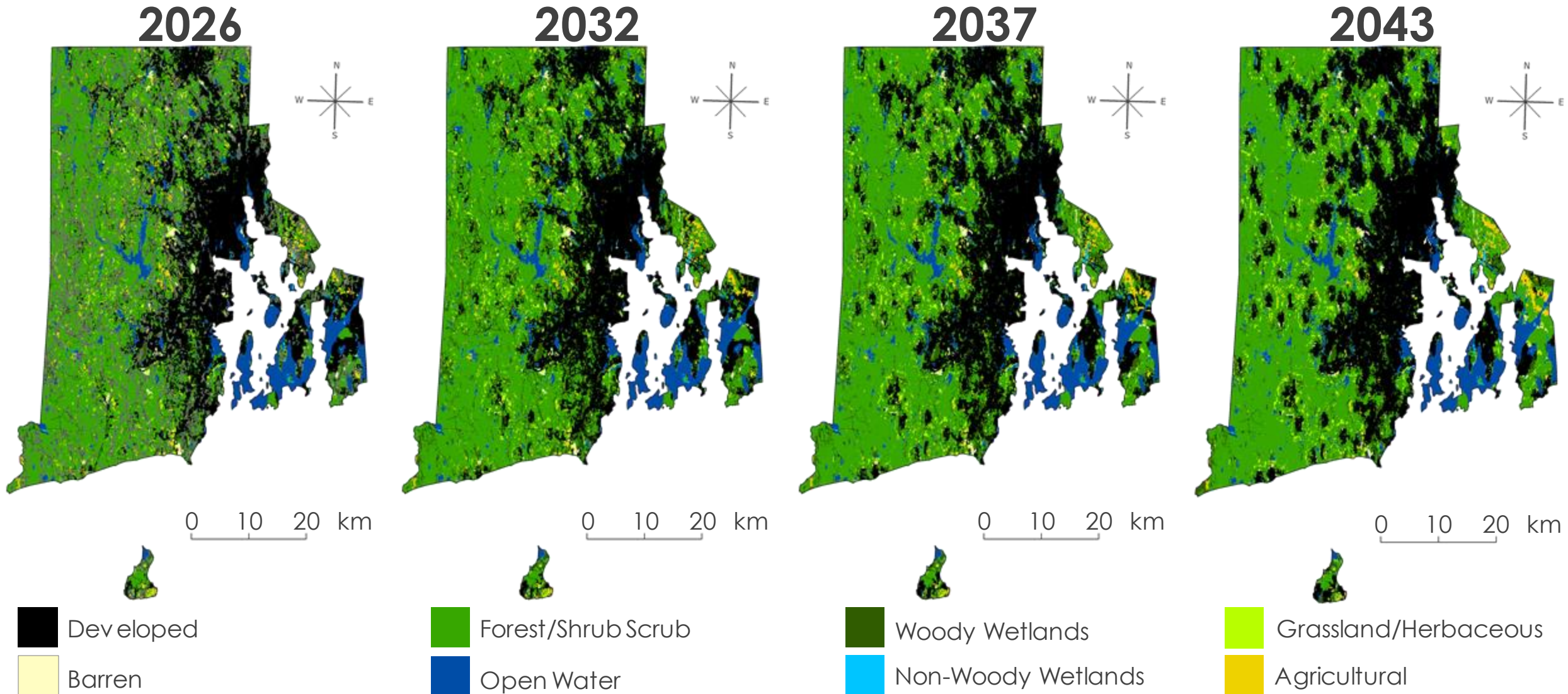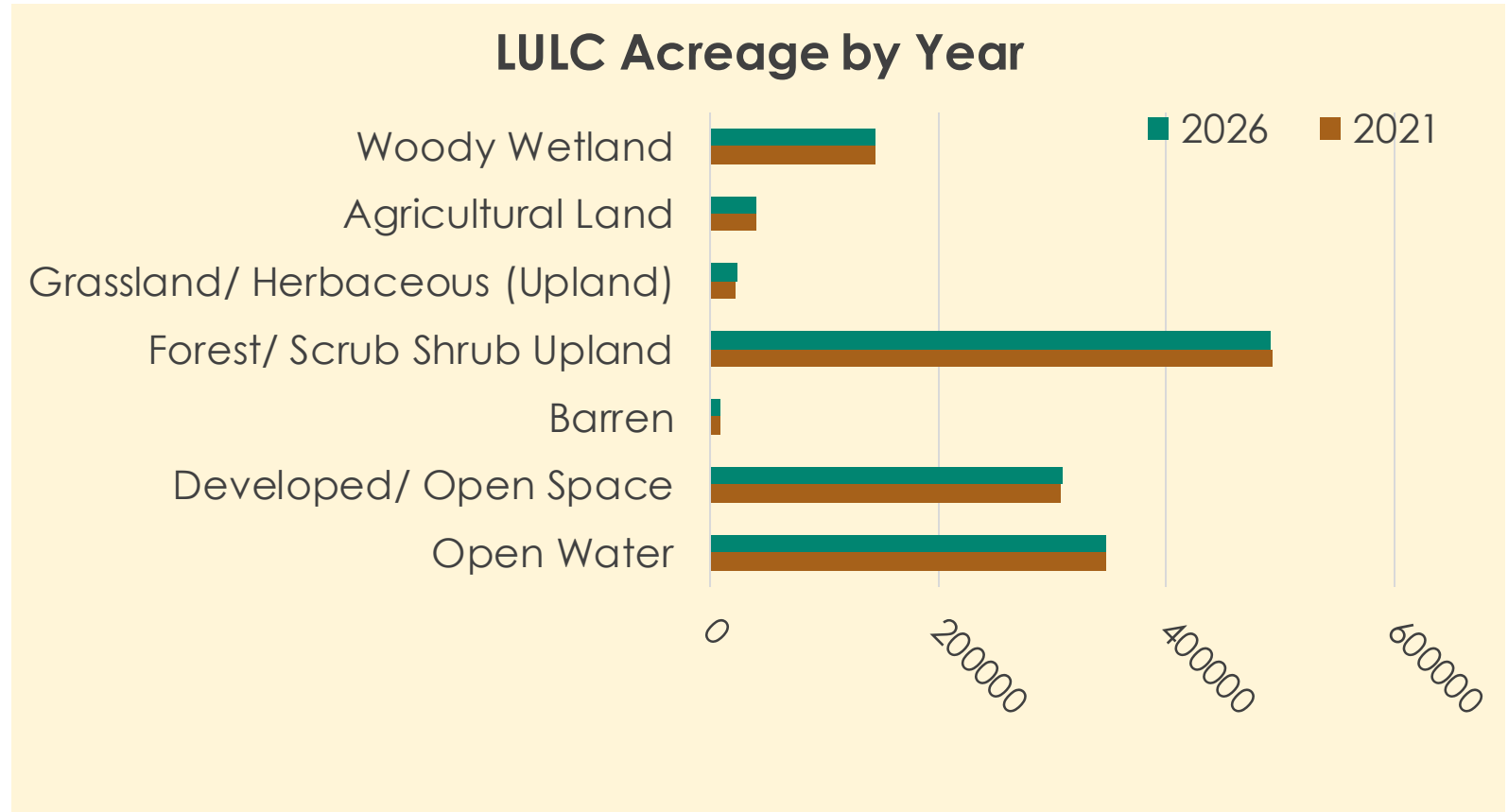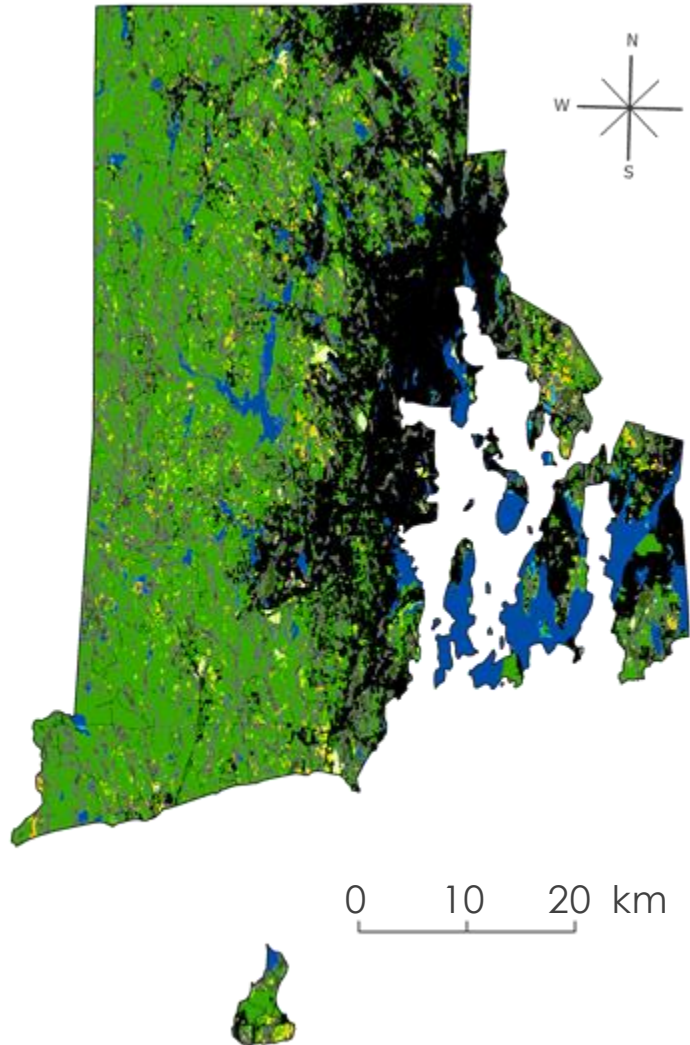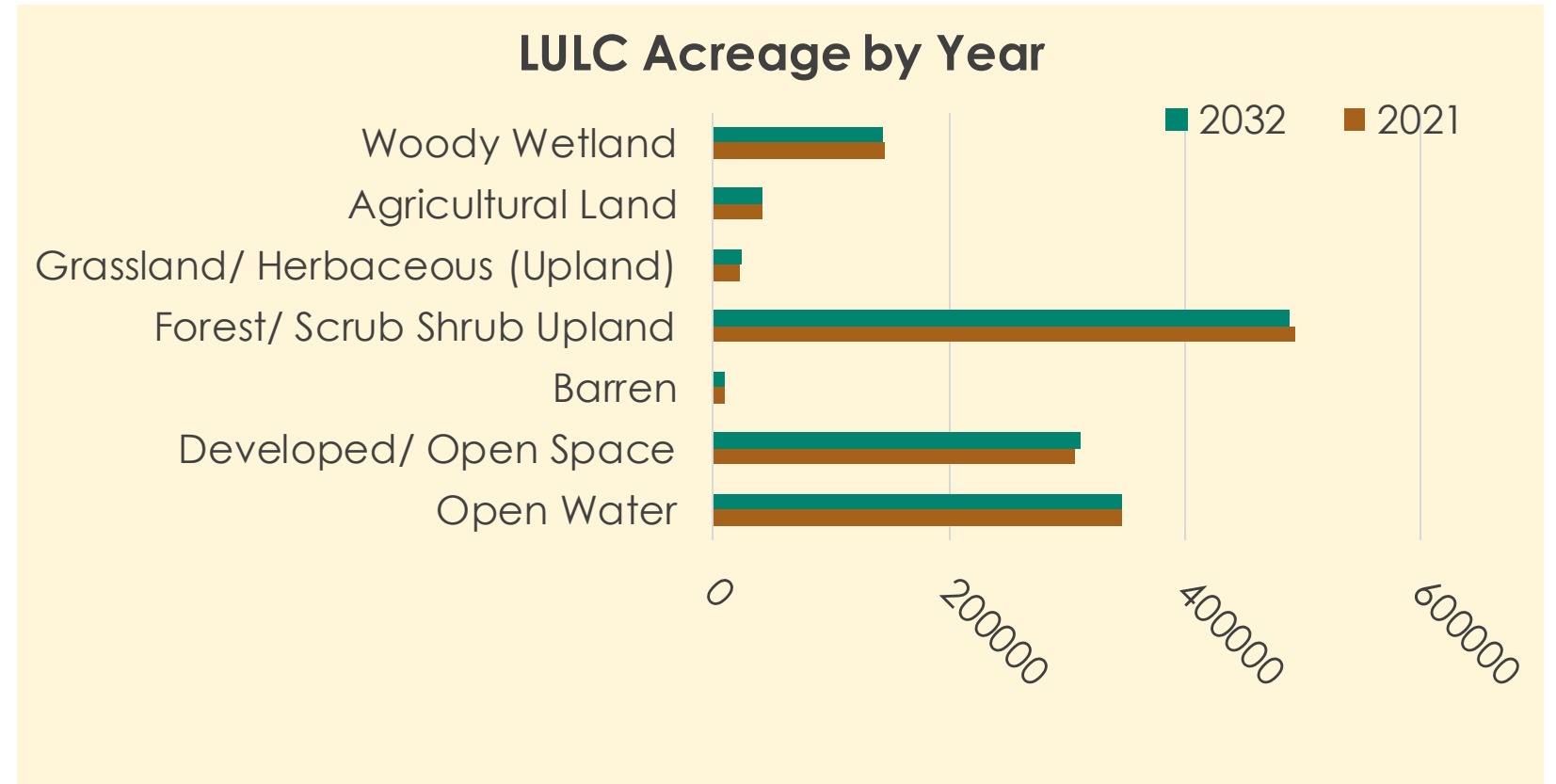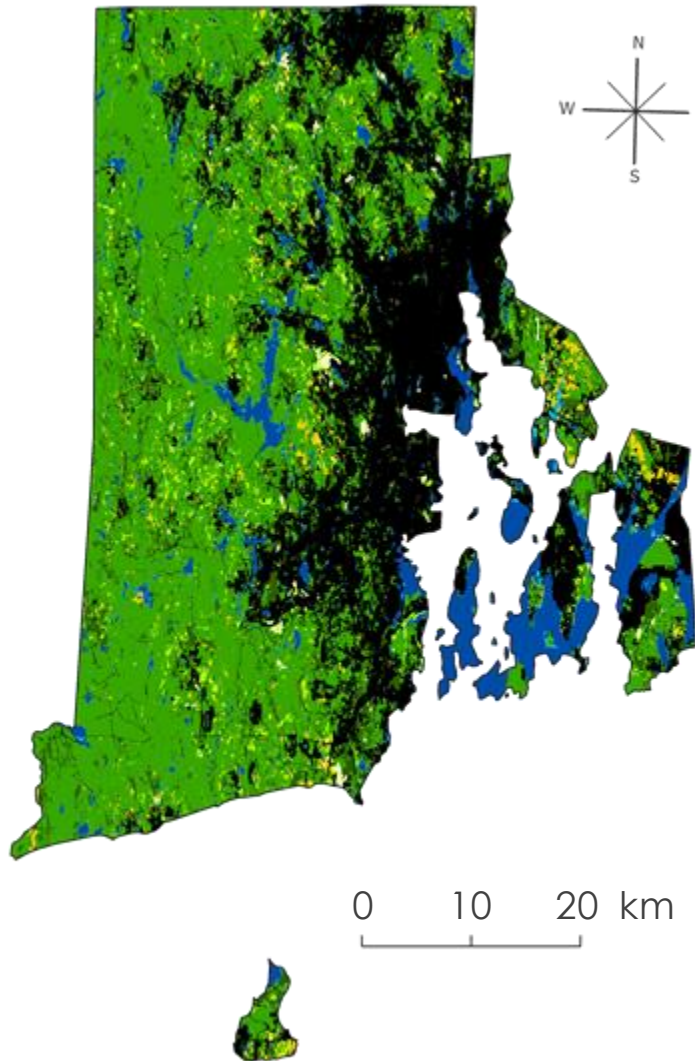
Ecological Forecasting Results – TerrSet 2032
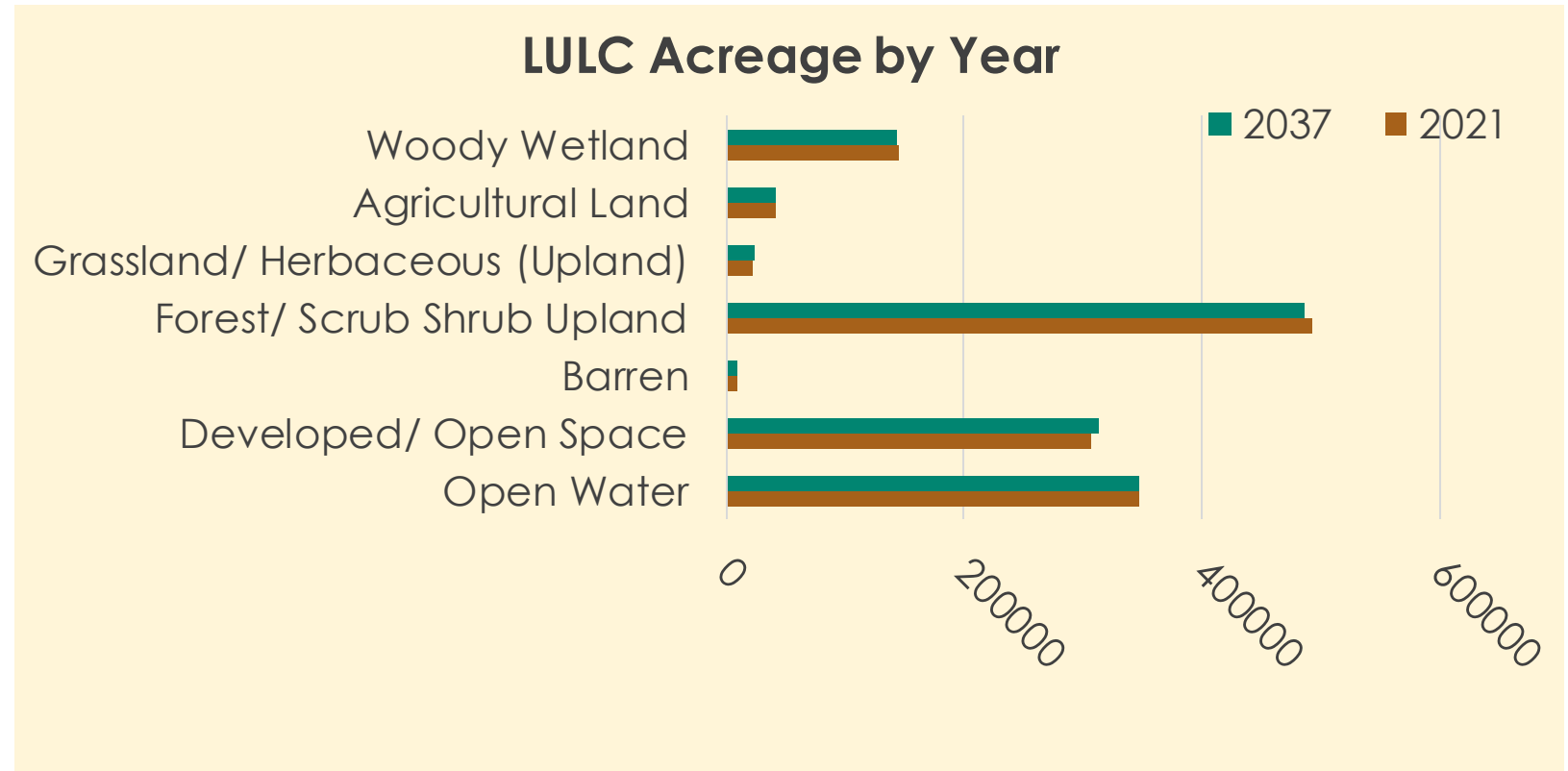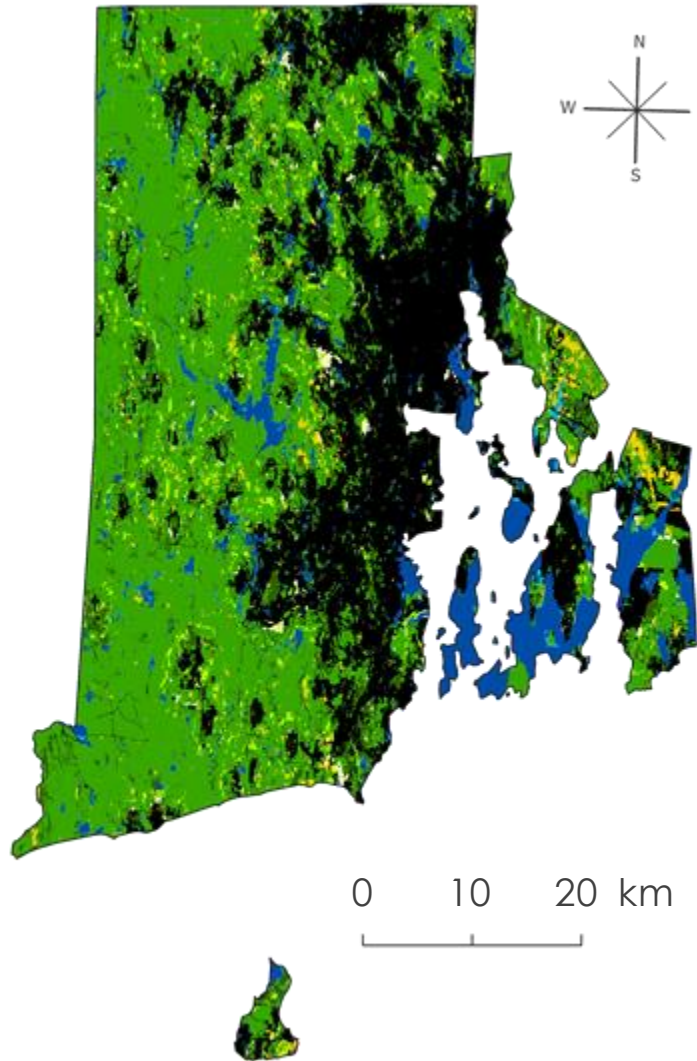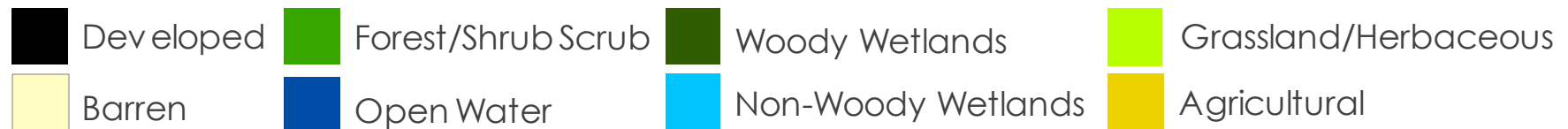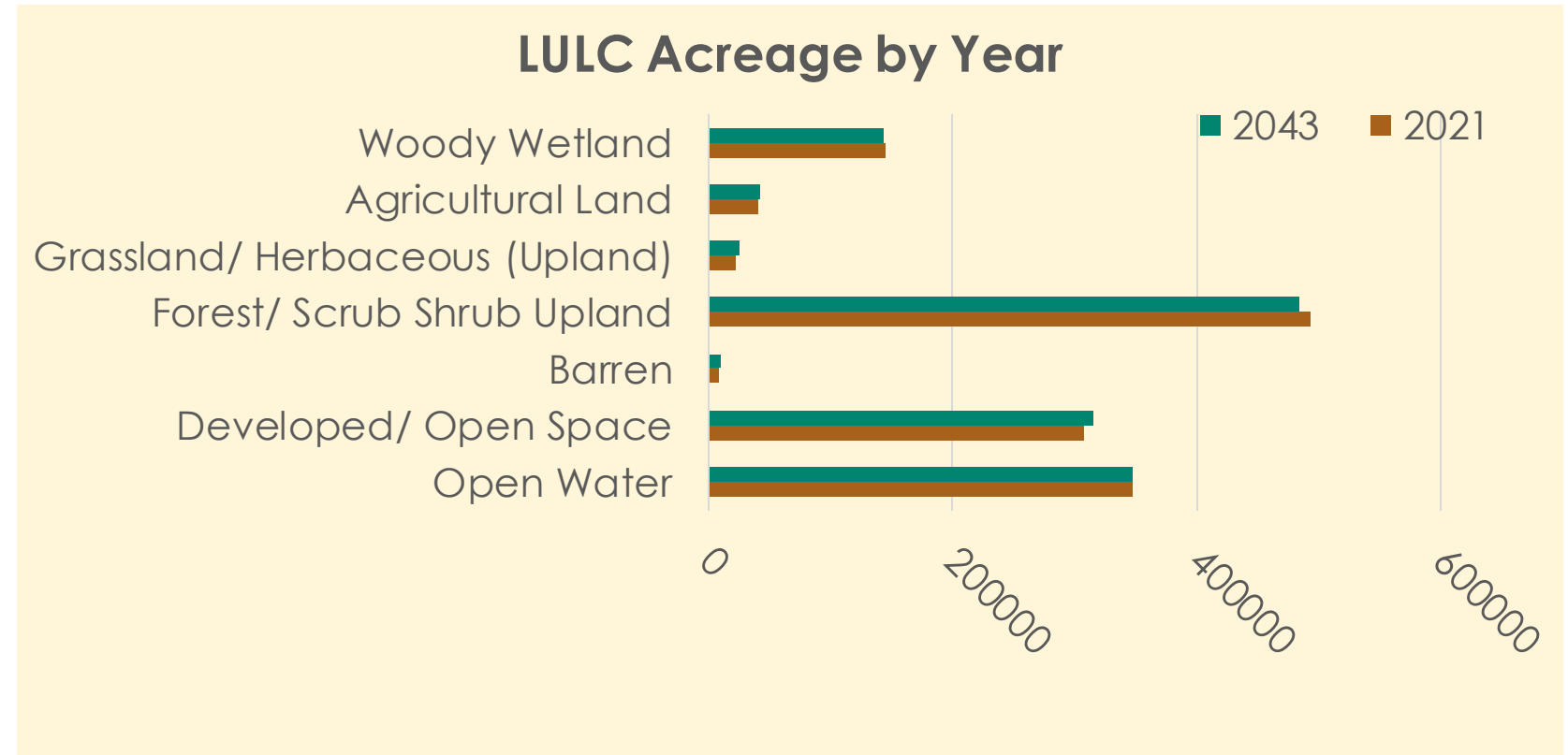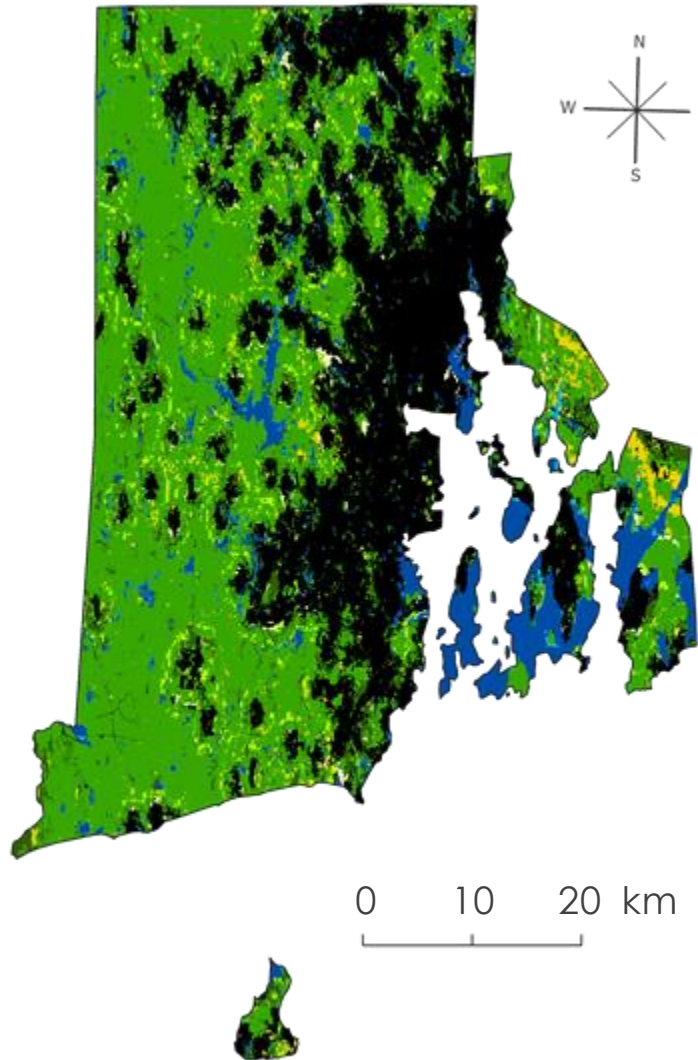
Accuracy Assessments - Forecasting

2043 Projected Accuracies	Minimum	Maximum
Open Water	79.5%	88.0%
Developed / Open Space	54.6%	73.9%
Barren	3.4%	84.2%
Forest / Scrub Shrub	32.2%	73.7%
Grassland / Herbaceous	38.4%	64.3%
Agriculture	38.4%	77.0%
Woody Wetland	61.0%	75.2%

Ecological Forecasting Results & Conclusions

Land Class Acreage by Year

(Bar chart showing acreage for land classes by year)

- Woody Wetland
- Agricultural Land
- Grassland/ Herbaceous (Upland)
- Forest/ Scrub Shrub Upland
- Barren
- Developed/ Open Space
- Open Water

X-axis: 0, 200000, 400000, 600000

Legend: 2043, 2037, 2032, 2026
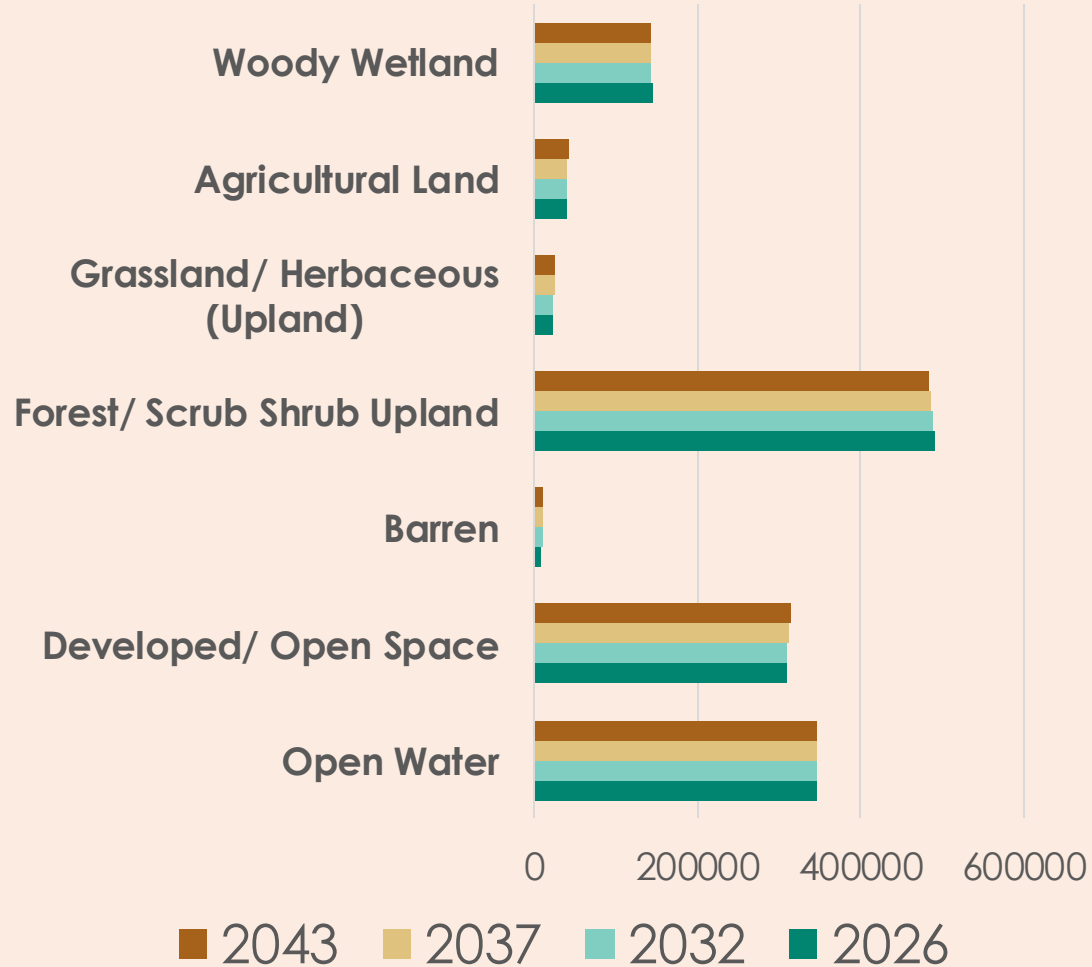
Net LULC Acreage Change 2023-2043

(Bar chart, Y-axis: Acres)

- Open Water: 788
- Developed/ Open Space: 6360
- Barren: 759
- Forest/ Scrub Shrub Upland: -8933
- Grassland/ Herbaceous (Upland): 2119
- Agricultural Land: 487
- Woody Wetland: -1582

Y-axis: 8000, 6000, 4000, 2000, 0, -2000, -4000, -6000, -8000, -10000
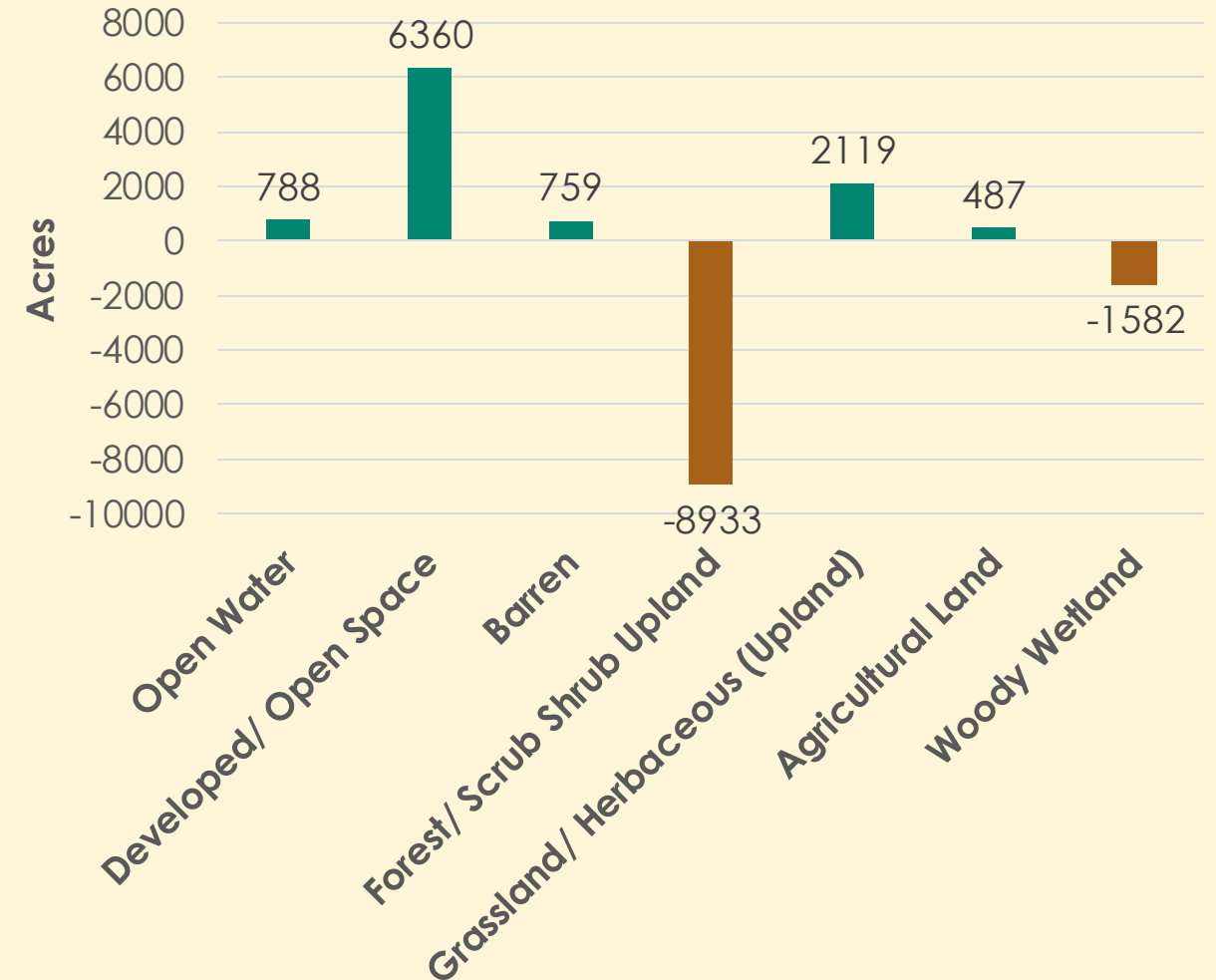
Errors & Uncertainties

Clear Earth Observations

Spatial Data Availability

Spatial Resolution

Comparisons and Ancillary Datasets

Static vs Dynamic Variables

Accuracy and Validity

Feasibility Assessment

Project Goals

- LULC Maps 2013, 2018 & 2023

- LULCC Map 2013 – 2023

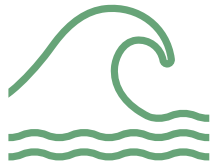- Ecological forecasting with LULC for years: 2026, 2032, 2037, and 2043.

Project Outcomes

- LULC Maps 2013 & 2023 (GEE)

- LULC Map 2023 (GIS)

- LULC Map 2023 (TerrSet)

- LULCC Map 2013 – 2023 (GEE)

- Ecological forecasting with NLCD for years: 2026, 2032, 2037, and 2043.
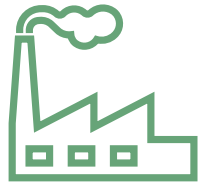
Image credits: Microsoft

Future Recommendations

- Create a 2013 LULC map with GIS method

- Incorporate drought and sea-rise data

- Tease out industrial applications and further define the "developed" classification

- Classify different upland habitat types (deciduous, mixed-forest, scrub/shrub, etc.)

Image credits: Microsoft

Conclusions

- Earth observations were used to create **current** LULC maps of Rhode Island.

- Forecasting revealed the likelihood of continued development of wildlands, resulting in the loss of forest and wetland habitats.

- Current and forecasted LULC maps created in this project can help Audubon, and other non-profit organizations in Rhode Island, to prioritize vulnerable habitats for conservation.

Image credits: Audubon Society of Rhode Island

Acknowledgments

Partner
- Rhode Island Audubon Society
- Specifically, Dr. Charles Clarkson & Paige Therien

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- Sylvia Reeves, NOAA

Support
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- Sean McCartney, Science Systems and Applications, Inc.
- Keith Weber, Idaho State University

Thank you from the Rhode Island Eco Team!

Questions?

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Project Lead

Joseph Barnes
Participant

Kristen Mecke
Participant

Nancy Nthiga
Participant