Land Use Back-Cast

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USGS, Lower Mississippi Gulf Water Science Center

Land Use Work Group

June 18, 2025

U.S. Department of the Interior
U.S. Geological Survey

Overview

- Background
  - What is a summary unit?
  - What does “Land Use” mean?
  - How do we assess land use over time?
- How is the land use back-cast used?
- Phase 7 land use back-cast methods
- Comparison of methods with Phase 6
- Potential effects to using the Phase 7 methods

What is a summary unit?

The analysis units used in CAST (Chesapeake Assessment Scenario Tool)

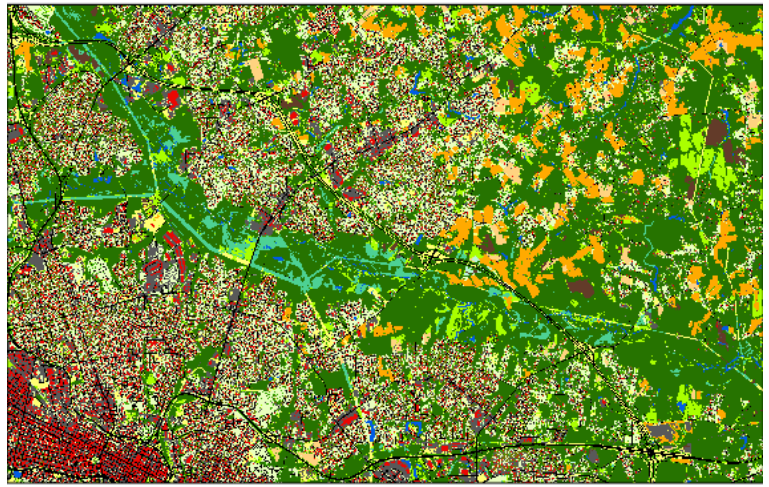
- A combination of layers (has not yet been approved for Phase 7)

- Land-River segments (LRSEGs)
  - Land segments = county boundaries
  - River segments = 12-digit Hydrologic Unit Codes (HUCs)
  - Shoreline = tidal shoreline boundary
  - Climate boundaries = orographic regions
    - Mostly apparent in mountainous areas

- Summary Units
  - LRSEGs
  - Municipal Separate Storm Sewer System (MS4)
  - Federal Lands
  - Combined Sewer Overflows (CSO)

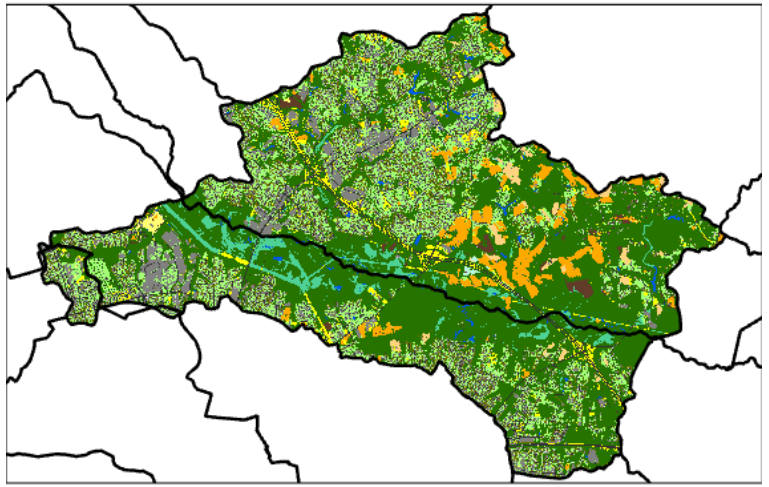
What Does “Land Use” Mean?

High-resolution LULC
56 classes



Mapped from aerial imagery, Light Detecting and Ranging (LiDAR), and ancillary data sources.

Phase 7 Rollup Land Use
*16 classes



Reclassifies mapped LULC and summarizes as acres per class per summary unit to form the base land use for CAST.

CAST Land Use
49 classes (or load sources)

County	LRSEG	Land Use	Acres
ABC	1	Grass	100
ABC	2	CSS Roads	200
ABC	3	Pasture	50
DEF	4	Septic	35
DEF	5	True Forest	500

Incorporates reported data (census of agriculture, state annually-reported forest harvest and construction acres, CSO separations) with the base land use acres. Produces acres of land use by summary unit in which BMPs are applied and loads are calculated.

LULC = Land Use/Land Cover
LRSEG = Land River Segment
CAST = Chesapeake Assessment Scenario Tool
BMP = Best Management Practice
CSO = Combined Sewer Overflows
* Final classification schema for Phase 7 has not yet been approved.

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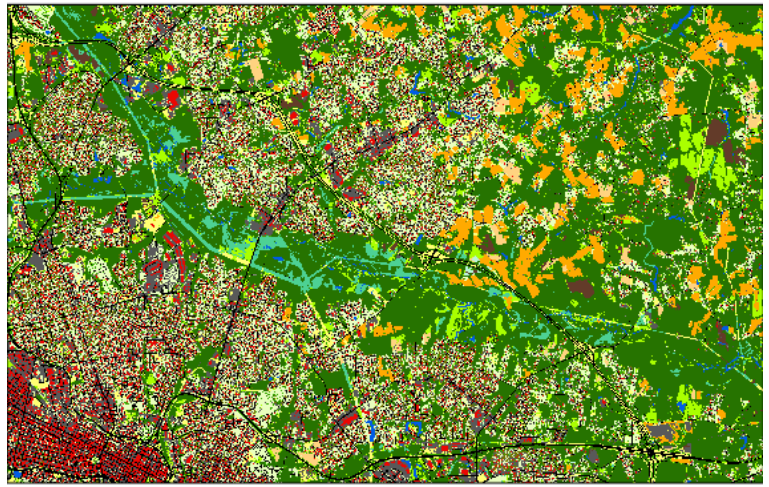

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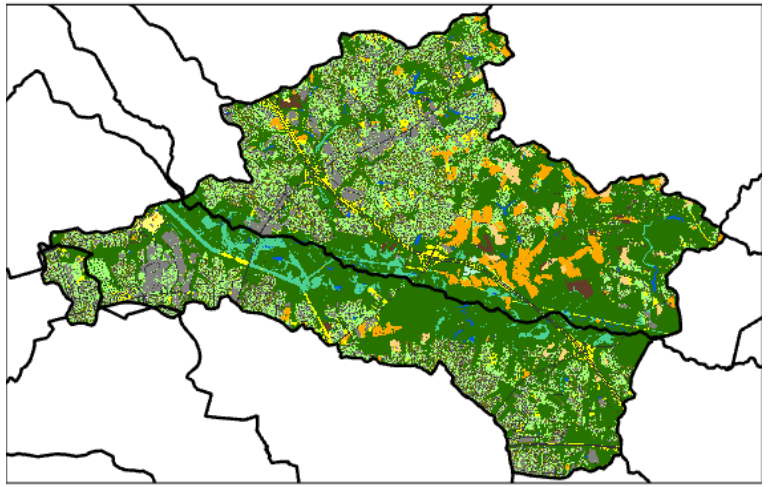

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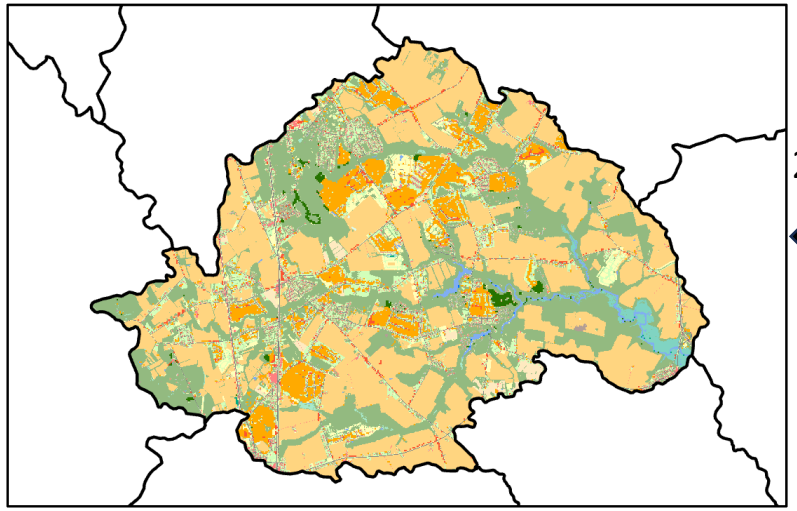
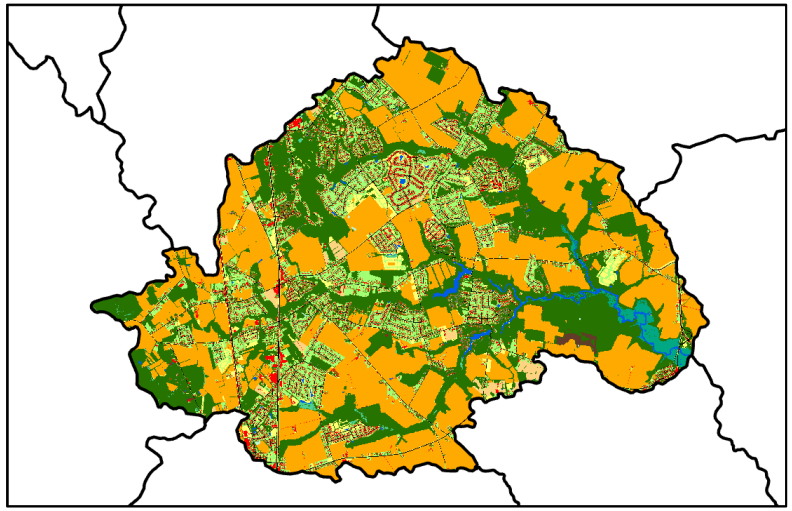
How do we assess land use over time?

Past Land Use (30m)
1985-2012



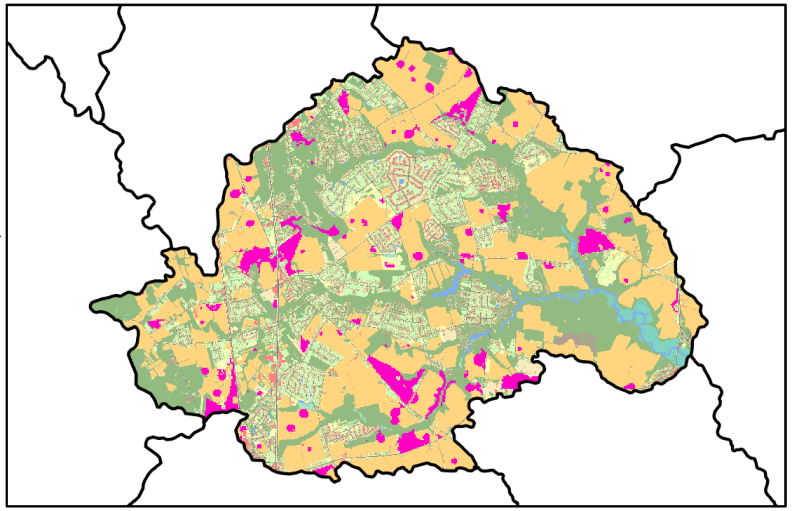
2013

Present Land Use (1m)
2013-2022



2022

Future Land Use (30m)
2023-2100



Annual historic land use condition and trends by summary unit. NLCD detects and classifies change back through time with historical satellite imagery from Landsat at 30-meter resolution. The present is deconstructed where change is detected and summarized by summary unit.

LULC = Land Use/Land Cover
LRSEG = Land River Segment
NLCD = National Land Cover Database

The land use conditions in the present, derived from the LULC at 1-meter resolution and by summary unit. Annualized from the mapped dates 2013/14, 2017/18, and 2021/22. Serves as the starting point for the back-cast and forecasts.

Future land use trends modeled with the Chesapeake Bay Land Change Model (CBLCM). Urban growth model that converts forest and farmland to development to allocate for population growth. Usually predicted in 5- or 10-year increments. Modeled at 30-meter resolution and summarizes land use by summary unit for modeled years.

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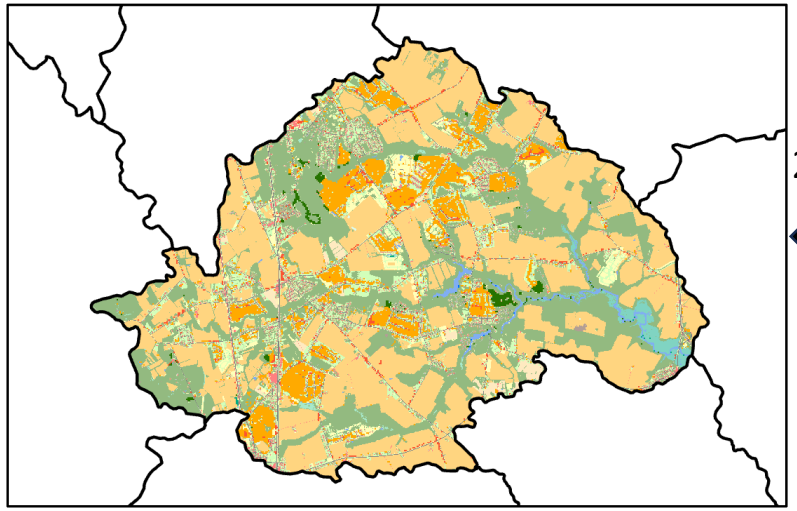

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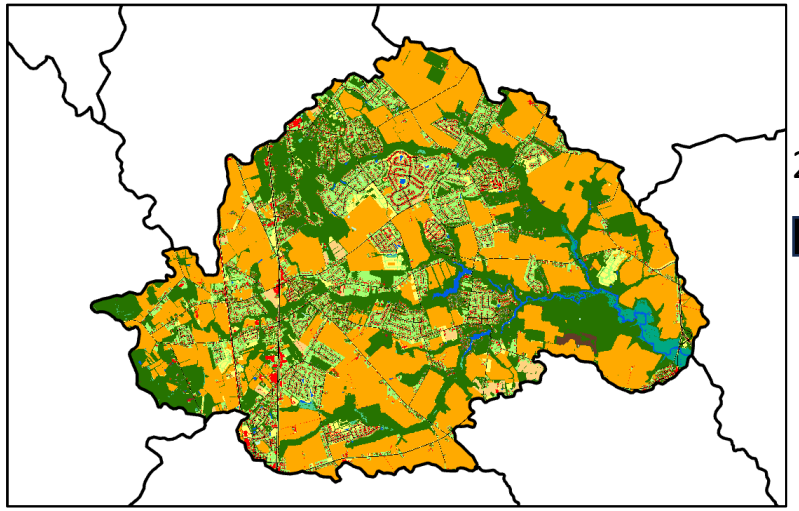

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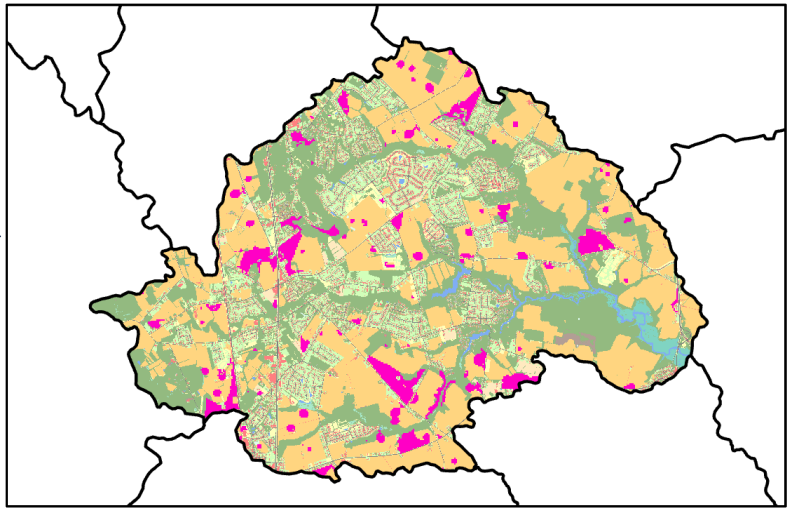

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The land use conditions in the
for the back-cast and forecasts.

Three distinct land use products that work together to provide a consistent classification of land use trends for the past, present and future

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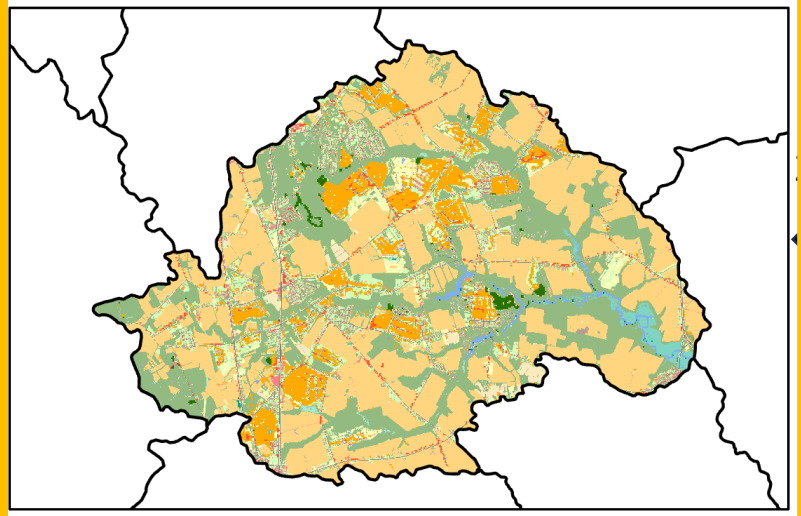

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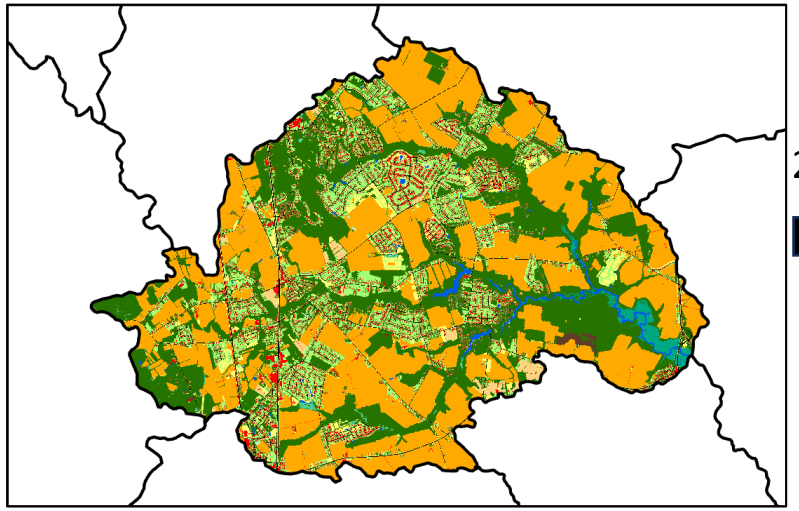

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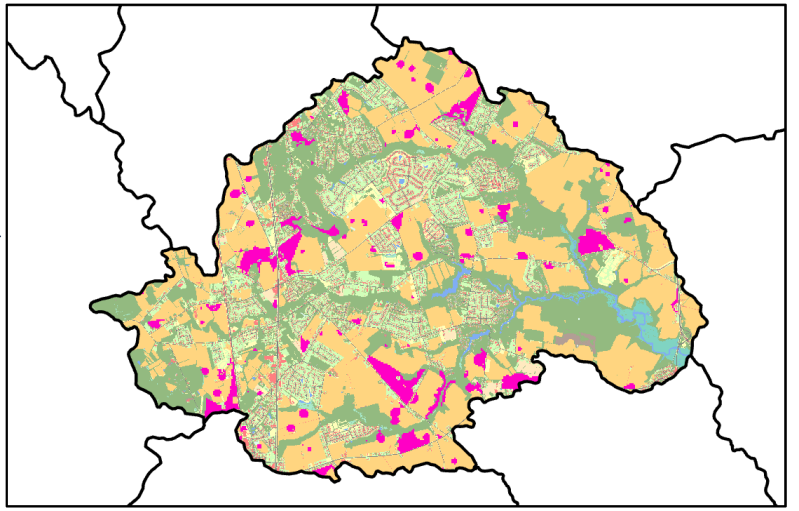
2021

Future Land Use
To 2025 and beyond



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Phase 7 Back-cast Goal

This project will utilize the spatial and categorical accuracy of 1-meter resolution Land Use/Land Cover (LULC) to represent the present and the temporal accuracy of Landsat derived products to deconstruct the landscape back through time.

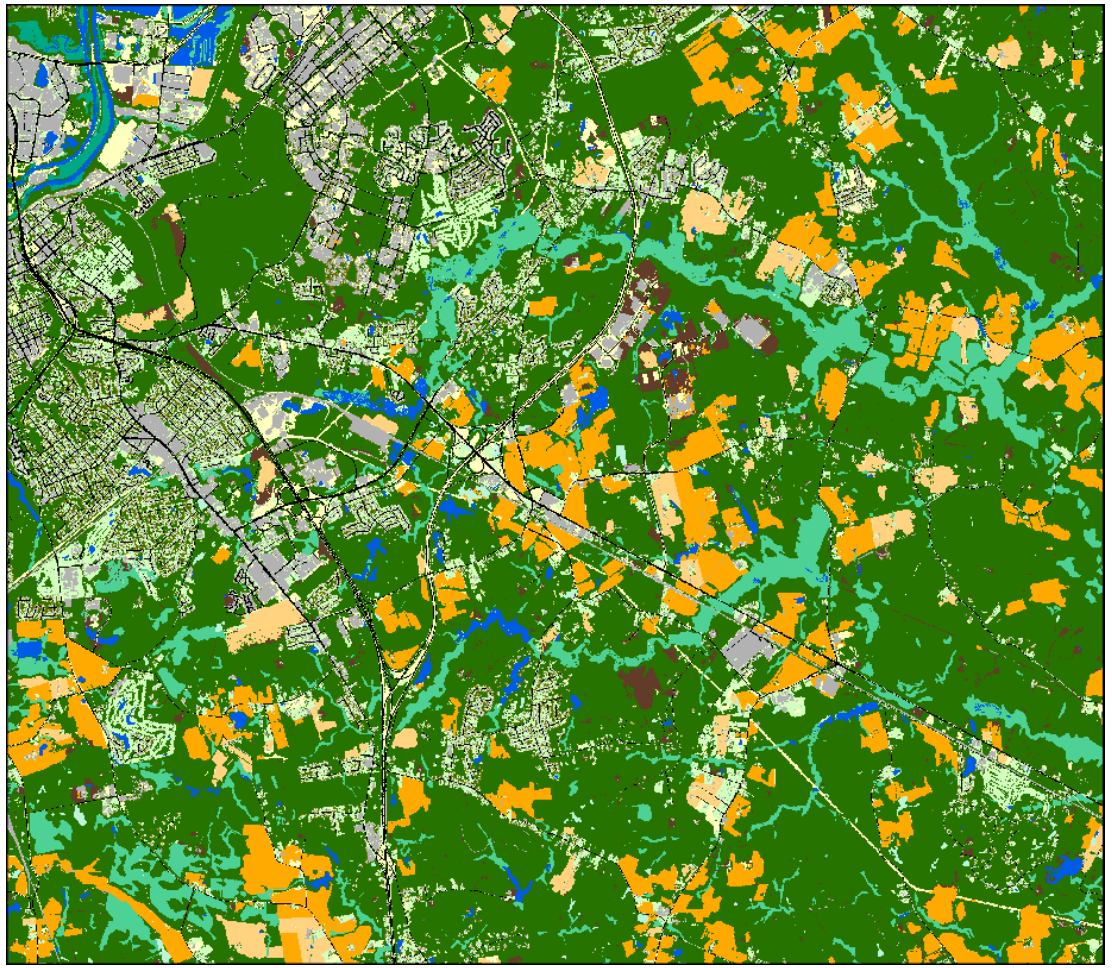
How is the Land Use Back-cast Used?

1. To set appropriate planning targets and Total Maximum Daily Load (TMDL) allocations
    a) Phase III WIPS were based on necessary change in anthropogenic sources of nitrogen, phosphorus, and sediment from 1995. If the partnership follows past precedent, an accurate land use trend will be important for appropriate goal setting.
2. To estimate spatially explicit loading rates from monitored loads.
    a) The historical land use is used as an input to CalCAST, a statistical version of Chesapeake Assessment Scenario Tool (CAST) used to estimate optimal parameters for use in CAST during the development period (Berger et al., 2024), to estimate spatially explicit loading rates from monitored loads. The resulting loading rates are input to CAST to apply Best Management Practices (BMPs) and other information to produce Nitrogen (N), Phosphorus (P), and Sediment (S) loads. An accurate land use status and trend is important for producing a model that best matches observed data.
3. The historical land use is used as inputs to scenarios run in CAST and the Dynamic Watershed Model representing those land use years. The scenarios are evaluated against monitored loads to evaluate model performance and load reduction progress in the TMDL indicator and Monitored and Expected Total Reduction Indicator for the Chesapeake (METRIC).

Phase 7 Back-cast Methods

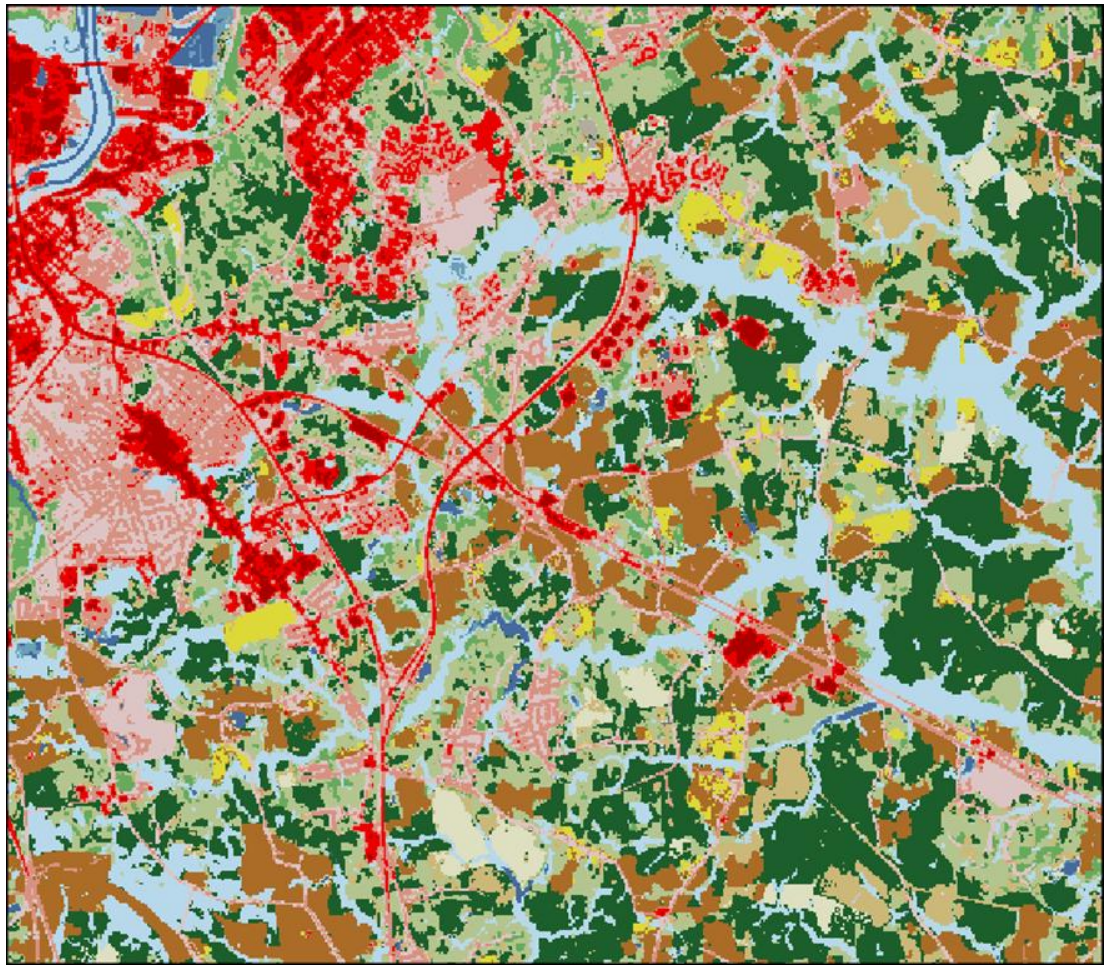
Step 1: Compare 1-meter LULC and 30-meter NLCD

1-meter LULC: 2014



56-classes, displaying 16 phase 7 classes

30-meter NLCD: 2014



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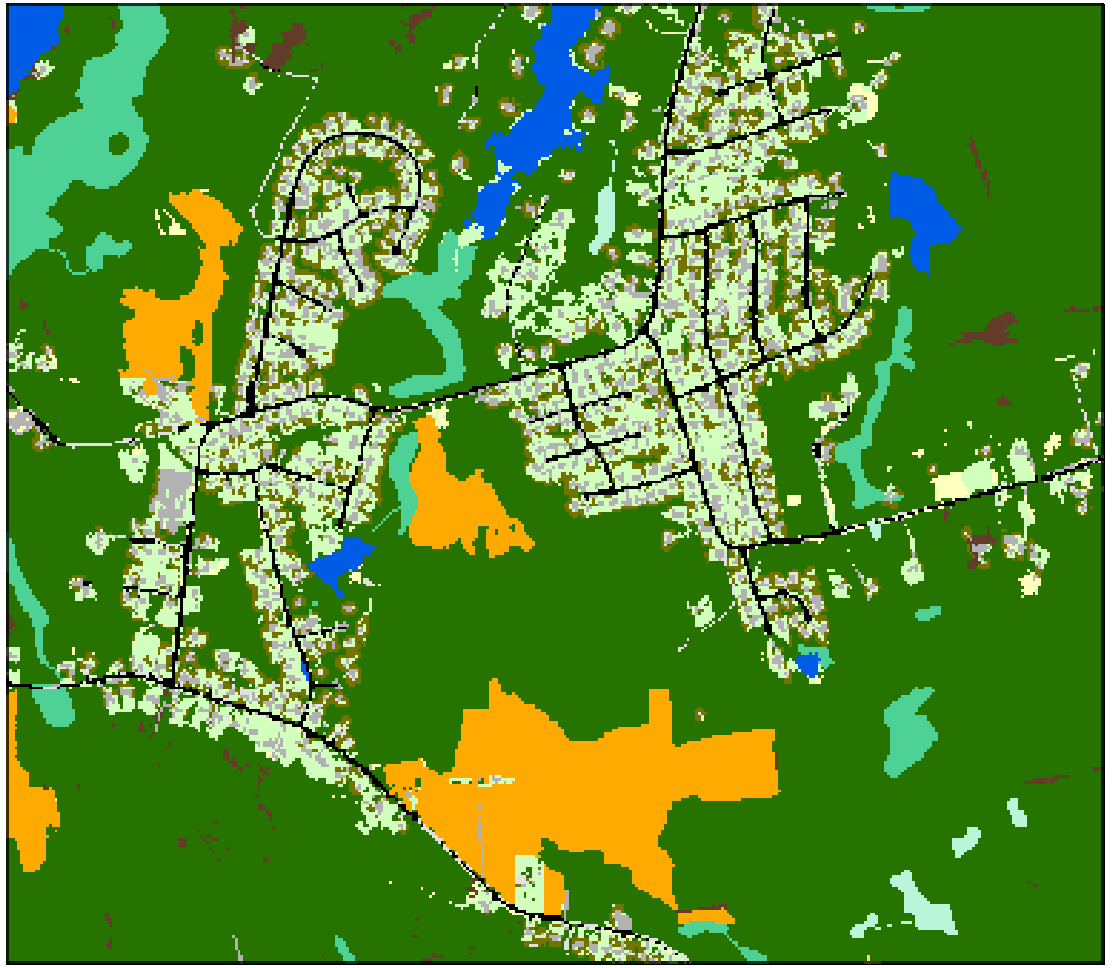

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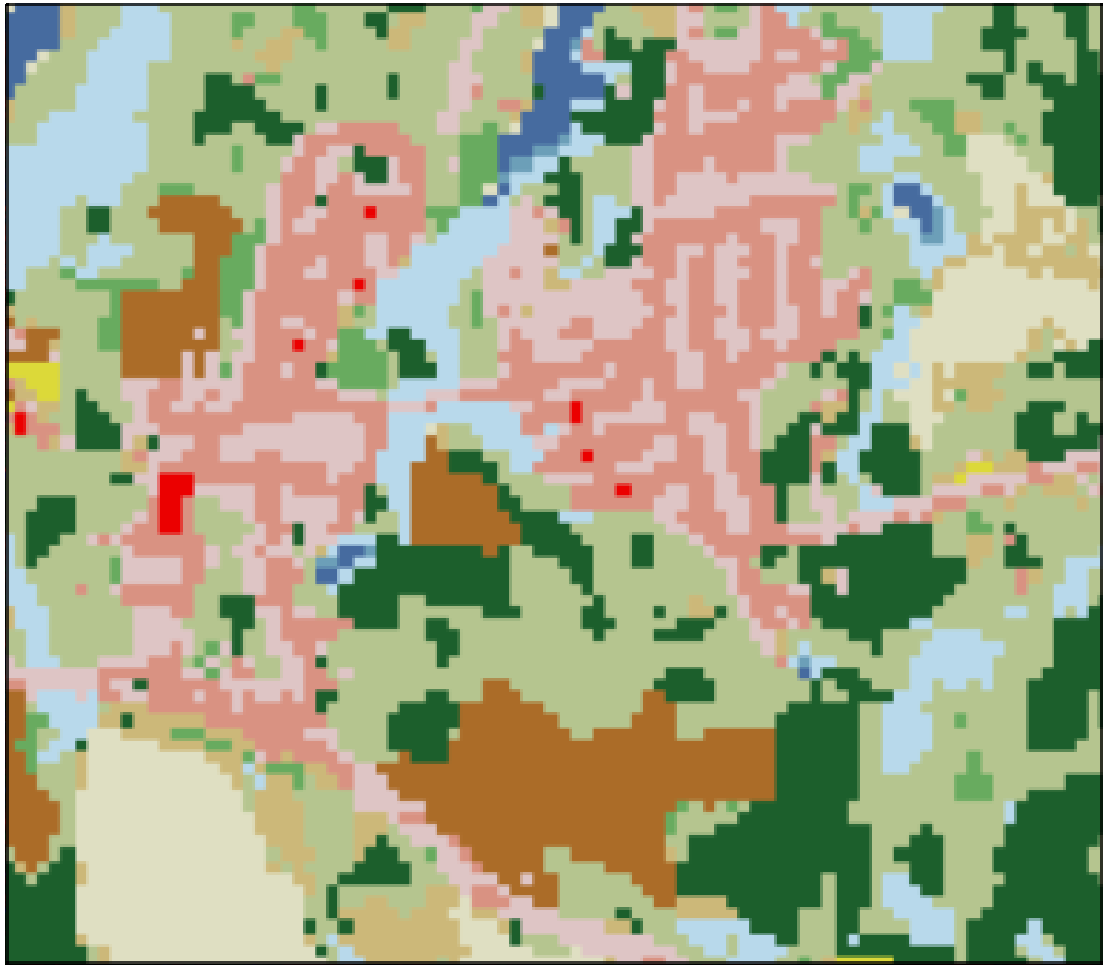

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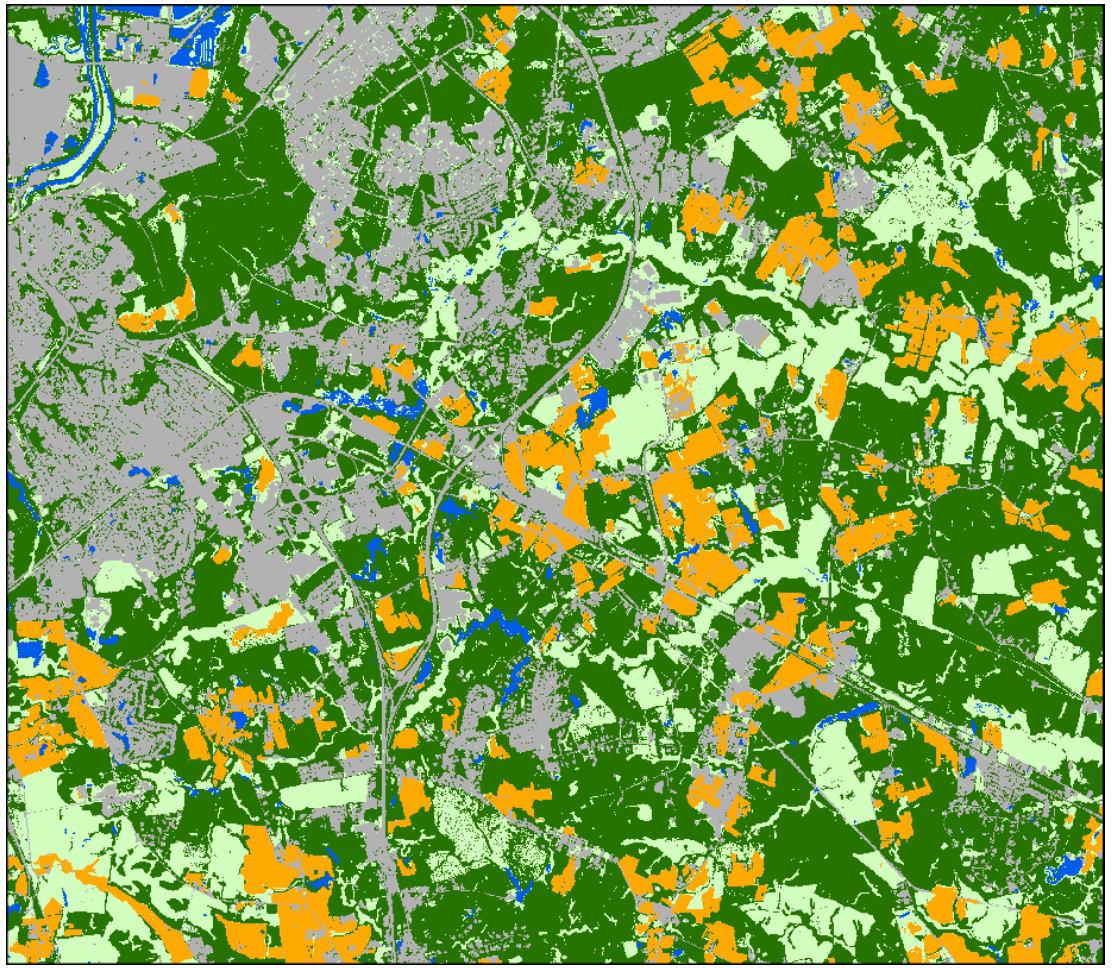
Phase 7 Back-cast Methods

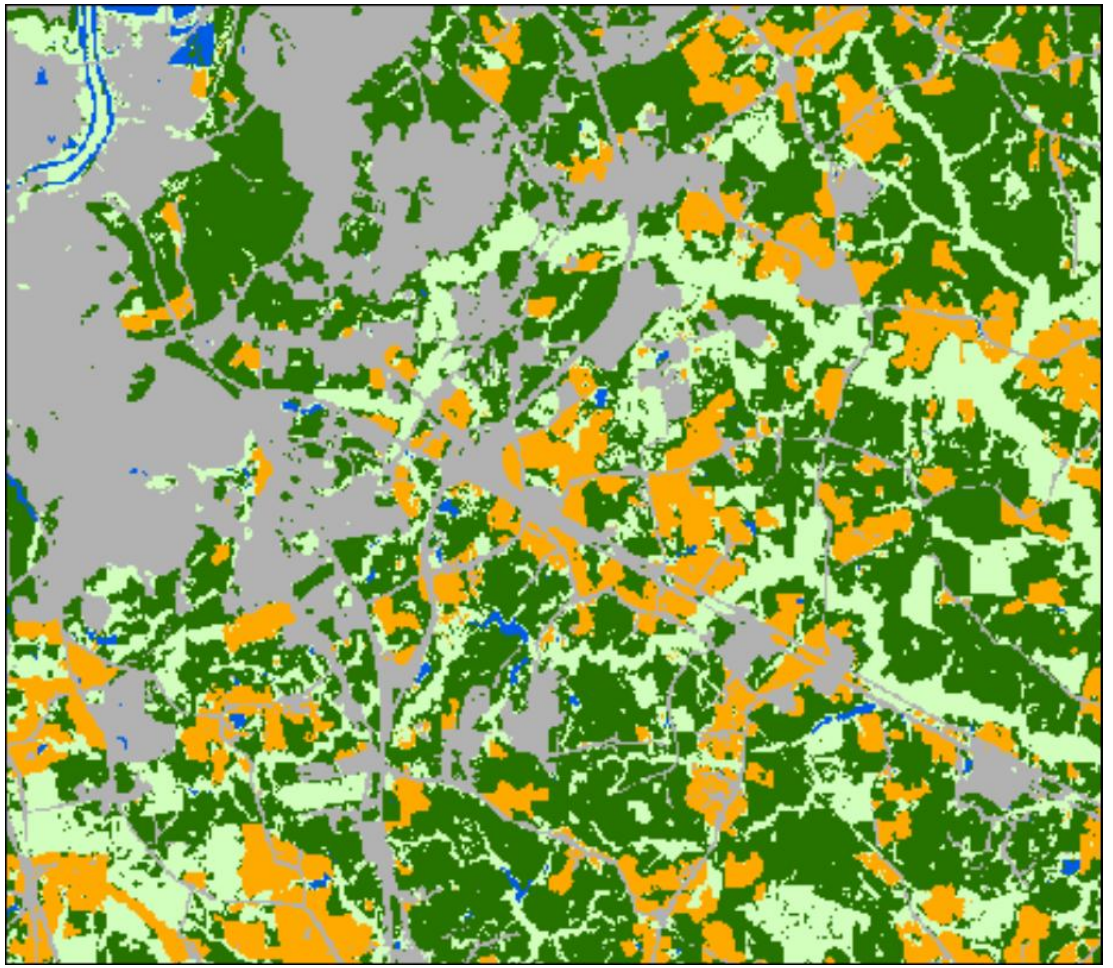
Step 2: Create shared schema for apples-to-apples analysis

1-meter LULC: 2021



56-classes, displaying 5-class schema

30-meter NLCD: 2021



16 classes, displayed 5-class schema

Phase 7 Back-cast Methods

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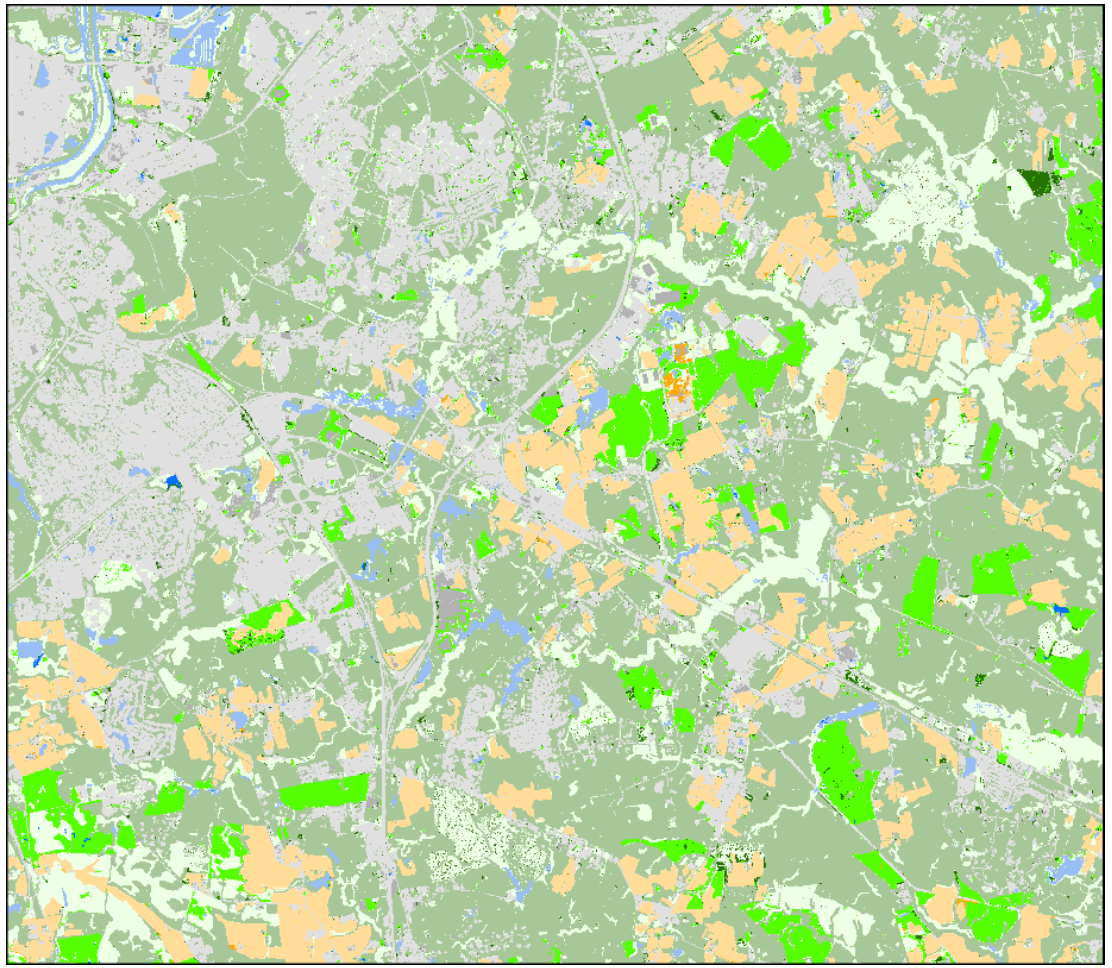
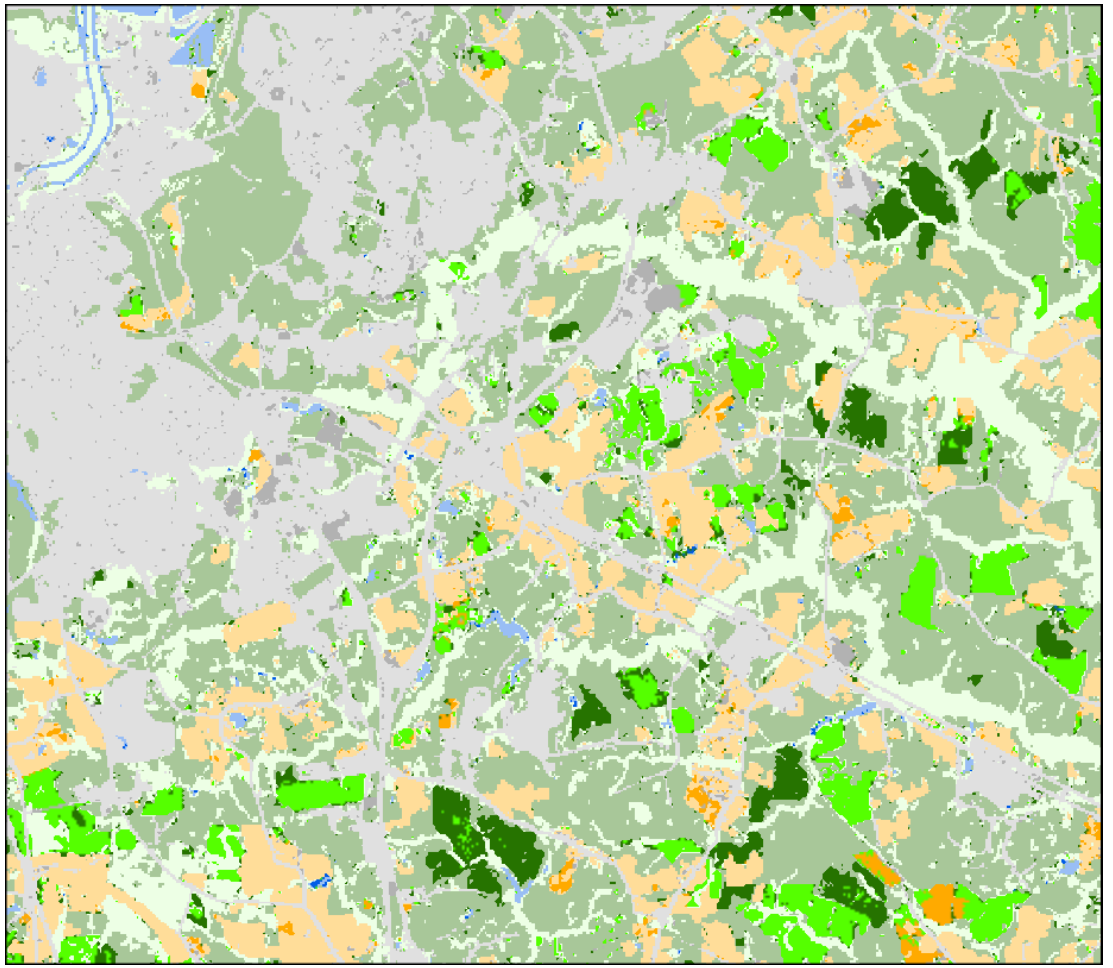
1-meter LULC Change: 2014-2021 (2021 shown)



56-classes, displaying 5-class schema

30-meter NLCD: Change 2014-2021 (2021 shown)



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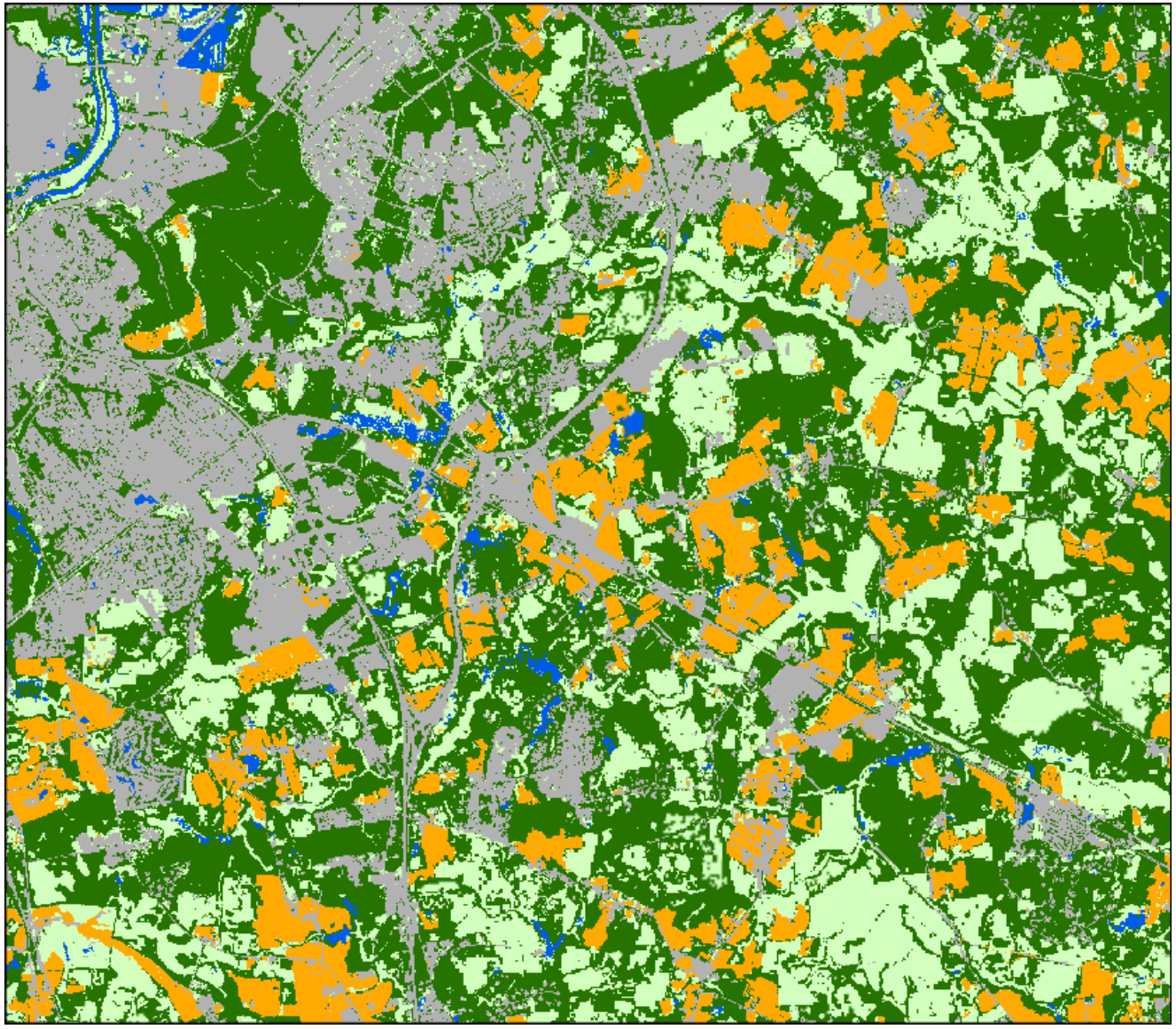
Phase 7 Back-cast Methods

Step 3: Deconstruct 2012 LULC with historical NLCD change



Starting from the 1-meter resolution in 2014 to…

2012

2010

2005

2000

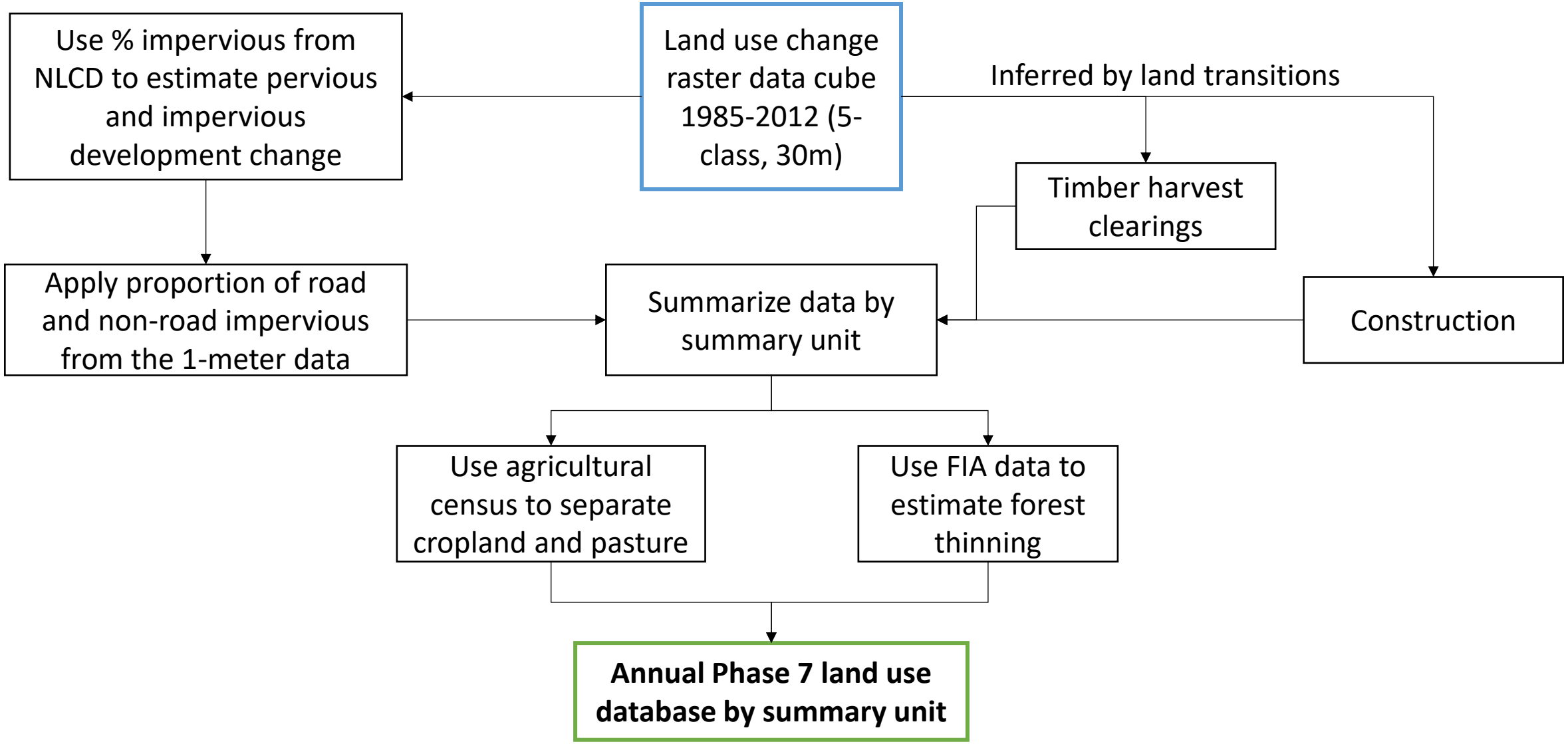
1995

1990

This animation is every 5 years for visualization purposes, the method will do this annually.

Phase 7 Back-cast Methods

Step 4: Expand the 5-classes to the Phase 7 classes



Phase 7 Back-cast Methods

Step 5: Validate trends

1. Development
    a) Compare mapped development change with Maryland and Delaware parcel data that contains “year built” attribute.

2. Agriculture
    a) Census of agriculture to validate trends in the agricultural footprint

3. Forestry
    a) Forest Inventory and Analysis (FIA) data to validate forestry trends

How does the Phase 7 Process Differ with Phase 6 Methods?

1. Temporal resolution is finer in the Phase 7 method
    a) Phase 6 method deconstructed residential development to be farm or forest using the Decennial Census (every 10 years) and the Chesapeake Bay Land Cover Data Series (CBLCD) (every 4-6 years). Phase 7 method utilizes annual data that did not exist during Phase 6 development.

2. Spatial Resolution is finer in the Phase 7 method
    a) Although the change detected from CBLCD and NLCD are 30-meter resolution products, the Phase 6 method aggregated the 30-meter products to the summary unit to identify the proportions of natural and agricultural lands to convert to development from the census. The Phase 7 method maps the land use change transitions explicitly at 30-meter resolution.

What are the potential effects of these changes?

- More temporal granularity (annual Landsat derivatives versus 4-6 year timesteps)
- More development change than Phase 6 because it is not restricted to change in housing units
- More change overall (e.g. timber harvest, ag expansion and contraction)

- The effects on loads have not yet been quantified

Approval of Back-cast Methods

- The back-cast methods need formal approval by LUWG.

- To ensure we meet the September 30th, 2025 deadline, we should plan to make this decision prior to the September LUWG meeting.

- What is the group preference for making this decision?
  - Decision request via email
  - Add a shortened meeting in July or August

Questions?

Sarah McDonald
smcdonald@chesapeakebay.net