

High-res Land Use Data to inform CAST

Peter R. Claggett¹, Labeeb Ahmed¹, Matthew Baker⁴, Jacob Czawlytco², Sean MacFaden³, Sarah McDonald¹, Jarlath O'Neil-Dunne³, David Saavedra², and Rachel Soobitsky²

1 Presenting Author, Lower Mississippi-Gulf Water Science Center, U.S. Geological Survey, Annapolis, MD 21403

2 Chesapeake Conservancy, Annapolis, MD 21403

3 University of Vermont Spatial Analysis Laboratory, Burlington, VT 05405

4 University of Maryland, Baltimore County, Baltimore, MD 21250

**Land Use Workgroup Meeting
May 5, 2021**

Disclaimer

"This information is preliminary or provisional and is subject to revision. It is being provided to meet the need for timely best science. The information has not received final approval by the U.S. Geological Survey (USGS) and is provided on the condition that neither the USGS nor the U.S. Government shall be held liable for any damages resulting from the authorized or unauthorized use of the information."

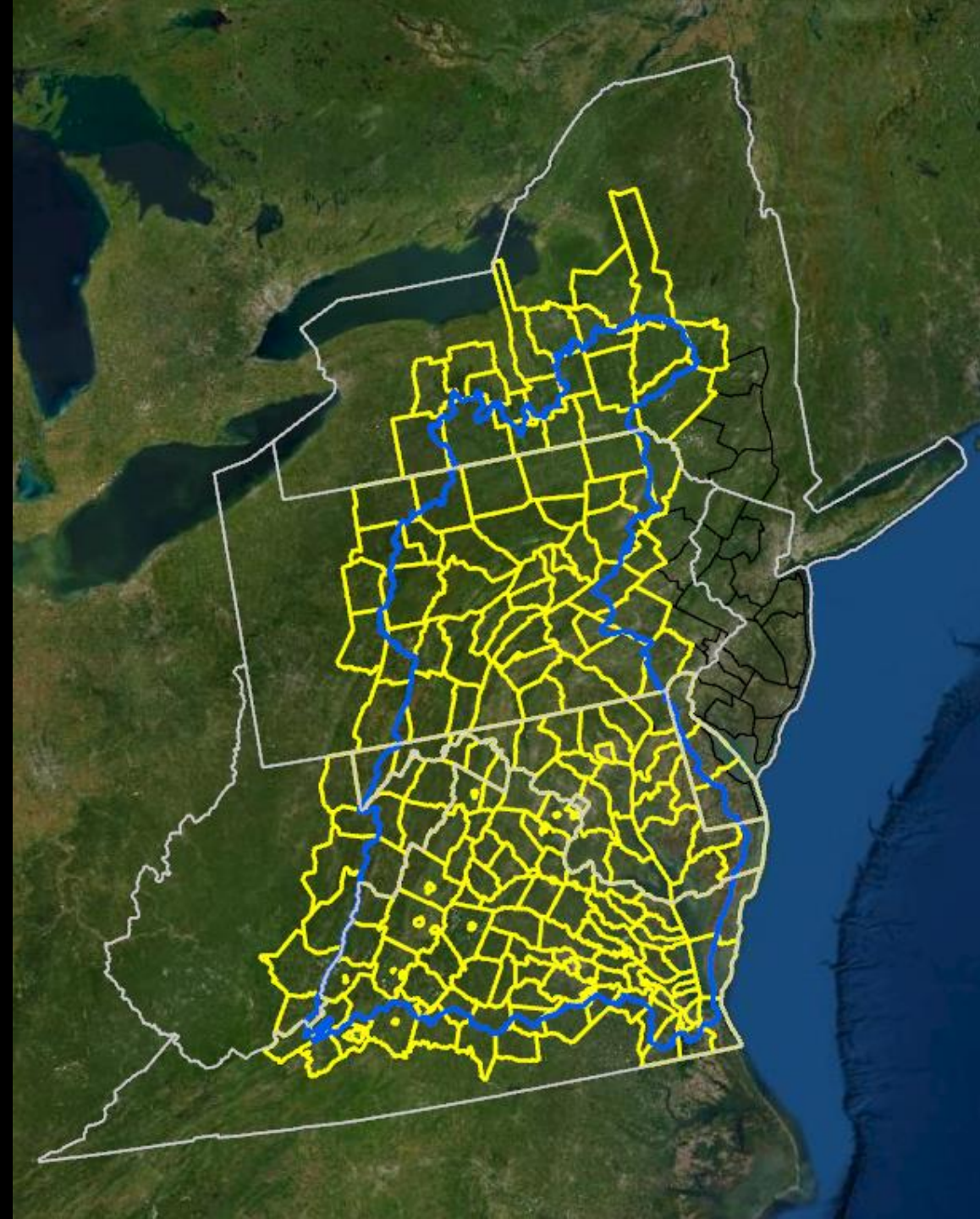


Chesapeake Bay Land Use Mapping Domain

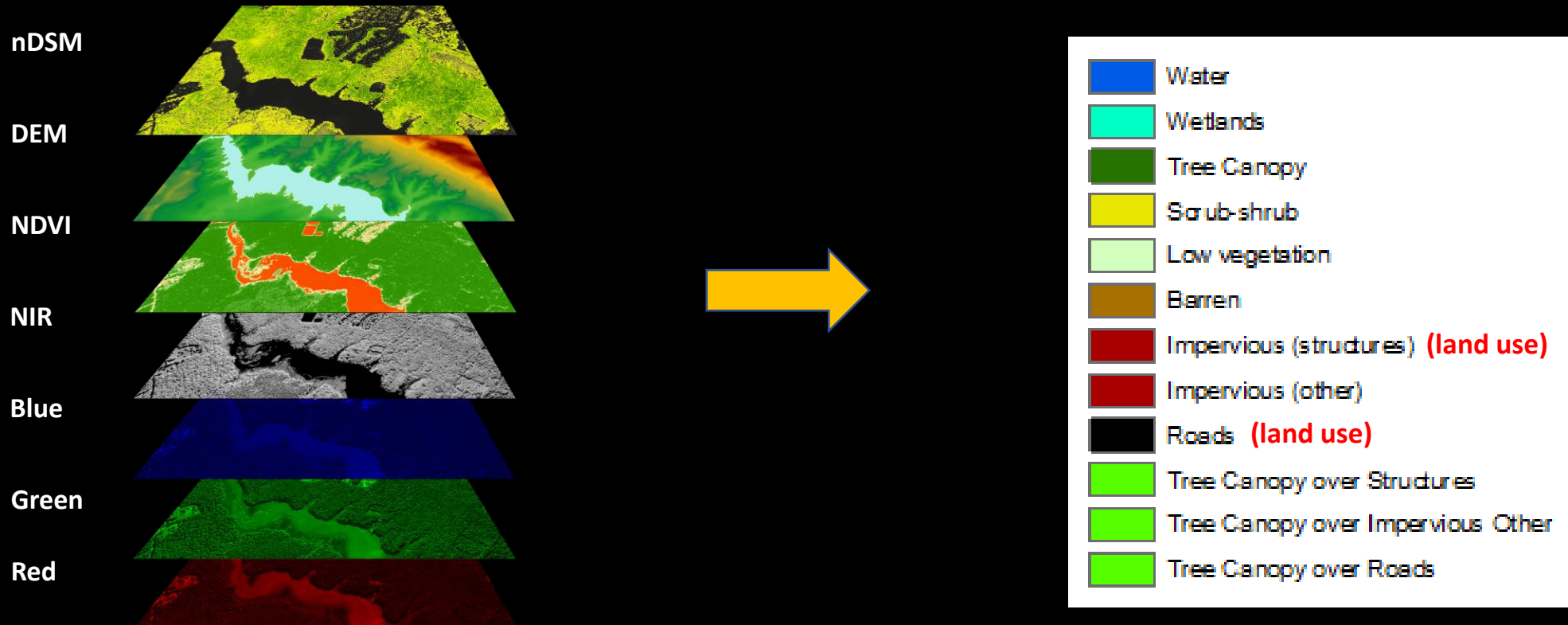
Cost for 2017/18 land cover and land use:
~\$20 per square mile

~\$15,000 per county

~ 8 staff (UVM, CIC, USGS) + 40 students



CBP Land Cover Classification (12 classes)

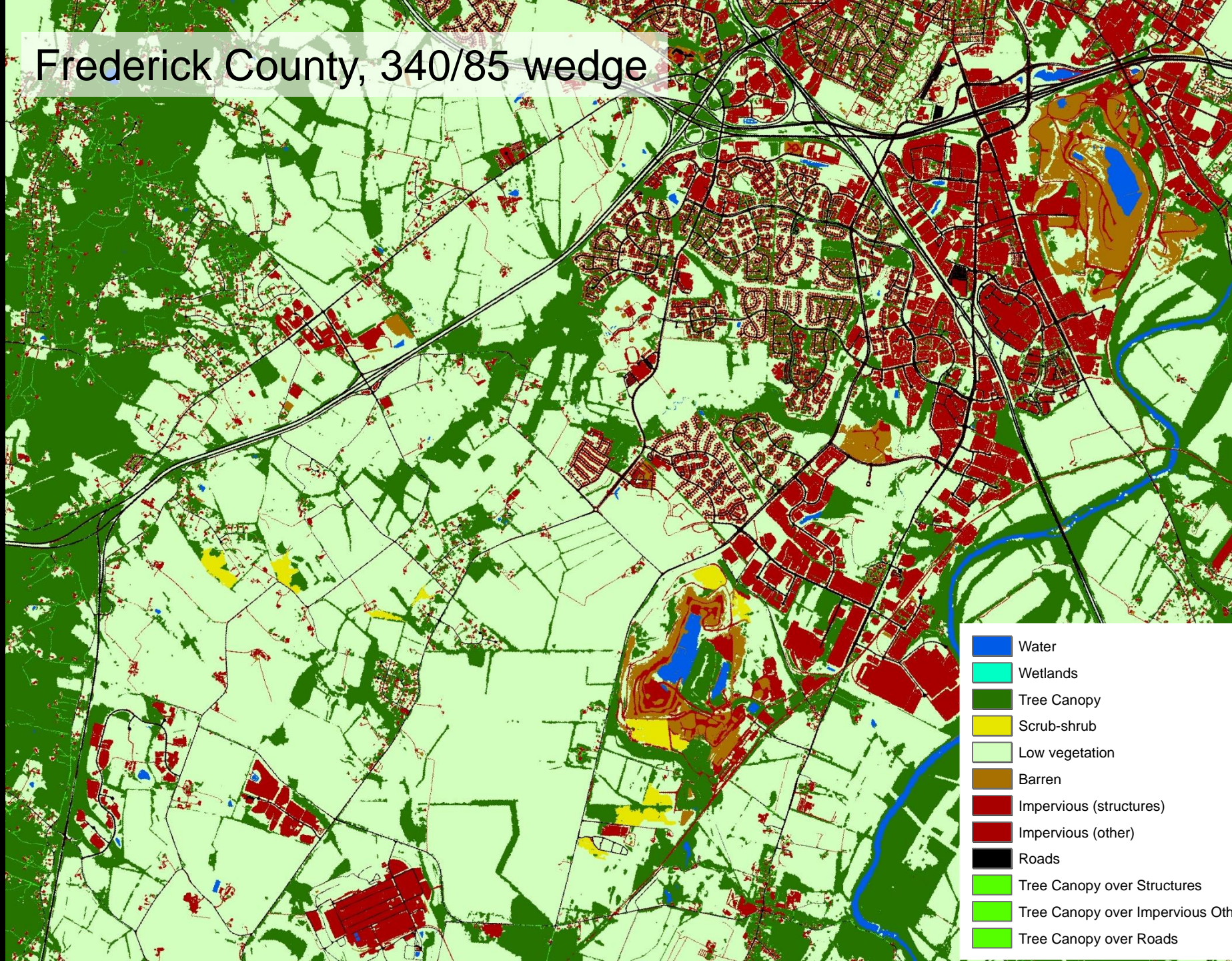


Land cover = physical land surface conditions classified from spectral imagery

Frederick County, 340/85 wedge



Frederick County, 340/85 wedge

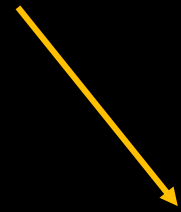


- Water
- Wetlands
- Tree Canopy
- Scrub-shrub
- Low vegetation
- Barren
- Impervious (structures)
- Impervious (other)
- Roads
- Tree Canopy over Structures
- Tree Canopy over Impervious Other
- Tree Canopy over Roads

Ancillary Data



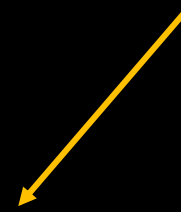
- County Land Use
- Abandoned Mine Lands
- Roads
- Parcels



Land Cover Data



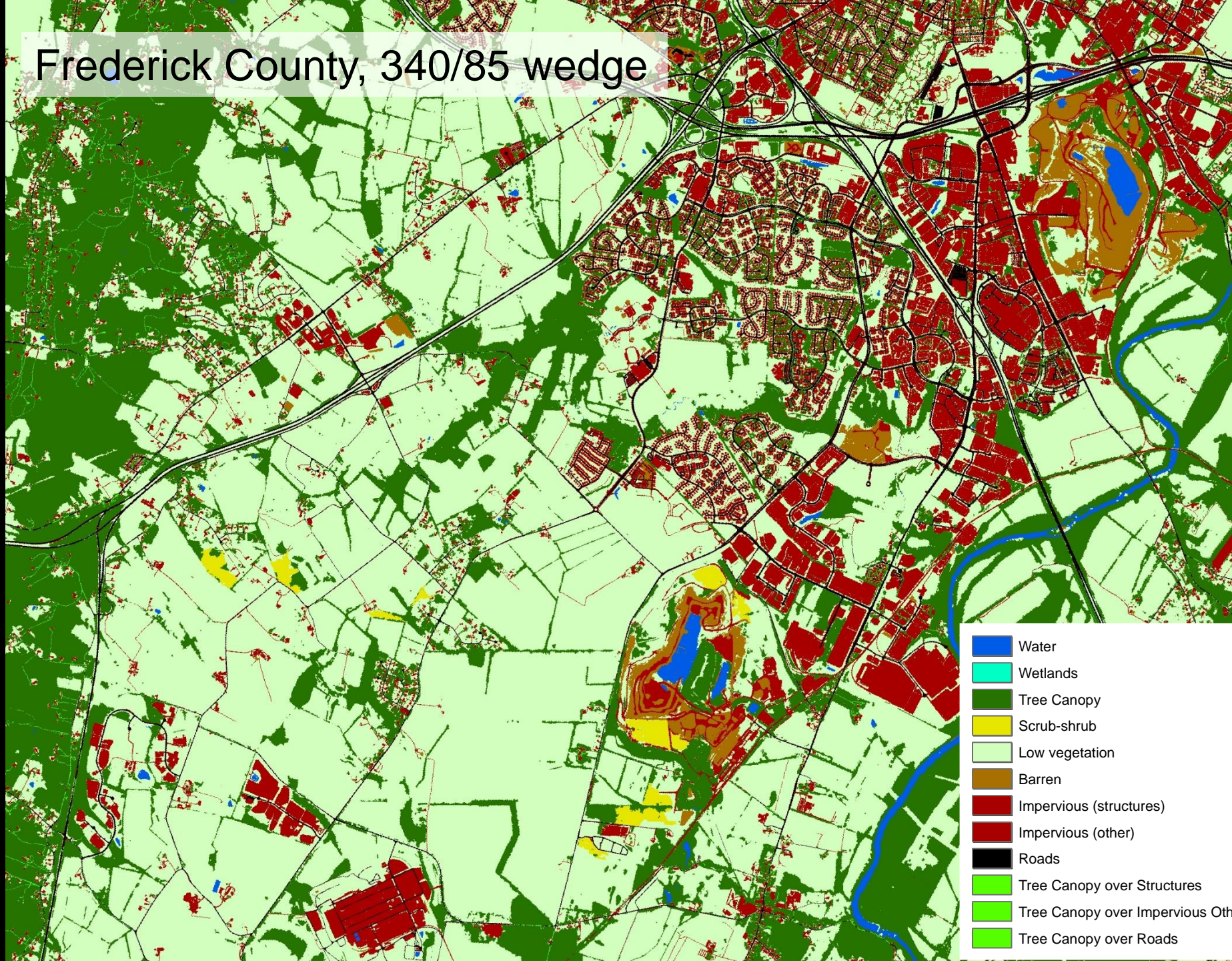
- Impervious surfaces
- Tree canopy
- Low vegetation
- Water



Land Use Data

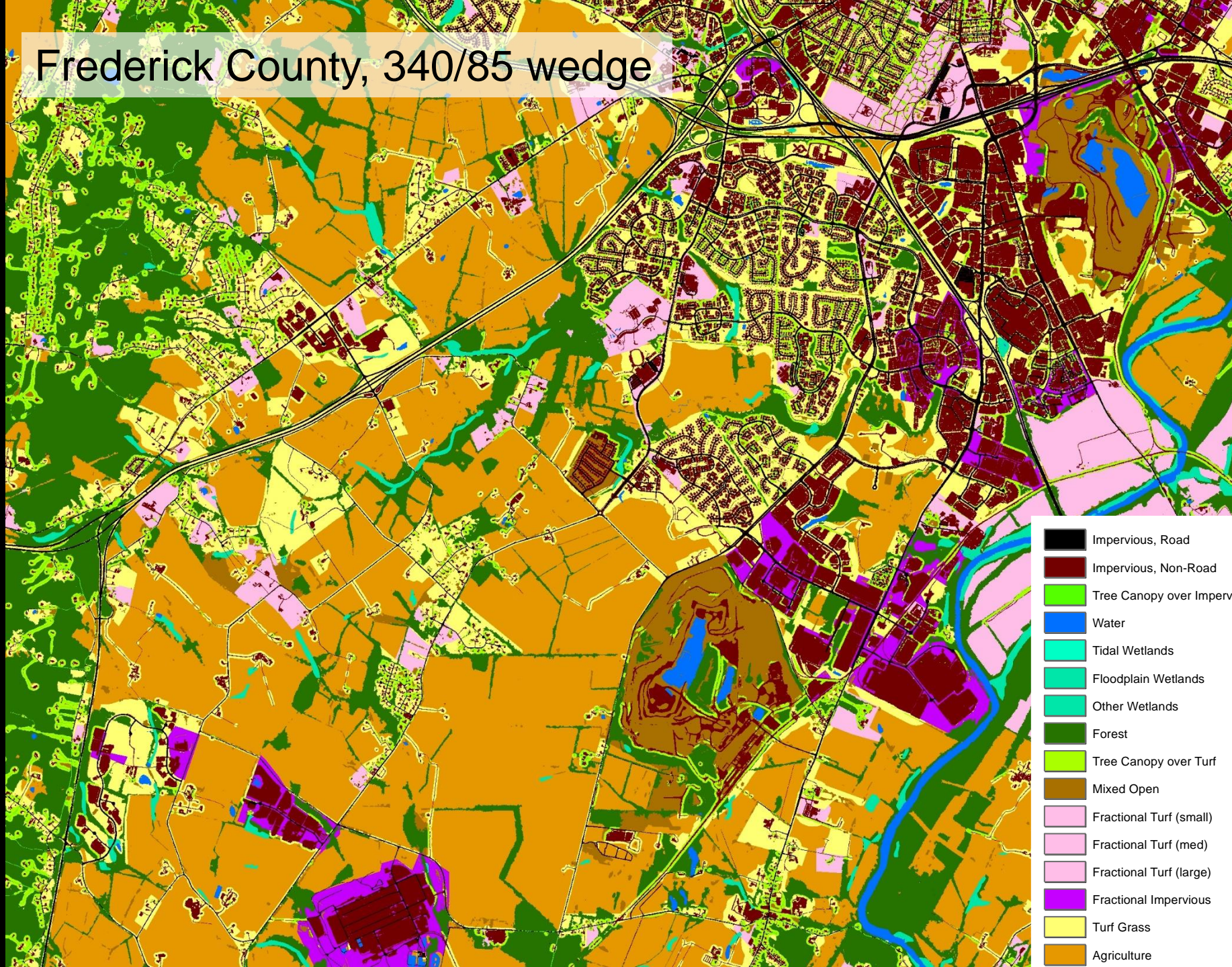
- Roads
- Forests
- Turf Grass
- Cropland

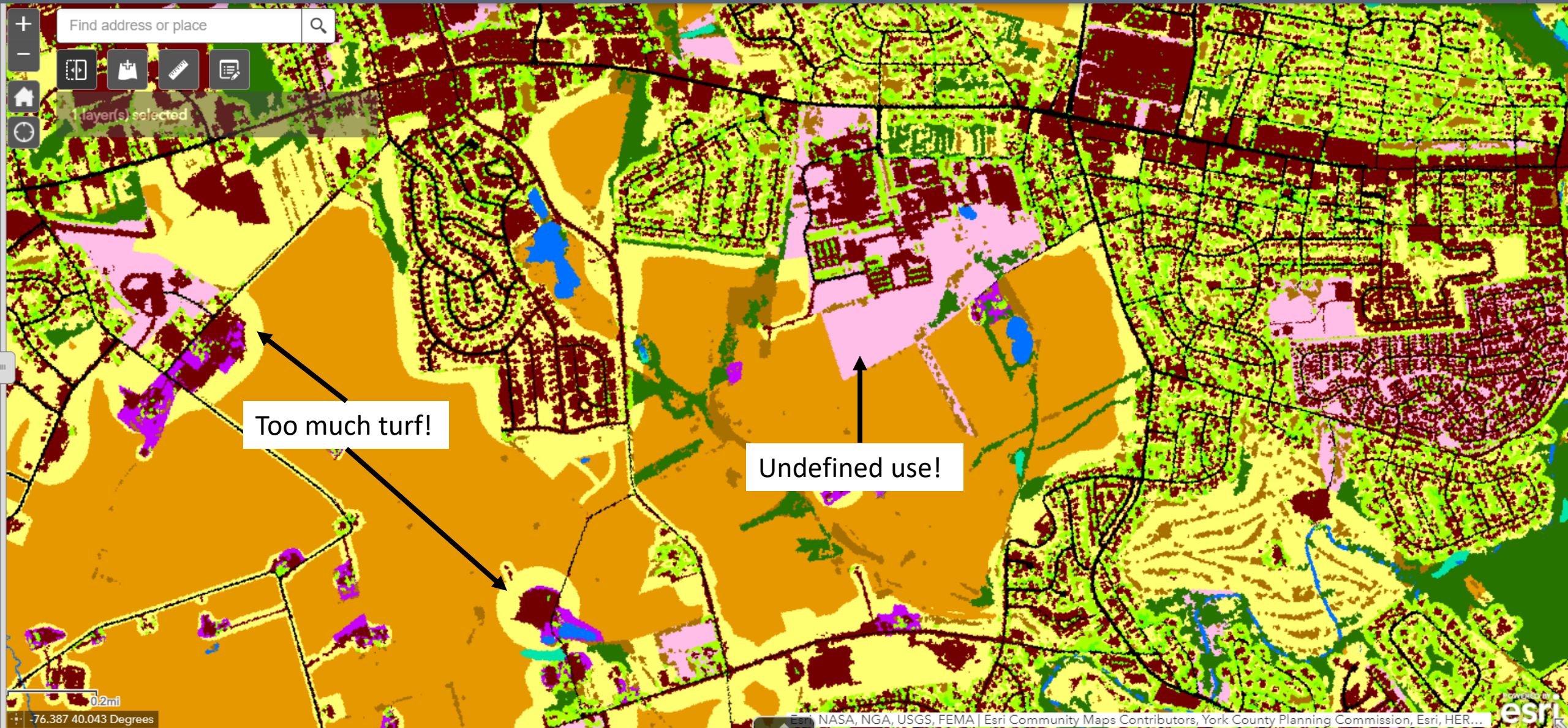
Frederick County, 340/85 wedge



- Water
- Wetlands
- Tree Canopy
- Scrub-shrub
- Low vegetation
- Barren
- Impervious (structures)
- Impervious (other)
- Roads
- Tree Canopy over Structures
- Tree Canopy over Impervious Other
- Tree Canopy over Roads

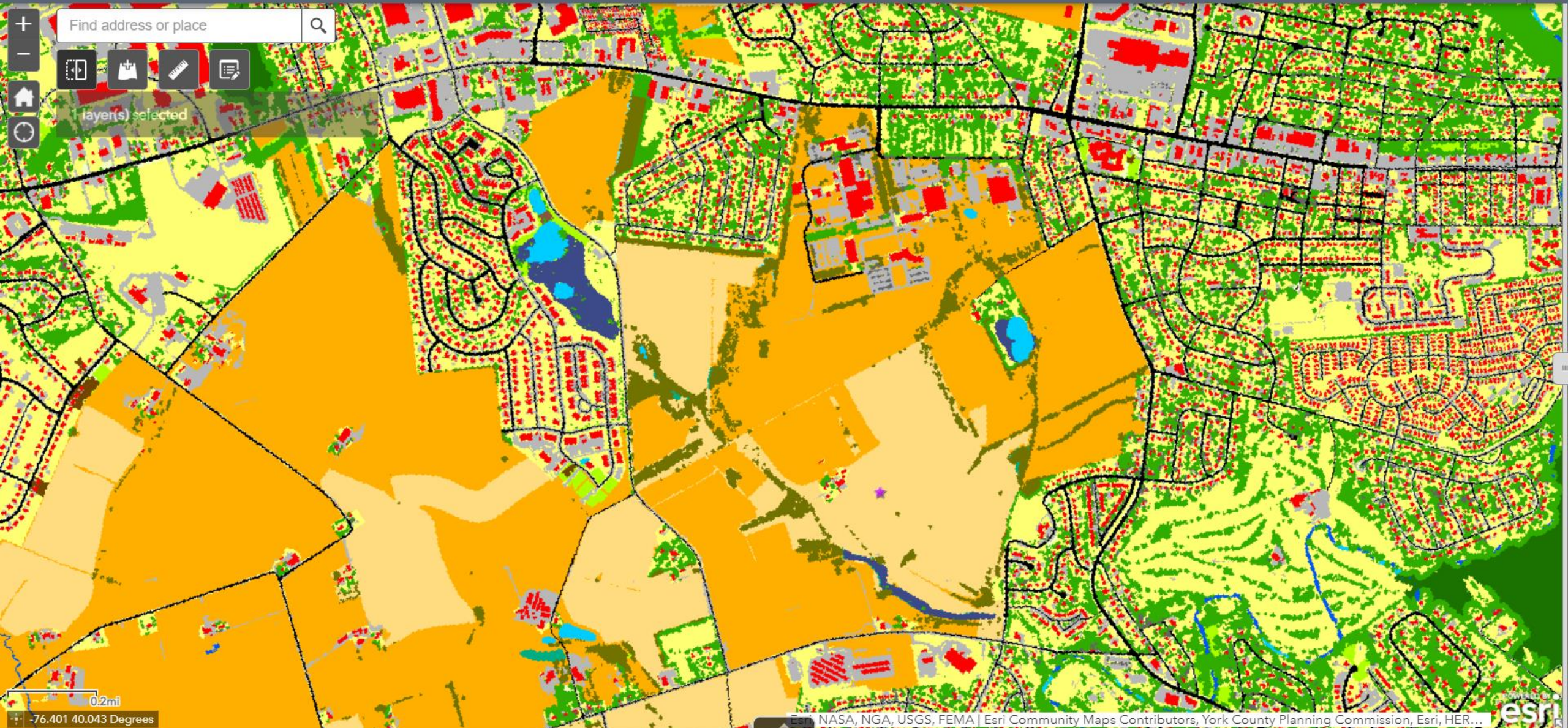
Frederick County, 340/85 wedge





Too much turf!

Undefined use!



CBP Full Land Use/Cover Classification (61 classes, final version)

1. Water (10)

1.1 Lentic

- 1.1.1 Estuary (tidal)
- 1.1.2 Lakes & Ponds

1.2 Lotic

- 1.2.1 Streams
 - 1.2.1.1 Open Channel
 - 1.2.1.2 Tree Canopy over Channel
 - 1.2.1.3 Culverted/ Buried Channel
- 1.2.2 Ditches
 - 1.2.2.1 Open Ditch
 - 1.2.2.2 Tree Canopy over Ditch
 - 1.2.2.3 Culverted/ Buried Ditch

2. Developed (12)

2.1 Impervious

- 2.1.1 Roads
- 2.1.2 Structures
- 2.1.3 Other Impervious (Parking lots, driveways)
- 2.1.4 Tree Canopy (TC) over Impervious
 - 2.1.4.1 TC over Roads
 - 2.1.4.2 TC over Structures
 - 2.1.4.3 TC over Other Impervious

2.2 Pervious

- 2.2.1 Turf Grass
- 2.2.2 Bare Developed
- 2.2.3 Suspended Succession (rights-of-way)
 - 2.2.3.1 Barren
 - 2.2.3.2 Herbaceous
 - 2.2.3.3 Scrub-shrub
- 2.2.4 Tree Canopy over Turf Grass

3. Forest (7)

- 3.1 Forest (≥ 1 acre, 240-ft width)
- 3.2 Tree Canopy in Agriculture
- 3.3 Harvested Forest (≤ 3 years)
 - 3.3.1 Barren
 - 3.3.2 Herbaceous
- 3.4 Natural Succession (> 3 years)
 - 3.4.1 Barren
 - 3.4.2 Herbaceous
 - 3.4.3 Scrub-shrub

4. Production (16)

4.1 Agriculture

- 4.1.1 Cropland
 - 4.1.1.1 Barren
 - 4.1.1.2 Herbaceous
- 4.1.2 Pasture
 - 4.1.2.1 Barren
 - 4.1.2.2 Herbaceous
- 4.1.3 Orchard/vineyard
 - 4.1.3.1 Barren
 - 4.1.3.2 Herbaceous
 - 4.1.3.3 Scrub-shrub
- 4.1.4 Animal Operations (TBD)
 - 4.1.4.1 Impervious
 - 4.1.4.2 Barren
 - 4.1.4.3 Herbaceous

4.2 Solar fields

- 4.2.1 Impervious
- 4.2.2 Pervious
 - 4.2.2.1 Barren
 - 4.2.2.2 Herbaceous
 - 4.2.2.3 Scrub-shrub

4.3 Extractive (active mines)

- 4.3.1 Barren
- 4.3.2 Impervious

5. Wetlands and Water Margins (16)

5.1 Tidal

- 5.1.1 Barren
- 5.1.2 Herbaceous
- 5.1.3 Scrub-shrub
- 5.1.4 Tree Canopy
- 5.1.5 Forest

5.2 Riverine (Non-tidal)

- 5.2.1 Barren
- 5.2.2 Herbaceous
- 5.2.3 Scrub-shrub
- 5.2.4 Tree Canopy
- 5.2.5 Forest

5.3 Terrene/Isolated (Non-tidal)

- 5.3.1 Barren
- 5.3.2 Herbaceous
- 5.3.3 Scrub-shrub
- 5.3.4 Tree Canopy
- 5.3.5 Forest

5.4 Bare shore

CBP 2017 Land Use Classification (25 classes, version 1)

1. Water (3)

1.1 Lentic

- 1.1.1 Estuary (tidal)
- 1.1.2 Lakes & Ponds

1.2 Lotic

- 1.2.1 Streams

2. Developed (8)

2.1 Impervious

- 2.1.1 Roads
- 2.1.2 Structures
- 2.1.3 Other Impervious (Parking lots, driveways)
- 2.1.4 Tree Canopy (TC) over Impervious

2.2 Pervious

- 2.2.1 Turf Grass
- 2.2.2 Bare Developed
- 2.2.3 Suspended Succession (rights-of-way)
- 2.2.4 Tree Canopy over Turf Grass

3. Forest (4)

- 3.1 Forest (≥ 1 acre, 240-ft width)
- 3.2 Tree Canopy in Agriculture
- 3.3 Harvested Forest (≤ 3 years)
- 3.4 Natural Succession (> 3 years)

4. Production (6)

4.1 Agriculture

- 4.1.1 Cropland
- 4.1.2 Pasture
- 4.1.3 Orchard/vineyard

4.2 Solar fields

- 4.2.1 Impervious
- 4.2.2 Pervious

4.3 Extractive (active mines)

5. Wetlands and Water Margins (4)

- 5.1 Tidal
- 5.2 Riverine (Non-tidal)
- 5.3 Terrene/Isolated (Non-tidal)
- 5.4 Bare shore

CBP 2017 Land Use Roll-up to Phase 6 Land Use/Cover Classes

1. Impervious Roads

- 2.1 Impervious
 - 2.1.1 Roads

2. Impervious Non-Roads

- 2.1 Impervious
 - 2.1.2 Structures
 - 2.1.3 Other Impervious
- 4.2 Solar fields
 - 4.2.1 Impervious

3. Tree Canopy Over Impervious

- 2.1 Impervious
 - 2.1.4 Tree Canopy over Impervious

4. Turf Grass

- 2.2 Pervious, Developed
 - 2.2.1 Turf Grass

5. Tree Canopy over Turf Grass

- 2.2 Pervious, Developed
 - 2.2.4 Tree Canopy over Turf Grass

6. Forest

- 3.1 Forest (≥ 1 acre, 240-ft width)
- 3.2 Tree Canopy in Agriculture

7. Wetlands, Floodplain

- 5.2 Riverine, Wetlands

8. Wetlands, Other

- 5.3 Terrene/Isolated, Wetlands

9. Wetlands, Tidal

- 5.1 Tidal, Wetlands

10. Mixed Open

- 2.2 Pervious, Developed
 - 2.2.2 Bare Developed
 - 2.2.3 Suspended Succession
- 3.3 Harvested Forest (≤ 3 years)
- 3.4 Natural Succession (> 3 years)
- 4.2 Solar fields
 - 4.2.2 Pervious
- 4.3 Extractive (active mines)
- 5.4 Bare shore, Water Margins

11. Cropland

- 4.1 Agriculture
 - 4.1.1 Cropland
 - 4.1.3 Orchard/vineyard

12. Pasture

- 4.1 Agriculture
 - 4.1.2 Pasture

13. Water

- 1.1 Lentic
 - 1.1.1 Estuary (tidal)
 - 1.1.2 Lakes & Ponds
- 1.2 Lotic
 - 1.2.1 Streams

One-meter Resolution Land Use Products for CAST

CAST-17, CAST-19: 2013/14 Land Use

Focus: producing a consistent 13 class land use dataset that rolls up to the 13 Phase 6 mapped classes.

Methodology: raster-based decision rules implemented by USGS using python in ESRI's ArcGIS software on CBPO's GIS workstations.

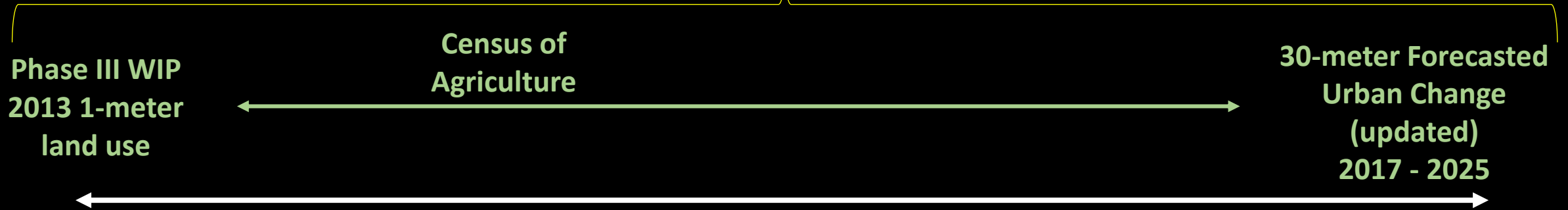
CAST-21: Land Use Change from 2013/14 to 2017/18

Focus: producing a temporally consistent 60+ class land use change dataset that rolls up to the 13 Phase 6 mapped classes. Additional classes required to correctly interpret changes over time.

Methodology: vector-based decision rules implemented by CIC using python and open-source algorithms within a cloud infrastructure. The vector approach enables spatially refined mapping of land uses based on land cover, image segments, tax parcels, USDA's Cropland Data Layer and USGS' Land Change Monitoring, Assessment, and Projection data.

CAST-19

CBPO-estimated annual Feeding
Space and Double Crop acres
+
State-reported annual
Construction &
Timber harvest acres



Phase III WIP
2013 1-meter
land use

Census of
Agriculture

30-meter Forecasted
Urban Change
(updated)
2017 - 2025

2013

2017

2025

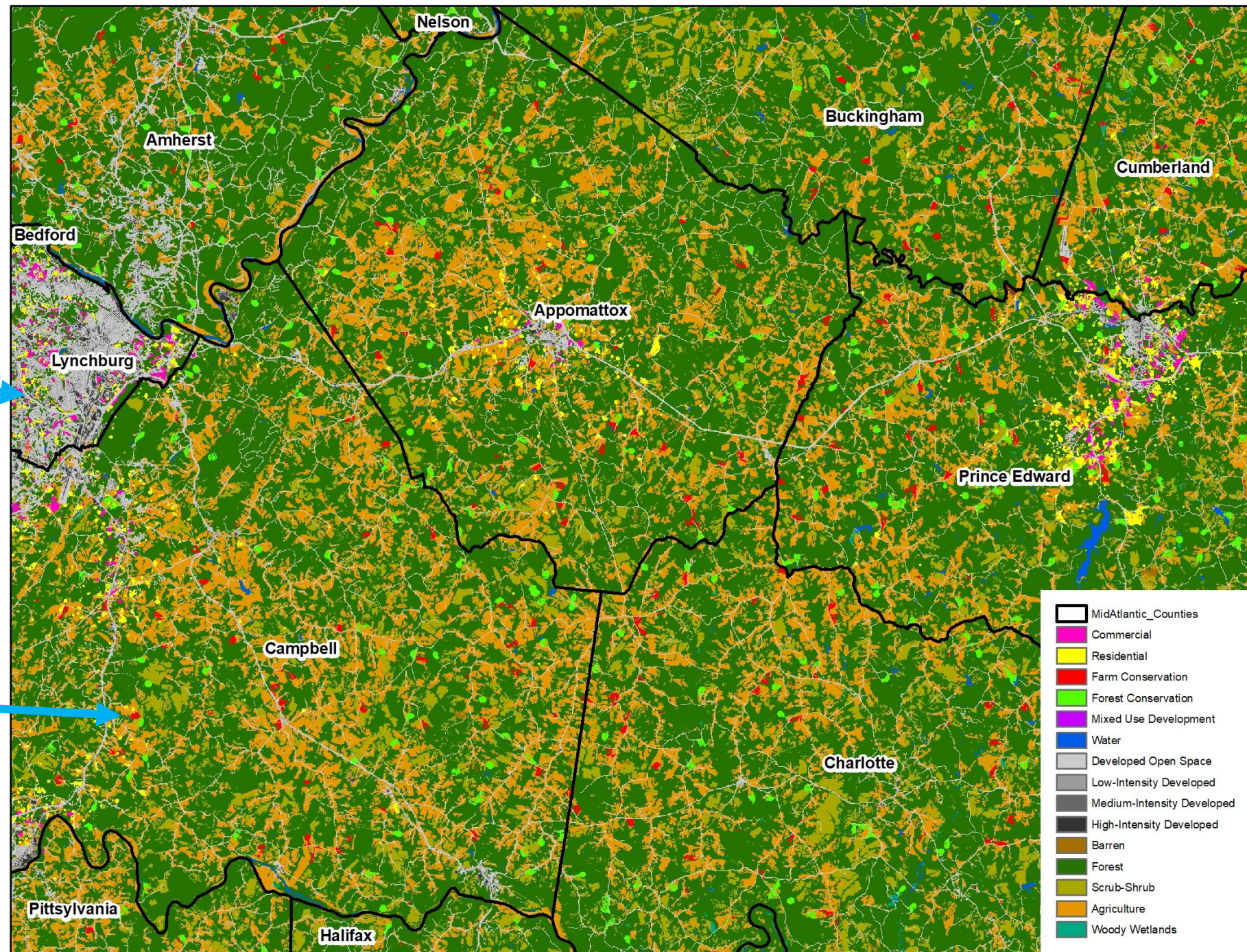
Urban land interpolated between
2013 and 2025, Agricultural land
trends and crop composition
determined by the Census of
Agriculture.

Forecasted Urban Growth

Commercial  and Residential  Growth



Farmland  and Forest  Conservation



CBP 2025 Forecasted Land Use Allocated to Phase 6 Classes

CBLCM* Classes

Phase 6 Classes

Non-Changing Classes:

Impervious

- 1. Impervious Roads
- 2. Impervious Non-Roads
- 3. Tree Canopy Over Impervious

9. Tidal, Wetlands

13. Water

Turf Grass

→ 4. Turf Grass

Tree Canopy over Turf Grass

→ 5. Tree Canopy over Turf Grass

Woodland Conversion

- 6. Forest
- 7. Wetlands, Floodplain
- 8. Wetlands, Other

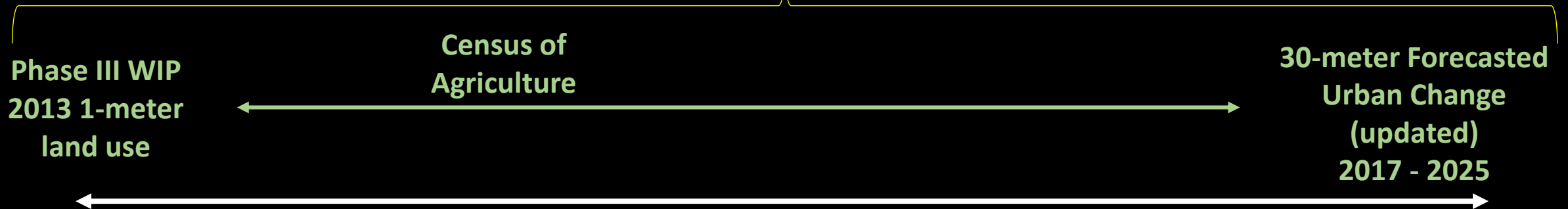
Open Space Conversion
& Expansion

- 10. Mixed Open
- 11. Cropland
- 12. Pasture

* Chesapeake Bay Land Change Model (CBLCM)

CAST-19

CBPO-estimated annual Feeding
Space and Double Crop acres
+
State-reported annual
Construction &
Timber harvest acres



2013

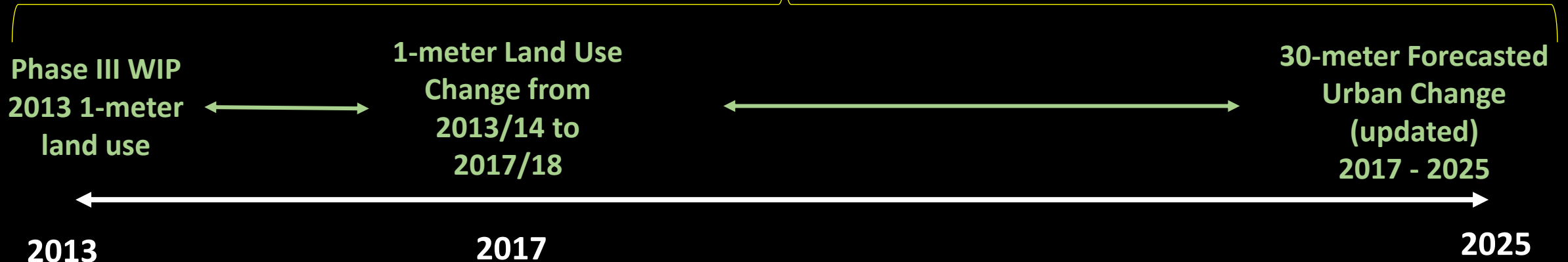
2017

2025

Urban land interpolated between
2013 and 2025, Agricultural land
trends and crop composition
determined by the Census of
Agriculture.

CAST-21

CBPO-estimated annual Feeding
Space and Double Crop acres
+
State-reported annual
Construction &
Timber harvest acres

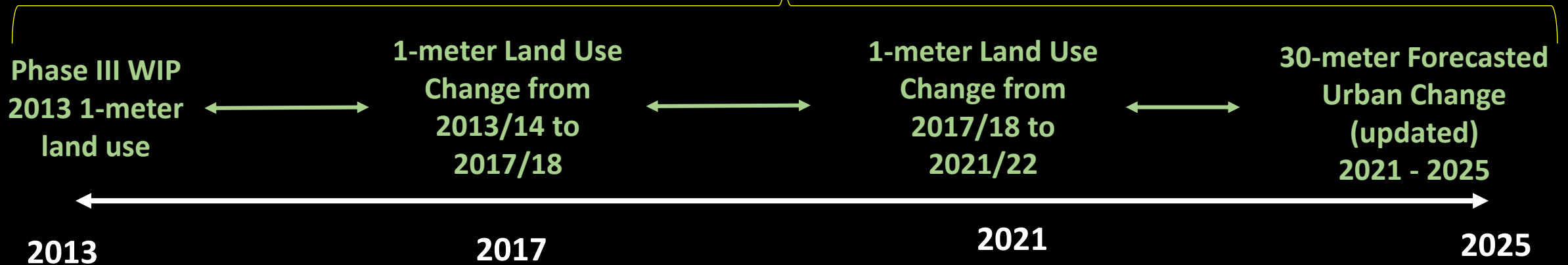


Land uses change as observed in aerial imagery; crop composition changes as reported in Census of Agriculture

Urban and agricultural lands change due to modeled urban development; crop composition changes as extrapolated from the Census of Agriculture

CAST-23

CBPO-estimated annual Feeding
Space and Double Crop acres
+
State-reported annual
Construction &
Timber harvest acres



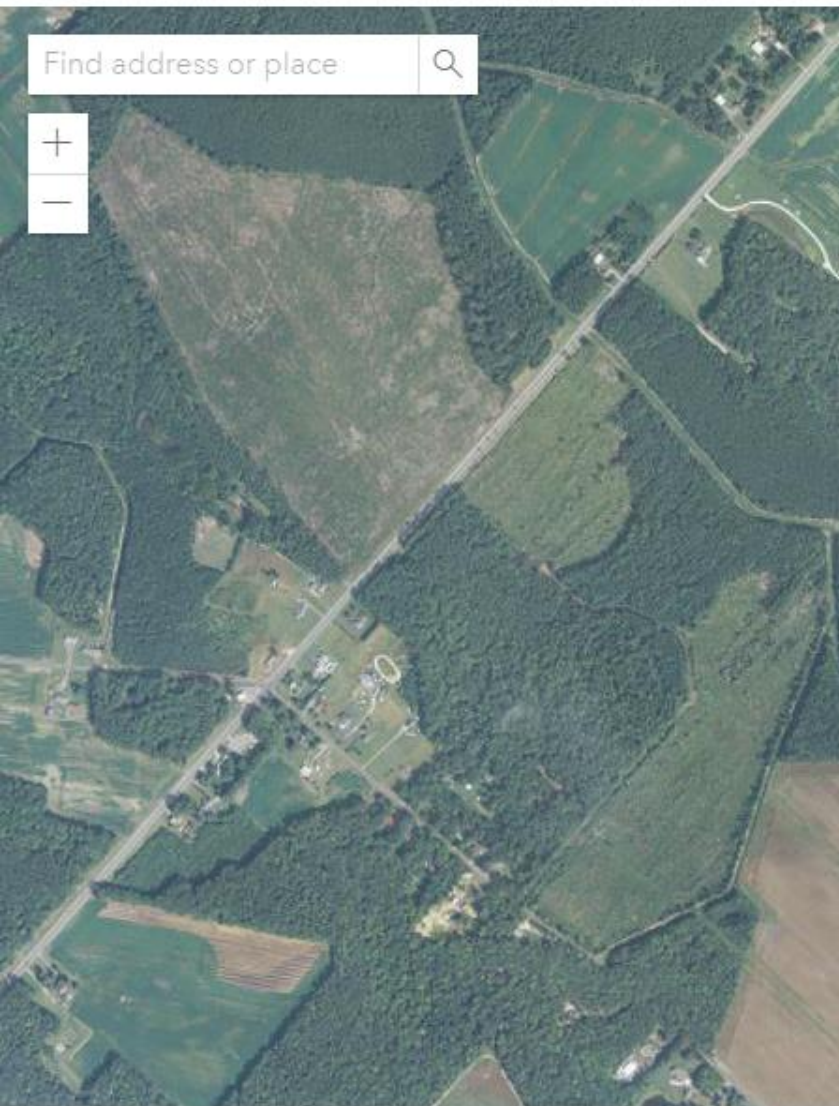
Land uses change as observed in aerial imagery; crop composition changes as reported in Census of Agriculture

Urban and agricultural lands change due to modeled urban development; crop composition changes as extrapolated from the Census of Agriculture

NAIP 2013/2014

NAIP 2017/2018

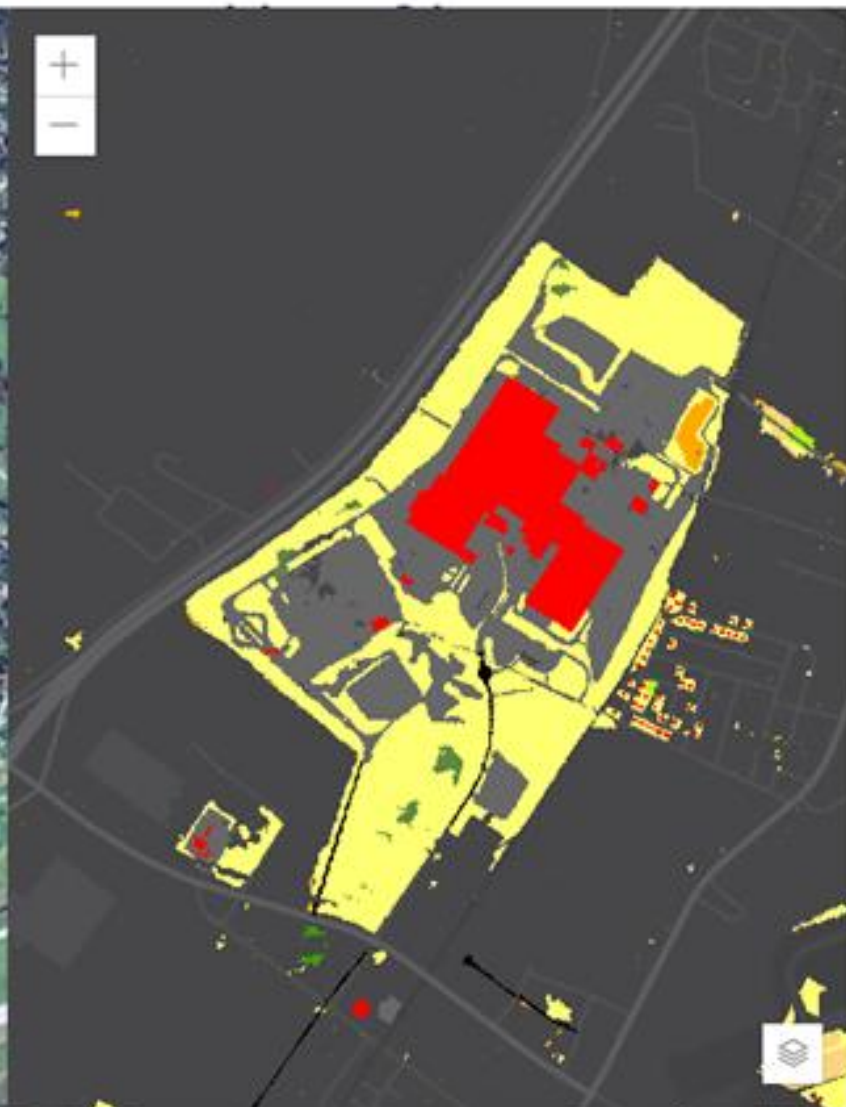
NAIP 17/18 and Land



NAIP 2013/2014

NAIP 2017/2018

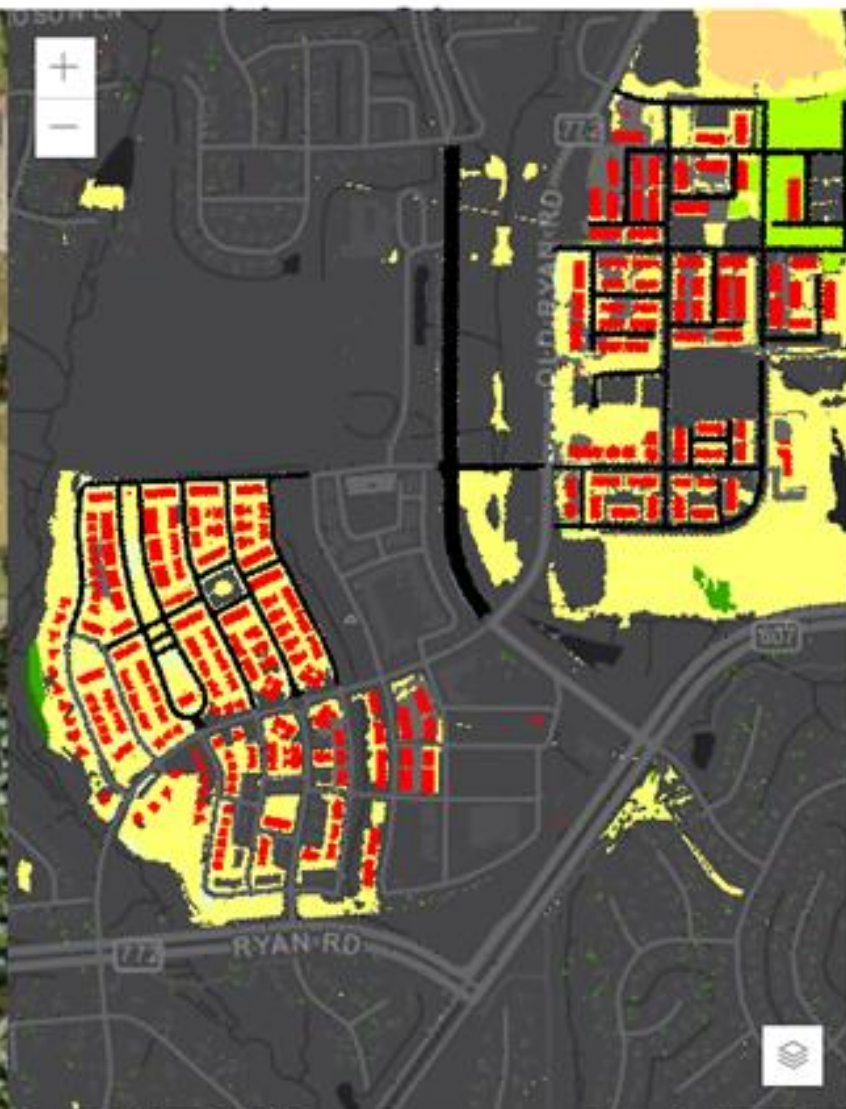
NAIP 17/18 and Land



NAIP 2013/2014

NAIP 2017/2018

NAIP 17/18 and Land



Four Land Change Products

2013/14 - 2017/18

Land Cover Change: derived from aerial imagery for two time periods, only changed areas are mapped

Land Use Change (Slow method): derived from differencing maps of complete, wall-to-wall, land use data for two time periods.

Land Use Change (Quick method- draft 2017LU): derived from Land Cover Change data, only changed areas are mapped, process is informed by the initial draft 2017 land use posted on web app.

Land Use Change (Quick method- revision#1 2017LU): derived from Land Cover Change data, only changed areas are mapped, process is informed by the first revision of the 2017 land use in response to comments on the draft.

Quick Methods Compared: Draft (oldLU) vs Revision #1 2013/14 - 2017/18

Wicomico, MD		CRP	FOR	INR	IR	MO	PAS	TCI	TCT	TG	WAT
Quick Method, oldLU	LOSS	582	1,592	90	5	3,693	50	52	317	568	8
	GAIN	1,674	3,101	638	19	53	89	0	555	824	3
	NET	1,093	1,509	548	15	(3,640)	39	(52)	239	256	(6)
Quick Method, rev1LU	LOSS	499	1,620	89	5	3,018	25	52	262	460	8
	GAIN	1,489	2,397	637	20	258	71	0	454	710	3
	NET	990	777	547	15	(2,760)	45	(52)	192	249	(5)
Clearfield, PA		CRP	FOR	INR	IR	MO	PAS	TCI	TCT	TG	WAT
Quick Method, oldLU	LOSS	75	4,712	191	7	3,543	205	63	592	407	3
	GAIN	669	920	819	2	4,539	1,442	20	426	955	7
	NET	593	(3,792)	629	(5)	996	1,237	(43)	(166)	547	4
Quick Method, rev1LU	LOSS	43	5,042	191	7	3,687	76	63	337	331	3
	GAIN	682	920	820	2	4,495	1,453	20	426	955	7
	NET	639	(4,122)	629	(5)	809	1,377	(43)	89	624	4
Loudoun, VA		CRP	FOR	INR	IR	MO	PAS	TCI	TCT	TG	WAT
Quick Method, oldLU	LOSS	104	1,886	438	54	8,332	71	95	1,812	886	2
	GAIN	318	450	2,841	504	1,462	1,276	153	469	6,187	19
	NET	214	(1,436)	2,404	450	(6,869)	1,204	57	(1,343)	5,302	17
Quick Method, rev1LU	LOSS	26	2,396	438	54	8,601	53	87	1,310	670	2
	GAIN	366	445	2,842	504	1,327	1,277	153	471	6,233	19
	NET	340	(1,951)	2,404	450	(7,274)	1,224	66	(839)	5,563	17

CRP = cropland
FOR = forest
INR = imperv non-road
IR = impervious road
MO = mixed open
PAS = pasture
TCI = tree canopy over impervious
TCT = tree canopy over turf grass
TG = turf gras
WAT = water

Units = acres

Land Use Change vs Land Cover Change

Clearfield County, PA

2013/14 (rows), 2017/18 (columns), units = acres

Land Use

2013/14 Land Use	Cropland	Forest	Impervious Non-Roads	Impervious Roads	Mixed Open	Pasture	Tree Canopy Over Impervious	Tree Canopy over Turf Grass	Turf Grass	Water	Loss (from)
Cropland	0.67	2.66	35.35	-	2.36	2.36	-	0.22	0.17	-	43.11
Forest	70.76	1.30	308.22	0.50	4,150.57	144.56	-	0.10	367.43	-	5,042.15
Impervious Non-Roads	2.23	0.26	16.61	0.37	127.57	9.79	12.99	0.17	37.33	-	190.72
Impervious Roads	-	0.60	0.22	-	0.04	-	6.49	0.14	-	-	7.49
Mixed Open	593.67	908.36	245.70	0.25	2,099.47	1,275.24	0.10	203.20	452.84	7.14	3,686.51
Pasture	7.41	7.15	50.45	1.02	9.71	-	-	0.18	0.49	-	76.40
Tree Canopy Over Impervious	0.39	-	2.90	0.00	38.07	0.32	-	-	21.31	-	62.98
Tree Canopy over Turf Grass	5.97	0.00	88.81	0.00	149.69	16.97	-	-	75.52	-	336.97
Turf Grass	1.51	0.71	87.86	0.00	17.36	3.99	-	219.89	-	-	331.32
Water	-	0.59	-	-	-	-	-	2.13	-	-	2.72
Gain (To)	681.94	920.34	819.52	2.14	4,495.38	1,453.22	19.57	426.02	955.09	7.14	9,780.37

Land Cover Change

	Water	Wetlands	Tree Canopy	Shrub-scrub	Low Vegetation	Barren	Structures	Other Impervious	Roads	TC over Structures	TC over Other Imp	TC over Roads	Total Change
Water	6,253	-	3	-	-	-	-	-	-	-	-	-	3
Wetlands	-	3,395	1	-	-	2	0	2	-	-	-	-	5
Tree Canopy	-	-	528,380	-	4,116	797	40	301	0	-	-	-	5,254
Shrub-scrub	-	-	304	9,204	-	26	1	6	-	-	-	-	337
Low Vegetation	-	-	889	-	159,820	602	39	421	1	-	-	-	1,952
Barren	-	-	8	-	1,853	3,598	0	-	-	-	-	-	1,861
Structures	-	-	0	-	5	-	2,428	6	-	3	-	-	14
Other Impervious	-	-	0	-	142	33	11	7,663	0	-	10	-	197
Roads	-	-	1	-	0	-	-	0	5,862	-	-	6	7
TC over Structures	-	-	-	-	9	0	-	0	-	133	-	-	9
TC over Other Imp	-	-	-	-	19	1	2	0	-	-	615	-	22
TC over Roads	-	-	-	-	33	0	0	0	0	-	-	1,372	33
Total Change	-	-	1,207	-	6,176	1,460	93	736	2	3	10	6	9,693

Land Use Change vs Land Cover Change Clearfield County, PA

Land Use

2013/14 Land Use	Cropland	Forest	Impervious Non-Roads	Impervious Roads	Mixed Open	Pasture	Tree Canopy Over Impervious	Tree Canopy over Turf Grass	Turf Grass	Water	Loss (from)
Cropland	0.67	2.66	35.35	-	2.36	2.36	-	0.22	0.17	-	43.11
Forest	70.76	1.30	308.22	0.50	4,150.57	144.56	-	0.10	367.43	-	5,042.15
Impervious Non-Roads	2.23	0.26	16.61	0.37	127.57	9.79	12.99	0.17	37.33	-	190.72
Impervious Roads	-	0.60	0.22	-	0.04	-	6.49	0.14	-	-	7.49
Mixed Open	593.67	908.36	245.70	0.25	2,099.47	1,275.24	0.10	203.20	452.84	7.14	3,686.51
Pasture	7.41	7.15	50.45	1.02	9.71	-	-	0.18	0.49	-	76.40
Tree Canopy Over Impervious	0.39	-	2.90	0.00	38.07	0.32	-	-	21.31	-	62.98
Tree Canopy over Turf Grass	5.97	0.00	88.81	0.00	149.69	16.97	-	-	75.52	-	336.97
Turf Grass	1.51	0.71	87.86	0.00	17.36	3.99	-	219.89	-	-	331.32
Water	-	0.59	-	-	-	-	-	2.13	-	-	2.72
Gain (To)	681.94	920.34	819.52	2.14	4,495.38	1,453.22	19.57	426.02	955.09	7.14	9,780.37

Land Cover Change

	Water	Wetlands	Tree Canopy	Shrub-scrub	Low Vegetation	Barren	Structures	Other Impervious	Roads	TC over Structures	TC over Other Imp	TC over Roads	Total Change
Water	6,253	-	3	-	-	-	-	-	-	-	-	-	3
Wetlands	-	3,395	1	-	-	2	0	2	-	-	-	-	5
Tree Canopy	-	-	528,380	-	4,116	797	40	301	0	-	-	-	5,254
Shrub-scrub	-	-	304	9,204	-	26	1	6	-	-	-	-	337
Low Vegetation	-	-	889	-	159,820	602	39	421	1	-	-	-	1,952
Barren	-	-	8	-	1,853	3,598	0	-	-	-	-	-	1,861
Structures	-	-	0	-	5	-	2,428	6	-	3	-	-	14
Other Impervious	-	-	0	-	142	33	11	7,663	0	-	10	-	197
Roads	-	-	1	-	0	-	-	0	5,862	-	-	6	7
TC over Structures	-	-	-	-	9	0	-	0	-	133	-	-	9
TC over Other Imp	-	-	-	-	19	1	2	0	-	-	615	-	22
TC over Roads	-	-	-	-	23	0	0	0	0	-	-	1,372	33
Total Change	-	-	1,207	-	6,176	1,460	93	736	2	3	10	6	9,693

Timeline for 2013 - 2017 Land Use Change Review for CAST-21

May – June 2021

- May 5: LUWG discusses 2013-2017 land use change data, methodology, and how these data are incorporated into CAST.
- May 5 – May 19: Sector workgroups (AGWG, USWG, FWG) review 2013-2017 land use change in the 14 prototype counties. Data will be available to review online through a web application built by the Chesapeake Conservancy's Conservation Innovation Center's (CIC).
- May 20: AGWG meets to discuss comments on the land use change data. LUWG meets to review comments from sector workgroups on the land use change data and makes recommendation to the WQGIT on the quality of the data.
- May 24: WQGIT decision: approval of method for using 2013 – 2017 land use change data in CAST as implemented in the 14 prototype counties.
- Jun 30: CIC completes the 2013-2017 land use change dataset for all Bay watershed counties using corrected land cover data from UVM and revised 2017 land use data to fix all systematic errors.



science for a changing world