Monitoring Very-High Resolution Land Use/Land Cover Change

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11 Mar 2022 |Metropolitan Washington Council of Governments Meeting

What is Land Cover/Land Use?

- **Land cover describes the physical land surface** (e.g., tree canopy, open water, low vegetation)

- Land cover is classified using satellite/aerial imagery, digital elevation data, and building footprints. The pixels within the imagery are grouped and segmented into "objects" that get classified.

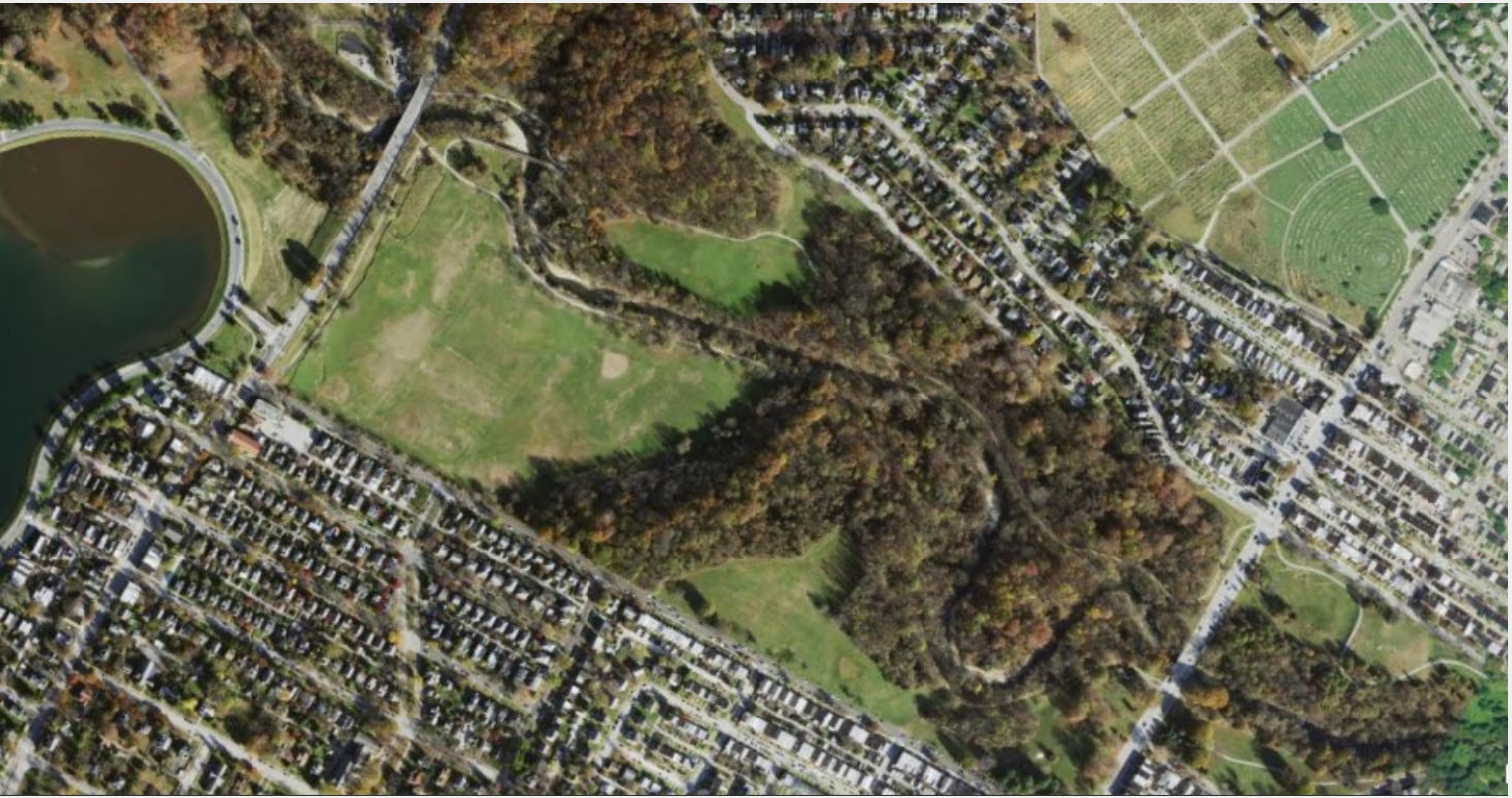
- The 2017/18 land cover data were produced by the University of Vermont team after preliminary data was reviewed by local stakeholders, LUWG, and other Chesapeake Bay Program partners. Feedback was used to revise classification protocols and re-classify the landscape.

- **Land use indicates how people make use of the land** (e.g., cropland, recreation, solar)

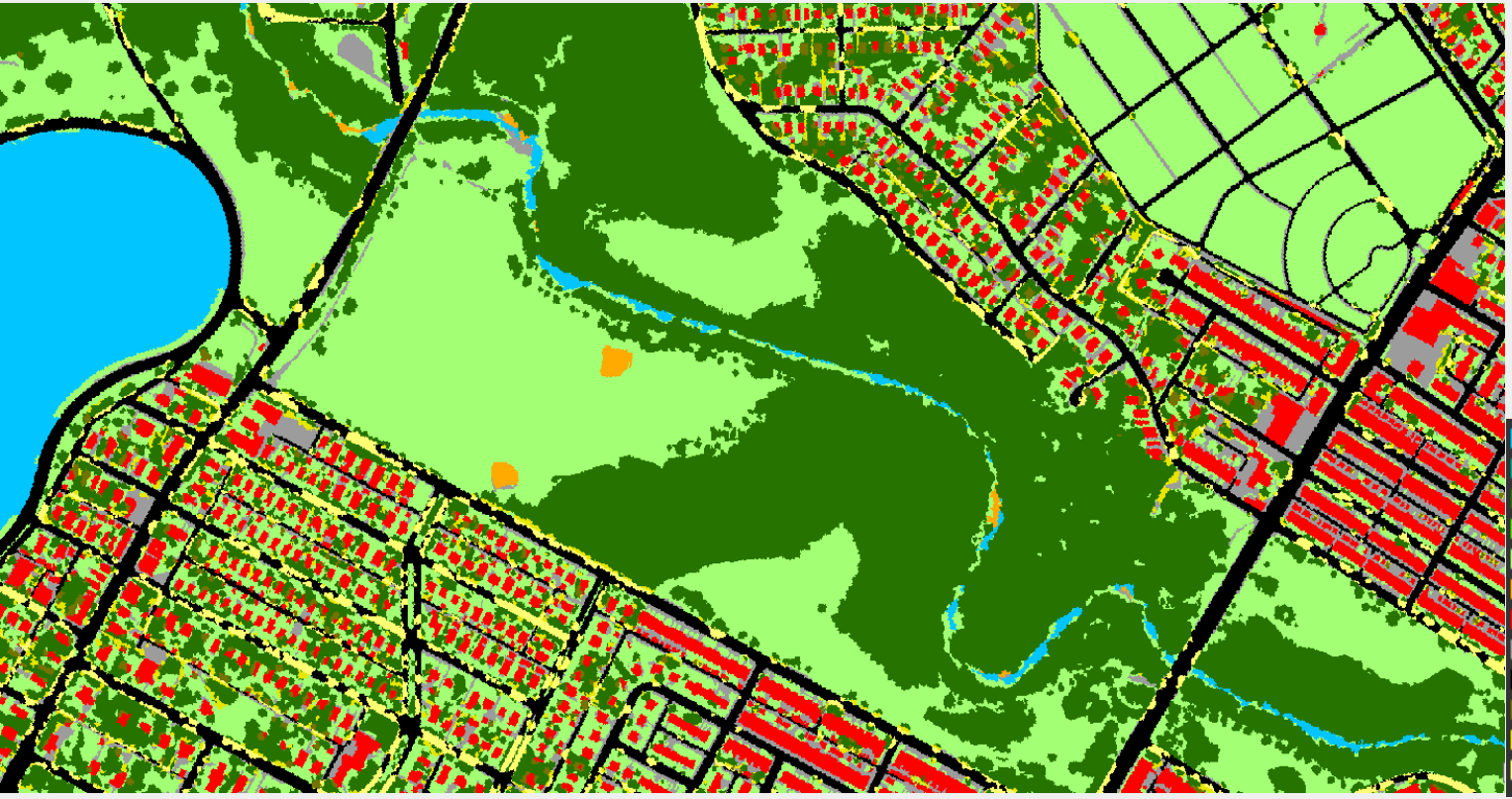
- Land use is derived from land cover data using ancillary data to translate physical land features into nuanced classes indicating the type of human activities on the land.

- The 2017/18 land use data are being produced by Chesapeake Conservancy in partnership with staff at USGS. Preliminary data was reviewed by Chesapeake Bay Program partners; feedback was used to revise the decision rules and protocols used to produce the classification.

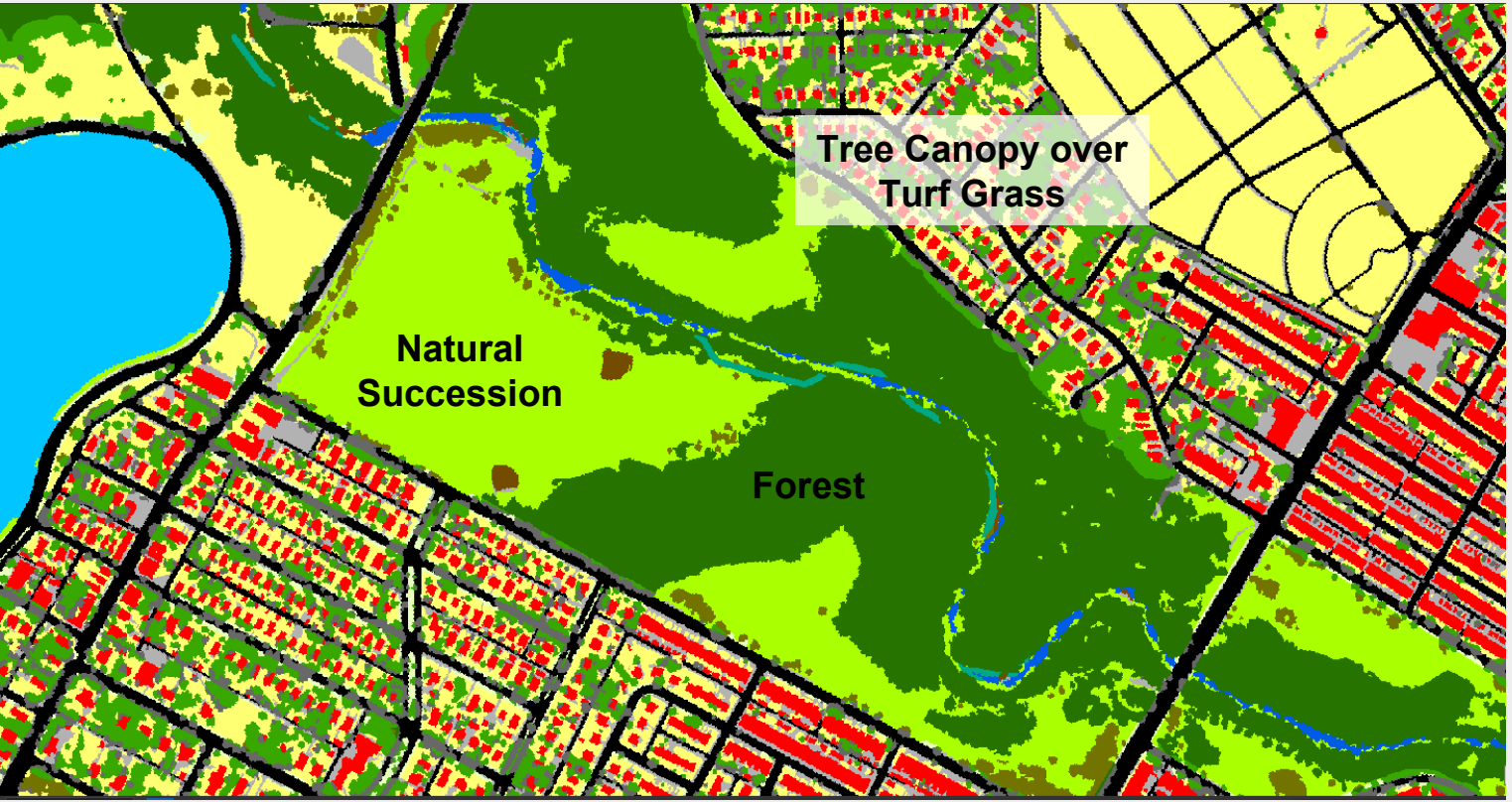
2017/18 Aerial Imagery (USDA's NAIP)



2017/18 Land Cover (12 class, Baltimore City)



2017/18 Land Use/Land Cover (18 class, Baltimore City)



- Water
- Tree Canopy
- Scrub-Shrub
- Herbaceous
- Bare Developed
- Structures
- Other Impervious
- Impervious Roads
- Lakes/Ponds
- Tree Canopy over Roads
- Tree Canopy over Structures
- Tree Canopy over Other Impervious
- Turf Grass
- Suspended Succession- Barren
- Suspended Succession- Herbaceous
- Suspended Succession- Scrub/shrub
- Tree Canopy over Turf Grass
- Forest
- Tree Canopy in Agriculture
- Harvested Forest- Barren
- Harvested Forest- Herbaceous
- Natural Succession- Barren
- Natural Succession- Herbaceous
- Natural Succession- Scrub/shrub
- Cropland- Barren
- Cropland- Herbaceous
- Cropland- Scrub/shrub
- Orchard/Vineyard- Herbaceous
- Pasture/Hay- Herbaceous
- Wetland

CBP Land Use/Cover Classification (62 planned for 2021/22, 54 classes mapped for 2017/18)

- **1. Water (11)**
  - 1.1 Estuarine/ Marine
  - 1.2 Lentic (fresh)
    - 1.2.1 Lakes and reservoirs
    - 1.2.2 Riverine ponds
    - 1.2.3 Terrene ponds
  - 1.3 Lotic
    - 1.3.1 Channels
      - 1.3.1.1 Open Channel
      - 1.3.1.2 Tree Canopy over Channel
      - 1.3.1.3 Culverted
    - 1.3.2.Ditches
      - 1.3.2.1 Open Ditch
      - 1.3.2.2 Tree Canopy over Ditch
      - 1.3.2.3 Culverted
- **2. Development (12)**
  - 2.1 Impervious
    - 2.1.1 Roads
    - 2.1.2 Structures
    - 2.1.3 Other Impervious
    - 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 Transitional- barren
    - 2.2.3 Suspended Succession
      - 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. Natural (forest-related) (7)**
  - 3.1 Forest (>= 1 acre, 240-ft width)
  - 3.2 Other Tree Canopy
  - 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 (17)**
  - 4.1 Agriculture
    - 4.1.1 Cropland
      - 4.1.1.1 Barren
      - 4.1.1.2 Herbaceous
    - 4.1.2 Pasture/Hay
      - 4.1.2.1 Barren
      - 4.1.2.2 Herbaceous
      - 4.1.2.3 Scrub-shrub
    - 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
      - 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 Other 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 Other 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 Other Tree Canopy
    - 5.3.5 Forest
  - 5.4 Bare shore

Note: White, yellow, and blue classes are mapped for 2017/18. Grey classes will be added to all years with the production of the 2021/22 LULC.

Proposed Generalized Land Use (18 classes)

1. Impervious, Roads
- 2.1 Impervious
  - 2.1.1 Roads

2. Impervious, Structures
- 2.1 Impervious
  - 2.1.2 Structures

2. Impervious, Other
- 2.1 Impervious
  - 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. Pervious Developed, Other
- 2.2 Pervious. Developed
  - 2.2.2 Transitional- barren
  - 2.2.3 Suspended Succession
- 4.2 Solar fields
  - 4.2.2 Pervious

7. Forest
- 3.1 Forest (>= 1 acre, 240-ft width)
- 5.1 Tidal
  - 5.1.5 Forest (>= 1 acre, 240-ft width)
- 5.2 Riverine (Non-tidal)
  - 5.2.5 Forest (>= 1 acre, 240-ft width)
- 5.3 Terrene/Isolated (Non-tidal)
  - 5.3.5 Forest (>= 1 acre, 240-ft width)

8. Tree Canopy, Other
- 3.2 Other Tree Canopy
- 5.1 Tidal
  - 5.1.4 Other Tree Canopy
- 5.2 Riverine (Non-tidal)
  - 5.2.4 Other Tree Canopy
- 5.3 Terrene/Isolated (Non-tidal)
  - 5.3.4 Other Tree Canopy

9. Harvested Forest
- 3.3 Harvested Forest (<= 3 years)

10. Natural Succession
- 3.4 Natural Succession (> 3 years)
- 5.4 Bare shore, Water Margins

11. Wetlands, Tidal non-forested
- 5.1 Tidal Wetlands
  - 5.1.1 Barren
  - 5.1.2 Herbaceous
  - 5.1.3 Scrub-shrub

12. Wetlands, Riverine Non-forested
- 5.2 Riverine Wetlands (Non-tidal)
  - 5.1.1 Barren
  - 5.1.2 Herbaceous
  - 5.1.3 Scrub-shrub

13. Wetlands, Terrene Non-forested
- 5.3 Terrene/Isolated Wetlands (Non-tidal)
  - 5.1.1 Barren
  - 5.1.2 Herbaceous
  - 5.1.3 Scrub-shrub

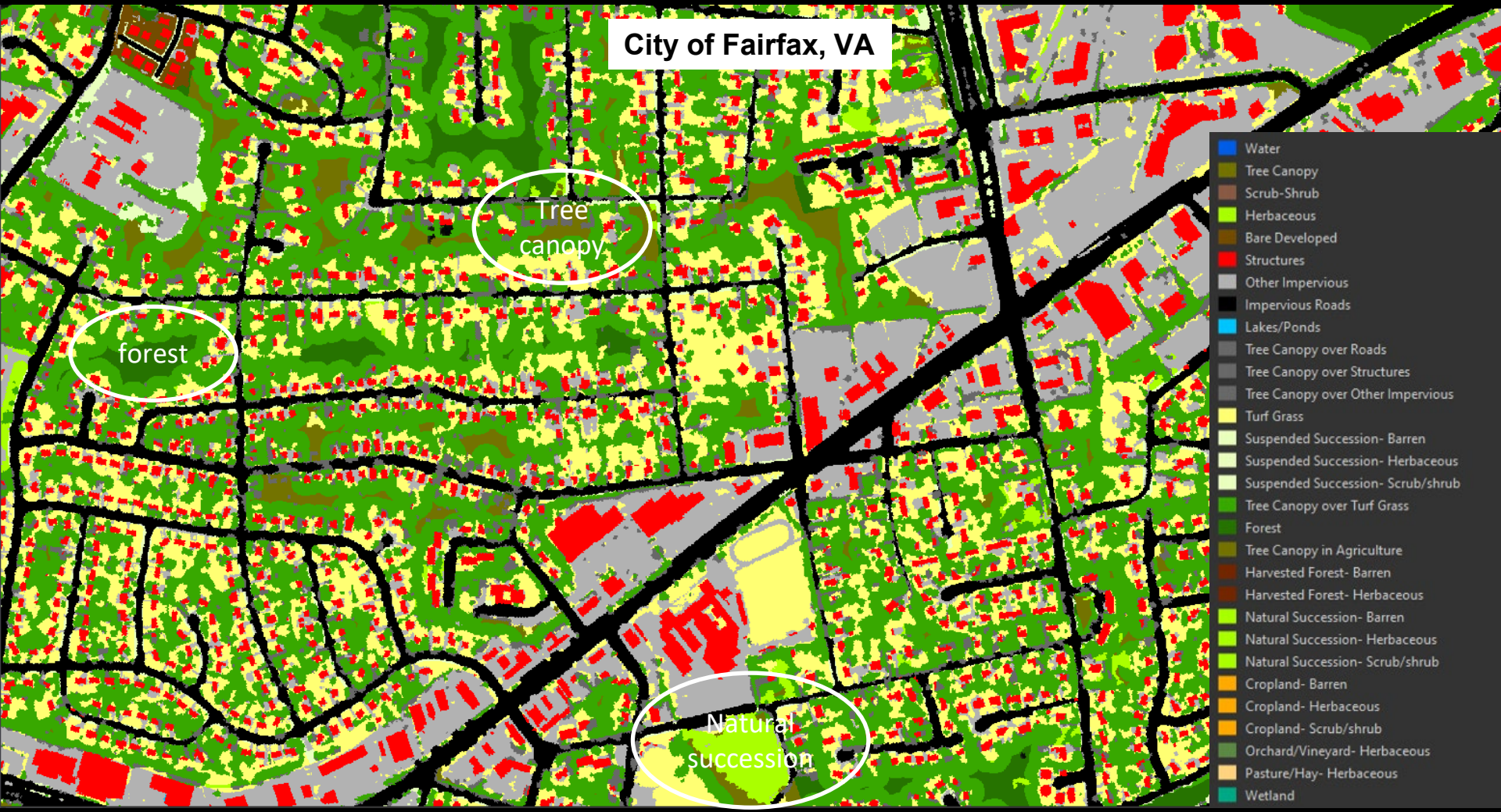
14. Extractive
- 4.3 Extractive (active mines)
  - 4.3.1 Barren
  - 4.3.2 Impervious

15. Cropland
- 4.1 Agriculture
  - 4.1.1 Cropland
  - 4.1.3 Orchard/vineyard

16. Pasture/Hay
- 4.1 Agriculture
  - 4.1.2 Pasture/Hay

17. Water
- 1.1 Estuarine/ Marine
- 1.2 Lentic
- 1.3 Lotic


City of Fairfax, VA


City of Fairfax, VA
Tree canopy
forest
Natural succession
Water
Tree Canopy
Scrub-Shrub
Herbaceous
Bare Developed
Structures
Other Impervious
Impervious Roads
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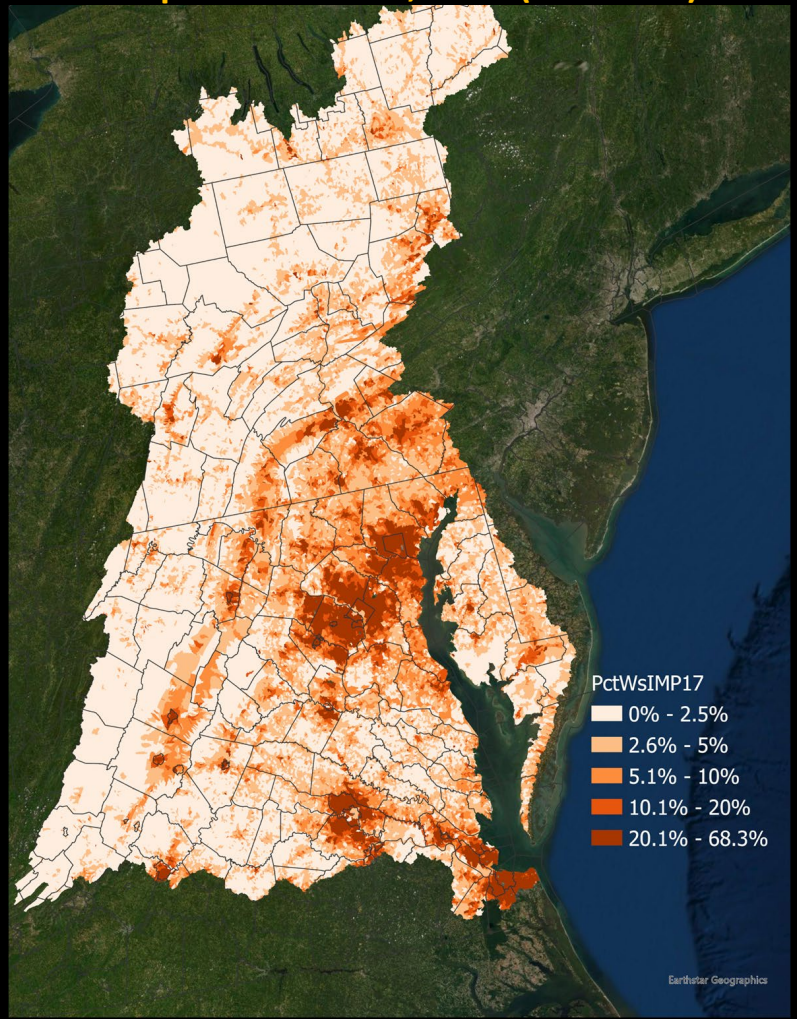
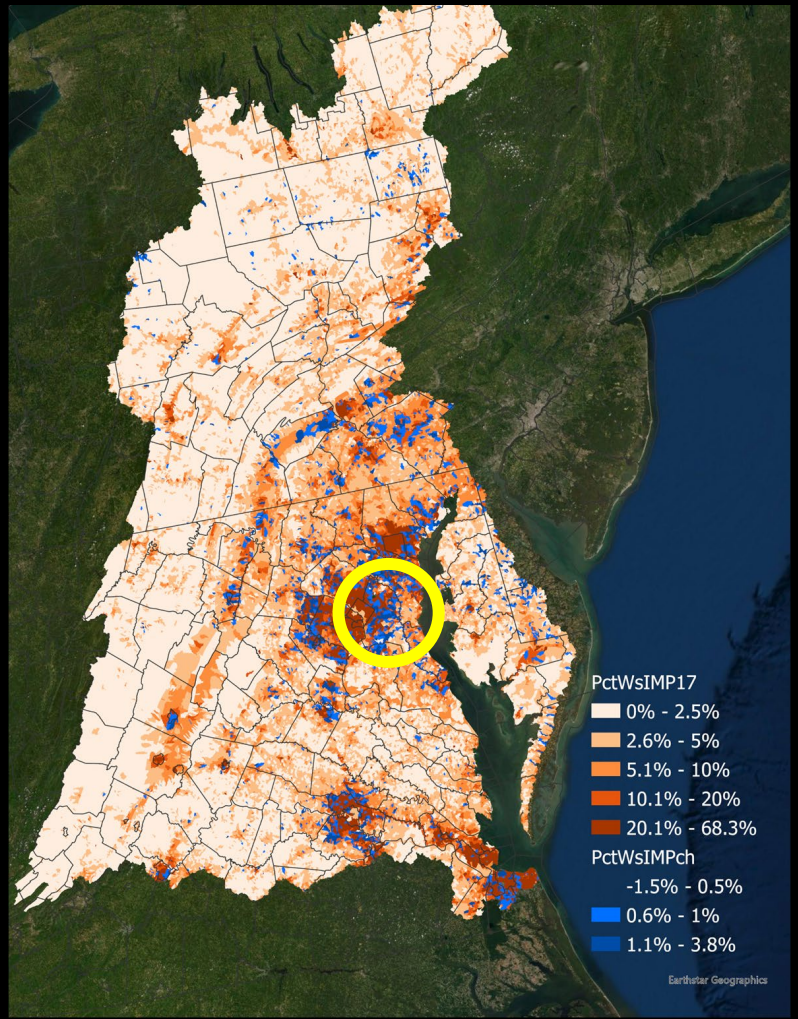
Cropland- Scrub/shrub
Orchard/Vineyard- Herbaceous
Pasture/Hay- Herbaceous
Wetland

Impervious Cover, 2017 (accum. %)



Impervious Cover Change, 2013-17 (accum. %)



NAIP 2013/2014

NAIP 2017/2018

Version 1 Land Use Change

NAIP 2017/2018

Land Use Change Pivot Tables

My Drive - Google Drive | 2017/18 LU QAQC - Google Slide | Land Use Change Viewer

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NAIP 2013/2014

NAIP 2017/2018

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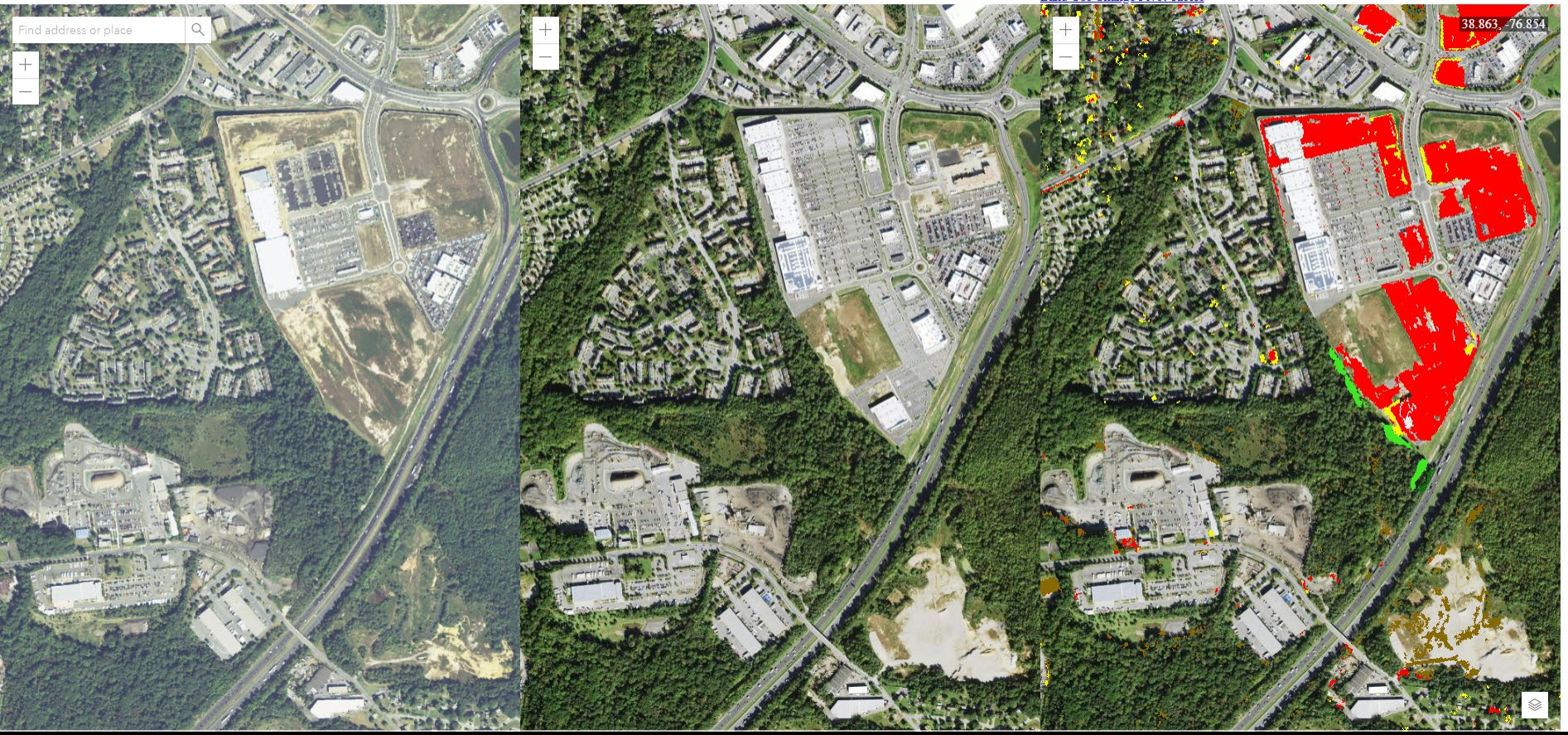

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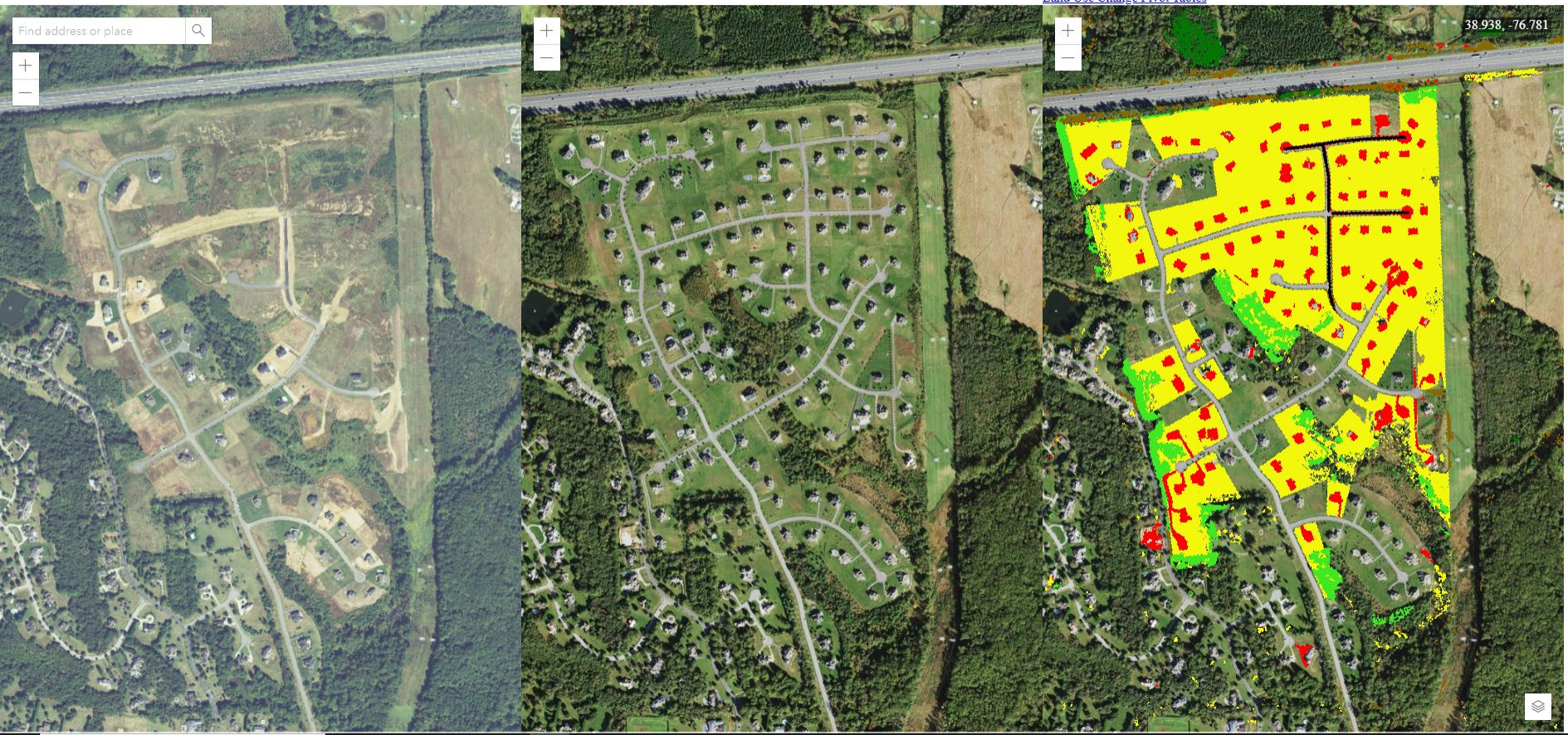

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Land Use Change Matrices (by county, state*, and watershed)

2013/14 Land Use	2017/18 Land Use																	
	ROAD	IMPO	TCIS	TURF	TCTG	PDEV	FORE	TCOT	NATS	HARF	RIVW	TERW	TDLW	CROP	PAST	EXTR	WATR	Decrease
ROAD	-	56	1,143	6	47		217			24	3	0	0	1	2		0	1,499
IMPO	598	-	2,632	4,653	533		230			3,985	41	12	4	442	1,124		16	14,272
TCIS	114	1,307	-	2,167	13		6			2,702	11	1	0	57	91		0	6,470
TURF	250	5,904	0	-	11,210		344			1,879	17	3	2	45	69		13	19,736
TCTG	104	5,954	0	11,368	-		98			4,495	-	-	-	516	472		4	23,011
PDEV																		
FORE	1,152	15,164	17	10,660	15,779		-			299,732	-	-	-	20,609	22,054		143	385,312
TCOT																		
NATS																		
HARF	1,519	27,718	1							-	-	-	-	943	1,788		748	169,132
RIVW	0	0	-	2	-		-			-	-	-	-	-	-		0	2
TERW	-	-	-	2	-		-			-	-	-	-	-	-		-	2
TDLW	-	-	-	0	-		-			-	-	-	-	-	-		-	0
CROP	61	3,944	0	302	40		3,263			1,348	-	-	-	-	151		104	9,213
PAST	51	4,655	0	451	44		4,591			1,038	-	-	-	178	-		63	11,070
EXTR																		
WATR	1	103	-	2	25		192			264	14	0	9	29	19		-	657
Increase	3,852	64,806	3,794	58,116	28,729		115,815			315,469	85	17	14	22,818	25,770		1,092	640,378
TotIncr	3,852	64,806	3,794	58,116	28,729		115,815			315,469	85	17	14	22,818	25,770		1,092	
TotDecr	1,499	14,272	6,470	19,736	23,011		385,312			169,132	2	2	0	9,213	11,070		657	
NetChng	2,353	50,534	(2,675)	38,380	5,717		(269,496)			146,337	83	15	14	13,605	14,700		434	

Impervious surface gains

Land Use Change Matrices (by county, state*, and watershed)

2013/14 Land Use	2017/18 Land Use: ROAD	IMPO	TCIS	TURF	TCTG	PDEV	FORE	TCOT	NATS	HARF	RIVW	TERW	TDLW	CROP	PAST	EXTR	WATR	Decrease
ROAD	-	56	1,143	6	47		217			24	3	0	0	1	2		0	1,499
IMPO	598	-	2,632	4,653	533		230			3,985	41	12	4	442	1,124		16	14,272
TCIS	114	1,307	-	2,167	13		6			2,702	11	1	0	57	91		0	6,470
TURF	250	5,904	0		11,210					79	17	3	2	45	69		13	19,736
TCTG	104	5,954	0	11,368			98			4,495	-	-	-	516	472		4	23,011
PDEV																		
FORE	1,152	15					-			299,732	-	-	-	20,609	22,054		143	385,312
TCOT																		
NATS																		
HARF	1,519	27,718	1	28,503	1,037		106,876			-	-	-	-	943	1,788		748	169,132
RIVW	0	0	-	2	-		-			-	-	-	-	-	-		0	2
TERW	-	-	-	2	-		-			-	-	-	-	-	-		-	2
TDLW	-	-	-	0	-		-			-	-	-	-	-	-		-	0
CROP	61	3,944	0	302	40		3,263			1,348	-	-	-	-	151		104	9,213
PAST	51	4,655	0	451	44		4,591			1,038	-	-	-	178	-		63	11,070
EXTR																		
WATR	1	103	-	2	25		192			264	14	0	9	29	19		-	657
Increase	3,852	64,806	3,794	58,116	28,729		115,815			315,469	85	17	14	22,818	25,770		1,092	640,378
TotIncr	3,852	64,806	3,794	58,116	28,729		115,815			315,469	85	17	14	22,818	25,770		1,092	
TotDecr	1,499	14,272	6,470	19,736	23,011		385,312			169,132	2	2	0	9,213	11,070		657	
NetChng	2,353	50,534	(2,675)	38,380	5,717		(269,496)			146,337	83	15	14	13,605	14,700		434	

Urban tree canopy gain

Urban tree canopy loss

Land Use Change Matrices (by county, state*, and watershed)

2013/14 Land Use	2017/18 Land Use: ROAD	IMPO	TCIS	TURF	TCTG	PDEV	FORE	TCOT	NATS	HARF	RIVW	TERW	TDLW	CROP	PAST	EXTR	WATR	Decrease
ROAD	-	56	1,143	6	47		217			24	3	0	0	1	2		0	1,499
IMPO	598	-	2,632	4,653	533		230			3,985	41	12	4	442	1,124		16	14,272
TCIS	114	1,307	-	2,167	13		6			2,702	11	1	0	57	91		0	6,470
TURF	250	5,904	0	-	11,210		344			1,879	17	3	2	45	69		13	19,736
TCTG	104	5,954	0	11,368	-		98			4,495	-	-	-	516	472		4	23,011
PDEV																		
FORE	1,152	15,164	17	10,660	15,779												143	385,312
TCOT																		
NATS																		
HARF							106,876			-	-	-	-	943	1,788		748	169,132
RIVW	0	0	-	2	-		-			-	-	-	-	-	-		0	2
TERW	-	-	-	2	-		-			-	-	-	-	-	-		-	2
TDLW	-	-	-	0	-		-			-	-	-	-	-	-		-	0
CROP	61	3,944	0	302	40		3,263			1,348	-	-	-	-	151		104	9,213
PAST	51	4,655	0	451	44		4,591			1,038	-	-	-	178	-		63	11,070
EXTR																		
WATR	1	103	-	2	25		192			264	14	0	9	29	19		-	657
Increase	3,852	64,806	3,794	58,116	28,729		115,815			315,469	85	17	14	22,818	25,770		1,092	640,378
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TotDecr	1,499	14,272	6,470	19,736	23,011		385,312			169,132	2	2	0	9,213	11,070		657	
NetChng	2,353	50,534	(2,675)	38,380	5,717		(269,496)			146,337	83	15	14	13,605	14,700		434	

Forest re-defined due to new development in forested areas

Forest loss to development

Unique Qualities of the Land Use Data

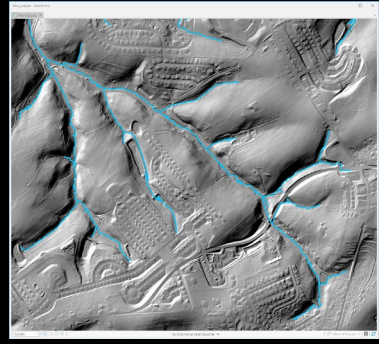
- Monitoring change (every 3-5 years)
- Spatial resolution (1-meter cells)
  - i.e. 53% more impervious in the Bay watershed compared to 30-meter resolution LULC data
- Categorical resolution (50+ classes)
- Accuracy (95% accuracy anticipated for tree canopy and impervious surface classes)
- Consistency across counties and regions

Upcoming Data Release (March 2022)

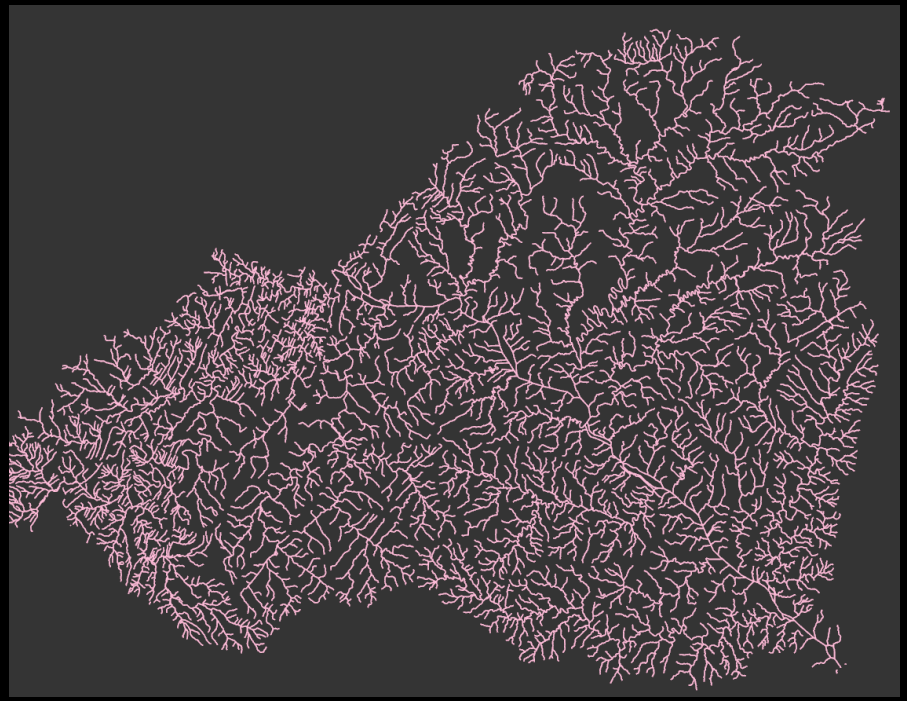
- LC, LULC, and LULC Change data will be available in raster format for download at the county scale via web viewers.
- Tabular summaries of class area (detailed and general classification scheme) and change matrices will also be made available for download.
- Documentation on methodology, interpretation guides, and high-level interpretations will also be provided.

Future: Hyper-res Streams (1:2000 scale)

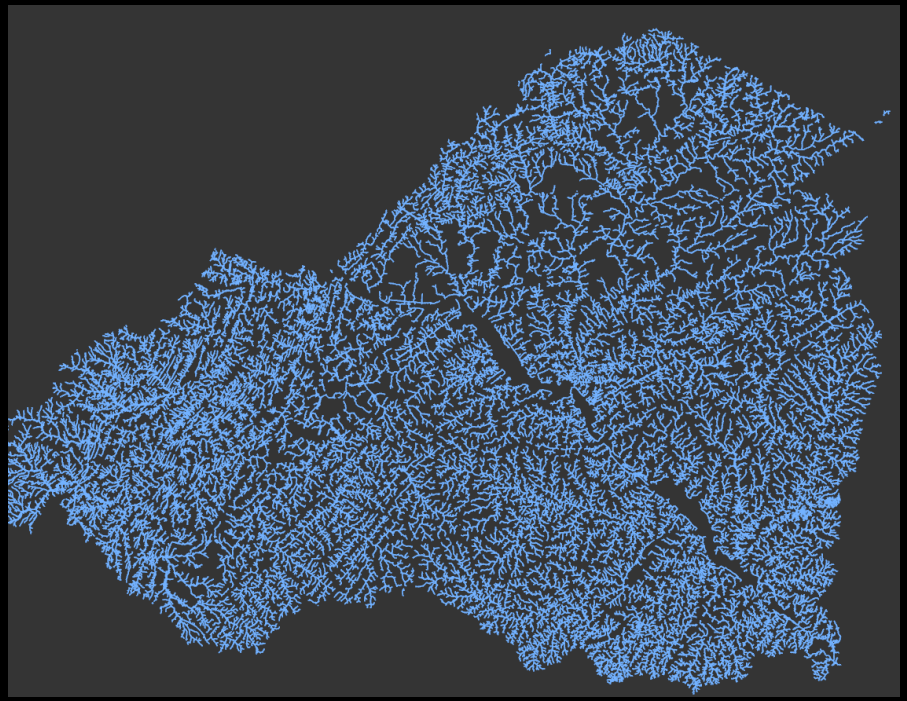
Lower Susquehanna Example

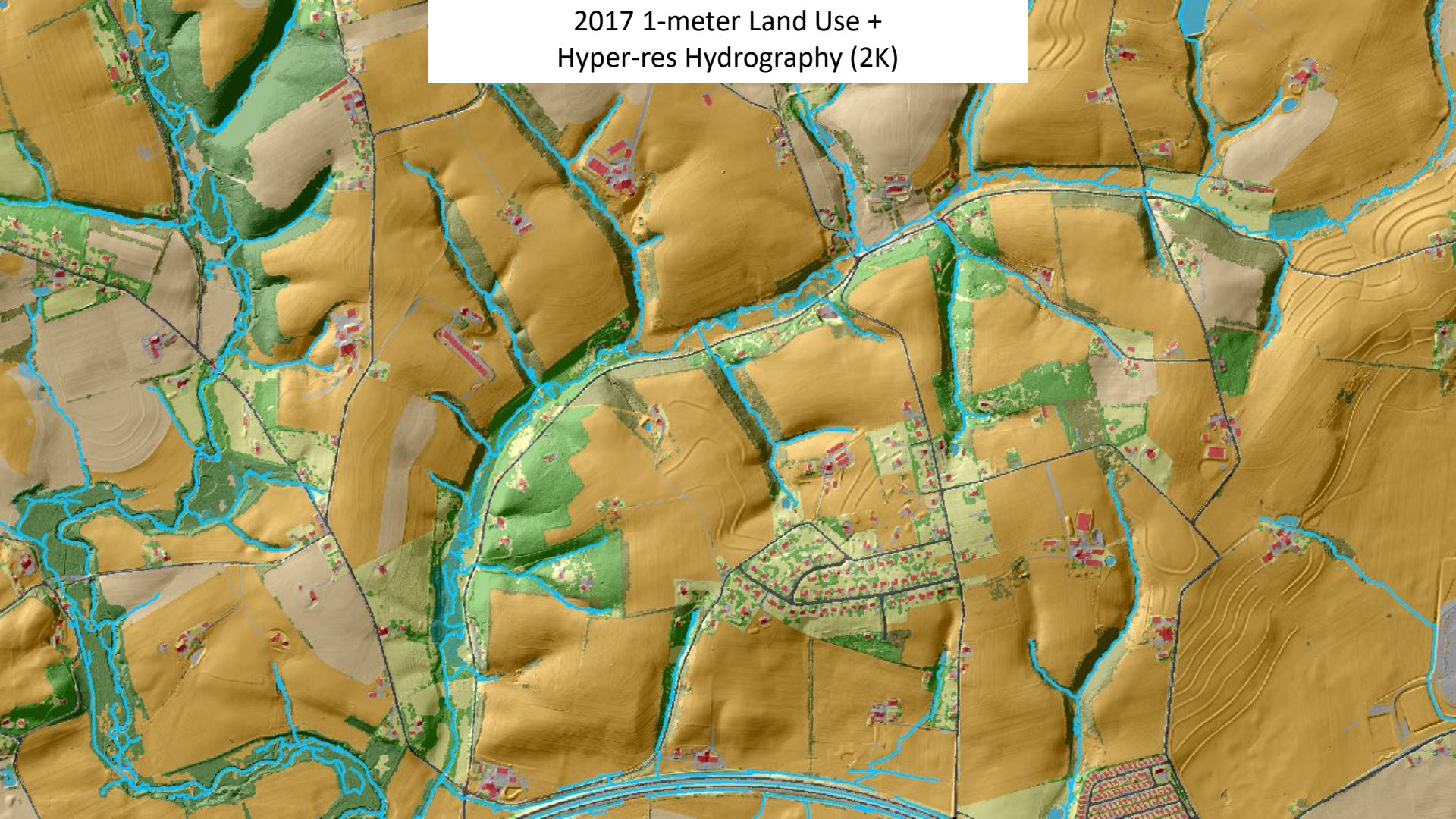


National Hydrography Dataset, 1:24,000
6,923.6 km



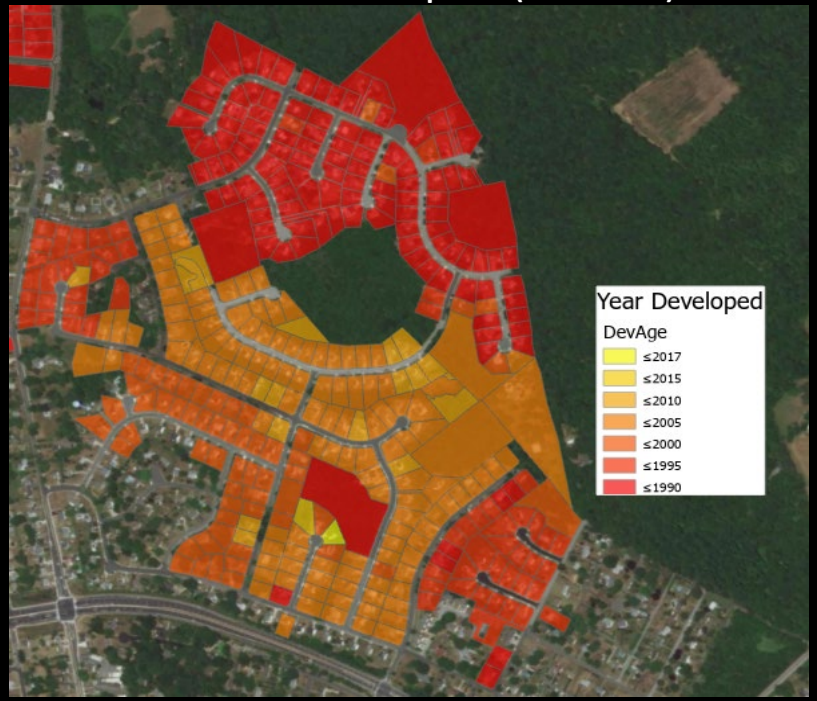
CBP Hyper-Resolution Streams
16,784.6 km



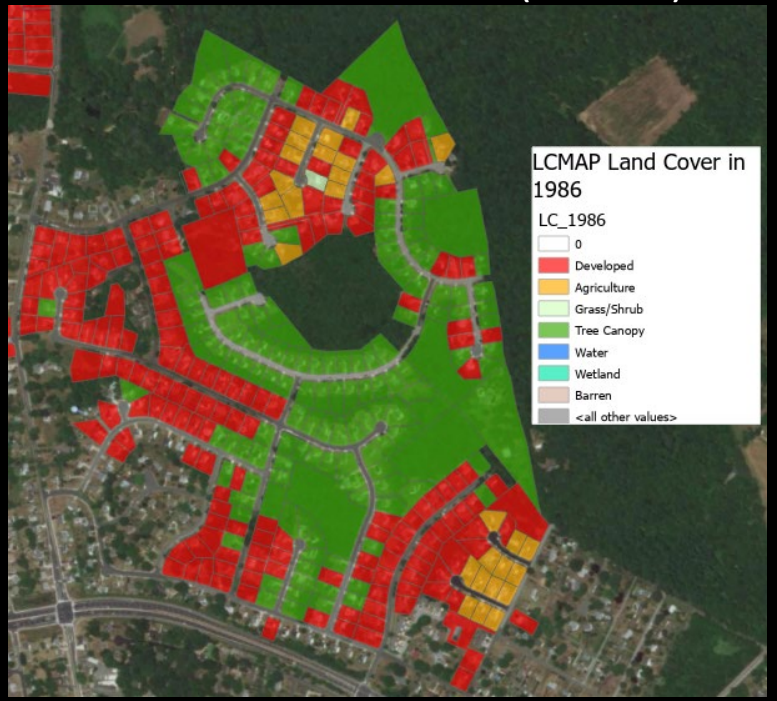

2017 1-meter Land Use +
Hyper-res Hydrography (2K)

Future: backcasting development to mid 1980's

Year Developed (LCMAP)



Land Cover 1986 (LCMAP)



USGS
science for a changing world

Applications, Caveats, and Future Releases

Applications:

- Identifying BMP opportunities (e.g., riparian forest buffers, urban tree planting, stream restoration) and locating BMPs where they may be most effective (2025 WIP Outcome)
- CAST (2025 WIP Outcome)
- Targeting land conservation (Protected Lands Outcome)
- Identifying potential healthy and vulnerable watersheds (Healthy Watersheds Outcome)
- Informing land use planning decisions (Land Use Methods and Metrics Outcome)
- Assessing net change in forest buffers (Forest Buffer Outcome)
- Assessing net change in tree canopy (Tree Canopy Outcome)
- Assessing extent of shaded streams (Brook Trout Outcome)
- Assessing stream geomorphic conditions and impairments (Stream Health Outcome)
- Assessing land use conditions in areas of future marsh migration (Climate Adaptation Outcome)

Applications, Caveats, and Future Releases

Caveats:

- Data will be retrospectively revised with future data releases
  - Streams, ditches, and animal operations will be added in 2021/22 data planned for release in 2024
  - Digital surface models (elevation of objects) will be added to workflow
  - Methods and ancillary data will be further refined
  - All updates will be applied to 2013/14 and 2017/18 LULC data to ensure accurate change

- A longer temporal record is needed to interpret certain types of LULC change
  - Pre-2013/14 land use data are needed to distinguish forest and farmland conversion to development
  - Post-2017/18 land use are needed to verify the end state of transitional land uses (e.g., natural succession, suspended succession)

- Potential to confuse transitional and temporary change with permanent change
  - Timber harvest is the largest change in the Bay watershed but signifies only a temporary change in tree cover, not a loss.
  - Changes from forest to tree canopy over turf grass represent a contextual change, not a loss of tree cover.

- Periods of change vary by state: 5 years for MD and DE; 4 years for DC, NY, PA, VA, and WV.

Applications, Caveats, and Future Releases

Future Releases:

- Spring 2024
  - 2021/22 LULC and LULC change from 2013/14 to 2017/18 to 2021/22
  - Hyper-resolution streams, channels, and ditches with channel and flow permanence attributes
- Spring 2028 (TBD funding)
  - 2025/26 LULC and LULC change from 2013/14 to 2017/18 to 2021/22 to 2025/26
- Spring 2032 (TBD funding)
  - 2029/30 LULC and LULC change from 2013/14 to 2017/18 to 2021/22 to 2025/26 to 2029/30

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Questions?
Feedback?

Interested in being notified when the data is released? Email Katie.