

**Purpose:**

Several outcomes specified in the 2014 Chesapeake Bay Program Agreement and the proposed Chesapeake Bay Regional Hydrologic Model will benefit from the enhancement of the 2013 Chesapeake Bay Program land use dataset<sup>1</sup>. The current 2013 land use dataset was designed to inform the development of Phase III Watershed Implementation Plans as part of the 2017 Mid-Point Assessment. All unique classes, except for “wetlands”, were required to exhibit proven unique nutrient and/or sediment loading rates. While this approach was very effective for informing water quality management decisions, it limited the utility of the data for informing other Chesapeake Bay outcomes. Limitations of the current data include:

- Inaccuracies associated with class confusion, e.g., solar fields mapped as impervious surfaces, forest fragments mapped as “mixed open”;
- Loss of land cover information (e.g., Tree Canopy, herbaceous, Scrub-Shrub) within wetlands and “fractional” classes (areas estimated to contain part cropland, pasture, turf grass, mixed open, and/or impervious surfaces);
- Over-estimation of agricultural land in areas with extensive mining and oil & gas development;
- Inability to clearly communicate high-resolution net changes in forests and urban Tree Canopy due to inherent data bias towards detecting loss and absence of successional classes;
- Inability to inform models about forest succession due to the absence of successional classes;
- Inability to accurately portray the spatial extent and shading of streams

To remedy these issues, a new land use classification scheme based on updated decision rules and additional ancillary data is proposed for translating land cover into land use for the years 2013/14, 2017/18, and 2021/22. The proposed new classification was developed in the fall of 2019 through consultation with the Land Use Workgroup, Forestry Workgroup, Wetlands Workgroup, Climate Resiliency Workgroup, Agricultural Workgroup, Scientific Technical Assessment and Reporting team, and both the Habitat and Healthy Watersheds Goal Implementation Teams. It has been reviewed from a feasibility perspective by the Chesapeake Conservancy and the University of Vermont’s Spatial Analysis Laboratory. The proposed classification is both feasible and within the scope of the USEPA’s 2018 Cooperative Agreement with the Chesapeake Conservancy.

The proposed classification will not impact the WIPs, Milestones, or annual Progress runs. Land use changes based on the new classification will be directly cross-walked and aggregated into the Phase 6 thirteen mapped land use classes to compute change from 2013/14 to 2017/18 to 2021/22. These changes will then be applied to the original 2013 land use dataset to update it to more current conditions. Nutrient and sediment loads will change as a result of changes in land use and management practices but not as a result of changes in the classification.

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<sup>1</sup> <https://chesapeakeconservancy.org/conservation-innovation-center-2/high-resolution-data/land-use-data-project/>

The following pages outline the proposed new classification scheme from two perspectives. The Phase 6 perspective illustrates how fifteen proposed new classes nest under the original thirteen land uses. The new classification disaggregates four Phase 6 classes into additional subclasses. Water is disaggregated into four new classes: estuary, lakes & ponds, streams, and ditches. This disaggregation will help the CBP partners distinguish different types of shoreline change and leverage recent investments in mapping streams and ditches from 1-meter resolution LiDAR imagery. Mapping all streams and distinguishing them from ditches will inform riparian buffer assessments, planting opportunities, and targeting efforts. It will also enable assessments of shaded vs daylighted stream miles. For impervious surfaces, solar fields will be identified as a unique class and railroad rights-of-way will be included within existing impervious classes. Solar fields do not exhibit the same hydrologic functions as other types of impervious cover. Mapping them explicitly will enable their consideration in the development of future hydrologic models. Moreover, solar fields are a rapidly growing feature on the rural landscape that contribute to climate resiliency. For the cropland class, orchards/vineyards and idle/fallow lands will be explicitly mapped to reduce confusion with forest and mixed open classes, thereby improving the accuracy of multiple classes.

Most efforts invested in the new classification will focus on disaggregating the “mixed open” class. For Phase 6, “mixed open” represents a catch-all class including Barren lands (e.g., waterbody margins and surface mines), areas undergoing managed or natural succession (e.g., timber harvests, abandoned and reclaimed mines, fallow lands), areas maintained as herbaceous or Scrub-Shrub vegetation (e.g., landfills, unconventional oil and gas development, and utility rights-of-way), and small forest fragments. Such areas compose a significant portion of the landscape in some counties. Insufficient ancillary data defining these different types of lands and over-reliance on local land use and zoning data led to an under-classification of “mixed open” in rural areas corresponding to an over-classification of agriculture. Understanding the composition of mixed open is vital for mapping wildlife habitats, projecting future changes in land use, and assessing alternative land management opportunities. Proposed classes previously represented as “mixed open” include: natural succession, suspended succession, bare developed, bare shore, extractive, and fragmented forest. “Natural Succession” represents unmanaged, non-forested lands that are slowly transitioning to forest such as fallow lands and reclaimed mines. “Suspended Succession” represents areas maintained as herbaceous or Scrub-Shrub such as transmission line, highway, and rail rights-of-ways. “Bare Developed” represent patches of bare land in urban and suburban landscapes. “Bare Shore” represents beaches, gravel bars, and lake margins not included in wetland ancillary data. “Extractive” represents active surface mines, quarries, and gas pads. “Fragmented Forest” represent patches of trees less than 1-acre in size that are presumed to have an unmanaged understory such as narrow riparian forest buffers.

Because these new classes do not all logically nest under the thirteen Phase 6 land uses, the second outline, “General-Purpose Land Use Perspective”, rearranges the new classes into a more logical land use classification and intersects them with land cover so that all mapped land use/cover information is represented in a single dataset. Thus, a single dataset with these 61 classes will be the basis for multiple derived datasets such as the Phase 6 land use classification, the original land cover map, or a detailed land use map. The CBPO will develop various GIS layer files to facilitate the visualization of these alternative classifications.

**Phase 6 Land Use (crosswalk with general-purpose land use)**

(15 additional classes):

**1. Water (WAT; from 1 to 4 classes)**

- 1.1. Estuary
- 1.2. Lakes & Ponds
- 1.3. Streams
- 1.4. Ditches
- 1.5. Bare Shore

**2. Impervious, Roads (IR; no change)**

**3. Impervious, Non-Roads (INR; 2 to 4 classes)**

- 3.1. Structures
- 3.2. Other Impervious
- 3.3. Solar fields (impervious portions)

**4. Tree Canopy over Impervious (TCI; no change)**

**5. Turf Grass (TG; no change)**

**6. Tree Canopy over Turf Grass (TCT; no change)**

**7. Forest (FORE; change in name only)**

- 7.1. Contiguous ( $\geq 1$  acre)

**8. Tidal Wetland (WLT; no change)**

**9. Non-Tidal Floodplain Wetland (WLF; update mapping to include headwaters)**

**10. Non-Tidal Other Wetlands (WLO; no change)**

**11. Mixed Open (1 to 7 classes)**

- 11.1. Natural Succession
- 11.2. Timber Harvest
- 11.3. Suspended Succession
- 11.4. Bare Developed
- 11.5. Extractive
- 11.6. Fragmented Forest ( $< 1$  acre)

**12. Cropland (CRP; 1 to 2 classes)**

- 12.1. Cropland
- 12.2. Orchard/vineyard
- 12.3. Idle/Fallow
- 12.4. Solar fields (pervious portions)

**13. Pasture (PAS; no change)**

**General-Purpose Land Use (61 classes)**

**1. Water (8)**

**1.1. Lentic**

- 1.1.1. Estuary
- 1.1.2. Lakes & Ponds

**1.2. Lotic**

- 1.2.1. Streams
  - 1.2.1.1. Sunlit
  - 1.2.1.2. Shaded
  - 1.2.1.3. Buried
- 1.2.2. Ditches
  - 1.2.2.1. Sunlit
  - 1.2.2.2. Shaded
  - 1.2.2.3. Buried

**2. Developed (12)**

**2.1. Impervious**

- 2.1.1. Roads
- 2.1.2. Structures
- 2.1.3. Other Impervious, e.g., Parking Lots, Driveways, Railroads, etc.

**2.2. Pervious**

- 2.2.1. Turf Grass
- 2.2.2. Bare Developed
- 2.2.3. Suspended Succession
  - 2.2.3.1. Barren
  - 2.2.3.2. Herbaceous
  - 2.2.3.3. Scrub-Shrub

**2.3. Tree Canopy (TC)**

- 2.3.1. TC over Roads
- 2.3.2. TC over Structures
- 2.3.3. TC over Other Impervious
- 2.3.4. TC over Turf Grass

**3. Forest (5)**

**3.1. Contiguous ( $\geq 1$  acre)**

**3.2. Fragmented ( $< 1$  acre)**

**3.3. Natural Succession**

- 3.3.1. Barren
- 3.3.2. Herbaceous
- 3.3.3. Scrub-Shrub

**4. Production (15)**

**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

**4.1.3. Orchard/ Vineyard**

- 4.1.3.1. Barren
- 4.1.3.2. Herbaceous
- 4.1.3.3. Scrub-Shrub

**4.2. Timber Harvest ( $< 3$  years)**

- 4.2.1. Barren
- 4.2.2. Herbaceous

**4.3. Solar fields**

- 4.3.1. Barren
- 4.3.2. Herbaceous
- 4.3.3. Scrub-Shrub
- 4.3.4. Impervious

**4.4. Extractive (active)**

- 4.4.1. Barren
- 4.4.2. Other Impervious

**5. Wetlands and Water Margins (21)**

**5.1. Tidal**

- 5.1.1. Barren
- 5.1.2. Herbaceous
- 5.1.3. Scrub-Shrub
- 5.1.4. Contiguous Forest
- 5.1.5. Fragmented Forest

**5.2. Non-Tidal**

- 5.2.1. Riverine (groundwater/headwater)
  - 5.2.1.1. Barren
  - 5.2.1.2. Herbaceous
  - 5.2.1.3. Scrub-Shrub
  - 5.2.1.4. Contiguous Forest
  - 5.2.1.5. Fragmented Forest
- 5.2.2. Riverine (surface water/floodplain)
  - 5.2.2.1. Barren
  - 5.2.2.2. Herbaceous
  - 5.2.2.3. Scrub-Shrub
  - 5.2.2.4. Contiguous Forest
  - 5.2.2.5. Fragmented Forest
- 5.2.3. Terrene (ground and surface water)
  - 5.2.3.1. Barren
  - 5.2.3.2. Herbaceous
  - 5.2.3.3. Scrub-Shrub
  - 5.2.3.4. Contiguous Forest
  - 5.2.3.5. Fragmented Forest

**5.3. Bare shore**

For images of all classes, please see

[LU\\_classification\\_Proposed\\_Rules\\_images\\_20210108.pdf](#)

### Summary of Changes from 12.18.20 Document to 01.08.21 Document:

- “Bare Construction” land use class name changed to “Bare Developed”.
- “Bare Developed” methodology incorporated.
- “Forest”, “Fragmented Forest,” and “Tree Canopy over Turf Grass” changes:
  - Updating definition of “Urban Areas”:
    - Now calling them “Densely Developed” areas.
    - Utilizing Census Urban Area Clusters
    - Previous rules:
      - Small parcels, less than or equal to an acre, with any sized structure; and
      - Parcels in neighborhoods where density is greater than 8 parcels per acre based on a 1-acre circular focal window; and
      - Large parcels less than 100 acres with 50% impervious cover.
  - New rules can be seen under “Forest”, “Fragmented Forest”, and “Tree Canopy over Turf Grass” sections below. Previous rules:
    - Tree Canopy over Turf Grass:
      - “Turf Grass” and “Agriculture” methods applied first.
      - In urban areas, buffer “Turf Grass” segments adjacent to structures and “Structure” segments by 20 meters. Classify any “Tree Canopy” within buffer as “Tree Canopy over Turf Grass.”
      - In non-urban areas, buffer “Turf Grass” segments adjacent to structures and “Structure” segments by 10 meters. Classify any “Tree Canopy” within buffer as “Tree Canopy over Turf Grass.”
      - “Tree Canopy” segment less than 1 acre adjacent to “Turf Grass” (confined within parcel boundary), classify as “Tree Canopy over Turf Grass.”
    - Fragmented Forest (Pending Decision):
      - Use “Tree Canopy over Turf Grass” definition of urban areas.
      - In urban areas, “Tree Canopy” segments less than an acre, classify as “Fragmented Forest.”
      - In non-urban areas, “Tree Canopy” segments less than an acre adjacent to “Agriculture” (confined within parcel boundary), classify as “Fragmented Forest.”
    - Forest (Pending Decision):
      - “Tree Canopy over Turf Grass” and “Fragmented Forest” method
- “Non-Tidal Wetlands”, “Streams and Ditches”, and “Lakes and Ponds” methodologies incorporated.

### Water Classes

**Definition:** all surface water and water conveyance features including estuaries, lakes, ponds, streams (sunlit, shaded, buried), and ditches (sunlit, shaded, buried).

**2013 LU Issues:** most fluvial surface water features were not represented in the 1-meter land use classification because streams were derived at 10-meter resolution using an average drainage-area threshold (60-acres) estimated from the 1:24K NHD-HR end nodes. Stream widths were modeled similarly throughout the watershed using a statistical formula based on drainage area developed for Maryland.

**Summary Methods:** Overlay Tree Canopy and impervious land cover on the new hyper-resolution (1-meter) raster channel data under development by CIC and UMBC. Reclass the channel cells as daylighted or shaded (including culverts). Data representing buried streams (e.g., “pipelines” in the 1:24K NHD or stretches of network discontinuity within urban areas) will be examined to potentially represent “buried” sections of the hyper-res vector network developed by CIC and UMBC.

CIC and UMBC will use a Machine Learning model to automate separation of gullies/ditches from streams followed by minor manual classification.

Assess and assign stream flow permanence attributes to reaches in the using state-specific low-flow regression equations relating 7-day 2-year low flows to drainage area under dry (summer) and wet (winter) periods as recommended by UMBC and CIC as part of their CBT grant. Channels exhibiting extreme low flows, <0.1 cfs, in both wet and dry periods will be classed as “ephemeral.” Channels exhibiting extreme low flows in the dry season only will be classed as “intermittent.” Channels exhibiting extreme low flows in neither season will be classed as “perennial.”

### **Technical Methods:**

#### Lakes and Ponds:

- I. Rasterize “Water” segment from land cover, and region group.
- II. Calculate Perimeter-Area Ratio (PAR) and Polsby-Popper test (PPT)
- III. Generate variable channel width buffer using channel width attribute in FACET stream network and select all water polygons that intersect with stream buffer (water\_inside\_channel). Save the inverse as (water\_outside\_channel).
- IV. Perform two queries where PPT < 0.1 and then PAR > 0.17 on water\_inside\_channel. The goal is to eliminate any elongated features (ONLY inside stream buffer) that may look like fragmented channels. Save as ponds\_inside\_channel.
- V. Merge water\_outside\_channel and ponds\_inside\_channel. Assume all water bodies outside the stream channel network are pond/lake like features.

#### Streams and Ditches:

- I. When a “Water”, “Wetland”, “Herbaceous Vegetation”, “Scrub-Shrub”, or “Barren” pixel intersect with the Objective 1 hydrography “stream” or “ditch” class, classify as “Stream” or “Ditch”, respectively.
- II. When “Tree Canopy” pixels intersect with Objective 2 hydrography “stream” or “ditch” class, classify as “Tree Canopy over Stream” or “Tree Canopy over Ditch”, respectively.

## **Developed Classes**

**Definition:** All impervious and pervious lands associated with residential, commercial, and industrial development and associated infrastructure including roads, structures, other impervious (e.g., parking lots, driveways), turf grass, bare developed, and utility rights-of-way (i.e., suspended succession), and Tree Canopy obscuring roads, structures, other impervious, and turf grass.

**Summary Methods:** Continue to rely on the land cover data to directly map all types of impervious surfaces and Tree Canopy over all types of impervious surfaces. Buffer all rail lines in Open Street Map by 3m and reclassify these areas either “Other Impervious” or “Tree Canopy over Other Impervious.” Identify all herbaceous land on developed parcels or on residential, commercial, or industrial lands as “turf grass.” Use ancillary data on transmission lines, pipelines, and landfills to identify herbaceous, Scrub-Shrub, and Barren lands as “Suspended Succession.” Use solar model AI output polygons to reclassify land as “solar impervious”, “solar Barren”, “solar herbaceous”, and “solar Scrub-Shrub.” Map all small groups of Tree Canopy located on small developed parcels or within 10 meters of a structure or turf grass as “Tree Canopy over turf grass.” Identify lands likely undergoing construction by their Barren cover type and neighborhood context (i.e., adjacent to developed lands), or lands

that are any other type of compacted barren land that do not fall under any other land use class. This does not include dirt roads, as dirt roads are considered “Other Impervious”.

**Technical Methods:**Structures:

- I. Same as Land Cover

Other Impervious:

- I. Same as Land Cover. Buffer all rail lines from Open Street Map by 3 meters and reclassify “Herbaceous Vegetation”, “Barren”, “Scrub-Shrub”, and “Wetlands” as “Other Impervious.”

Impervious roads:

- I. Same as Land Cover.

Tree Canopy over Structures:

- I. Same as Land Cover.

Tree Canopy over Other Impervious:

- I. Same as Land Cover. Buffer all rail lines in Open Street Map by 3 meters and reclassify “Tree Canopy” as “Tree Canopy over Other Impervious.”

Tree Canopy over Impervious Roads:

- I. Same as Land Cover.

Turf Grass (Pending Decision):

- I. Subset HERE data (LandUseA and LandUseB layers) to include only the following classes: 'AIRCRAFT ROADS', 'AIRPORT', 'AMUSEMENT PARK', 'CEMETERY', 'GOLF COURSE', 'HOSPITAL', 'PARKING LOT', 'SEAPORT/HARBOUR', 'SHOPPING CENTRE', 'SPORTS COMPLEX'
- II. If a parcel is less than or equal to 1 acre, and has greater than or equal to 93 square meters of impervious surface, classify all “Herbaceous Vegetation” as “Turf Grass.”
- III. If the center of an “Herbaceous Vegetation” segment falls within subset HERE data from step I., classify as “Turf Grass.”

Suspended Succession (Pending Decision):

- I. “Herbaceous Vegetation”, “Scrub-Shrub”, and “Barren” image segments that intersect with digitized landfill dataset, classify as “Suspended Succession.”
- II. “Herbaceous Vegetation”, “Scrub-Shrub”, and “Barren” image segments that are less than or equal to 50 square meters and touch “Impervious Road”, classify as “Suspended Succession.”
- III. Buffer transmission line dataset from Homeland Infrastructure Foundation by 25 meters. If “Herbaceous Vegetation”, “Scrub-Shrub”, and “Barren” segments intersect the buffered transmission line dataset and are less than or equal to 1,000 square meters, classify as “Suspended Succession.”

Tree Canopy over Turf Grass (Pending Decision):

- I. “Turf Grass” and “Agriculture” methods applied first.
- II. Densely Developed areas, defined by:
  - a. Census Urban Area Clusters;
  - b. Parcels where Impervious Coverage is greater than 25%, structure size is greater than 1070 square meters, has no railroads and parcel area is less than 1 million square meters;
  - c. Region grouped parcels where the majority of area is made up of:
    - i. Parcels where Impervious Coverage is greater than 25%, structure size is greater than 1070 square meters, has no railroads and parcel area is less than 1 million square meters;

- ii. Parcels where Impervious Coverage is greater than 25%, parcel density is greater than 10, has no railroads and parcel area is less than 1 million square meters.
- III. Forested parcels, defined by:
  - a. "Tree Canopy" coverage greater than or equal to 25% of the parcel;
  - b. "Structure" is present in the parcel;
  - c. No "Agriculture" classes are present in the parcel.
- IV. Less Densely Developed areas, defined by:
  - a. Areas remaining after Densely Developed and Forested parcels are assigned.
- V. In Densely Developed areas:
  - a. Buffer "Structure" and "Other Impervious" segments that share the boundary of "Structures" and "Turf Grass" segments by 20 meters. Classify any "Tree Canopy" within buffer as "Tree Canopy over Turf Grass".
- VI. In Forested parcels:
  - a. Buffer "Structures" and "Other Impervious" sharing boundary of "Structure" and "Turf Grass" segments by 10 meters. Buffer must only apply within same parcel. Reclassify any "Tree Canopy" within buffer as "Tree Canopy over Turf Grass".
- VII. In Less Densely Developed areas:
  - a. Buffer "Structures" and "Other Impervious" sharing boundary of "Structure" and "Turf Grass" segments by 10 meters. Buffer must only apply within the same parcel. Reclassify any "Tree Canopy" within buffer as "Tree Canopy over Turf Grass".
  - b. Assess size of remaining tree canopy patches within parcel boundaries. Class patches less than 1 acre as "Tree Canopy over Turf Grass".

**Bare Developed:**

- I. All other land use methods that analyze barren lands are applied first. This includes: "Suspended Succession", "Natural Succession", all "Agriculture" classes, "Timber Harvest", "Solar Fields", "Extractive", all "Wetland" classes, and "Bare Shore".
- II. Remaining "Barren" segments are classified as "Bare Developed".

**LUWG Decisions:**

**09-02-20:** Reclass cover type within railroad right-of-ways. Use railroad centerline dataset from Open Street Map (OSM). Buffer center lines by 3-meters on either side (for multi-line rails, overlapping buffers will not be double counted). Reclass land cover within the buffer as follows: "low vegetation" + "Barren" + "Scrub-Shrub" + "wetlands" = "other impervious." "Tree Canopy" = "Tree Canopy over other impervious." No change to existing "roads", "structures", "other impervious", "Tree Canopy over roads", "Tree Canopy over structures", "Tree Canopy over other impervious", and "water."

**Forest Classes**

**Definition:** all areas covered by Tree Canopy that are presumed to have an unmanaged understory including contiguous forest (patches  $\geq 1$  acre), fragmented forest (patches  $< 1$  acre), and lands undergoing natural succession.

**2013 LU Issues:** Small fragments of trees ( $< 1$  acre) were classed as "mixed-open." Patch width was not accounted for when distinguishing forests from mixed open such that narrow strips of trees  $\geq 1$  acre were classed as "forest." Forests were not included as a sub-class of wetlands. Reliance on focal windows (e.g., 3x3, 5x5, etc.) for distinguishing trees over turf from forests is prone to producing change artifacts if applied over multiple years. In addition, areas undergoing natural or managed succession back to forest were not explicitly mapped preventing accurate assessments of net changes in forest cover and preventing the modeling of successional processes into the future.

**Summary Methods:** After accounting for Tree Canopy over turf grass and over impervious cover, map all remaining Tree Canopy as "fragmented forest" or "forest." Areas undergoing natural succession are patches of



Barren, herbaceous, or Scrub-Shrub lands that are not classed as agriculture, turf grass, wetlands, or timber harvest.

**Technical Methods:**

Fragmented Forest (Pending Decision):

- I. Classify "Tree Canopy over Turf Grass" first.
- II. Use "Tree Canopy over Turf Grass" definition of Densely Developed and Less Densely Developed areas.
- III. In Densely Developed areas:
  - a. Assess the size of remaining "Tree Canopy" patches irrespective of parcel boundaries. Class patches less than 1 acre as "Fragmented Forest".
- IV. In Less Densely Developed areas:
  - a. Assess the size of remaining "Tree Canopy" patches within parcel boundaries. Class patches less than 1 acre adjacent to "Agriculture" classes as "Fragmented Forest". Adjacency is confined to the parcel.

Forest (Pending Decision):

- I. Classify "Tree Canopy over Turf Grass" and "Fragmented Forest" first.
- II. All remaining "Tree Canopy" is classified as "Forest".

Natural Succession:

- I. "Turf Grass", "Agriculture", and "Suspended Succession" methods applied first.
- II. If an "Herbaceous Vegetation" or "Barren" segment intersects with ancillary abandoned mines dataset, classify as "Natural Succession."
- III. If greater than or equal to 10% of "Herbaceous Vegetation" or "Barren" segment is timber harvest according to data mined LCMAP, classify as "Natural Succession."

**Production Classes**

**Definition:** All lands used for the production of food, fiber, energy, or minerals including cropland, pasture, orchards/vineyards, idle/fallow cropland, timber harvests, mines/quarries, and solar fields.

**2013 LU Issues:** Agricultural lands were not directly mapped due to the confidentiality of high-resolution farm field data (e.g., the Farm Service Agency's Common Land Unit data). Instead, all other land uses were mapped directly or with the aid of ancillary data and the left-over, unclassified lands were classed as agriculture by default. This resulted in overestimating agriculture in some rural counties where extractive activities and/or agricultural abandonment are prevalent and underestimating agriculture in some suburban counties due to overestimate of turf grass. Extractive lands such as mines and quarries and solar fields were not explicitly mapped and often classed as mixtures of impervious surfaces and turf grass. Timber harvests were not mapped resulting in an overestimation of forest loss and contributing to local overestimates of agriculture.

**Summary Methods:** Cropland, Pasture, Idle/Fallow, and orchards/vineyards will be mapped simultaneously or directly after turf grass, using parcel and image segment characteristics and ancillary data from NASS Cropland Data Layer (CDL) (2017-2019) and USGS National Land Cover Database (NLCD) (2016). Solar fields will be mapped by Chesapeake Conservancy using point data identifying potential solar field arrays from the United States Energy Information Administration and the Solar Energy Industries Association. Active mines and quarries will be mapped by Chesapeake Conservancy and Washington College using national, state, and local data. Included will be shale gas infrastructure and pads in Pennsylvania (digitized by USGS). Timber harvests will be mapped using state data coupled with the USGS' Land Change Monitoring, Assessment, and Projection (LCMAP) database. The LCMAP data can be used to identify parcel-image segments that have exhibited forest rotations over the past 30 years (1985-2017). Note that the LCMAP data are only useful for identifying clear cuts. They have limited utility for identifying selective cuts. Moreover, once a harvested site regenerates to the point

where samplings reach a height of ~6 meters and can then be identified in LiDAR and/or NAIP imagery as “Tree Canopy”, the harvested site will be classified as “forest.” It’s important to distinguish succession following a harvest from natural succession because managed succession occurs at a faster rate than natural succession. This information is needed to accurately forecast forest dynamics into the future.

**Technical Methods:**

Cropland (Pending Decision):

- I. Reclassify CDL into non-agricultural, cropland, pasture, idle/fallow, and orchards/vineyards.
- II. If “Herbaceous Vegetation”, “Barren”, or “Scrub-Shrub” segments have an area greater than or equal 1 hectare and include 20% or greater coverage of the reclassified CDL cropland pixels, classify as “Cropland.”
- III. Identify adjacent “Herbaceous Vegetation”, “Barren”, or “Scrub-Shrub” segments after “Turf Grass”, successional and other non-cropland classes have been assigned in previous passes. If the segment is touching cropland and no other segments with confusable classes, classify as “Cropland.”
  - a. Repeat
- IV. Identify adjacent “Herbaceous Vegetation”, “Barren”, or “Scrub-Shrub” segments after “Turf Grass”, successional and other non-cropland classes have been assigned in previous passes.

Pasture (Pending Decision):

- I. If “Herbaceous Vegetation”, “Barren”, or “Scrub-Shrub” segments have an area greater than or equal 1 hectare and include 20% or greater coverage of the reclassified CDL pasture pixels, classify as “Pasture.”
- II. If “Herbaceous Vegetation”, “Barren”, or “Scrub-Shrub” segments have an area greater than or equal 1 hectare and include 20% or greater coverage of pasture NLCD class, classify as “Pasture.”
- III. Identify adjacent “Herbaceous Vegetation”, “Barren”, or “Scrub-Shrub” segments after “Turf Grass”, successional and other non-pasture classes have been assigned in previous passes. If the segment is touching pasture and no other segments with confusable classes, classify as “Pasture.”
  - a. Repeat
- IV. Identify adjacent “Herbaceous Vegetation”, “Barren”, or “Scrub-Shrub” segments after “Turf Grass”, successional and other non-pasture classes have been assigned in previous passes.

Idle/Fallow (Pending Decision):

- I. If “Herbaceous Vegetation”, “Barren”, or “Scrub-Shrub” segments have an area greater than or equal 1 hectare and include 20% or greater coverage of the reclassified CDL idle/fallow pixels, classify as “Idle/Fallow.”
- II. Identify adjacent “Herbaceous Vegetation”, “Barren”, or “Scrub-Shrub” segments after “Turf Grass”, successional and other non- idle/fallow classes have been assigned in previous passes. If the segment is touching idle/fallow and no other segments with confusable classes, classify as “Idle/Fallow.”
  - a. Repeat
- III. Identify adjacent “Herbaceous Vegetation”, “Barren”, or “Scrub-Shrub” segments after “Turf Grass”, successional and other non- idle/fallow classes have been assigned in previous passes.

Orchards/Vineyards (Pending Decision):

- I. If “Herbaceous Vegetation”, “Barren”, or “Scrub-Shrub” segments have an area greater than or equal 1 hectare and include 20% or greater coverage of the reclassified CDL orchards/vineyards pixels, classify as “Orchards/Vineyards.”
- II. Identify adjacent “Herbaceous Vegetation”, “Barren”, or “Scrub-Shrub” segments after “Turf Grass”, successional and other non-orchards/vineyards classes have been assigned in previous passes. If the segment is touching orchards/vineyards and no other segments with confusable classes, classify as “Orchards/Vineyards”.
  - a. Repeat

- III. Identify adjacent “Herbaceous Vegetation”, “Barren”, or “Scrub-Shrub” segments after “Turf Grass”, successional and other non-orchards/vineyards classes have been assigned in previous passes.

Solar Fields:

- I. Identify “Herbaceous Vegetation”, “Barren”, or “Scrub-Shrub” segments after “Turf Grass”, successional and other non-solar field classes have been assigned in previous passes. Intersect segments where their centroid falls within digitized solar field boundaries or AI solar field outputs and classify as “Solar Fields”

Timber Harvests:

- I. “Herbaceous Vegetation” or “Barren” segment contains greater than or equal to 10% of LCMAP detected timber harvest + deforestation, and the clearing occurred between 2015 and 2017, classify as “Timber Harvest.”

Extractive:

- I. “Barren” or “Other Impervious” segments that intersect with ancillary active “mines” dataset, classify as “Extractive.”

**LUWG Decisions:**

**10-07-20:** Solar fields will be mapped as four separate classes: “solar impervious”, “solar Barren”, “solar herbaceous”, and “solar Scrub-Shrub.”

**Wetland and Water Margin Classes**

**Definition:** Wetlands are areas that are perennially or intermittently saturated and exhibit related soil and vegetation characteristics including “tidal” wetlands, non-tidal “floodplain” wetlands, and isolated non-tidal “other” wetlands. Bare shore represents non-wetland Barren areas adjacent to surface waters and includes lake margins, beaches, exposed mudflats, and gravel bars categorized into two classes: lentic and lotic.

**2013 LU Issues:** Because wetland characteristics are challenging to map using just LiDAR and NAIP imagery, field reconnaissance is required to verify hydric soil conditions, hydrologic connections, and the presence of wetland-dependent plant species. Lacking the resources to conduct a field campaign, the CBP Partners relied on existing data such as the National Wetlands Inventory (NWI) coupled with state wetland maps developed for Delaware, Maryland, and Virginia to map wetlands. For Pennsylvania, a modeling effort was supported in 2016 to map probabilistic wetlands (Raney and others, 2017) that could augment the NWI. In addition, manual updates to emergent wetland footprints in Maryland and Delaware were performed by the Chesapeake Conservancy and University of Vermont for wetlands recently impacted by development. While NWI attribute data can be used to discriminate between tidal and non-tidal wetlands, sole reliance on the NWI attributes for identifying tidal NWI wetlands resulted in classifying some isolated wetlands as tidal.

Emergent wetlands mapped by the Chesapeake Conservancy and University of Vermont were classed as “tidal” if they were within 2-meters of surface water based on a 10-meter Digital Elevation Model downloaded in 2015. Newer, high-resolution DEM’s now exist for some counties along the Bay shoreline.

Floodplains were mapped using County Soil Survey data on frequently flooded soils coupled with FEMA 100-year Digital Flood Insurance Rate Maps. These data are helpful but may omit potential floodplains along lower-order, headwater streams.

The extent of bare shore areas visible in NAIP imagery varies over time due to changes in water levels associated with the tides, rainfall, and reservoir management plans. Bare shore is included in the Phase 6 “mixed open” class. By mapping bare shore specifically, the CBP Partners may consider whether to include its change in future updates to CAST.

**Summary Methods:** Map all “Barren” land close to a large body of water as “bare shore.” Continue to rely on the NWI and state wetland datasets, and the probabilistic wetland dataset for Pennsylvania but expand this dataset to the entire watershed to represent the universe of verified and potential wetlands in the watershed. Update the tidal zone map using a 2-ft. rise above Mean Higher High Water as modeled by NOAA’s Sea Level Rise Viewer. Update the floodplain zone map using the latest available LiDAR imagery and the USGS’ Floodplain and Channel Evaluation Tool (FACET).

**Technical Methods:**

Data needed: LC Water, NWI (vector), UVM Wetlands (raster), NHFL FEMA 100-yr floodplain, SSGURGO hydric and frequently flooded soils, FACET 24k stream network (with channel metrics) or Hyper-resolution streams (2K)

Non-Tidal Wetlands:

- I. SSURGO frequently flooded soils: flodfreqdcd == "Frequent" (Flooding Frequency - Dominant Condition)
- II. SSURGO hydric soils: hydclprs >= 1 (Hydric Classification - Presence)
- III. FEMA 100 year floodplain.
- IV. Create riverine mask: Select all hydric and FEMA polygons if they intersect with streams, and merge hydric soils, FEMA, freq. flooded soils, streams as riverine\_mask.
- V. Riverine:
  - a. Create temporary layer from UVM wetlands without water and NWI wetlands without Freshwater ponds and Lakes. Call them uvm\_wetlands\_tmp and nwi\_wetlands\_tmp.
  - b. Spatial overlay: REMOVE all ponds that intersect with nwi\_wetlands\_tmp. call it nwi\_wetlands\_tmp\_wo\_ponds.
  - c. Merge uvm\_wetlands\_tmp + nwi\_wetlands\_tmp\_wo\_ponds as wetlands\_tmp.
  - d. Spatial overlay: classify all ponds that intersect with riverine mask as riverine\_ponds and inverse as terrene\_ponds.
  - e. Reclassify wetlands\_tmp polygons as "riverine", if they spatially intersect the riverine mask or if their boundary touches riverine\_ponds.
- VI. Terrine:
  - a. Reclassify wetlands\_tmp polygons as "terrene" if they spatially DO NOT intersect the riverine mask or if their boundary touches terrene\_ponds.

Bare Shore:

- I. “Barren” segment is within 3 meters of water and is less than or equal to 15 square meters
- II. Exclude “Barren” segments that are less than or equal to 100,000 square meters and intersect “Wetland” segments greater than or equal to 15 square meters
- III. Exclude “Barren” segments that intersect with: mines, landfills, and local land use classes (suspended succession, extractive, agriculture, wetlands)
- IV. Classify those Barren segments as “Bare Shore.”

**LUWG Decisions:**

**10-07-20:** Bare shore = Barren land that is not wetland and adjacent to water

**Schedule of Tasks and Coordination for CAST 21**

2017 Land Use Production Schedule		2020			2021							
Order	Task	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG
1	Local review of 2017 Land Cover Data			LUWG			LUWG	LUWG				
2	Draft Hyper-resolution Hydrography			LUWG	gaps		LUWG	LUWG				
3	Cropland, Pasture, Orchards, and Turf Grass	AGWG										
4	Suspended Succession, Bare Shore, and Solar Fields	LUWG										
5	Tidal & NonTidal Wetlands	WWG										
6	Review ag and wetland mapping procedures, schedule		LUWG									
7	Forests, Tree Canopy, Timber Harvests, and Natural Succession			FWG								
8	Finalize Wetland Methodology			WWG								
9	Bare Construction, P6 Roll-up Decision Rules, FedFac Land Uses				LUWG, FedFac							
10	Prototype Land Use in 14 counties											
11	Approve 2017 Land Use Mapping and P6 Roll-up Methods					LUWG, AGWG, USWG, WWG, FWG, FedFac						
12	Complete 2017 Land Use Dataset									LUWG		
13	Revise 2013 Land Use (to match 2017)						LUWG			LUWG		
14	Update MS4s, Sewer, Septic, Zoning, and Population Estimates and Projections											
15	Revise Agricultural Forecast Methodology	AGWG					AGWG					
16	Update Land Use Forecasts									LUWG		
17	Update 2013, 2017, and 2025 CAST Inputs										LUWG	WQGIT