CBP Land Use Classification Scheme 2013 - 2021 09.1.2020

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[1]. 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.

[1] https://chesapeakeconservancy.org/conservation-innovation-center-2/high-resolution-data/land-use-data-project/

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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 construction, 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 Construction” 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 62 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
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
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 (>= 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 Construction
    - 11.5. Bare Shore
    - 11.6. Extractive
    - 11.7. Fragmented Forest (< 1 acre)
12. ***Cropland (CRP; 1 to 2 classes)***
    - 12.1. Cropland
    - 12.2. Orchard/vineyard
    - 12.3. Idle/Fallow
13. ***Pasture (PAS; no change)***

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General-Purpose Land Use (62 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 Construction
     - 2.2.3.Suspended Succession
       - 2.2.3.1. Barren
       - 2.2.3.2. Herbaceous
       - 2.2.3.3. Scrub-shrub
   - **2.3. Urban 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 (>= 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 (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
     - 4.1.3.**Orchard/ Vineyard**
       - 4.1.3.1. Barren
       - 4.1.3.2. Herbaceous
       - 4.1.3.3. Scrub-shrub
     - 4.1.4.**Fallow/ Idle**
       - 4.1.4.1. Barren
       - 4.1.4.2. Herbaceous
       - 4.1.4.3. Scrub-shrub
   - **4.2. Timber Harvest**
     - 4.2.1.Barren
     - 4.2.2.Herbaceous
     - 4.2.3.Scrub-shrub
   - **4.3. Extractive (active)**
     - 4.3.1.Barren
     - 4.3.2.Herbaceous
     - 4.3.3.Scrub-shrub
   - **4.4. Solar fields**

5. ***Wetlands and Water Margins (20)***
   - **5.1. Tidal**
     - 5.1.1.Open water
     - 5.1.2.Barren
     - 5.1.3.Herbaceous
     - 5.1.4.Scrub-shrub
     - 5.1.5.Contiguous Forest
     - 5.1.6.Fragmented Forest
   - **5.2. Non-Tidal**
     - 5.2.1.Floodplain/ Headwater
       - 5.2.1.1. Open water
       - 5.2.1.2. Barren
       - 5.2.1.3. Herbaceous
       - 5.2.1.4. Scrub-shrub
       - 5.2.1.5. Contiguous Forest
       - 5.2.1.6. Fragmented Forest
     - 5.2.2.Other
       - 5.2.2.1. Open water
       - 5.2.2.2. Barren
       - 5.2.2.3. Herbaceous
       - 5.2.2.4. Scrub-shrub
       - 5.2.2.5. Contiguous Forest
       - 5.2.2.6. Fragmented Forest
   - **5.3. Bare shore**
     - 5.3.1.Lentic
     - 5.3.2.Lotic

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.

Proposed New 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.

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".

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 construction, and utility rights-of-way (i.e., suspended succession), and tree canopy obscuring roads, structures, other impervious, and turf grass.

2013 LU Issues: Turf grass was slightly overestimated in some areas due to inclusion of road rights-of-way, reliance on focal windows to identify residential patches, inclusion of turf in fractional land uses, and over-generalization or misinterpretation of local land use data. In addition, transmission line rights-of-way were mapped inconsistently, and pipelines omitted.

Proposed New 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. However, buffer all rail lines in Open Street Map by 3m and reclassify these areas either "Other Impervious" or "Tree Canopy over Other Impervious". Use parcel and image segment characteristics to identify patches of turf grass and differentiate them from patches of agriculture. Characteristics under consideration include parcel and image segment size, number of non-herbaceous inclusions per unit area, and shape compactness (Polsby-Popper test). Continue to rely on land cover data to directly map tree canopy over roads, structures, and other impervious surfaces. Map all tree canopy on small lots including turf grass and tree canopy over turf grass. Use ancillary data on transmission lines, pipelines, and landfills to identify herbaceous, scrub-shrub, and barren lands as "Suspended Succession". Identify lands likely undergoing construction by their barren cover type and neighborhood context (i.e., adjacent to developed lands).

Forest Classes

Definition: all areas covered by tree canopy that are presumed to have an unmanaged understory including contiguous forest (patches >= 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 >= 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.

Proposed New Methods: After accounting for tree canopy over turf grass and over impervious cover, map all remaining patches of tree canopy as either contiguous forest or fragmented forest using the Polsby-Popper test of compactness. Patches of tree canopy large enough to contain an acre-circle will be classed as contiguous forest, all others will be classed as fragmented 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.

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.

Proposed New Methods: Agricultural lands will be mapped directly and simultaneously with turf grass using parcel and image segment characteristics such as size, number of non-herbaceous inclusions per unit area, and shape compactness (Polsby-Popper test). Agriculture typically occurs on large parcels which may be subdivided and organized into multiple fields which can be identified based on the above characteristics. Moreover, multiple years of the NASS Cropland Data Layer (2017-2019) coupled with the 2016 USGS National Land Cover Database will be used to further verify the presence of agriculture and to differentiate cropland, pasture, orchards/vineyards, and idle/fallow fields.

Solar fields will be mapped by Washington College using point data identifying potential solar field arrays.

Mines and quarries will be mapped 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. 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 are 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 reclassed back to 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.

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 barren lands adjacent to surface waters and includes lake margins, beaches, exposed mudflats, and gravel bars simplified into two categories: 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.

Proposed New Methods: Continue to rely on the NWI and state wetland datasets, and the probabilistic wetland dataset for Pennsylvania to represent the universe of 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).

Prioritization of Tasks (September - December 2020)

1. Railroad rights-of-way as impervious cover
2. All types of agriculture and turf grass
3. Suspended succession using ancillary data on transmission lines and pipelines
4. Timber harvest areas with ancillary and LCMAP data
5. Bare construction using LCMAP, landscape context, and ancillary data
6. Contiguous and fragmented forests
7. Tree canopy over turf grass
8. Tidal and floodplain zone delineations
9. Shaded vs sunlit streams
10. Streams vs ditches, gullies and trenches
11. Bare-shore margins
12. Solar fields
13. Natural succession
14. Clean up: reconciliation of slivers
15. Incorporation of federal land uses