Designing Sustainable Landscapes: DSLland and Subsysland

A project of the Landscape Ecology Lab, Department of Environmental Conservation, University of Massachusetts, Amherst

Principals:

- Kevin McGarigal, Emeritus Professor
- Brad Compton, Research Associate
- Ethan Plunkett, Research Associate
- William V. DeLuca, Adjunct Assistant Professor
- Joanna Grand, Research Associate

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UMass Amherst

Reference:

McGarigal K, Compton BW, Plunkett EB, DeLuca WV, and Grand J. 2020. Designing sustainable landscapes: DSLland and Subsysland. Report to the North Atlantic Conservation Cooperative, US Fish and Wildlife Service, Northeast Region.

Changes in 2020 version

1. We derived a new development surface from the Microsoft building footprint data (Bing Maps Team, 2018) and overlaid it on our NLCD-based development. This captured newer development as well as roadside and rural development that were greatly underrepresented in the prior landcover. The result is that we finally have a fairly accurate representation of development throughout the region.
2. We updated the Open Street Map (OSM) roads to November 2018 thus incorporating new roads and other corrections in the OSM dataset.
3. We dropped tracks from the OSM data and our landcover as we found that the tracks in OSM were mapped inconsistently and the track tag was often erroneously and inconsistently applied to trails.
4. We improved the capture of the tunnel tag for both railroads and roads dropping roads and railroads where the OSM metadata indicated tunnels. We had done this for some but not all instances in the prior version.
5. We captured more abandoned railways by augmenting the railway data with cycleway data in which the cycleway included “rail” in the name.
6. The edges of the landscape were adjusted slightly to conform to other layers and regional boundaries.
7. We used an three-cell minimum mapping unit to smooth stream classes.

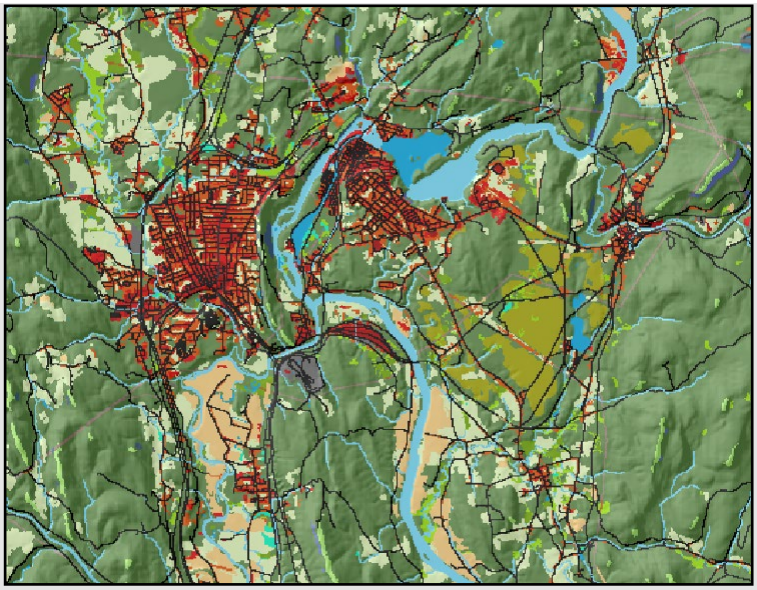

Figure 1. Sample DSLland map without a legend.

General description

DSLland is the land cover map used as an organizational framework in the Designing Sustainable Landscapes (DSL) project (McGarigal et al 2017)**.** It is derived primarily from The Nature Conservancy's Northeast Habitat Classification map (Ferree and Anderson 2013; Anderson et al. 2013; Olivero and Anderson 2013; Olivero-Sheldon et al 2014). To meet the needs of the DSL project, we substantially modified the TNC map, as described below (**Fig. 1**)**.** The TNC map is a hierarchical classification (see **Appendix**). For our purposes, we adopted the 'habitat' level of the hierarchy, which we refer to as "ecosystems", as our finest scale, as it is the most appropriate classification for our ecological assessment. The attribute table also includes the ‘formation’ level for users that prefer a coarse classification.

Use and interpretation of this layer

DSLland is used extensively in the DSL Landscape Change, Assessment and Design (LCAD) model as an organizational framework. Its principal uses are three-fold:

1. It is an important component of the landscape change model. Specifically, urban growth (see technical document on urban growth, McGarigal et al 2017) is excluded from certain ecosystems (e.g., water, wetlands, etc.) and succession (see technical document on disturbance and succession, McGarigal et al 2017) is limited to forested ecosystems, as depicted in this layer. Thus, the DSLland map provides the spatial template on which urban development and vegetation change take place.
2. It is the basis for scaling the index of ecological integrity, which is the foundation of our ecosystem-based assessment of ecological integrity (see technical document on integrity, McGarigal et al 2017) and thus central to the derivation of core areas in our landscape conservation design (see technical document on landscape design, McGarigal et al 2017). Specifically, the index of ecological integrity is scaled by ecosystem, as depicted in this layer, such that the index ranges from 0 (worst) to 1 (best) within each ecosystem. A principal aim of the core area network in the landscape conservation design is to identify an integral network of places that include redundant representation of all ecosystems as delineated in this layer.
3. It is a major component of the landscape capability models for representative species, which is the foundation of our species-based ecological assessment (see technical document on species, McGarigal et al 2017) and thus central to the derivation of core areas in our landscape conservation design (see technical document on landscape design, McGarigal et al 2017). Specifically, ecosystems, as depicted in this layer, are assigned scores as part of the habitat capability component of the individual species' models. A principal aim of the core area network in the landscape conservation design is to identify an integral network of places that capture a minimum proportion of each species' landscape capability, which is strongly determined by the distribution of ecosystems as delineated in this layer.

The potential uses of this, or any other land cover map, outside of the DSL project are too numerous to list here. However, the use of DSLland should be done with the following consideration:

- It is important to acknowledge that DSLland was derived from a model, and thus subject to the limitations of any model due to incomplete and imperfect data, and a limited understanding of the phenomenon being represented. In particular, the GIS data upon which this product was built are imperfect; they contain errors of both omission and commission. Consequently, there will be places where the model gets it wrong, not necessarily because the model itself is wrong, but rather because the input data are wrong. In addition, DSLland employs a classification system that unavoidably involves categorizing the land into a somewhat arbitrary set of discrete classes (see **Appendix**). All categorical land cover maps are fraught with problems owing to the arbitrariness of any classification scheme applied to a

continuous environment and the resulting imposition of discrete lines on the map that don't always correspond to discrete lines on the ground. Thus, the DSLland map should be used and interpreted with caution and an appreciation for the limits of the available data and models. However, getting it wrong in some places should not undermine the utility of the product as a whole. As long as the model gets it right most of the time, it still can have great utility.

- In this version we dropped tracks from the landcover. Tracks were often mismapped to include hiking trails, mountain bike trails, and long-abandoned cart roads, and they were mapped inconsistently. This resulted in massive overestimation road effects in mostly natural areas. Unfortunately, by dropping tracks, we also lost some of the extensive logging roads in Maine and some heavily tracked areas associated with natural gas extraction in Pennsylvania. Thus some of the real impacts of tracks are no longer captured in our models.

Derivation of this layer

An overview of the major modifications and justifications for those changes is provided below.

Figure 2. Sample NLCD versus OSM roads.

1. Roads

The TNC map relied on the National Land Cover Dataset (NLCD 2001) developed by the Multi-Resolution Land Characteristics Consortium (MRLC) for the mapping of roads. These roads are significantly misaligned, in addition to being conflated with all other development, as the NLCD 2001 contained only a single developed class (value = 20). Because the DSL ecological integrity and urban growth models require differentiation of road and development classes, and to mitigate the misalignment, we replaced the NLCD roads embedded in the TNC map with the more spatially accurate and differentiated Open Street Map (OSM) roads and rails (**Fig. 2**). Specifically, DSLland includes seven transportation classes; motorway, primary road, secondary road, tertiary road, local road, active train, and abandoned train.

2. Development and agriculture

To further refine DSLland, we replaced the remainder of the single development class in the TNC map with the four development classes contained in the NLCD 2011 map (high-, medium-, and low-intensity developed, and developed open space; pink scale, **Fig. 3**). In addition, we replaced the single agriculture class with the two NLCD 2011 agriculture classes (pasture/hay and cultivated crops; yellow scale, **Fig. 3**), and added road-stream crossings empirically derived from OSM roads and the high-resolution (1:24k) National Hydrography Dataset (NHD) streams, dams compiled by TNC for their Northeast Aquatic

Connectivity project, and Ventex powerlines also obtained from TNC. Finally, we augmented the NLCD development with development derived from the Microsoft building footprint polygons with cells containing buildings assigned to one of the three development classes based on the building density of the area around the cell. This last step both updated the building footprint and overcame the lack of rural development in the prior dataset.

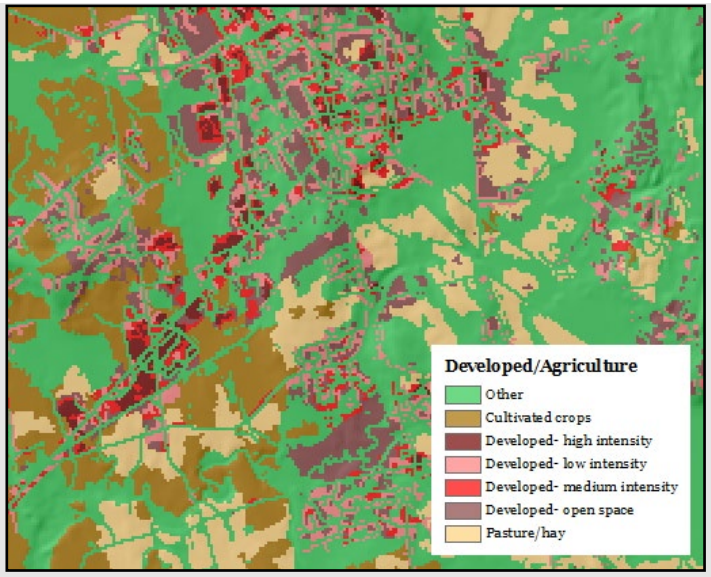

Figure 3. Sample DSLland depicting NLCD development and agriculture classes.

3. Open water

The TNC map contained a single open water class that we deemed inadequate for our ecosystem-based and individual species-based ecological assessment. We therefore replaced it with open water classes from three sources: high-resolution NHD large river polygons, National Wetlands Inventory (NWI) and NHD lentic polygons, and NHD high-resolution streams (**Fig. 4**). We classified the streams into 21 classes based on size, gradient, temperature, and tidal status. Temperature was derived by assigning TNC's Northeast Aquatic Habitat Classification System temperature classes based on medium-resolution NHDplus streams to our high-resolution NHD streams. Size and gradient were based on the DSL flow accumulation and stream gradient layers, respectively, and split into separate classes using the corresponding TNC threshold values. We divided lentic into 13 classes based on size (lake versus pond), temperature (warm, cool, cold, very cold) and trophic status (oligo-mesotrophic versus eutrophic) based on TNC's classification of lentic water bodies derived from medium-resolution NHDplus supplemented with water bodies from high-resolution NHD and NWI. Finally, coastal NHD streams were reclassified as estuarine intertidal or subtidal depending on the class of neighboring cells.

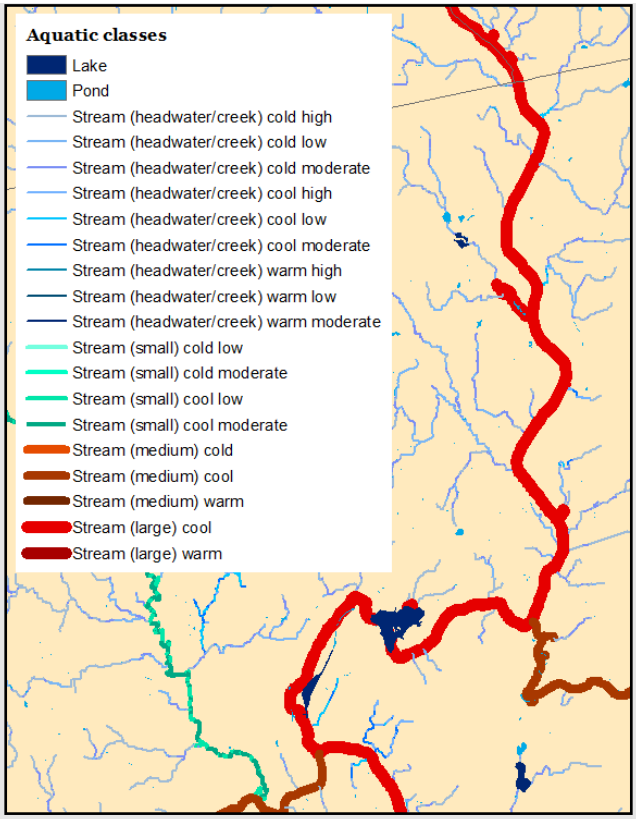

Figure 4. Sample DSLland depicting aquatic ecosystem classes.

4. Coastal wetlands

The NWI completed updates to coastal wetlands in 2013. In order to take advantage of these updates, we replaced the five TNC salt marsh classes with the updated NWI estuarine and marine subtidal and intertidal classes that occur in the Northeast Region (**Fig. 5**). Note, we did not incorporate NWI's subclass level.

5. Future timesteps

The results of the DSL urban growth model is used to update DSLland with new low-, medium-, and high-intensity development projected for 2030 and 2080 (not shown).

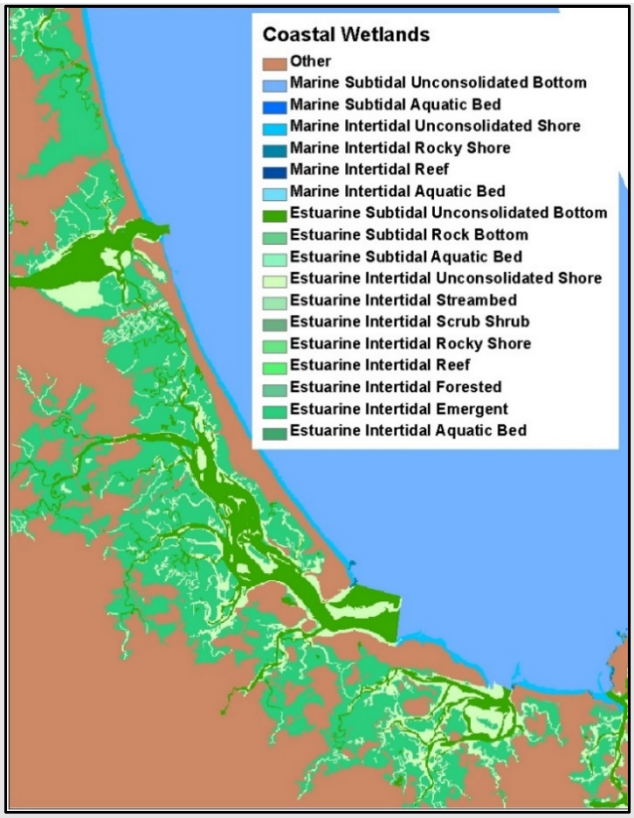

Figure 5. Sample DSLland depicting coastal wetland classes.

Subsysland

Subsysland is a derivation of DSLland that is used specifically for the focal species landscape capability models (see technical document on species, McGarigal et al 2017). DSLland and Subsysland are identical with the exception of two important differences.

1. Subsystems

The finer subsystem classifications assigned by TNC, which are nested within the ecosystem classifications used for DSLland, are used in Subsysland (See **Appendix**). The finer classifications of Subsysland are used to index habitat capability values in the HABIT@ component of the Landscape Capability models. The finer classifications of Subsysland are often important determinants of habitat capability in HABIT@ models. For example, Laurentian-Acadian Northern Hardwood Forest: high conifer, is preferred by the blackburnian warbler over the other subsystems within that ecosystem with less conifers.

2. Headwater streams

Because DSLland is a raster with 30m pixels, it dramatically overestimates the area of headwater streams given that most headwater streams are less than 1m wide. Therefore, in the context of forest species HABIT@ models, headwater streams could act as fragmenting features in an otherwise unfragmented forest. To alleviate this effect, Subsysland does not include most headwater streams. Note, for headwater stream-dependant species such as the Louisiana waterthrush, we use a version of Subsysland that includes all headwater streams.

GIS metadata

DSLland and Subsysland are distributed as Geotiff rasters (30 m cells), attributed as follows, and can be found at McGarigal et al (2017):

- OID = ESRI assigned unique number (meaningless).
- Value = unique number assigned to each ecological system.
- Count = number of cells of the corresponding ecological system.
- ecosystem = ecological system (note, ecosystem here is based on the field named 'sumgroupname' in the ArcGIS raster distributed by TNC named 'syst_ne130930' , or the field named 'habitat' in the ArcGIS raster distributed by TNC named 'syst_ne141611').
- formation = ecological formation, consisting of closely related ecosystems.
- index = arbitrary number assigned for internal use to facilitate sorting of ecological systems.

Literature Cited

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Appendix

DSLland and Subsysland classification. DSLland classification refers to Ecosystems and Subsysland refers to Subsystem classifications. Note, Subsystems are nested within Ecosystems.

Formation	Ecosystem	Ecosystem Value	Subsystem	Subsystem Value
Agriculture	Pasture/hay	81	Pasture/hay	81
	Cultivated crops	82	Cultivated crops	82
Alpine	Acadian-Appalachian Alpine Tundra	5000	Acadian-Appalachian Alpine Tundra	567
Boreal Upland Forest	Acadian Low Elevation Spruce-Fir-Hardwood Forest	2050	Acadian Low Elevation Spruce-Fir-Hardwood Forest	5650
	Acadian Sub-boreal Spruce Flat	4000	Acadian Sub-boreal Spruce Flat	562
	Acadian-Appalachian Montane Spruce-Fir-Hardwood Forest	6000	Acadian-Appalachian Montane Spr-Fir-Hwd Forest	566
	Central and Southern Appalachian Spruce-Fir Forest	30000	Central and Southern Appalachian Spruce-Fir Forest	28
Cliff & Rock	Acidic Cliff and Talus	8000	Cumberland Acidic Cliff and Rockhouse	309
	Acidic Cliff and Talus	8000	Southern Appalachian Montane Cliff and Talus	330
	Acidic Cliff and Talus	8000	Laurentian-Acadian Acidic Cliff and Talus	569
	Acidic Cliff and Talus	8000	North-Central Appalachian Acidic Cliff and Talus	601
	Acidic Cliff and Talus	8000	Central Interior Acidic Cliff and Talus	689
	Calcareous Cliff and Talus	21000	Southern Interior Calcareous Cliff	356

Formation	Ecosystem	Ecosystem Value	Subsystem	Subsystem Value
	Calcareous Cliff and Talus	21000	Laurentian-Acadian Calcareous Cliff and Talus	570
	Calcareous Cliff and Talus	21000	Central Interior Calcareous Cliff and Talus	690
	Circumneutral Cliff and Talus	31000	North-Central Appalachian Circumneutral Cliff and Talus	603
Coastal Scrub-Herb	Atlantic Coastal Plain Beach and Dune	14000	Northern Atlantic Coastal Plain Dune and Swale/Sandy Beach	264
	Atlantic Coastal Plain Beach and Dune	14000	Northern Atlantic Coastal Plain Dune and Swale/Central Atlantic Coastal Plain Sandy Beach	264064
	Great Lakes Dune and Swale	37000	Great Lakes Dune	26
	Great Lakes Dune and Swale	37000	Great Lakes Dune and Swale	726
	North Atlantic Coastal Plain Heathland and Grassland	51000	North Atlantic Coastal Plain Heathland and Grassland	895
Developed	Motorway	1	Motorway	1
	Primary road	2	Primary road	2
	Secondary road	3	Secondary road	3
	Tertiary road	4	Tertiary road	4
	Local road	5	Local road	5
	Track	6	Track	6
	Active train	7	Active train	7

Formation	Ecosystem	Ecosystem Value	Subsystem	Subsystem Value
	Abandoned train	8	Abandoned train	8
	Developed- open space	21	Developed- open space	21
	Developed- low intensity	22	Developed- low intensity	22
	Developed- medium intensity	23	Developed- medium intensity	23
	Developed- high intensity	24	Developed- high intensity	24
	Barren land	31	Barren land	31
	Dam	101	Dam	101
	Culvert/bridge	102	Culvert/bridge	102
Estuarine Intertidal	Estuarine Subtidal Sheltered	301	Estuarine Subtidal Sheltered	301
	Estuarine Intertidal Aquatic Bed	404	Estuarine Intertidal Aquatic Bed	404
	Estuarine Intertidal Reef	405	Estuarine Intertidal Reef	405
	Estuarine Intertidal Rocky Shore	407	Estuarine Intertidal Rocky Shore	407
	Estuarine Intertidal Unconsolidated Shore	408	Estuarine Intertidal Streambed	406
	Estuarine Intertidal Unconsolidated Shore	408	Estuarine Intertidal Unconsolidated Shore	408
	Estuarine Intertidal Emergent	409	Estuarine Intertidal Emergent	409
	Estuarine Intertidal Scrub Shrub	410	Estuarine Intertidal Scrub Shrub	410

Formation	Ecosystem	Ecosystem Value	Subsystem	Subsystem Value
	Estuarine Intertidal Forested	411	Estuarine Intertidal Forested	411
	Estuarine Subtidal Unconsolidated Bottom	400	Estuarine Subtidal Unconsolidated Bottom	400
	Estuarine Subtidal Aquatic Bed	402	Estuarine Subtidal Aquatic Bed	402
Grassland & Shrubland	Acidic Rocky Outcrop	9000	Laurentian Acidic Rocky Outcrop	19
	Acidic Rocky Outcrop	9000	Southern Piedmont Granite Flatrock and Outcrop	329
	Acidic Rocky Outcrop	9000	Northern Appalachian-Acadian Rocky Heath Outcrop	571
	Appalachian Shale Barrens	13000	Appalachian Shale Barrens	598
	Calcareous Rocky Outcrop	22000	Laurentian-Acadian Calcareous Rocky Outcrop	572
	Central Appalachian Alkaline Glade and Woodland	23000	Central Appalachian Alkaline Glade and Woodland	602
	Eastern Serpentine Woodland	33000	Eastern Serpentine Woodland	347
	Great Lakes Alvar	36000	Great Lakes Alvar	721
	Shrubland & grassland (NLCD 52/71)	78000	NLCD 52/71: shrublands/grasslands	5271
	Southern Ridge and Valley Calcareous Glade and Woodland	95000	Southern Ridge and Valley Calcareous Glade and Woodland	25
	Mafic Glade and Barrens	97000	Southern Piedmont Glade and Barrens	328

Formation	Ecosystem	Ecosystem Value	Subsystem	Subsystem Value
	Mafic Glade and Barrens	97000	Southern and Central Appalachian Mafic Glade and Barrens	348
	Southern Appalachian Grass and Shrub Bald	98000	Southern Appalachian Grass and Shrub Bald	294
Lentic	Lentic	200	Lentic	200
	Great Lakes	201	Great Lakes	201
	Very Cold Lake	210	Very Cold Lake	210
	Cold Lake	211	Cold Lake	211
	Cold Pond	212	Cold Pond	212
	Cool Eutrophic Lake	213	Cool Eutrophic Lake	213
	Cool Oligo-Mesotrophic Lake	214	Cool Oligo-Mesotrophic Lake	214
	Cool Eutrophic Pond	215	Cool Eutrophic Pond	215
	Cool Oligo-Mesotrophic Pond	216	Cool Oligo-Mesotrophic Pond	216
	Warm Eutrophic Lake	217	Warm Eutrophic Lake	217
	Warm Oligo-Mesotrophic Lake	218	Warm Oligo-Mesotrophic Lake	218
	Warm Eutrophic Pond	219	Warm Eutrophic Pond	219
	Warm Oligo-Mesotrophic Pond	220	Warm Oligo-Mesotrophic Pond	220
	Small Pond	221	Small Pond	221
Lotic	Lotic	100	Lotic	100

Formation	Ecosystem	Ecosystem Value	Subsystem	Subsystem Value
Marine Intertidal	Marine Intertidal Aquatic Bed	504	Marine Intertidal Aquatic Bed	504
	Marine Intertidal Rocky Shore	506	Marine Intertidal Reef	505
	Marine Intertidal Rocky Shore	506	Marine Intertidal Rocky Shore	506
	Marine Intertidal Unconsolidated Shore	507	Marine Intertidal Unconsolidated Shore	507
	Marine Subtidal Unconsolidated Bottom	500	Marine Subtidal Unconsolidated Bottom	500
	Marine Subtidal Aquatic Bed	502	Marine Subtidal Aquatic Bed	502
Northeastern Upland Forest	Allegheny-Cumberland Dry Oak Forest and Woodland	11000	Allegheny-Cumberland Dry Oak Forest and Woodland	359
	Appalachian (Hemlock)-Northern Hardwood Forest	12000	Appalachian (Hemlock)-Northern Hardwood Forest: typic	5930
	Appalachian (Hemlock)-Northern Hardwood Forest	12000	Appalachian (Hemlock)-Northern Hardwood Forest: drier	5938
	Appalachian (Hemlock)-Northern Hardwood Forest	12000	Appalachian (Hemlock)-Northern Hardwood Forest: moist-cool	5939
	Central Appalachian Dry Oak-Pine Forest	24000	Central Appalachian Dry Oak-Pine Forest	591
	Central Appalachian Pine-Oak Rocky Woodland	25000	Central Appalachian Pine-Oak Rocky Woodland	600
	Central Atlantic Coastal Plain Maritime Forest	27000	Central Atlantic Coastal Plain Maritime Forest	261

Formation	Ecosystem	Ecosystem Value	Subsystem	Subsystem Value
	Central and Southern Appalachian Montane Oak Forest	29000	Central and Southern Appalachian Montane Oak Forest	596
	Glacial Marine & Lake Mesic Clayplain Forest	34000	Glacial Marine & Lake Mesic Clayplain Forest	998
	Laurentian-Acadian Northern Hardwood Forest	42000	Laurentian-Acadian Northern Hardwood Forest: typic	5640
	Laurentian-Acadian Northern Hardwood Forest	42000	Laurentian-Acadian Northern Hardwood Forest: high conifer	5642
	Laurentian-Acadian Northern Hardwood Forest	42000	Laurentian-Acadian Northern Hardwoods Forest: moist-cool	5649
	Laurentian-Acadian Northern Pine-(Oak) Forest	43000	Laurentian-Acadian Northern Pine-(Oak) Forest	719
	Laurentian-Acadian Pine-Hemlock-Hardwood Forest	44000	Laurentian-Acadian Pine-Hemlock-Hardwood Forest: typic	5630
	Laurentian-Acadian Pine-Hemlock-Hardwood Forest	44000	Laurentian-Acadian Pine-Hemlock-Hardwood Forest: moist-cool	5639
	Laurentian-Acadian Red Oak-Northern Hardwood Forest	45000	Laurentian-Acadian Red Oak-Northern Hardwood Forest	5644
	North Atlantic Coastal Plain Hardwood Forest	50000	North Atlantic Coastal Plain Hardwood Forest	475
	North Atlantic Coastal Plain Maritime Forest	53000	North Atlantic Coastal Plain Maritime Forest	302
	North Atlantic Coastal Plain	54000	North Atlantic Coastal Plain Pitch Pine Barrens	269

Formation	Ecosystem	Ecosystem Value	Subsystem	Subsystem Value
	Pitch Pine Barrens			
	Northeastern Interior Pine Barrens	61000	Northeastern Interior Pine Barrens	590
	North-Central Interior Beech-Maple Forest	62000	North-Central Interior Beech-Maple Forest	693
	Northeastern Coastal and Interior Pine-Oak Forest	67000	Northeastern Coastal and Interior Pine-Oak Forest	999
	Northeastern Interior Dry-Mesic Oak Forest	68000	Northeastern Interior Dry-Mesic Oak Forest: typic	5920
	Northeastern Interior Dry-Mesic Oak Forest	68000	Northeastern Interior Dry-Mesic Oak Forest: moist-cool	5929
	Piedmont Hardpan Woodland and Forest	72000	Piedmont Hardpan Woodland and Forest	268
	Pine plantation / Horticultural pines	77000	Pine plantation / Horticultural pines	9999
	South-Central Interior Mesophytic Forest	80000	South-Central Interior Mesophytic Forest	887
	Southern Appalachian Low Elevation Pine Forest	81000	Southern Appalachian Low Elevation Pine Forest	332
	Southern Appalachian Montane Pine Forest and Woodland	82000	Southern Appalachian Montane Pine Forest and Woodland	331
	Southern Appalachian Northern Hardwood Forest	83000	Southern Appalachian Northern Hardwood Forest	29
	Southern Appalachian Oak	84000	Southern Appalachian Oak Forest: typic	8860

Formation	Ecosystem	Ecosystem Value	Subsystem	Subsystem Value
	Forest			
	Southern Appalachian Oak Forest	84000	Southern Appalachian Oak Forest: moist-cool	8869
	Southern Atlantic Coastal Plain Upland Longleaf Pine Woodland	85000	Southern Atlantic Coastal Plain Dry and Dry-Mesic Oak Forest / ACP Upland Longleaf Pine Woodland	241281
	Southern Atlantic Coastal Plain Mesic Hardwood Forest	86000	Southern Atlantic Coastal Plain Mesic Hardwood Forest	242
	Southern Piedmont Dry Oak-Pine Forest	88000	Southern Piedmont Dry Oak-Pine Forest	339
	Southern Piedmont Mesic Forest	92000	Southern Piedmont Mesic Forest	342
	Southern Ridge and Valley / Cumberland Dry Calcareous Forest	94000	Southern Ridge and Valley / Cumberland Dry Calcareous Forest	457
	Southern and Central Appalachian Cove Forest	96000	Southern and Central Appalachian Cove Forest-- acidic	3731
	Southern and Central Appalachian Cove Forest	96000	Southern and Central Appalachian Cove Forest-- circumneutral	3732
	Southern and Central Appalachian Cove Forest	96000	Southern and Central Appalachian Cove Forest-- calcareous	3733
Northeastern Wetland	Ruderal Shrub Swamp	5272	Ruderal Shrub Swamp	5272
	Atlantic Coastal Plain Blackwater/Brownwater Stream	15000	Atlantic Coastal Plain Blackwater/Brownwater Stream Floodplain Forest Smaller river	247248

Formation	Ecosystem	Ecosystem Value	Subsystem	Subsystem Value
	Floodplain Forest		floodplain	
	Central Appalachian Stream and Riparian	26000	Central Appalachian Stream and Riparian Smaller river floodplain	609
	Central Interior Highlands and Appalachian Sinkhole and Depression Pond	28000	Central Interior Highlands and Appalachian Sinkhole and Depression Pond Isolated	18
	Glacial Marine & Lake Wet Clayplain Forest	35000	Glacial Marine & Lake Wet Clayplain Forest Undifferentiated	997
	High Allegheny Headwater Wetland	38000	High Allegheny Wetland Isolated/headwater streams	69
	Laurentian-Acadian Alkaline Conifer-Hardwood Swamp	39000	Laurentian-Acadian Alkaline Conifer-Hardwood Swamp Isolated	5750
	Laurentian-Acadian Alkaline Conifer-Hardwood Swamp	39000	Laurentian-Acadian Alkaline Conifer-Hardwood Swamp Lake/pond: any size	5752
	Laurentian-Acadian Alkaline Conifer-Hardwood Swamp	39000	Laurentian-Acadian Alkaline Conifer-Hardwood Swamp Smaller river riparian	5757
	Laurentian-Acadian Alkaline Conifer-Hardwood Swamp	39000	Laurentian-Acadian Alkaline Conifer-Hardwood Swamp Smaller river floodplain	5758
	Laurentian-Acadian Freshwater Marsh	41000	Laurentian-Acadian Freshwater Marsh Isolated	5940
	Laurentian-Acadian Freshwater Marsh	41000	Laurentian-Acadian Freshwater Marsh Lake/pond: any size	5942
	Laurentian-Acadian Freshwater Marsh	41000	Laurentian-Acadian Freshwater Marsh Great Lakes	5945

Formation	Ecosystem	Ecosystem Value	Subsystem	Subsystem Value
	Laurentian-Acadian Freshwater Marsh	41000	Laurentian-Acadian Freshwater Marsh Smaller river riparian	5947
	Laurentian-Acadian Freshwater Marsh	41000	Laurentian-Acadian Freshwater Marsh Smaller river floodplain	5948
	Laurentian-Acadian Wet Meadow-Shrub Swamp	46000	Laurentian-Acadian Wet Meadow-Shrub Swamp Isolated	5820
	Laurentian-Acadian Wet Meadow-Shrub Swamp	46000	Laurentian-Acadian Wet Meadow-Shrub Swamp Lake/pond: any size	5822
	Laurentian-Acadian Wet Meadow-Shrub Swamp	46000	Laurentian-Acadian Wet Meadow-Shrub Swamp Great Lakes	5825
	Laurentian-Acadian Wet Meadow-Shrub Swamp	46000	Laurentian-Acadian Wet Meadow-Shrub Swamp Smaller river riparian	5827
	Laurentian-Acadian Wet Meadow-Shrub Swamp	46000	Laurentian-Acadian Wet Meadow-Shrub Swamp Smaller river floodplain	5828
	North Atlantic Coastal Plain Basin Peat Swamp	47000	North Atlantic Coastal Plain Basin Peat Swamp Isolated/headwater streams	5220
	North Atlantic Coastal Plain Basin Peat Swamp	47000	North Atlantic Coastal Plain Basin Peat Swamp Lake/pond: any size	5222
	North Atlantic Coastal Plain Basin Peat Swamp	47000	North Atlantic Coastal Plain Basin Peat Swamp Smaller river riparian	5227
	North Atlantic Coastal Plain Basin Peat Swamp	47000	North Atlantic Coastal Plain Basin Peat Swamp Larger river floodplain	5229
	North Atlantic Coastal Plain Basin Swamp and Wet	48000	North Atlantic Coastal Plain Basin Swamp and Wet Hardwood Forest Isolated	5200

Formation	Ecosystem	Ecosystem Value	Subsystem	Subsystem Value
	Hardwood Forest			
	North Atlantic Coastal Plain Basin Swamp and Wet Hardwood Forest	48000	North Atlantic Coastal Plain Basin Swamp and Wet Hardwood Forest Lake/pond: any size	5202
	North Atlantic Coastal Plain Basin Swamp and Wet Hardwood Forest	48000	North Atlantic Coastal Plain Basin Swamp and Wet Hardwood Forest Smaller river riparian	5207
	North Atlantic Coastal Plain Basin Swamp and Wet Hardwood Forest	48000	North Atlantic Coastal Plain Basin Swamp and Wet Hardwood Forest Larger river floodplain	5209
	North Atlantic Coastal Plain Pitch Pine Lowland	55000	North Atlantic Coastal Plain Pitch Pine Lowland Isolated	3740
	North Atlantic Coastal Plain Pitch Pine Lowland	55000	North Atlantic Coastal Plain Pitch Pine Lowland Lake/pond: any size	3742
	North Atlantic Coastal Plain Pitch Pine Lowland	55000	North Atlantic Coastal Plain Pitch Pine Lowland Smaller river riparian	3747
	North Atlantic Coastal Plain Pitch Pine Lowland	55000	North Atlantic Coastal Plain Pitch Pine Lowland Larger river floodplain	3749
	North Atlantic Coastal Plain Stream and River	56000	North Atlantic Coastal Plain Stream and River Smaller river floodplain	70
	North Atlantic Coastal Plain Tidal Swamp	58000	North Atlantic Coastal Plain Tidal Swamp Tidal	282
	North-Central Appalachian Acidic Swamp	59000	North-Central Appalachian Acidic Swamp Isolated	6040

Formation	Ecosystem	Ecosystem Value	Subsystem	Subsystem Value
	North-Central Appalachian Acidic Swamp	59000	North-Central Appalachian Acidic Swamp Lake/pond: any size	6042
	North-Central Appalachian Acidic Swamp	59000	North-Central Appalachian Acidic Swamp Great Lakes	6045
	North-Central Appalachian Acidic Swamp	59000	North-Central Appalachian Acidic Swamp Smaller river riparian	6047
	North-Central Appalachian Acidic Swamp	59000	North-Central Appalachian Acidic Swamp Smaller river floodplain	6048
	North-Central Appalachian Large River Floodplain	60000	North-Central Interior and Appalachian Rich Swamp Larger river floodplain	6059
	North-Central Interior Large River Floodplain	63000	Laurentian-Acadian Wet Meadow-Shrub Swamp Larger river floodplain	15829
	North-Central Interior Wet Flatwoods	64000	North-Central Interior Wet Flatwoods Undifferentiated	700
	North-Central Interior and Appalachian Rich Swamp	66000	North-Central Interior and Appalachian Rich Swamp Isolated	6050
	North-Central Interior and Appalachian Rich Swamp	66000	North-Central Interior and Appalachian Rich Swamp Lake/pond: any size	6052
	North-Central Interior and Appalachian Rich Swamp	66000	North-Central Interior and Appalachian Rich Swamp Great Lakes	6055
	North-Central Interior and Appalachian Rich Swamp	66000	North-Central Interior and Appalachian Rich Swamp Smaller river riparian	6057
	North-Central Interior and Appalachian Rich Swamp	66000	North-Central Interior and Appalachian Rich Swamp Smaller river floodplain	6058

Formation	Ecosystem	Ecosystem Value	Subsystem	Subsystem Value
	Northern Appalachian-Acadian Conifer-Hardwood Acidic Swamp	69000	Northern Appalachian-Acadian Conifer-Hardwood Acidic Swamp Isolated	5740
	Northern Appalachian-Acadian Conifer-Hardwood Acidic Swamp	69000	Northern Appalachian-Acadian Conifer-Hardwood Acidic Swamp Lake/pond: any size	5742
	Northern Appalachian-Acadian Conifer-Hardwood Acidic Swamp	69000	Northern Appalachian-Acadian Conifer-Hardwood Acidic Swamp Smaller river riparian	5747
	Laurentian-Acadian Large River Floodplain	70000	Laurentian-Acadian Floodplain Forest Larger river floodplain	587
	Laurentian-Acadian Large River Floodplain	70000	Eastern Boreal Floodplain Larger river floodplain	588
	Laurentian-Acadian Large River Floodplain	70000	Northern Appalachian-Acadian Conifer-Hardwood Acidic Swamp Larger river floodplain	105749
	Laurentian-Acadian Large River Floodplain	70000	Laurentian-Acadian Alkaline Conifer-Hardwood Swamp Larger river floodplain	105759
	Laurentian-Acadian Large River Floodplain	70000	Laurentian-Acadian Wet Meadow-Shrub Swamp Larger river floodplain	105829
	Laurentian-Acadian Large River Floodplain	70000	Laurentian-Acadian Freshwater Marsh Larger river floodplain	105949
	Laurentian-Acadian Large River Floodplain	70000	North-Central Appalachian Acidic Swamp Larger river floodplain	106049
	Piedmont Upland Depression	73000	Piedmont Upland Depression Swamp--	335

Formation	Ecosystem	Ecosystem Value	Subsystem	Subsystem Value
	Swamp		bedrock not mafic Isolated	
	Piedmont Upland Depression Swamp	73000	Piedmont Upland Depression Swamp-- mafic bedrock Isolated	336
	Piedmont-Coastal Plain Freshwater Marsh	74000	Piedmont-Coastal Plain Freshwater Marsh Isolated	5950
	Piedmont-Coastal Plain Freshwater Marsh	74000	Piedmont-Coastal Plain Freshwater Marsh Lake/pond: any size	5952
	Piedmont-Coastal Plain Freshwater Marsh	74000	Piedmont-Coastal Plain Freshwater Marsh Smaller river floodplain	5958
	Piedmont-Coastal Plain Large River Floodplain	75000	Atlantic Coastal Plain Small Brownwater River Floodplain Forest Larger river floodplain	250
	Piedmont-Coastal Plain Large River Floodplain	75000	Piedmont-Coastal Plain Large River Floodplain Larger river floodplain	608
	Piedmont-Coastal Plain Large River Floodplain	75000	Piedmont-Coastal Plain Shrub Swamp Larger river floodplain	5779
	Piedmont-Coastal Plain Large River Floodplain	75000	Piedmont-Coastal Plain Freshwater Marsh Larger river floodplain	5959
	Piedmont-Coastal Plain Shrub Swamp	76000	Piedmont-Coastal Plain Shrub Swamp Isolated	5770
	Piedmont-Coastal Plain Shrub Swamp	76000	Piedmont-Coastal Plain Shrub Swamp Lake/pond: any size	5772
	Piedmont-Coastal Plain Shrub Swamp	76000	Piedmont-Coastal Plain Shrub Swamp Smaller river floodplain	5778
	Central Atlantic Coastal Plain	79000	Central Atlantic Coastal Plain Non-riverine	3041

Formation	Ecosystem	Ecosystem Value	Subsystem	Subsystem Value
	Non-riverine Swamp and Wet Hardwood Forest		Swamp and Wet Hardwood Forest-- oak-dominated Isolated	
	Central Atlantic Coastal Plain Non-riverine Swamp and Wet Hardwood Forest	79000	Central Atlantic Coastal Plain Non-riverine Swamp and Wet Hardwood Forest-- conifer-dominated Isolated	3042
	Southern Atlantic Coastal Plain Tidal Wooded Swamp	87000	Southern Atlantic Coastal Plain Tidal Wooded Swamp Tidal	240
	Southern Piedmont Lake Floodplain Forest	91000	Southern Piedmont Lake Floodplain Forest Lake/pond: any size	325
	Southern Piedmont Small Floodplain and Riparian Forest	93000	Southern Piedmont Small Floodplain and Riparian Forest Smaller river floodplain	323
Peatland	Acadian Maritime Bog	3000	Acadian Maritime Bog Isolated	580
	Atlantic Coastal Plain Northern Bog	17000	Atlantic Coastal Plain Northern Bog Isolated	8930
	Atlantic Coastal Plain Northern Bog	17000	Atlantic Coastal Plain Northern Bog Lake/pond: any size	8932
	Atlantic Coastal Plain Northern Bog	17000	Atlantic Coastal Plain Northern Bog Smaller river riparian	8937
	Atlantic Coastal Plain Northern Bog	17000	Atlantic Coastal Plain Northern Bog Larger river floodplain	8939
	Atlantic Coastal Plain Peatland Pocosin and Canebrake	18000	Atlantic Coastal Plain Peatland Pocosin and Canebrake Isolated	267
	Boreal-Laurentian Bog	19000	Boreal-Laurentian Bog Isolated	581

Formation	Ecosystem	Ecosystem Value	Subsystem	Subsystem Value
	Boreal-Laurentian-Acadian Fen	20000	Boreal-Laurentian-Acadian Acidic Basin Fen Undifferentiated	583
	Boreal-Laurentian-Acadian Fen	20000	Laurentian-Acadian Alkaline Fen Isolated/headwater streams	585
	North-Central Interior and Appalachian Acidic Peatland	65000	North-Central Interior and Appalachian Acidic Peatland Isolated/headwater streams	6060
	North-Central Interior and Appalachian Acidic Peatland	65000	North-Central Interior and Appalachian Acidic Peatland Undifferentiated	6061
	North-Central Interior and Appalachian Acidic Peatland	65000	North-Central Interior and Appalachian Acidic Peatland Lake/pond: any size	6062
	North-Central Interior and Appalachian Acidic Peatland	65000	North-Central Interior and Appalachian Acidic Peatland Smaller river riparian	6067
	North-Central Interior and Appalachian Acidic Peatland	65000	North-Central Interior and Appalachian Acidic Peatland Smaller river floodplain	6068
Stream (headwater/ creek)	Stream (headwater/creek) cold low	1111	Stream (headwater/creek) cold low	1111
	Stream (headwater/creek) cold moderate	1112	Stream (headwater/creek) cold moderate	1112
	Stream (headwater/creek) cold high	1113	Stream (headwater/creek) cold high	1113
	Stream (headwater/creek) cool low	1121	Stream (headwater/creek) cool low	1121
	Stream (headwater/creek) cool	1122	Stream (headwater/creek) cool moderate	1122

Formation	Ecosystem	Ecosystem Value	Subsystem	Subsystem Value
	moderate			
	Stream (headwater/creek) cool high	1123	Stream (headwater/creek) cool high	1123
	Stream (headwater/creek) warm low	1131	Stream (headwater/creek) warm low	1131
	Stream (headwater/creek) warm moderate	1132	Stream (headwater/creek) warm moderate	1132
	Stream (headwater/creek) warm high	1133	Stream (headwater/creek) warm high	1133
Stream (large)	Stream (large) cool	1429	Stream (large) cool	1429
	Stream (large) warm	1439	Stream (large) warm	1439
Stream (medium)	Stream (medium) cold	1319	Stream (medium) cold	1319
	Stream (medium) cool	1329	Stream (medium) cool	1329
	Stream (medium) warm	1339	Stream (medium) warm	1339
Stream (small)	Stream (small) cold low	1211	Stream (small) cold low	1211
	Stream (small) cold moderate	1212	Stream (small) cold moderate	1212
	Stream (small) cool low	1221	Stream (small) cool low	1221
	Stream (small) cool moderate	1222	Stream (small) cool moderate	1222
	Stream (small) warm low	1231	Stream (small) warm low	1231
	Stream (small) warm moderate	1232	Stream (small) warm moderate	1232

Formation	Ecosystem	Ecosystem Value	Subsystem	Subsystem Value
Stream (tidal)	Freshwater Tidal Riverine	300	Freshwater Tidal Riverine	300