Data Analysis Workflow: Habitat Variables

Executive Summary

This document outlines the workflow used to generate the habitat analysis variables from the NHD+ (v2), NLCD, and other source datasets. We have generated a number of Python scripts to work in ArcMap (v10.2) to run many of these analyses, linking each script to an ArcGIS Tool in the *EEP\_Analysis* toolbox. Below, we provide a brief summary of each script/tool and a listing of the outputs produced. Additional documentation is provided both within the actual Python scripts and in the ArcMap tool interfaces. We also provide an additional ArcMap tool, “Master Model (v2)” that calls all these tools in proper sequence, automating the complete analysis for a single 6-digit HUC provided by the user.

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🡪Prep NHD Data

[EEP\_PrepData.py](https://github.com/Duke-NSOE/EEP/blob/master/Scripts/EEP_PrepData.py)

This script extracts data stored on the GIS Server, clipped to the boundary of all NHD catchments within the user defined HUC 6. All layers produced are projected to USA Contiguous Albers Equal Area Conic, USGS version {WKID: 102039}. Data are stored in a newly created geodatabase labeled by the supplied HUC 6 id (e.g. “EEP\_030201.gdb”).

This script is a prerequisite for most other scripts and should be run first. Outputs are describe below:

|  |  |
| --- | --- |
| **Output dataset** | ***Output name*** |
| HUC 6 watershed boundaries | *HUC6* |
| HUC12 features | *HUC12* |
| NHD+ (v2) Flowlines | *NHDFlowlines* |
| NHD+ (v2) Flow-line midpoints *\*(calculated from NHD flowlines)* | *FlowlineMidPts* |
| NHD+ (v2) Catchment features | *NHDCatchments* |
| Mask polygon | *MaskPoly* |
| Mask raster (30m) | *Mask* |
| NHD+ (v2) elev\_cm raster | *Elev\_cm* |
| NHD+ (v2) flowdir raster | *flowdir* |
| NHD+ (v2) flowdirnull raster | *fdrnull* |
| NHD+ (v2) catchment raster | *cat* |
| NLCD 2011 land cover raster | *nlcd\_2011* |
| NLCD 2011 canopy cover raster | *canopycov* |
| NLCD 2011 percent impervious raster | *impervious* |

🡪Extract ESRI Landscape Data

[EEP\_ExtractESRILandscapeData.py](https://github.com/Duke-NSOE/EEP/blob/master/Scripts/EEP_ExtractESRILandscapeData.py)

This script extracts data from ESRI's Landscape Layer collection and computes a specified zonal statistic on it for each NHD catchment. This script requires the ArcGIS Link files (\*.ags) located in the Data/ESRILayers folder to work. (These files provide authorized access to the ESRI Landscape Layers.) The output is a single table with the following fields:

|  |  |  |
| --- | --- | --- |
| **Field** | **Description** | **ESRI Source Layer** |
| COMID | NHD Catchment ID |  |
| FeatureID | NHD Feature ID |  |
| Flooding\_SUM | Sum of flooding frequency values within a catchment | [USA Soils Flooding Freq.](http://www.arcgis.com/home/item.html?id=2bbf8c1f28ae46d5b807592ccfe970b0) |
| Slope\_MEAN | Mean slope (degrees) | [Terrain: Slope Map](http://www.arcgis.com/home/item.html?id=a1ba14d09df14f42ad6ca3c4bcebf3b4) |
| Road\_density\_MEAN | Sum of road length w/in 1km cells, averaged across all cells w/in a catchment | [USA Road Density](http://www.arcgis.com/home/item.html?id=64a95b092457466388f09136e331ff09) |
| Water\_table\_MEAN | Mean depth to water table (cm) | [Water Table depth](http://www.arcgis.com/home/item.html?id=8739f213277943e390aa2111b95ab72a) |
| Erodability\_MEAN | Mean SSURGO Erodibility (K-factor) value | [Soils Erodibility Factor](http://www.arcgis.com/home/item.html?id=93be1788338d492e8d9079abb65d5722) |
| Flood\_risk\_MEAN | Proportion of catchment area in flood risk zone | [USA Food Risk](http://www.arcgis.com/home/item.html?id=6b09b1c163c740559dc31cce9144222e) |

🡪Compute flowline LU/LC values

[EEP\_ComputeFlowlineLULC.py](https://github.com/Duke-NSOE/EEP/blob/master/Scripts/EEP_ComputeFlowlineLULC.py)

This script computes the total area of each NLCD land cover class intersecting stream pixels within a given NHD+ catchment. Stream pixels are identified as pixels labeled NoData in the NHD+ *fdrnull* dataset. The output table lists each catchment and the total area (in m2) of each NLCD cover type of pixels intersecting NHD+ flowlines:

|  |  |
| --- | --- |
| Field | Description |
| GRIDCODE | NHD Catchment ID |
| FLNLCD\_11 | Area of NLCD 2011 *open water* pixels intersecting NHD+ flowlines |
| FLNLCD\_21 | Area of NLCD 2011 *developed open space* pixels intersecting NHD+ flowlines |
| *etc…* |  |

🡪Compute flowline shades statistics

[EEP\_ComputeFlowlineShadeStats.py](https://github.com/Duke-NSOE/EEP/blob/master/Scripts/EEP_ComputeFlowlineShadeStats.py)

This script intersects NHD+ flowlines with NLCD (2011) forested areas to isolate stream segments considered "shaded". The statistics calculated for these segments within each catchment include:

|  |  |
| --- | --- |
| Field | Description |
| COMID | NHD Component ID |
| ShadedSegments | Number of flowline segments classified as shaded |
| ShadedLength | Total flowline length (m) intersecting NLCD (2011) forest |
| LongestSegment | The length (m) of the longest shaded flowline segment |
| MeanShadeLength | Average length (m) of all the shaded segments w/in a catchment |

🡪Calculate riparian statistics

[EEP\_ComputeRiparianStats.py](https://github.com/Duke-NSOE/EEP/blob/master/Scripts/EEP_ComputeRiparianStats.py)

This script creates a raster of land cover (NLCD 2011) within riparian areas, defined as pixels located within set vertical distance (in cm) above the stream pixel into which it drains; non-riparian pixels are set to NoData. It also creates a table listing the total area (m2) and proportion (pct) of the riparian area within each catchment classified as Forest (NLCD 41, 42, 43), Wetland (90, 95), or Other.

|  |  |
| --- | --- |
| Field | Description |
| GRIDCODE | NHD COMID |
| Other lulc | Riparian area (m2) not classified as either forest or wetland |
| Riparian forest | Riparian area (m2) classified as forest |
| Riparian wetland | Riparian area (m2) classified as wetland |
| Pct riparian forest | Percent of riparian area classified as forest |
| Pct riparian wetland | Percent of riparian area classified as wetland |

🡪Calculate stream temperature statistics

[EEP\_ComputeFlowlineTemperature.py](https://github.com/Duke-NSOE/EEP/blob/master/Scripts/EEP_ComputeFlowlineTemperature.py)

This script calculates, for each catchment, the percent of flowline length classified as cold, cool, or warm according to the 2006 NC Wildlife Resources Commission stream thermal regime dataset (No link available).

|  |  |
| --- | --- |
| Field | Description |
| FEATUREID | NHD Feature ID |
| Cold | Percent of stream classified as cold |
| Cool | Percent of stream classified as cool |
| Warm | Percent of stream classified as warm |
| TotLength | Total stream length (m) |

🡪Count road crossings

[EEP\_ComputeRoadCrossings.py](https://github.com/Duke-NSOE/EEP/blob/master/Scripts/EEP_ComputeRoadCrossings.py)

Intersects the [NC DOT roads layer](https://connect.ncdot.gov/resources/gis/Lists/DataLayersTextAnnouncements/AllItems.aspx) with NHD+ flowlines and tabulates the number of road crossings found within each catchment. Output includes the following:

|  |  |
| --- | --- |
| Field | Description |
| COMID | NHD Component ID |
| Crossings | Count of road crossings found within the catchment |

🡪Extract NHD habitat attributes

[EEP\_ExtractNHDHabitatAttributes.py](https://github.com/Duke-NSOE/EEP/blob/master/Scripts/EEP_ExtractNHDHabitatAttributes.py)

Extracts numerous NHD+ (v2) attributes for the catchments within the selected HUC6. These attributes include the attributes listed below (see [NHD+ v2 metadata](ftp://ec2-54-227-241-43.compute-1.amazonaws.com/NHDplus/NHDPlusV21/Documentation/NHDPlusV2_User_Guide.pdf) and [NLCD Extension metadata](ftp://ec2-54-227-241-43.compute-1.amazonaws.com/NHDplus/NHDPlusV21/Data/Extensions/NLCD2011LandUse/0NHDPlusV2_NLCDLandUse_metadata_20141013.htm) for additional info). NOTE: This tool requires access to the table stored on the Nicholas School GIS Server and can only be run from Nicholas School or other authorized machines.

|  |  |  |
| --- | --- | --- |
| Field | Description | NHD Source |
| COMID | NHD Component ID | NHD Catchment features |
| LENGHTKM | Flowline length | NHD Catchment features |
| REACHCODE | Reach Code assigned to feature | NHD Catchment features |
| FTYPE | NHD Feature Type | NHD Catchment features |
| FCODE | Numeric code for feature attributes in the NHDFCode lookup table | NHD Catchment features |
| StreamOrde | Strahler Stream order | Flowline VAA |
| PathLength | Distance to the terminal Flowline feature downstream along the main path | Flowline VAA |
| ArbolateSum | Km of stream upstream of the bottom of the NHDFlowline feature | Flowline VAA |
| AreaSqKm | Catchment area in square kilometers | Flowline VAA |
| TotDASqKm | Total Upstream Cumulative Drainage Area (km2) at the downstream end of the NHDFlowline feature | Flowline VAA |
| Slope | Slope of flowline (meters/meters) based on smoothed elevations | ElevSlope |
| Q0001E | Mean annual flow from gage adjustment (cfs) | EROM\_MA0001 |
| V0001E | Mean annual velocity from gage adjustment (fps) | EROM\_MA0001 |
| Qincr0001E | Mean annual incremental flow from gage adjustment (cfs) | EROM\_MA0001 |
| TEMP0001 | Mean annual catchment temperature (Deg. C) | EROM\_MA0001 |
| PPT0001 | Mean annual catchment precipitation (mm) | EROM\_MA0001 |
| PET0001 | Mean annual catchment PET (mm) | EROM\_MA0001 |
| QLOSS0001 | Mean annual catchment flow loss from Excess ET (cfs) | EROM\_MA0001 |
| Q0001E\_min | Min. monthly flow (cfs) | EROM\_*mm*0001 |
| Q0001E\_max | Max. monthly flow (cfs) | EROM\_*mm*0001 |
| TempVC | Mean annual temp. upstream of the catchment (°C \* 100) | VPUAttributeExtension |
| TempVMA | Mean annual temperature within the catchment (°C \* 100) | VPUAttributeExtension |
| Temp\_min | Min. monthly mean temperature w/in the catchment (in °C \* 100) | VPUAttributeExtension |
| Temp\_max | Max. monthly mean temperature w/in the catchment (in °C \* 100) | VPUAttributeExtension |
| PrecipVC | Mean annual precipitation upstream of catchment (mm \* 100) | VPUAttributeExtension |
| PrecipVMA | Mean annual precipitation w/in the catchment (mm \* 100) | VPUAttributeExtension |
| Precip\_min | Min. monthly mean precipitation w/in the catchment (mm \* 100) | VPUAttributeExtension |
| Precip\_max | Max. monthly mean precipitation w/in the catchment (mm \* 100) | VPUAttributeExtension |
| RunOffVMA | Mean annual runoff in the area of the catchment (mm) | VPUAttributeExtension |
| RunOff\_min | Min. monthly mean runoff (mm) | VPUAttributeExtension |
| RunOff\_max | Max. monthly mean runoff (mm) | VPUAttributeExtension |
| NLCDxxP *(x15)* | Percent upstream area classified as NLCD class *xx* | VPUAttributeExtension |
| NLCDx *(x15)* | Percent upstream area classified as generalized NLCD class *x* | VPUAttributeExtension |
| NLCDxxPC *(x15)* | Percent catchment area classified as NLCD class *xx* | VPUAttributeExtension |
| NLCDx\_1 *(x15)* | Percent catchment area classified as generalized NLCD class *x* | VPUAttributeExtension |

🡪Calculate Canopy and Impervious Stats

[EEP\_CalculateNLCDCanopyAndImpervious.py](https://github.com/Duke-NSOE/EEP/blob/master/Scripts/EEP_CalculateNLCDCanopyAndImpervious.py)

This script calculates zonal means to tabulate the average values of the NLCD Canopy Cover and Percent Developed Impervious Surface datasets within each catchment. Output includes the following:

|  |  |
| --- | --- |
| Field | Description |
| COMID | NHD Component ID |
| FEATUREID | NHD Feature identifier |
| PctCanopy | Percent canopy cover within the catchment area |
| PctImpervious | Percent catchment area that is impervious |

🡪Merge Catchment Tables

[EEP\_MergeCatchmentTables.py](https://github.com/Duke-NSOE/EEP/blob/master/Scripts/EEP_MergeCatchmentTables.py)

This script joins all the tables created by the NHD catchment models into a single, master feature class whose attribute table contains all the attributes required for running statistical habitat models. This script also sets all null values in any column to -9999.

🡪Create Habitat Model Input

[EEP\_CreateHabitatModelInput.py](https://github.com/Duke-NSOE/EEP/blob/master/Scripts/EEP_CreateHabitatModelInput.py)

This script creates a table of NHD+ catchments with a column for numerous aquatic species (N=458) and values indicating whether the species was recorded within that catchment. This script is intended to work with Mark Endries' (USFWS - Asheville office) Aquatic Species Occurrence Data - a feature class with a multi-point record for each species showing its recorded location across North Carolina.

The script breaks species locations points into single-point features (one feature per species/location) and spatially joins them with the NHD+ Catchment ID (via intersecting). The resulting attribute table is cross-tabulated using the species field as the pivot field, thus producing the desired table which contains two relational fields (GRIDCODE and FEATUREID) along with a column for each of the 458 species, as below:

|  |  |
| --- | --- |
| Field | Description |
| GRIDCODE | NHD Component ID |
| FEATUREID | NHD Feature identifier |
| *species* | 1 = recorded in catchment; 0 = not-recorded |