Expert-based Model Guidance and Documentation (Version 1)

Project Information

- Species: Small Whorled Pogonia (*Isotria medeoloides*)
- Lead modeler contact info: Eric Black (e.black@sncgrp.com) 919-612-2591; Katie Talavera (ktalavera@ESINC.CC), 919-602-4430.
- Date started: August 2019
- Date completed: March 2020

Species Information

NCDOT NRTR Habitat Description

USFWS Optimal Survey Window: Mid-May to early July

Small whorled pogonia (SWP) occurs in young as well as maturing (second to third successional growth) mixed-deciduous or mixed-deciduous/coniferous forests. It does not appear to exhibit strong affinities for a particular aspect, soil type, or underlying geologic substrate. In North Carolina, the perennial orchid is typically found in open, dry deciduous woods and is often associated with pine white pine and rhododendron. The species may also be found on dry, rocky, wooded slopes; moist slopes; ravines lacking stream channels; or slope bases near braided channels of vernal streams. The orchid, often limited by shade, requires small light gaps or canopy breaks, and typically grows under canopies that are relatively open or near features like logging roads or streams that create long-persisting breaks in the forest canopy. Other information provided for the small whorled pogonia include an affinity for acidic, moist, soils with few nutrients as well as occurrence within Acidic Cove Forest, Rich Cove Forest and Mesic Mixed Hardwood Forest (Piedmont Subtype) natural communities.

Additional Information

GAP natural communities associated with these populations include Mixed Hardwood, Montane Oak-Acidic Cove Forest transition, Acidic Cove Forest, Grass lawn, Hemlock dominated forest, Montane-Oak Hickory forest, Rich Cove Forest, Pine/Mixed Hardwoods, Southern Piedmont Dry Oak-(Pine) Forest (Hardwood and Mixed Modifiers), and Maturing Pine plantation.

Eighteen confirmed SWP element occurrences (EO's) (11 current and 7 historic) are listed in North Carolina per Natural Heritage (July 2019).

County Information

- NHP 12 listed counties: Burke, Cherokee, Guilford, Haywood, Henderson, Jackson, Macon, McDowell, Rutherford, Surry (historic), Transylvania and Yancey.
- USFWS 13 listed current counties: Burke, Cherokee, Guilford, Haywood, Henderson, Jackson, Macon, McDowell, Polk, Rutherford, Surry (historic), Transylvania and Yancey Counties.
- Note: Existing NHP occurrences are listed in Burke, Cherokee, Guilford, Haywood, Henderson, Jackson, Macon, McDowell, Transylvania and Yancey Counties.

Environmental Data Information

The SWP model was separated into two models based on physiographic region. These include the Blue Ridge physiographic region (Burke, Cherokee, Haywood, Henderson, Jackson, Macon, McDowell, Polk, Rutherford, Transylvania and Yancey Counties), and Piedmont physiographic region (Guilford). All spatial data are in NAD 1983 StatePlane North Carolina FIPS 3200 (US feet).

Layer 1

- Layer name: County_Boundary (Burke, Cherokee, Guilford, Haywood, Henderson, Jackson, Macon, McDowell, Polk, Rutherford, Transylvania, and Yancey Counties).
- Layer description:
  - Select Burke, Cherokee, Guilford, Haywood, Henderson, Jackson, Macon, McDowell, Polk, Rutherford, Transylvania, and Yancey Counties from county boundary shapefile for project extent.
- Layer selection justification:
  - Species listed in Burke, Cherokee, Guilford, Haywood, Henderson, Jackson, Macon, McDowell, Polk, Rutherford, Transylvania and Yancey Counties.
- "Habitat" versus "Non-habitat" designations:
  - Potential habitat listed for Burke, Cherokee, Guilford, Haywood, Henderson, Jackson, Macon, McDowell, Polk, Rutherford, Transylvania and Yancey Counties.

Layer 2

- Layer name: NRCS_Soils_NC_2003 (Burke, Cherokee, Guilford, Haywood, Henderson, Jackson, Macon, McDowell, Polk, Rutherford, Transylvania and Yancey Counties).
- Layer description:
  - SSURGO Map Unit Polygon feature class for soil type and A horizon pH tabular data.
  - Soil series were joined to multiple tables to then extract soil series with A horizon pH levels from 3.5-6.5 for Burke, Cherokee, Haywood, Henderson, Jackson, Macon, McDowell, Polk, Rutherford, Transylvania and Yancey Counties, and 3.5-6.5 in Guilford County.
- Layer selection justification:
  - SWP is found in acidic soils. NRCS soil pH classification ranges of extremely acidic to slightly acidic (pH 3.5-6.5) were used for SWP occurrences located in both the Blue Ridge and Piedmont Physiographic regions. This pH range includes the soil pH range (4.5-4.7) observed by Montgomery (2014) in 15 extant SWP occurrences in North Carolina, Tennessee, and Georgia
  - "Habitat" versus "Non-habitat" designations:
    - Potential SWP habitat includes those soils with A horizon pH's that fall between 3.5-6.5.

Layer 3

- Layer name: County Q2 Digital Elevation Model (Q2DEM): (Burke, Cherokee, Guilford, Haywood, Henderson, Jackson, Macon, McDowell, Polk, Rutherford, Transylvania and Yancey Counties).
- Layer description:
  - County Elevation Grid rounded to nearest foot, 20 ft grid cell.
  - The Q2DEMs are derived from the latest point cloud LIDAR data provided by the NC Floodplain Mapping Program. This data was acquired in August 2018.
  - Per county, slope data was processed from these DEMS and slopes ranging from 5-40% was then extracted for the Blue Ridge Physiographic Region and 0-30% for the Piedmont Physiographic Region (Guilford County).
- Layer selection justification:
  - Slopes for documented SWP populations in Blue Ridge physiographic region ranged from 5-40%, and 0-30% in Piedmont physiographic region.
- "Habitat" versus "Non-habitat" designations: Habitat
  - Habitat for the SWP in Blue Ridge physiographic region was listed as 5-40% slopes, and 0-30% slopes in Piedmont physiographic region (Guilford County).

Layer 4

- Layer name: GAP_LANDFIRE_National_Terrestrial_Ecosystems_2011.
- Layer description:
  - The GAP data was re-projected, resampled and then clipped to the designated counties. GAP attributes were joined and extracted based on the corresponding community types outlined below.
- Layer selection justification:
  - Schafale and Weakley found an association between small whorled pogonia and the Acidic Cove Forest, Rich Cove Forest, and Mesic Mixed Hardwood Forest (Piedmont Subtype) communities. These communities correspond with GAP Data's Southern and Central Appalachian Cove Forest and Southern Piedmont Mesic Forest. The GAP Southern and Central Appalachian Oak Forest, South-Central Interior Small Stream and Riparian, Evergreen Plantation or Managed Pine, Southern Piedmont Dry Oak-(Pine) Forest (Hardwood and Mixed Modifiers), and Developed, Open Space communities were also used because of overlap with known North Carolina SWP populations. The GAP Developed, Open Space community was excluded from the Piedmont physiographic region model because the community included a majority of areas that were not suitable SWP habitat.
- "Habitat" versus "Non-habitat" designations: Habitat
  - Potential habitat for SWP corresponds with the Southern and Central Appalachian Cove Forest, Southern Piedmont Mesic Forest, and Southern and Central Appalachian Oak Forest, South-Central Interior Small Stream and Riparian, Evergreen Plantation or Managed Pine, Southern Piedmont Dry Oak-(Pine) Forest (Hardwood and Mixed Modifiers), and Developed, Open Space.

Layer 5

- Layer name: County Q2 Digital Elevation Model (Q2DEM): (Burke, Cherokee, Guilford, Haywood, Henderson, Jackson, Macon, McDowell, Polk, Rutherford, Transylvania and Yancey Counties).

- Layer description:
  - County Q2 Digital Elevation Models (Q2DEM); 20 ft grid cell: Elevation Range.
- Layer selection justification:
  - All North Carolina SWP populations in the Blue Ridge physiographic region except two fell between the elevations of 1200-3100'. The two exceptions (Macon and Haywood counties) fell between the range of 3400-4100'. The SWP population identified in the Piedmont physiographic region (Guilford County) fell between the range of 730-740'.
- "Habitat" versus "Non-habitat" designations: Habitat
  - Potential habitat for the SWP was designated as occurring between the 1200-4100' range in Burke, Cherokee, Haywood, Henderson, Jackson, Macon, McDowell, Rutherford, Transylvania, and Yancey Counties, and 700-1012' in Guilford County (1012' is the highest elevation in Guilford County, NC).

Layer 6

- Layer name: Hollows, Spurs and Valleys (per county).
- Layer description:
  - Geomorphon analysis was done in GRASS open source GIS software.
  - The elongated lowlands of the each Q2DEM was processed to output hollows, spurs and valleys which are three of ten landform classifications in the Geomorphon analysis. This data was then exported into a compatible raster for ArcGIS. The raster was then cleaned in ArcGIS.
- Layer selection justification:
  - This layer was used to capture slopes, moist slopes or drainages not captured with other layers.
- "Habitat" versus "Non-habitat" designations:
  - For these models, only habitat areas were designated, devoid of Non-habitat.

Known Issues with Model Data Layers

- Overall Habitat: NCNHP Tier II vector data for documented SWP populations was overlaid on other vector and raster data (GAP, NRCS Soils, Geomorphons etc.) to validate previous research describing SWP habitat. Ten of the seventeen SWP populations were designated as low to medium accuracy. Subsequently, the occurrence footprint may incorporate both non-habitat and habitat areas.
- Overall Habitat: Coarse resolution of raster files (i.e. GAP, SURGO pH data, etc.) may affect the ability to identify subtle/micro changes in the represented data.
- Canopy Cover: GAP Landfire canopy data did not correspond with aerial mapping.
- Community Type: NLCD data was excluded because GAP Landfire data provided more refined delineation of community types.
- Soils Data: NRCS soil maps are general representations of soil mapping units. Soil boundaries are approximate and small non-defined soil inclusions may be omitted potentially under predicting the presence of soils and their associated characteristics.

Model Information

- Model domain
  - This model identifies all year-round potential suitable habitat for the species.
- Model output
  - Figure 1 – Model prediction.
  - Model output is binary, and includes the USFWS species range, excluding historic counties. The species model range is split between "High" and "Low" potential habitat. "High potential habitat" represents GIS based layer areas deemed suitable habitat, and "Low potential habitat" representing areas identified as areas deemed low quality or non-habitat.
  - Shapefile covering listed current counties.
- ArcGIS Model Builder
  - version ArcGIS – 10.6.1
  - Model file included in Appendix 1.
  - Summary of model steps
    - Selected North Carolina counties where plant is listed in current USFWS counties
    - Extracted known community types from GAP Landfire data
    - Selected identified elevation range for species
    - Derived slopes from Q2DEM data, extracted ideal slopes for species
    - Selected soils with defined pH values
    - Created hollows, spurs and valleys Geomorphon from Q2DEM in Grass
    - All resulting output data was intersected to define potential SWP habitat
- AGOL review
  - A model prediction file was shared with select reviewers on ArcGIS Online (AGOL). Points were placed within the USFWS potential habitat as well as the model potential habitat in order to solicit feedback. Reviewers could place additional comments for consideration by modeler.
  - AGOL review was completed in March 2019 on the DRAFT version of this model (See Appendix 2).
- Independent Data Review
  - Describe data sources – NHP element occurrences
  - Describe methods – NHP element occurrences were compared to Model output to determine if predicted habitat intersected known habitat.
  - Provide summary result – NHP element occurrences intersected predicted habitat.

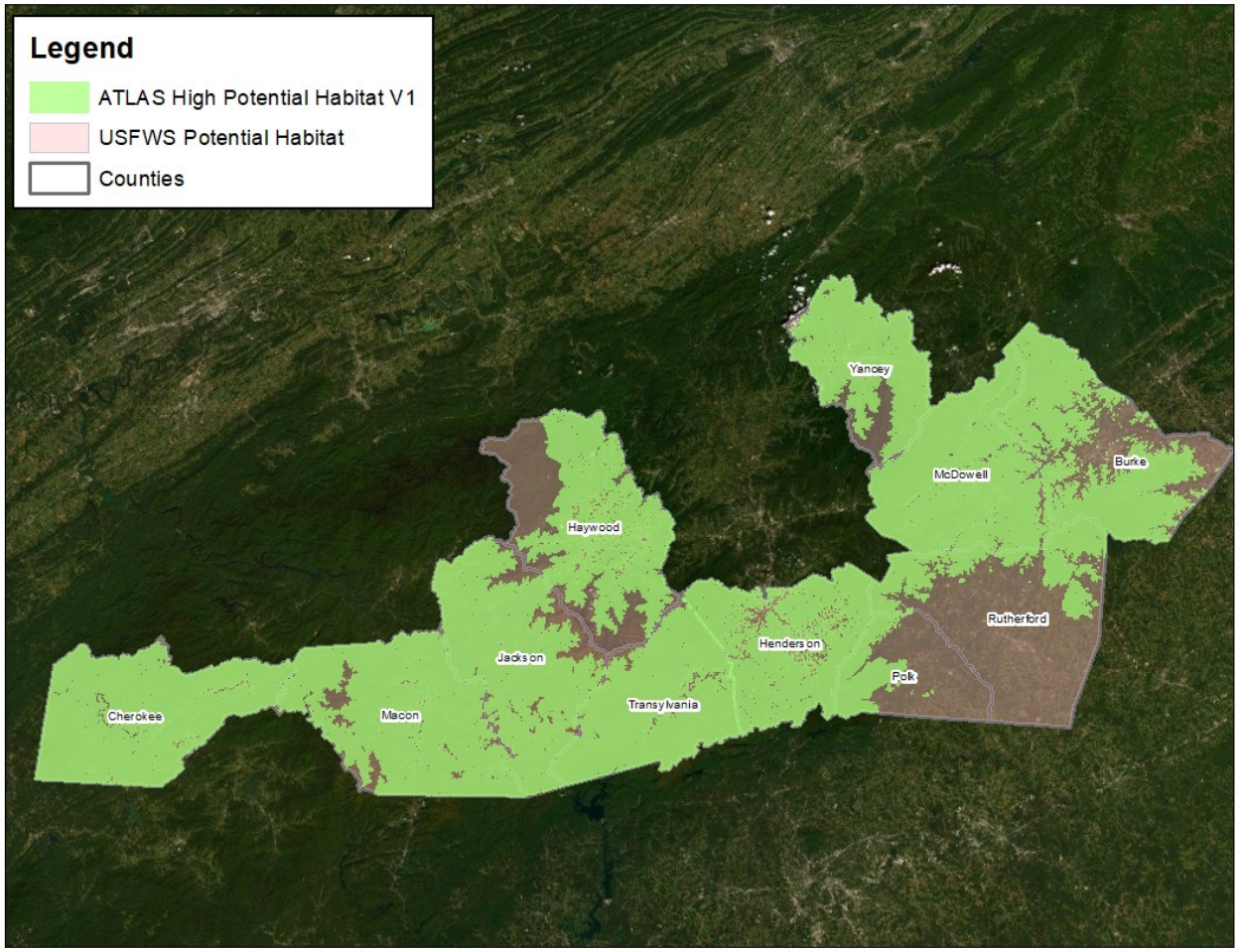


Figure 1. Range Map and High Potential Habitat Version 1 (Mountain)

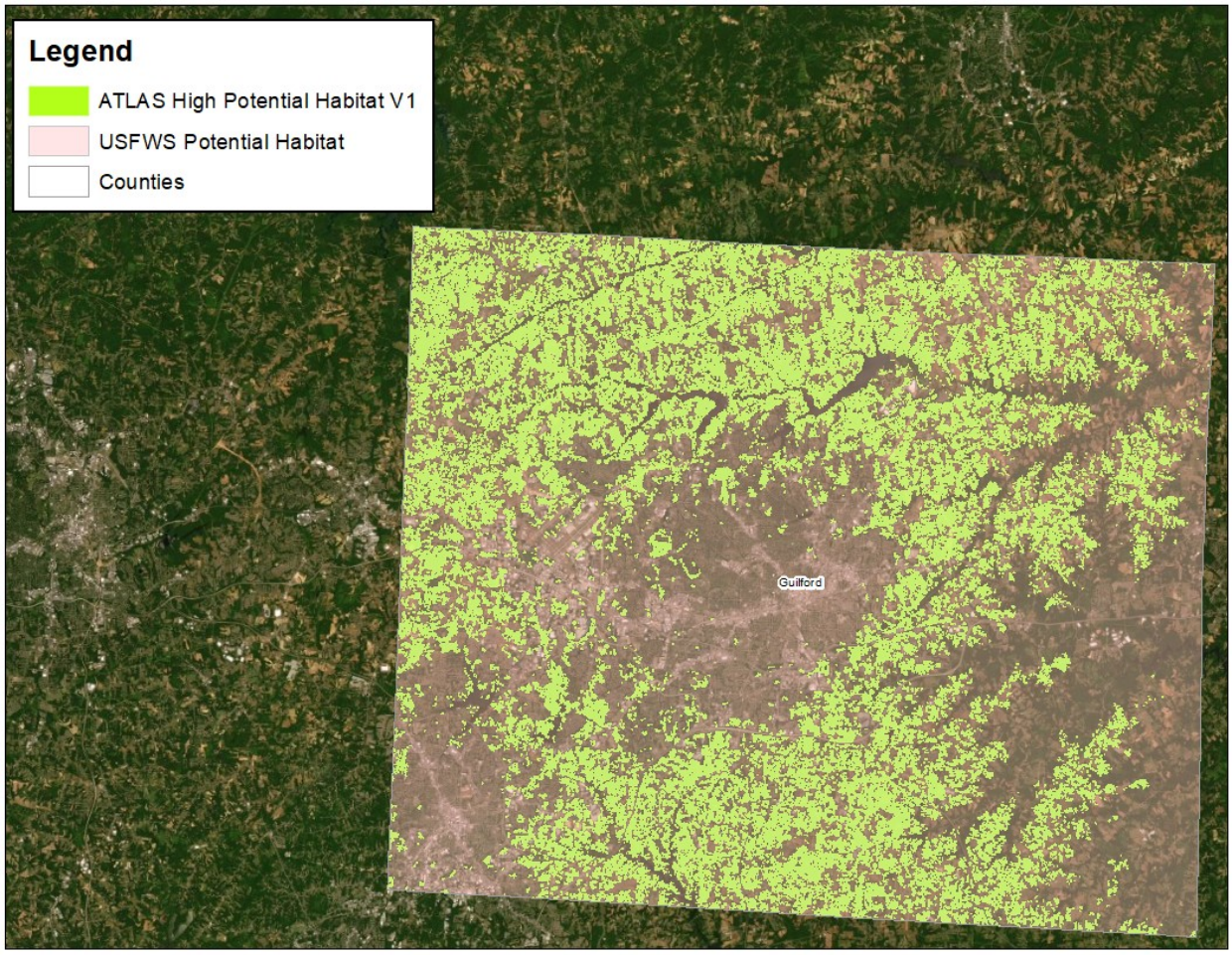


Figure 2. Range Map and High Potential Habitat Version 1 (Piedmont)

Previous Model Version (DRAFTS 1 & 2)

Two model DRAFTs were developed between the time period of 2018 and 2020. The county boundary, soil pH, GAP landcover, and Q2DEM elevation layers were modified following desk top reviews in March 2019, and valley and spur landforms were added to the GRASS geomorphon layer following field reviews in December 2019. Yancey County was added to the county layer following discovery of a new SWP population and Surry County (Historic) was deleted after these reviews.

Layer 1

- Layer name: County_Boundary (Burke, Cherokee, Guilford, Haywood, Henderson, Jackson, Macon, McDowell, Polk, Rutherford, Surry and Transylvania Counties).
- Layer description:
  - Select Burke, Cherokee, Guilford, Haywood, Henderson, Jackson, Macon, McDowell, Polk, Rutherford, Surry and Transylvania Counties from county boundary shapefile for project extent.
- Layer selection justification:
  - Species listed in Burke, Cherokee, Guilford, Haywood, Henderson, Jackson, Macon, McDowell, Polk, Rutherford, Surry and Transylvania Counties.
- "Habitat" versus "Non-habitat" designations:
  - Potential habitat listed for Burke, Cherokee, Guilford, Haywood, Henderson, Jackson, Macon, McDowell, Polk, Rutherford, Surry and Transylvania Counties.

Layer 4

- Layer name: GAP_LANDFIRE_National_Terrestrial_Ecosystems_2011.
- Layer description:
  - The GAP data was re-projected, resampled and then clipped to the designated counties. GAP attributes were joined and extracted based on the corresponding community types outlined below.
- Layer selection justification:
  - Schafale and Weakley found an association between small whorled pogonia and the Acidic Cove Forest, Rich Cove Forest, and Mesic Mixed Hardwood Forest (Piedmont Subtype) communities. These communities correspond with GAP Data's Southern and Central Appalachian Cove Forest and Southern Piedmont Mesic Forest. The GAP Southern and Central Oak Forest, South-Central Interior Small Stream and Riparian, Evergreen Plantation or Managed Pine, and Developed, Open Space communities were also used because of overlap with known North Carolina SWP populations. The GAP Developed, Open Space community because was excluded from the Piedmont physiographic region model because the community included a majority of areas that were not suitable SWP habitat.
- "Habitat" versus "Non-habitat" designations: Habitat
  - Potential habitat for SWP corresponds with the Southern and Central Appalachian Cove Forest, Southern Piedmont Mesic Forest, and Southern Appalachian Oak Forest, South-Central Interior Small Stream and Riparian, Evergreen Plantation or Managed Pine, and Developed, Open Space.

Layer 5

- Layer name: County Q2 Digital Elevation Model (Q2DEM): (Burke, Cherokee, Guilford, Haywood, Henderson, Jackson, Macon, McDowell, Polk, Rutherford, Surry and Transylvania).
- Layer description:
  - County Q2 Digital Elevation Models (Q2DEM); 20 ft grid cell: Elevation Range.
- Layer selection justification:
  - All North Carolina SWP populations in the Blue Ridge physiographic region except two fell between the elevations of 2100-3100'. The two exceptions (Macon and Haywood

counties) fell between the range of 3700-4100'. The SWP population identified in the Piedmont physiographic region (Guilford County) fell between the range of 730-740'.

- "Habitat" versus "Non-habitat" designations: Habitat
  - Potential habitat for the SWP was designated as occurring between the 2100-4100' range in Burke, Cherokee, Haywood, Henderson, Jackson, Macon, McDowell, Polk and Rutherford Counties, and 700-3565' in the Guilford and Surry Counties.

Layer 6

- Layer name: Hollows (per county).
- Layer description:
  - Geomorphon analysis was done in GRASS open source GIS software.
  - The elongated lowlands of the each Q2DEM was processed to output hollow, which is one of ten landform classifications in the Geomorphon analysis. This data was then exported into a compatible raster for ArcGIS. The raster was then cleaned in ArcGIS.
- Layer selection justification:
  - This layer was used to capture slopes, moist slopes or drainages not captured with other layers.
- "Habitat" versus "Non-habitat" designations:
  - For these models, only habitat areas were designated, devoid of Non-habitat.

<u>List of Delivered Model Products</u>

- This summary document
- Version 1 Model builder file (toolbox) and model screenshot (Appendix 1)
- Reviewer documentation (Appendix 2) – summary of desktop and field comments and general model recommendations.
- Version 1 Model prediction file(s) (shapefile)
- Desktop AGOL reviewer comments (shapefile)
- Field reviewer comments (shapefile) and word document

References

Montgomery, Ashley D. 2014. Predicting Threatened Orchid (*Isotria medeoloides* {PURSH] RAF. Habitat in the Southern Appalachian Region using Maxent Model (Unpublished master's thesis). Western Carolina University, Cullowhee, NC.

Schafale, M. P. and A. S. Weakly. 1990. Classification of the Natural Communities of North Carolina: Third Approximation. Natural Heritage Program, Division of Parks and Recreation, N.C. Department of Environment, Health and Natural Resources. Raleigh, NC 325 pp.

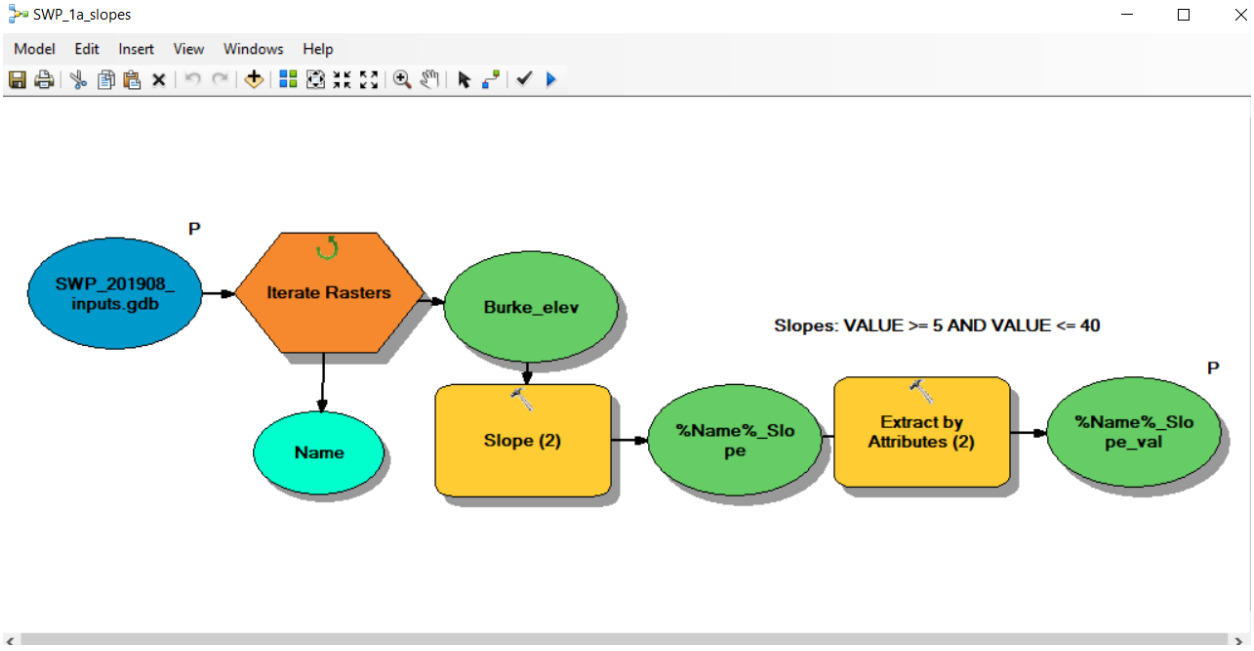
U.S. Fish and Wildlife Service (USFWS). 1992. Small Whorled Pogonia (*Isotria medeoloides*) Recovery Plan, First Revision. Newton Corner, Massachusetts. 75 pp.

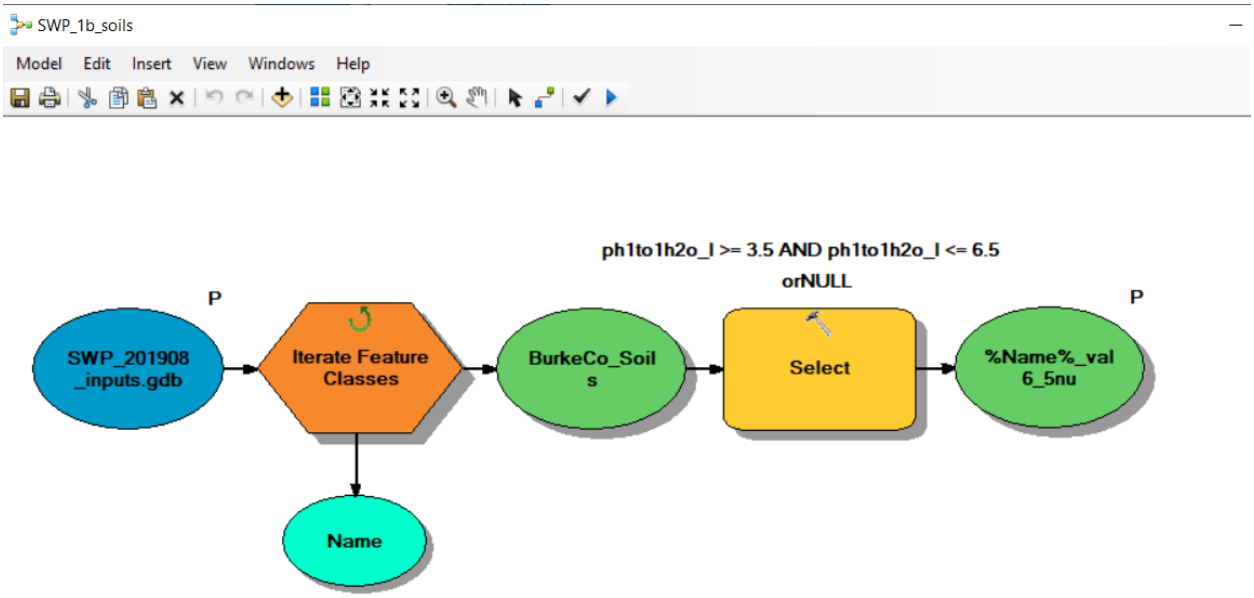
USFWS. 2008. Small Whorled Pogonia (*Isotria medeoloides*), 5-Year Review: Summary and Evaluation. https://ecos.fws.gov/docs/five_year_review/doc2002.pdf (Accessed September 17, 2018).

USFWS. 2017. Information on Threatened and Endangered Species: Small Whorled Pogonia.

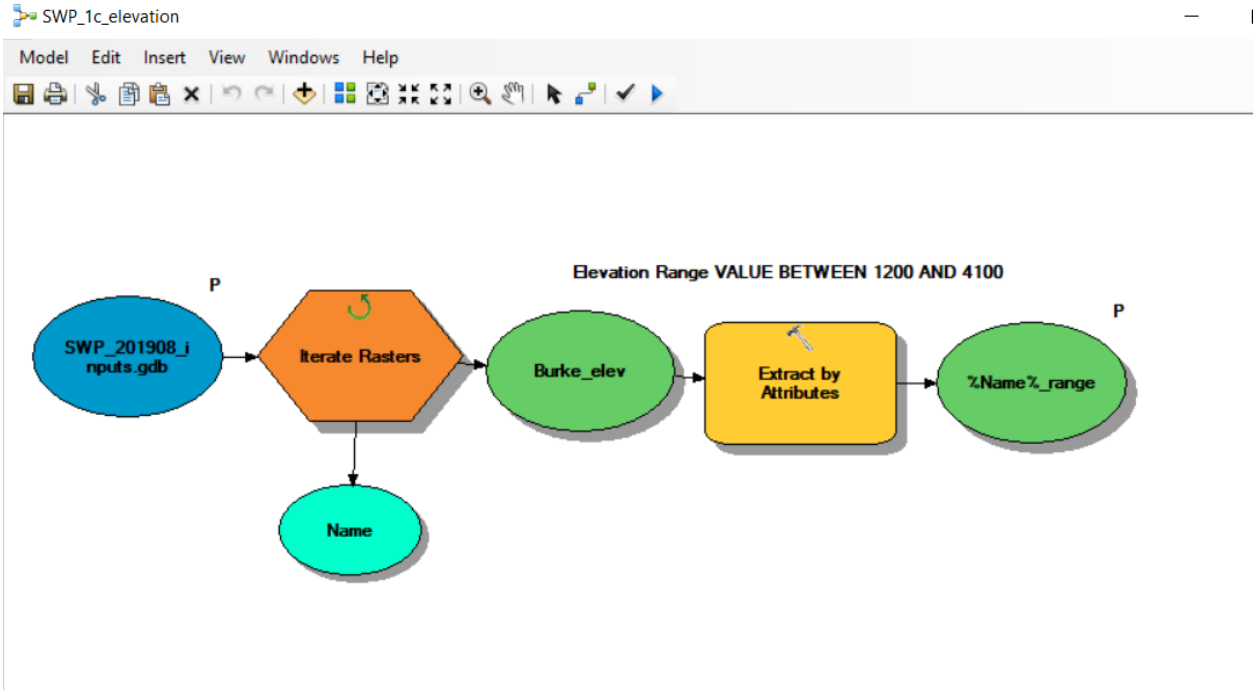
https://www.fws.gov/raleigh/species/es_small_whorled_pogonia.html (Accessed: April 3, 2018)

Appendix 1A: Small Whorled Pogonia Expert Model (Mountain: Slopes and Soils PH)

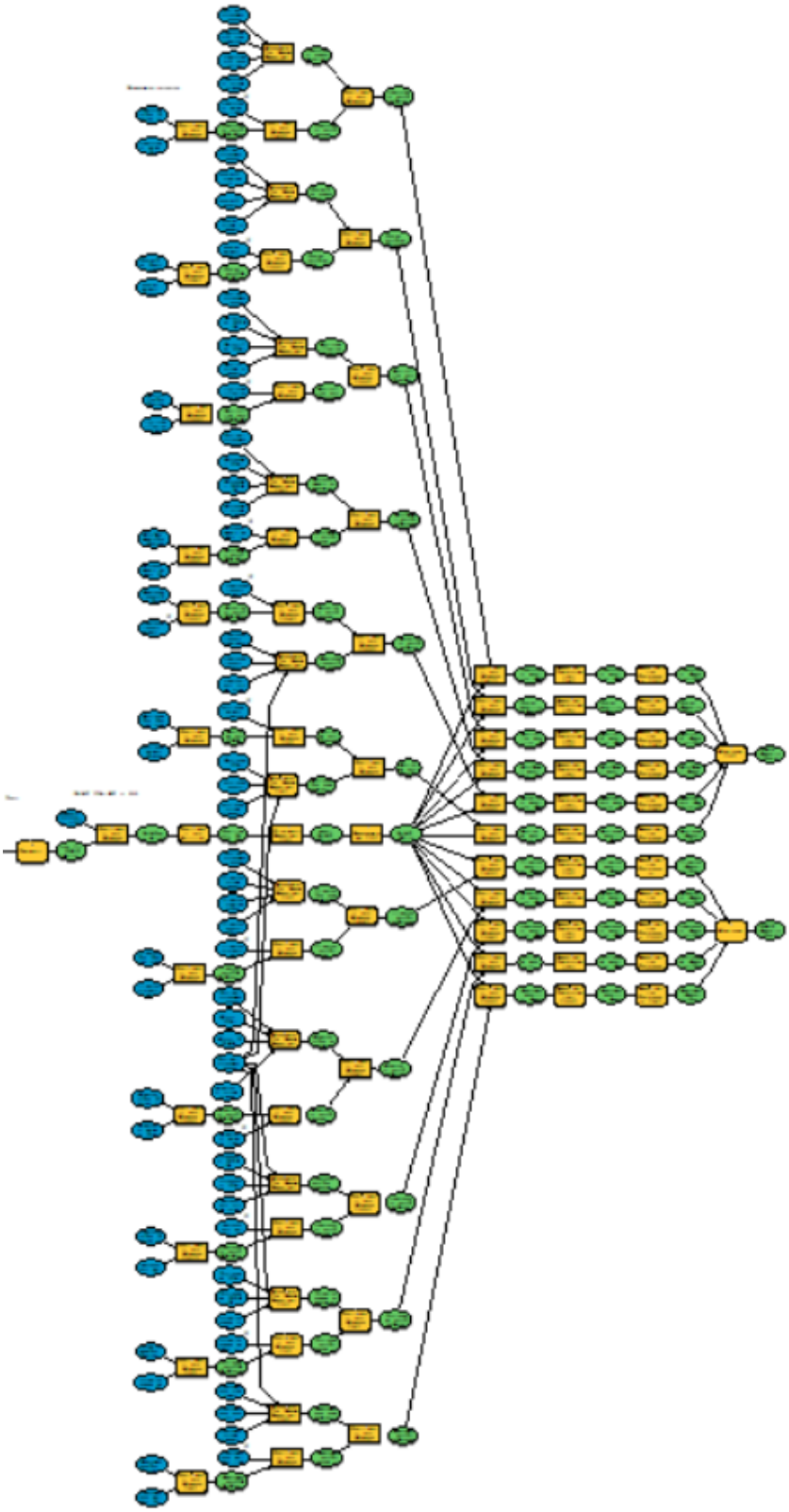




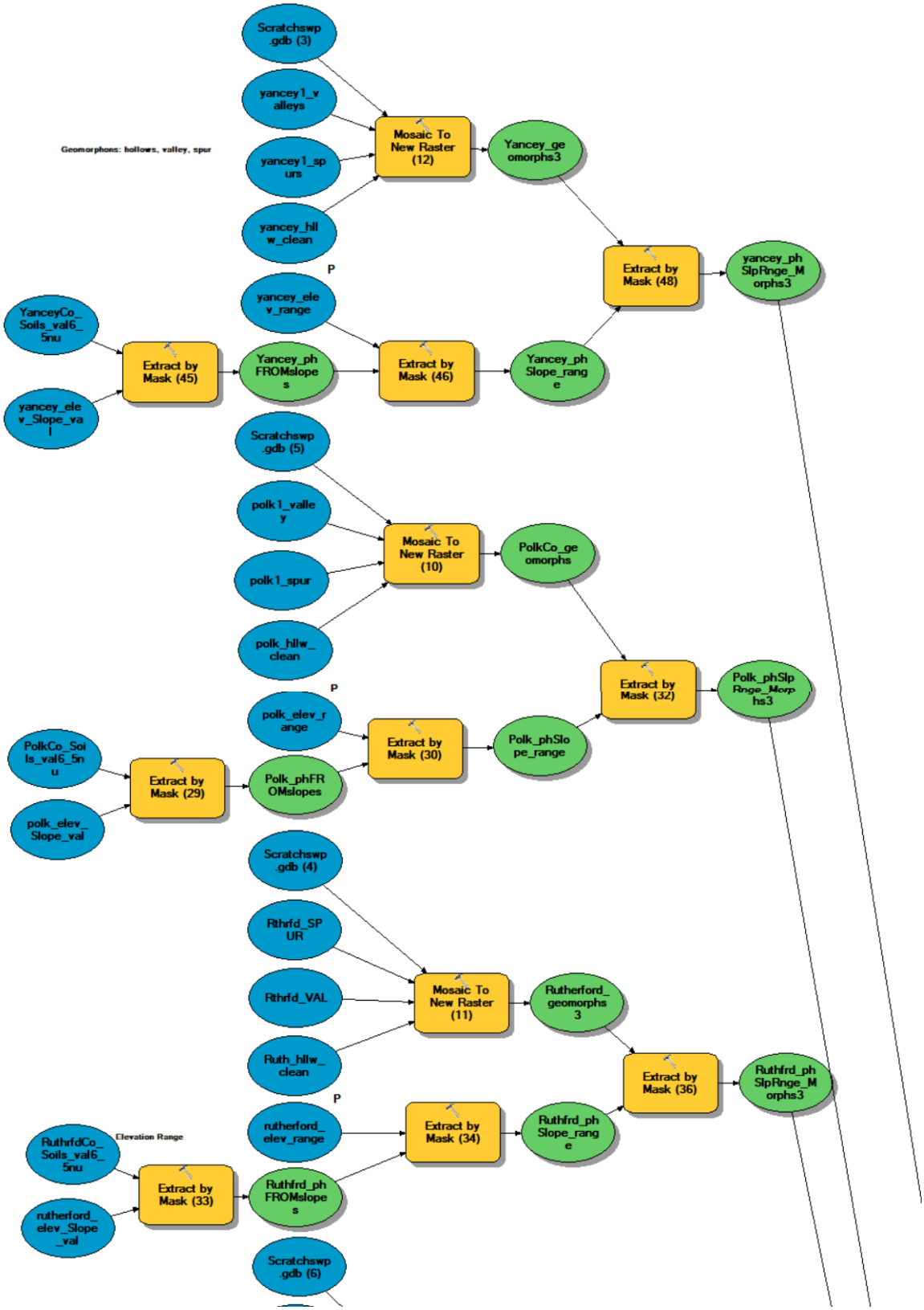
Appendix 1B: Small Whorled Pogonia Expert Model (Mountain: Elevation Range)



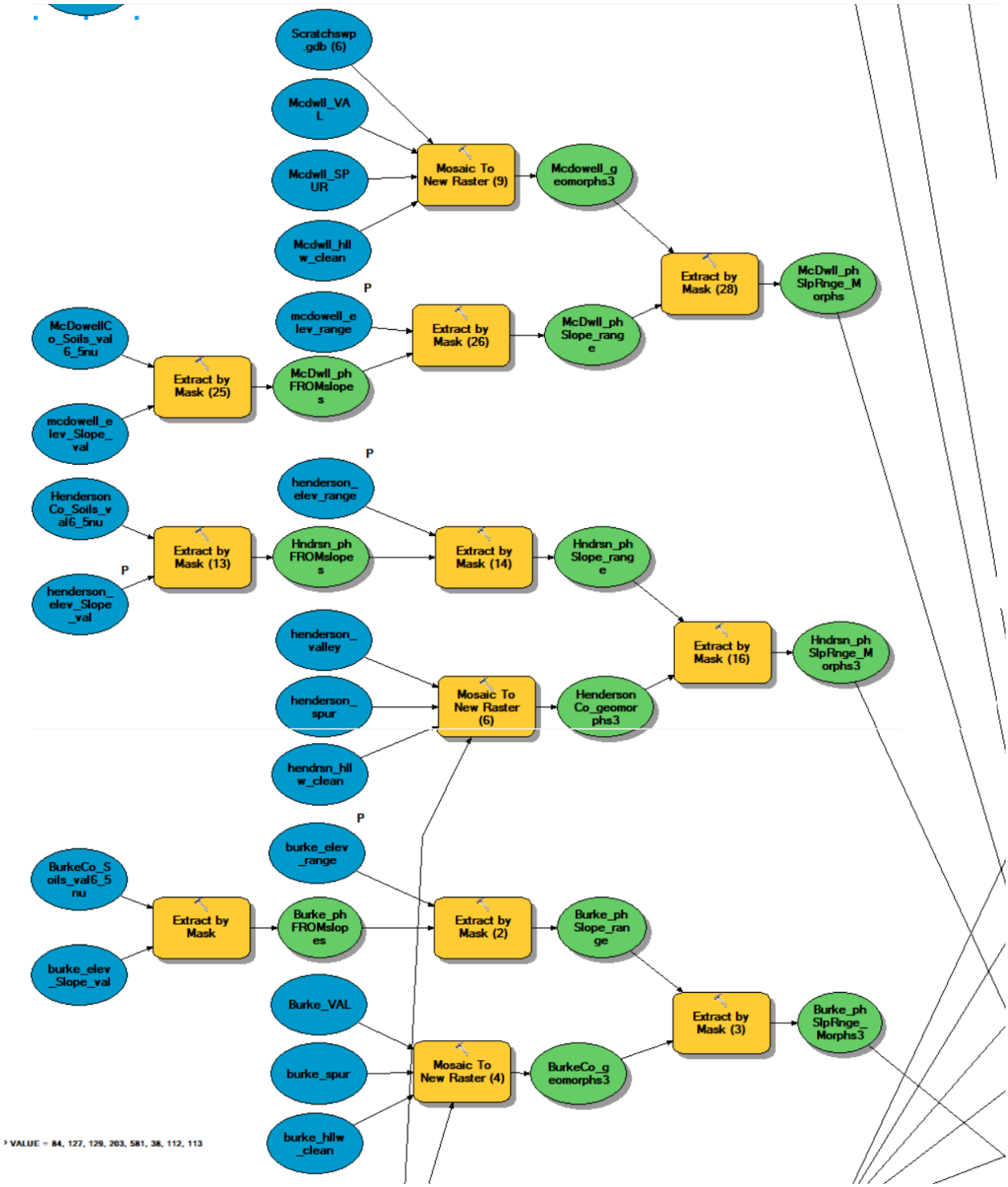
Appendix 1C: Small Whorled Pogonia Expert Model (Mountain: Full Model)



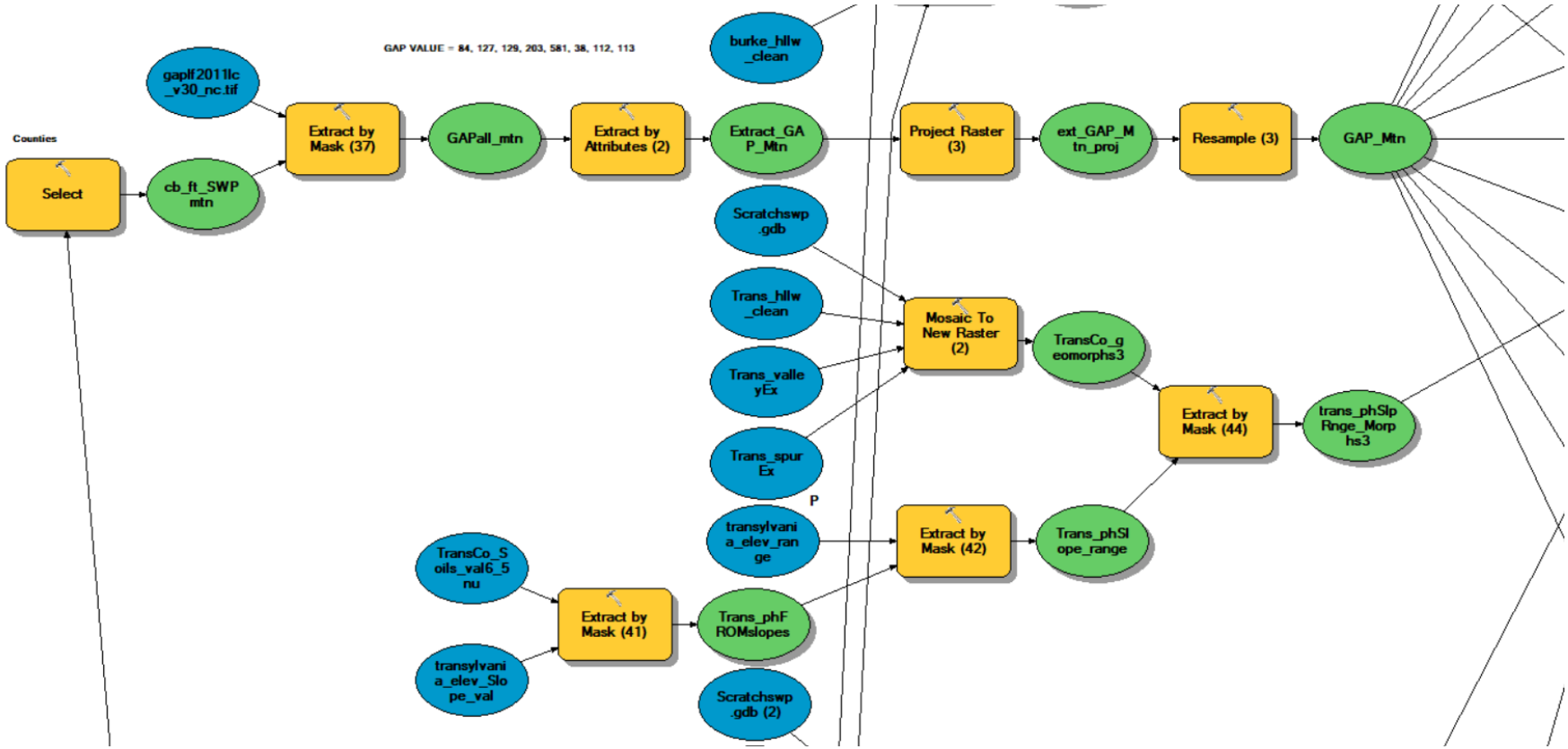
Appendix 1D: Small Whorled Pogonia Expert Model (Mountain: Details)



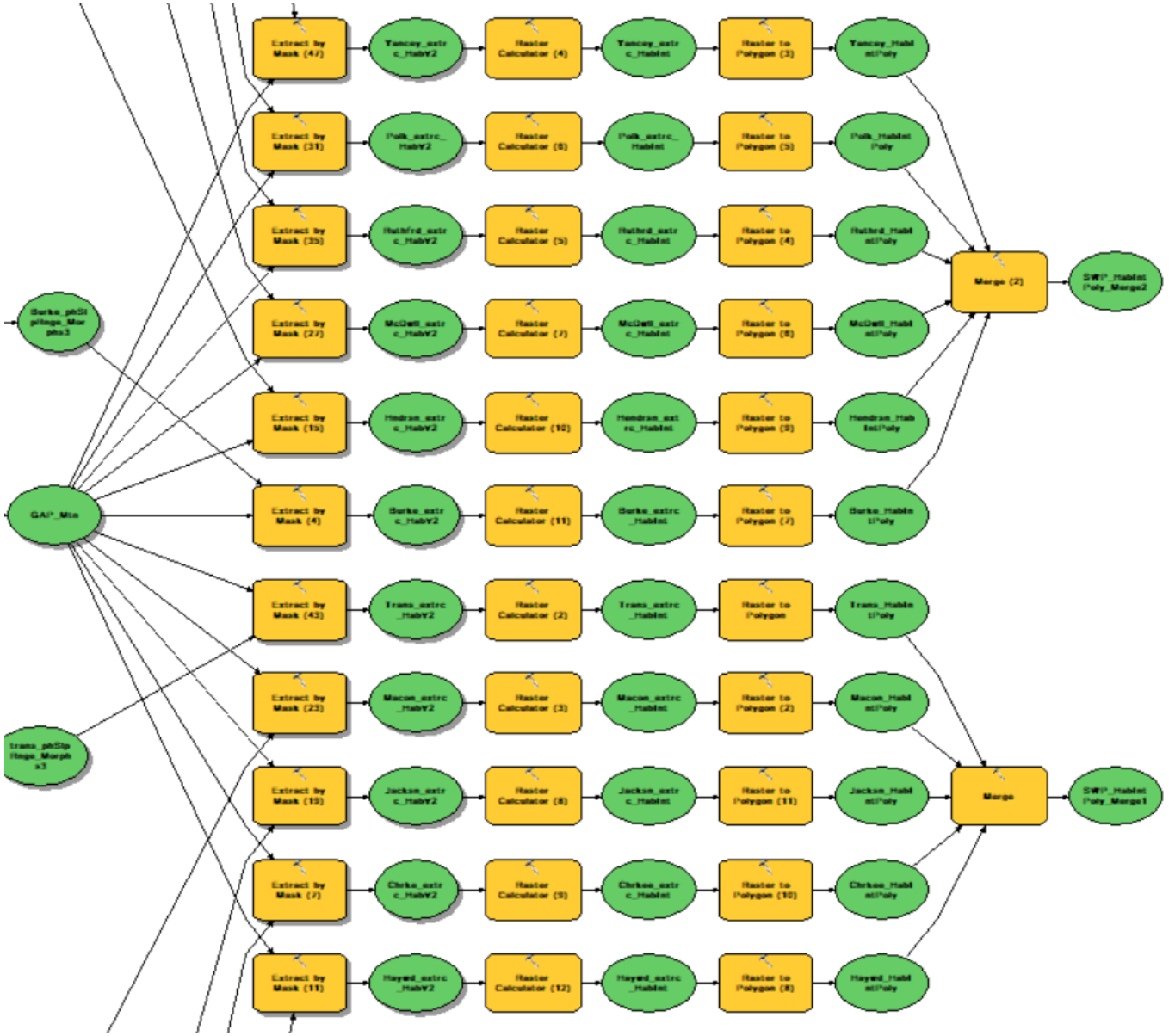
Appendix 1E: Small Whorled Pogonia Expert Model (Mountain: Details)



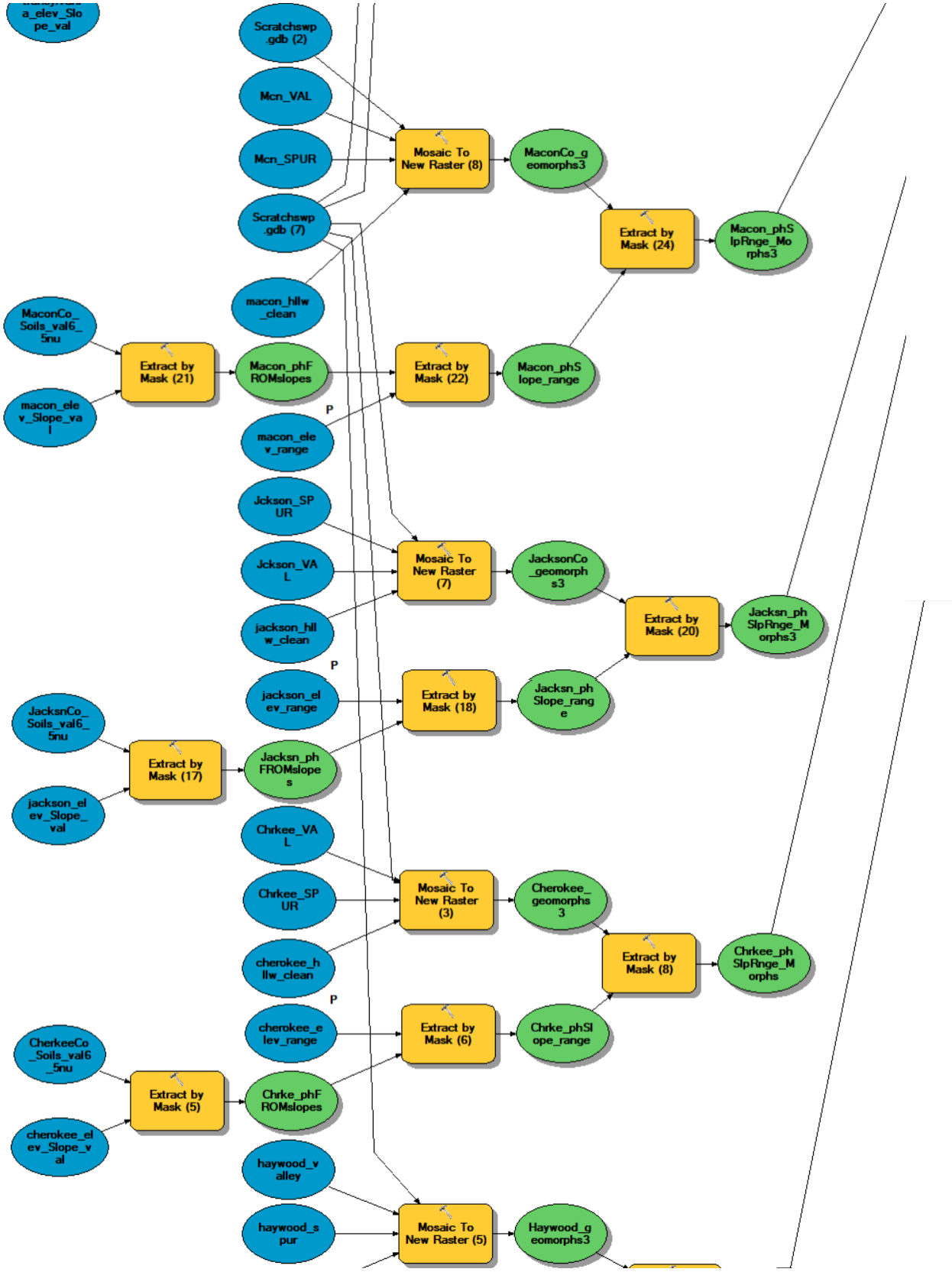
Appendix 1F: Small Whorled Pogonia Expert Model (Mountain: Details)



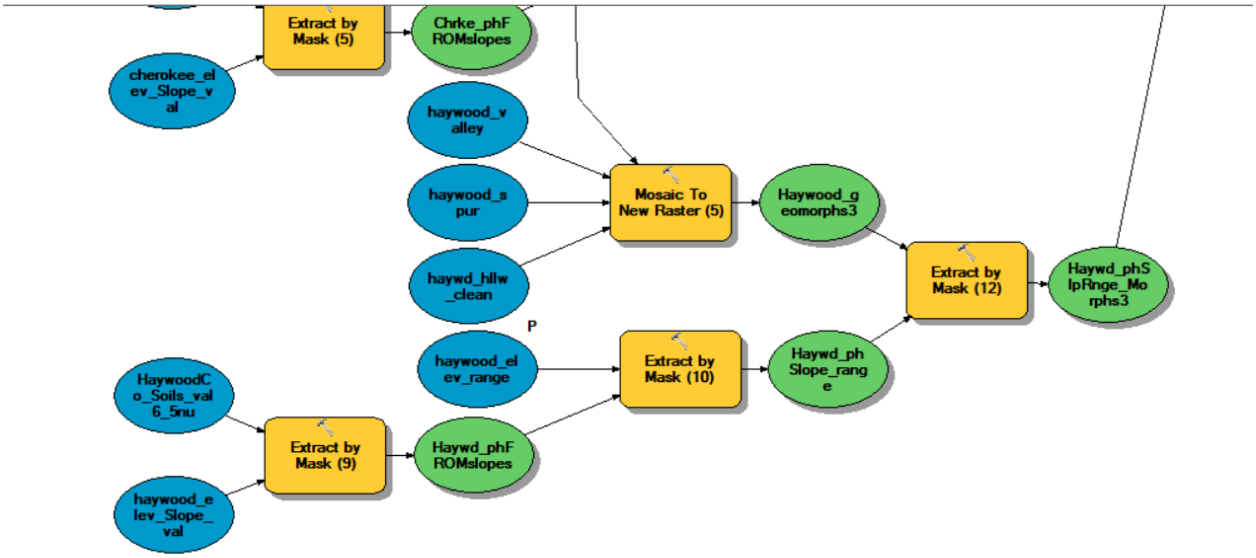
Appendix 1G: Small Whorled Pogonia Expert Model (Mountain: Details)



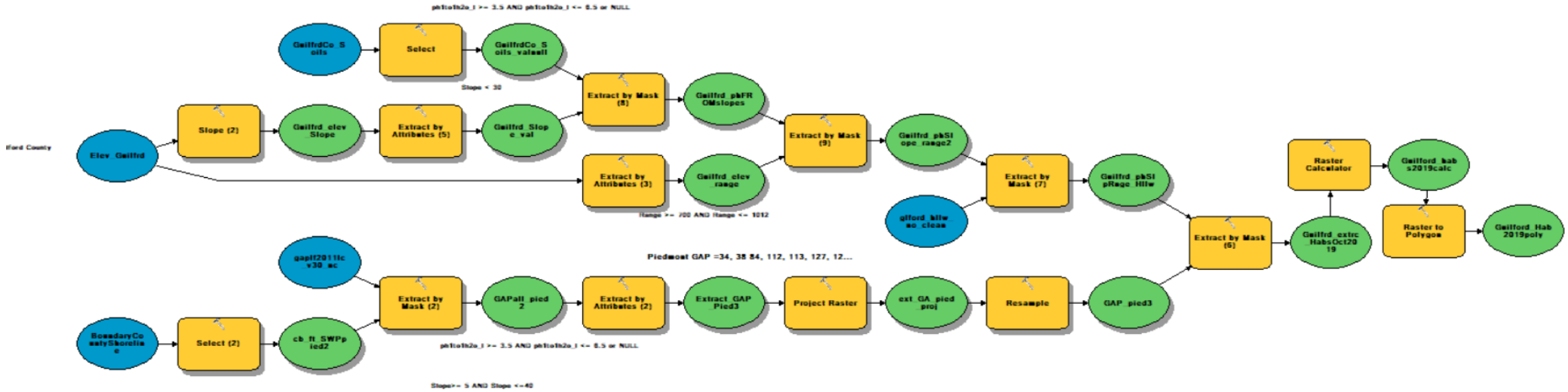
Appendix 1H: Small Whorled Pogonia Expert Model (Mountain: Details)



Appendix 1I: Small Whorled Pogonia Expert Model (Mountain: Details)



Appendix 1J: Small Whorled Pogonia Expert Model (Piedmont: Full Model)



Appendix 2: Reviewer Documentation

Project Information

- Species: Small Whorled Pogonia (*Isotria medeoloides*)
- Lead modeler: Eric Black (e.black@sncgrp.com) 919-612-2591; Katie Talavera (Katie.talavera@terracon.com), 919-602-4430.
- Reviewer names: 1. Jame Amoroso (NCNHP)
  2. Kevin Markham (ESI)
  3. Rebekah Reid (USFWS – West)
  - Jame Amoroso (NCNHP) – Jame is a Conservation Information Specialist for the North Carolina Natural Heritage Program. She has been with NCNHP since 1994, starting as Program Botanist. Past and current work has included publishing the NCNHP Rare Plant List and maintaining conservation data for federally protected species. Jame received her Master of Science degree in Botany from the University of Florida with the thesis A Floristic Study of Cedar Key Scrub State Reserve, Levy County, Florida.
  - Kevin Markham (ESI) – Kevin is a Principal in the Natural and Cultural Resource practice group for Environmental Services, Inc., a Terracon Company. He has more than 30 years of experience conducting and providing technical oversight for rare and protected species surveys and assessments in North Carolina.
  - Rebekah Reid (USFWS-West) – Rebekah is an endangered species listing and recovery biologist with the US Fish and Wildlife Service, Asheville. She specializes in plants and lichens

Range Map to Potential Habitat (DRAFT)

- USFWS Range 3,525,038 acres
- ATLAS Range 289,990 acres

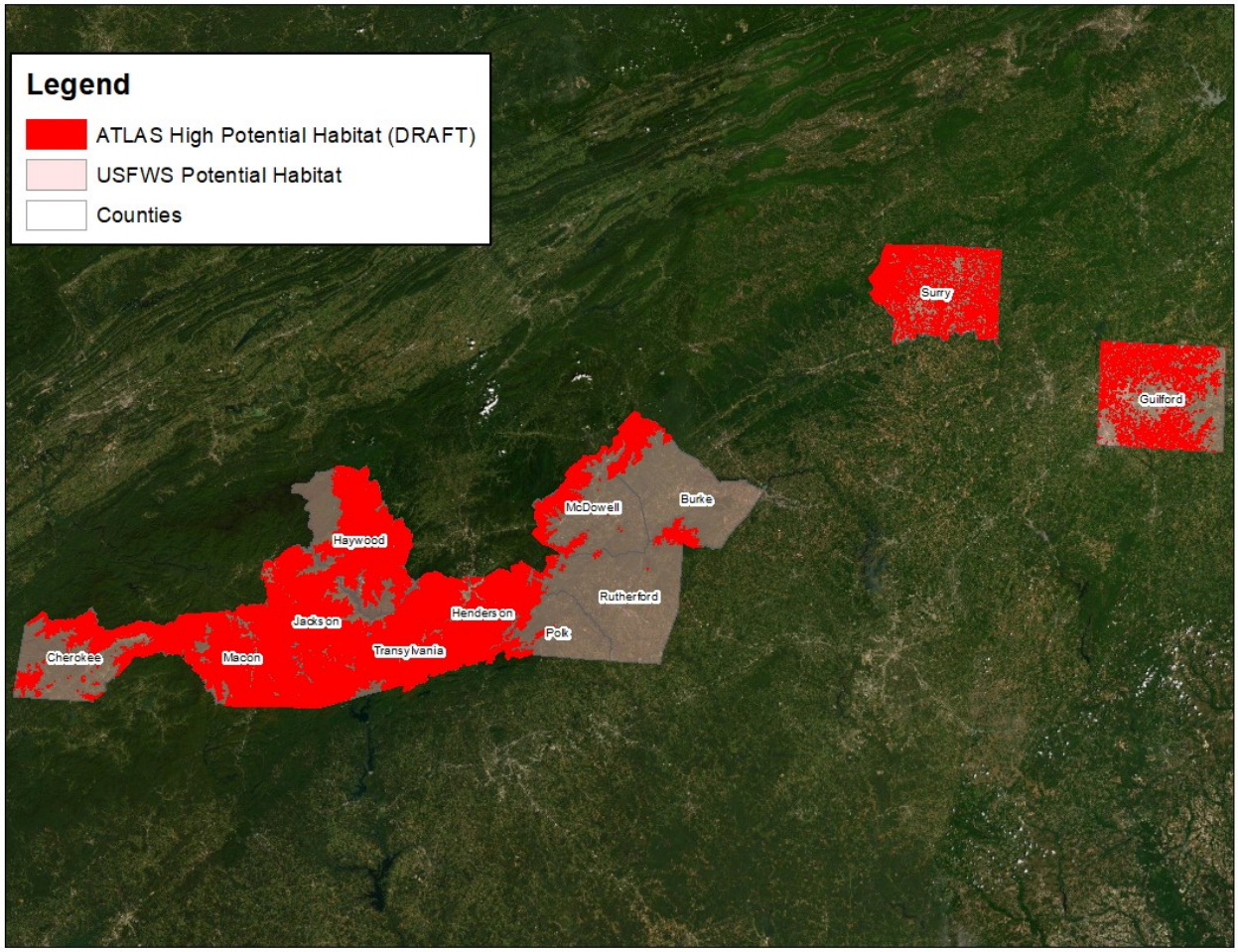


Figure 3. Range Map and High Potential Habitat (DRAFT).

Summary of Model (DRAFT)

Environmental data layers used included County Boundary, NRCS soils (pH), Q2DEM (slopes), GAP landcover, Q2DEM (elevation), and hollows (geomorphon analysis).

- Summary of model steps
  - Selected North Carolina counties where plant known to occur
  - Extracted known community types from GAP Landfire data
  - Selected identified elevation range for species
  - Derived slopes from Q2DEM data, extracted ideal slopes for species
  - Selected soils with defined pH values
  - Created hollows Geomorphon from Q2DEM in Grass
  - All resulting output data was intersected to define potential SWP habitat
- Response Rate
  - Reviewer Response Rate: 76%
  - 41 reviewer points placed by modeler
  - # Additional Comments (placed by reviewer): 18

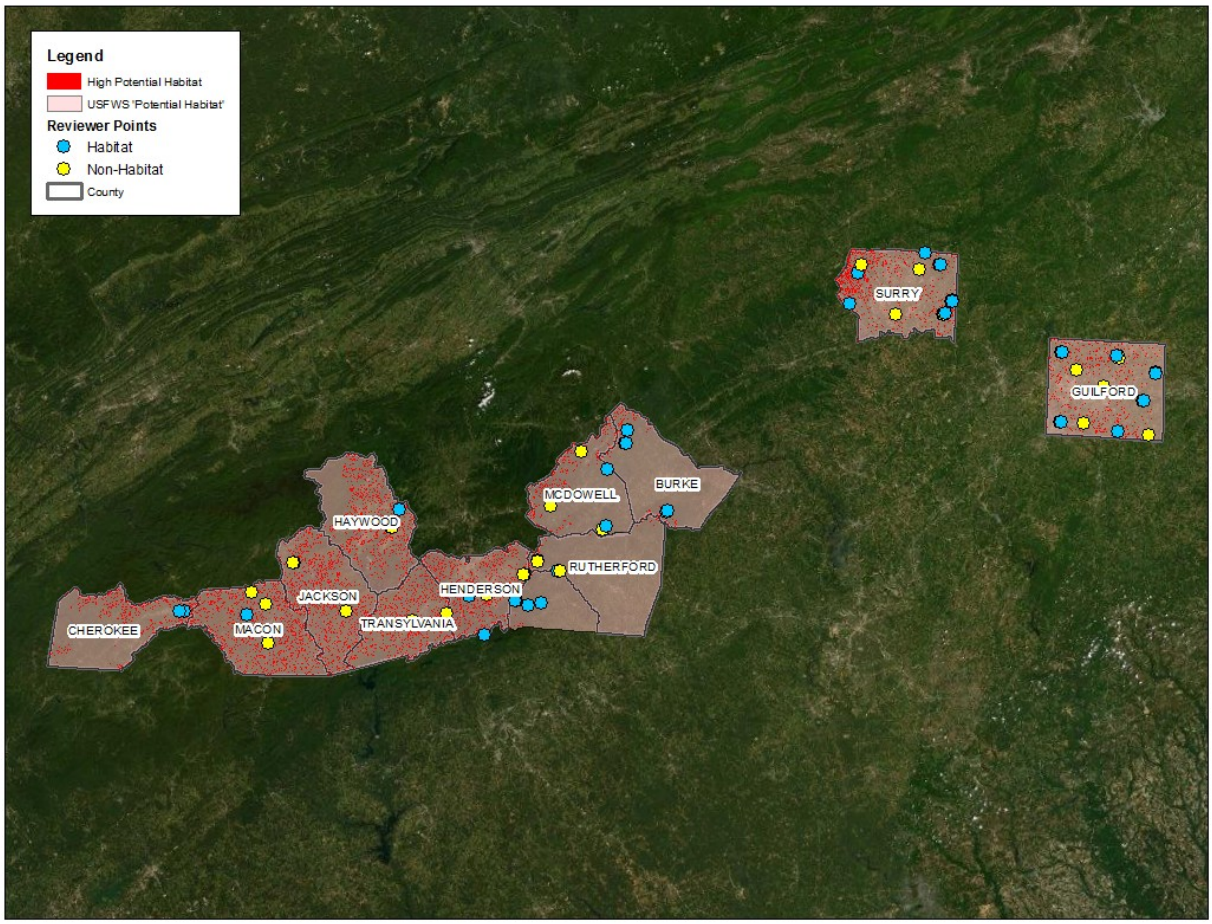


Figure 4. Reviewer Points (DRAFT)

Reviewer Responses

- Forty-one model flags were placed throughout the USFWS listed range to elicit reviewer response regarding model accuracy (i.e. Judgement Class: False negative, False positive, True Negative, and True Positive) for predicted SWP habitat. Reviewers provided a total of 111 responses consisting of 93 responses (76% response rate) for flagged location accuracy, and 18 responses for accuracy of unflagged locations.
- General agreement regarding judgment class for flagged locations was observed among reviewers. Reviewers for the most part agreed with the model's prediction of potential habitat (True Positive) but expressed concern the model was under predicting habitat on gentle slopes above topographic crenulations. Analysis of model layers used showed that the absence GAP landcover data (2011) Southern Piedmont Dry Oak-(Pine) Forest (Hardwood and Mixed Modifiers) and a lower elevation limit of 2100' in the SWP Mountain model resulted in reviewer perceived habitat under prediction for the False Negative judgement class. A shapefile including all comments is included as part of this appendix.

Proposed Version 1 Model

In order to address comments by reviewers, the following changes were made to the model:

- The lower elevation limit was decreased from 2100' to 1200' in the SWP mountain model.
- Added GAP landfire landcover community codes: Southern Piedmont Dry Oak-(Pine) Forest – Hardwood Modifier (ECOLSYS_LU 112) and Southern Piedmont Dry Oak-(Pine) Forest – Mixed Modifier (ECOLSYS_LU 113).
- Added Yancey County to range of known SWP populations.
- Removed Surry County (Historic) from range of SWP populations.
- Spur and valley landforms were added to the GRASS geomorphon layer
- Version 1 of the SWP potential habitat model consists of an additional 218,693 acres of for a total range of 508,685 acres.

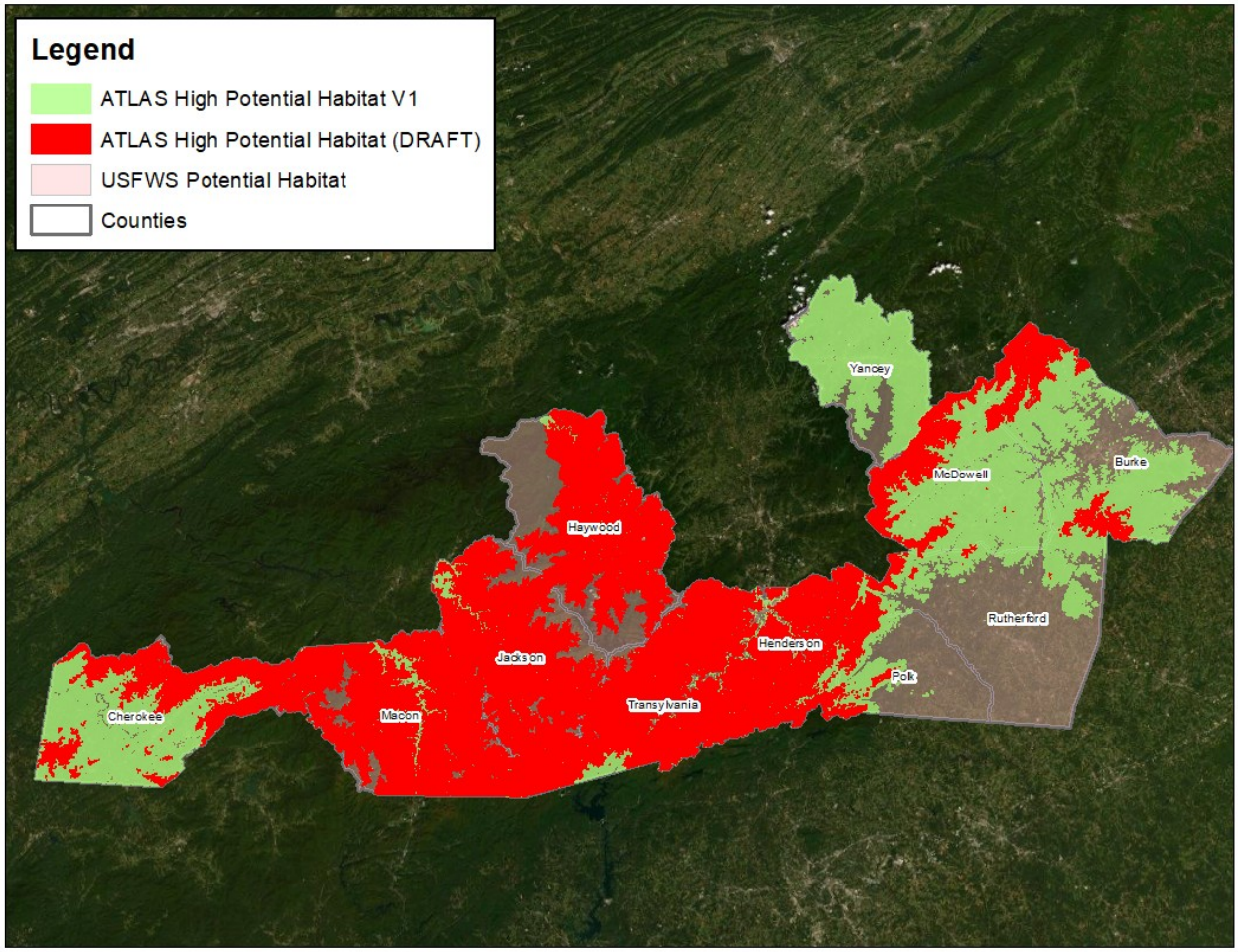


Figure 5. Range Map and High Potential Habitat Version 1 and DRAFT (Mountain)

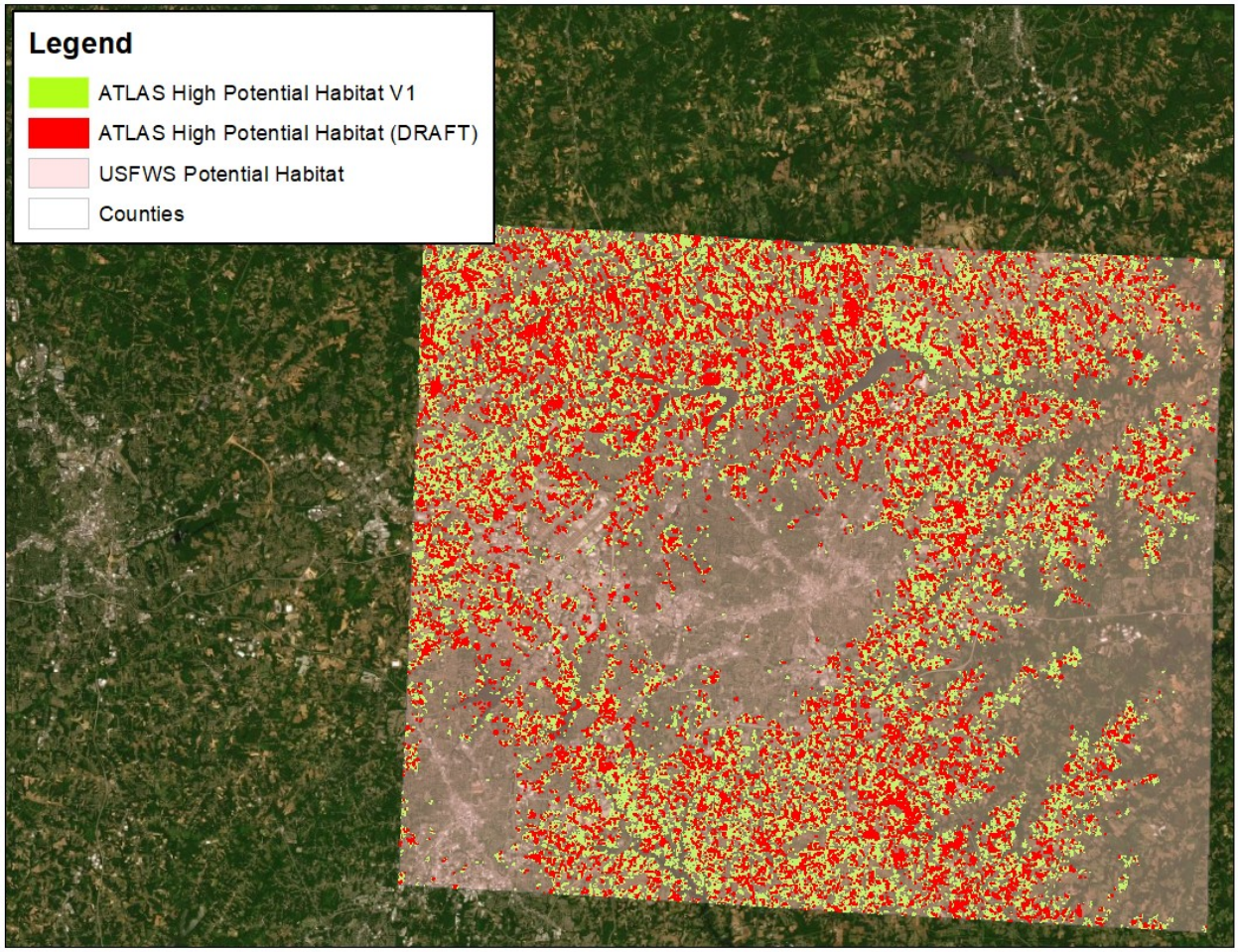


Figure 6. Range Map and High Potential Habitat Version 1 and DRAFT (Piedmont)

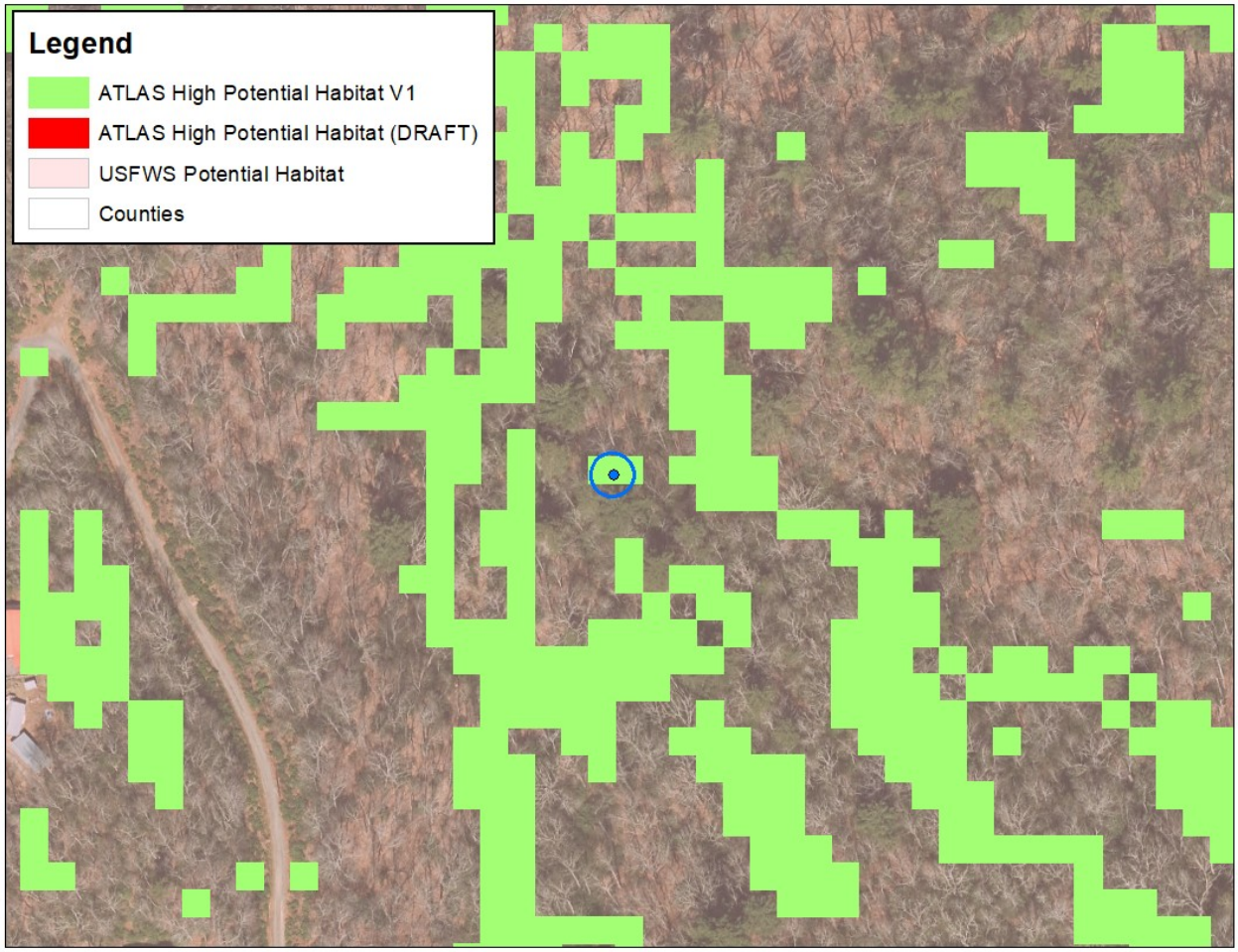


Figure 7. High Potential Habitat (Yancey County SWP Population) following revisions (Version 1)

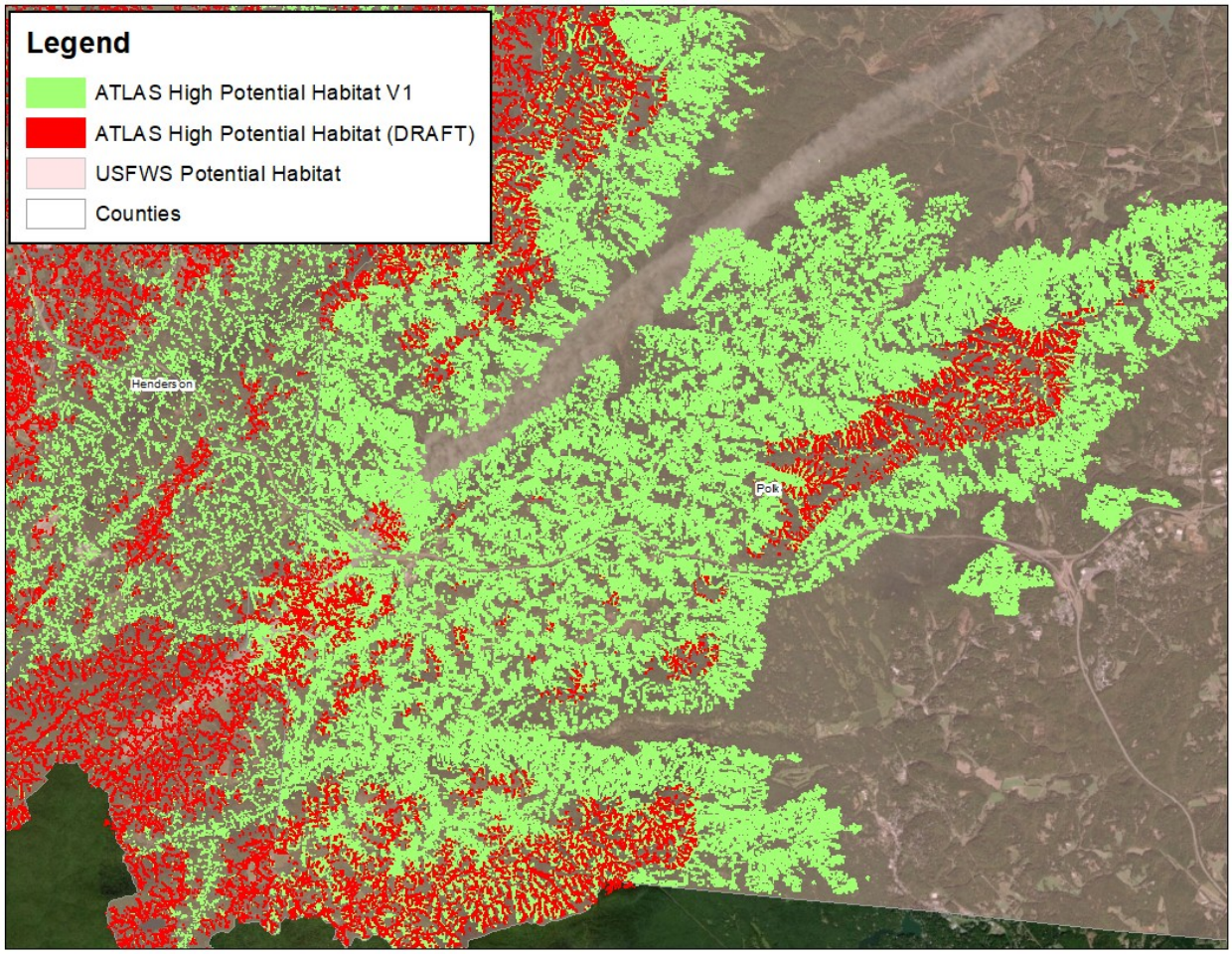


Figure 8. High Potential Habitat (Additional Habitat) following revisions (Version 1)

Model Field Assessment and Accuracy Statistics

Habitat model field assessments performed in 208 locations across the "current" USFWS listed counties in November and December 2019 assisted to clarify model strengths and weaknesses. A stratified sample of points were generated on "accessible lands" (generally public lands and right-of-ways), and biologists aimed to survey at least 10 points per county within the range. At a given point, biologists characterized the site as "Potential Habitat" or "Non-Habitat", mapped the area as a polygon, and provided site descriptions and photos to justify their conclusion. If a single site included both Potential Habitat and Non-Habitat (e.g., differing habitat on either side of a road), two polygon entries were logged.

Contributing Biologists

- Chris Sheats is a biologist with SEPI. He has been working with endangered species of North Carolina since 2003, with a focus on endangered plants and rare aquatic species.
- Bob Lepsic is a biologist with SEPI Inc. He has conducted plant and animal surveys throughout North Carolina for over 15 years.

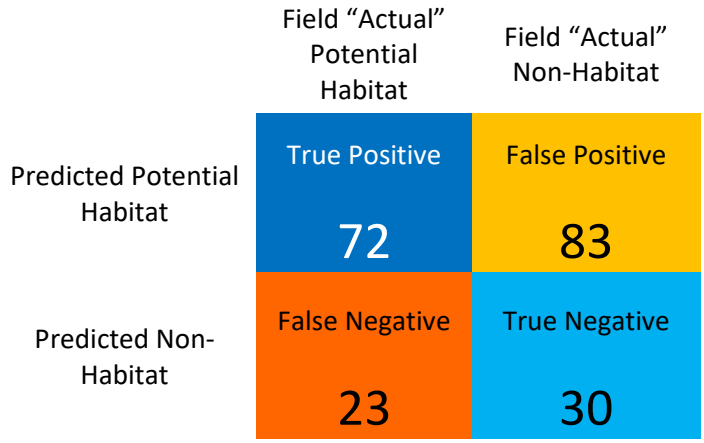


Figure 9. Accuracy summary based on field assessment of Draft 1 model. (units in the confusion matrix are polygons drawn by biologists)

Based on the biologists' field observations, accuracy of the binary classification model was as follows:

- Percent correctly classified was 49%
- Sensitivity was 0.757895
- Specificity was 0.265487

The biologists' summarized their observations as follows:

- Generally the model underpredicted, and should go further up slope, closer to saddle of landform and habitat is not necessarily within the drainage features
- Rhododendron thickets are picked up, but are not suitable. These areas will remain in model in order to reduce the risk of missing pockets of open area within the thickets

Further revisions were made to the model following field assessment to capture areas upslope and saddle landforms.