

Expert-based Model Guidance and Documentation (Version 1)

Project Information

- Species: Bunched Arrowhead (*Sagittaria fasciculata*)
- Team Contact: Eric Black (e.black@sncgrp.com) 919-612-2591; Matt Cobb (matt.cobb@stantec.com) 919-325-4773
- Date started: August 2019
- Date completed: March 2020

Species Information

NCDOT NRTR Habitat Description

USFWS Optimal Survey Window: Mid May-July

Bunched arrowhead (BA), endemic to the southern Appalachian Mountains of North Carolina and upper Piedmont of South Carolina, is rooted in shallow water seepage areas of bogs, wooded swamps, and deciduous woodlands. This early-successional perennial herb occurs in Swamp Forest-Bog Complex (Typic Subtype) and Southern Appalachian Bog (Southern Subtype) natural communities. A known occurrence also occurs in a maintained power line right-of-way along the headwaters of a river. The plant requires a slight but continuous and steady flow of cool, clean water that saturates or floods but does not stagnate. The species typically occurs in sandy loam soils found underneath a 10-24 inch layer of muck, sand, and silt. Undisturbed occurrences are usually located just below the origin of the seep on gently sloping terrain at the bluff-floodplain ecotone. While shaded areas contain the most vigorous plants, it will also grow in either full sun or partial shade beneath red maple, black gum, and alder at the base of steep slopes.

Additional Information

Occupied habitat consists of muck-filled seep areas on alluvial floodplains with a few exceptions on small sand bars in streams. Many North Carolina populations typically occur in highly degraded habitats representing ditched and channelized remnants of former wetland/stream systems.

Eight element occurrences (EO's) (7 current and 1 historic) are listed in North Carolina per Natural Heritage (July 2018). Landcover communities associated with these populations include forested/shrub bogs and field/pastures.

County Information

- NHP listed counties: Buncombe and Henderson
- FWS current listed counties: Henderson (Buncombe is historic)
- Extant occurrences are located in Henderson County

- Additions proposed by reviewers: NA

Environmental Data Information

All spatial data are in NAD 1983 StatePlane North Carolina FIPS 3200 (US feet).

Layer 1

- Layer name: County_Boundary
- Layer description:
 - Select Henderson County from County Boundary shapefile
- Layer selection justification:
 - Species only listed in Henderson
- “Habitat” versus “Nonhabitat” designations:
 - Potential habitat Henderson County.

Layer 2

- Layer name: NC_Wetlands
- Layer description:
 - NWI Wetlands Polygon
 - Clip polygon to Henderson County extent
 - Exclude Freshwater Pond, Lakes, and Riverine, wetland types.
- Layer selection justification:
 - Bunched arrowhead is associated with the Southern Appalachian Bog and Swamp Forest-Bog Complex Communities. NWI data showed overlap between the Southern Appalachian Bog and Swamp Forest-Bog Complex Communities with Freshwater Forested/Shrub Wetlands, Freshwater Emergent Wetlands, Riverine, Unconsolidated Bottom Wetlands, and Riverine, Intermittent Wetlands.
- “Habitat” versus “Nonhabitat” designations:
 - Potential habitat may be associated with certain types of NWI mapped wetlands described above.

Layer 3

- Layer name: NRCS_Soils_NC
- Layer description:
 - SSURGO Map Unit Polygon feature class of soil type and hydric percentage.
 - Clip polygon to Henderson County extent
 - Select soils with hydric percentage equal to or greater than 33%.
- Layer selection justification:
 - Bunched arrowhead is associated with saturated to flooded soils. Hydric soils layers were used to capture saturated to flooded soils that may serve as bunched arrowhead habitat.
- “Habitat” versus “Nonhabitat” designations:
 - Potential habitat is designated as hydric soils or soils having hydric inclusions equal to or greater than 33%.

- **Layer 4**
 - Layer name: hend_flat, hend_depres
 - Layer description:
 - Create terrain form and associated geometry layer from USGS elevation data using GRASS GIS Geomorphon add-on
 - Clip raster to Henderson County extent
 - Select flat and depression areas
 - Union with NWI Wetlands and Hydric Soils data to encompass all potential habitat areas.
 - Layer selection justification:
 - Bunched arrowhead is associated with water seepage areas of bogs, wooded swamps, and deciduous woodlands. Flats and depressions identified using Geomorphon add-on are landforms that may contain seepage areas.
 - “Habitat” versus “Nonhabitat” designations:
 - Potential habitat is designated as flats or depressions.

Layer 5

- Layer name: Gap_Ic
- Layer description:
 - USGS GAP Land Cover raster
 - Extract Ecological System Classes Evergreen Plantation or Managed Pine, Central and Southern Appalachian Montane Oak Forest, Central and Southern Appalachian Northern Hardwood Forest, Southern and Central Appalachian Oak Forest, Appalachian Hemlock-Hardwood Forest, Southern and Central Appalachian Cove Forest, South-Central Interior Large Floodplain - Forest Modifier, South-Central Interior Small Stream and Riparian, Southern and Central Appalachian Bog and Fen, South-Central Interior Large Floodplain - Herbaceous Modifier, Cultivated Cropland, and Pasture/Hay.
 - Convert Raster to Polygon
 - Union with NCNHP Swamp Forest Bog community layer data.
 - Intersect with Geomorphon/Wetland/Soils union layer data.
- Layer selection justification:
 - Bunched arrowhead is associated with water seepage areas of bogs, wooded swamps, and deciduous woodlands. Specific natural communities include the Swamp Forest-Bog Complex (Typic Subtype) and Southern Appalachian Bog (Southern Subtype). Gap communities associated with the eight known North Carolina EO’s included the communities listed above. These included GAP landcover communities that overlapped documented North Carolina Southern Bog and Swamp Forest-Bog Complex communities (Extrapolated from NHP Tier II Data).
- “Habitat” versus “Nonhabitat” designations:
 - Potential habitat includes specific GAP landcover communities as listed above.

Layer 6

- Layer name: ATLAS Hydrography Dataset v1.0
- Layer description:
 - ATLAS Hydro line features.
 - Select all intersected Geomorphon/Wetland/Soil/GAP layers located within 150 feet of ATLAS Hydrography Dataset v1.0
- Layer selection justification:
 - Bunched arrowhead is associated with water seepage areas of bogs, wooded swamps, and deciduous woodlands. Small seeps areas are often found in the drainage/floodplain of small streams. These areas may not be mapped as hydric soils and small wetland features may not captured by NWI mapping.
- “Habitat” versus “Nonhabitat” designations:
 - Potential habitat may occur near small stream and drainage features.

Layer 7

- Layer name: NCNHP Swamp_Forest-Bog_Complex_Natural Community
- Layer description:
 - NCNHP Swamp Forest-Bog Complex Natural Community data.
 - Union Swamp Forest-Bog Complex Natural Community layer with extracted GAP landcover raster.
- Layer selection justification:
 - Bunched arrowhead is associated with water seepage areas of bogs, wooded swamps, and deciduous woodlands.
- “Habitat” versus “Nonhabitat” designations:
 - Potential habitat may occur in Swamp Forest Bogs.

Layer 8

- Layer name: NHD_Waterbody & NHD Area
- Layer description:
 - National Hydrography Dataset polygon features representing open water.
 - Select only NHD Area and Waterbody features.
 - Erase BA areas with NHD Area and Waterbody features to remove habitat in open water.
- Layer selection justification:
 - Bunched arrowhead does not occur in open water or rivers but is associated with water seepage areas of bogs, wooded swamps, and deciduous woodlands. Small seeps areas are often found in the drainage/floodplain of small streams.
- “Habitat” versus “Nonhabitat” designations:
 - BA habitat does not occur in open water or river habitats.

Known Issues with Model Data Layers

- GAP Landcover: Gap Landcover data (2011) included buildings, roads, and other structures within landcover classes which subsequently overly predicted potential GPP habitat.

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 counties
- ArcGIS Model Builder
 - version ArcGIS – 10.3.1
 - Model file included in Appendix 1.
 - Summary of model steps:
 - Selected North Carolina counties where plant is known to occur
 - Union GAP landcover and NHP Swamp Bog Forest Community data
 - Union NWI wetlands, NRCS hydric soils, and Henderson county flats and depressions data to encompass all potential habitat areas.
 - Intersect result file with GAP landcover/Swamp Bog Forest Community data
 - Select areas from resulting file located within 150 feet of Atlas Hydrography water lines.
 - Union NHD Area and Waterbody layers and erase BA habitat occurring in open water areas.
- 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 November 2018 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 results – NHP element occurrences intersected predicted habitat.

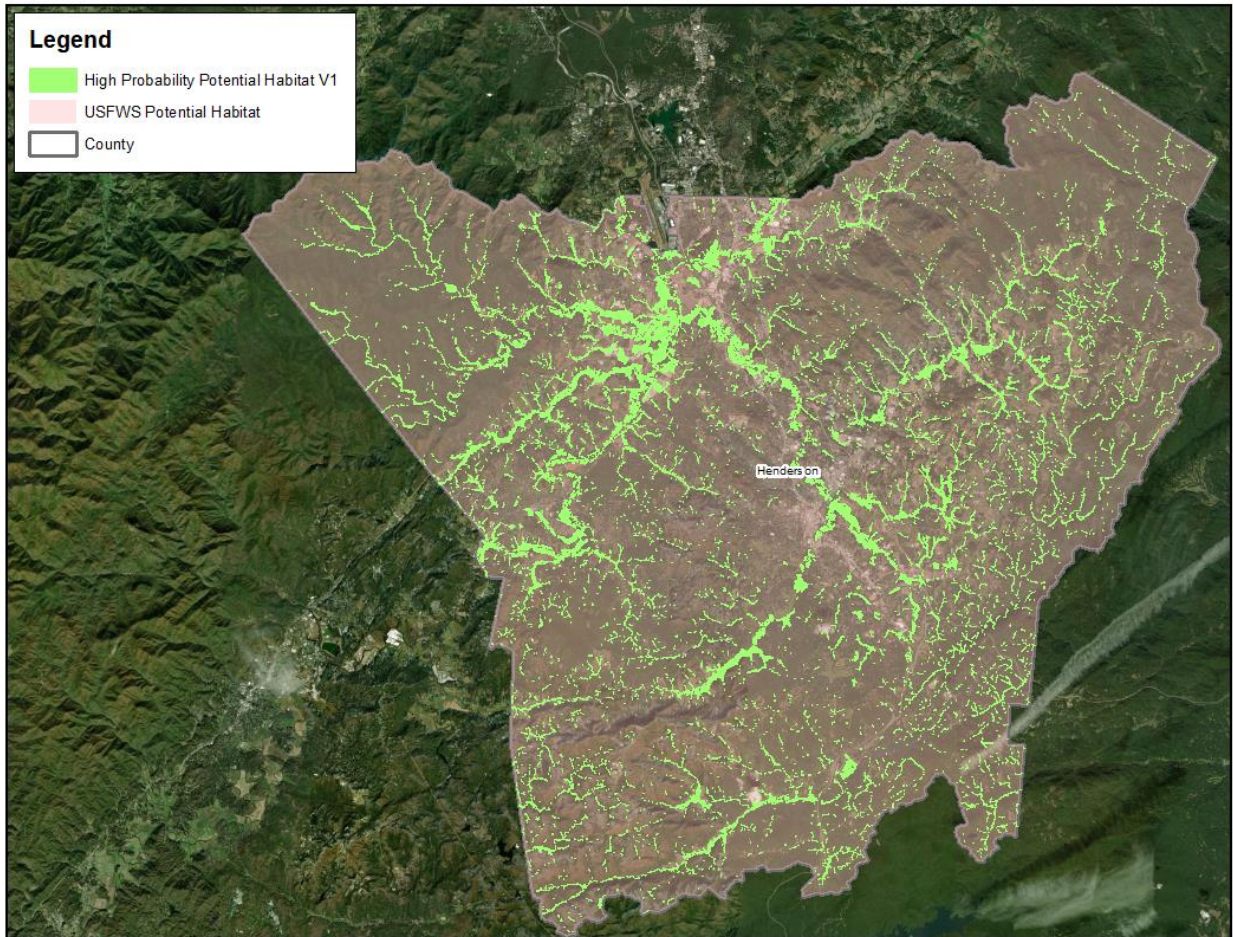


Figure 1. USFWS Range Map and High Probability Potential Habitat Version 1

Previous Model Versions (DRAFT)

The DRAFT version of the model was developed in 2018. The GAP landcover was modified following review to add an additional ECOSYS_LU code (Cultivated Cropland). The NHD Water line layer was modified to include only NHD Area and Waterbodies. The ATLAS Hydrography Dataset and NHP Swamp Bog Forest Community Layer was added following model review.

Layer 5

- Layer name: Gap_lc
- Layer description:
 - USGS GAP Land Cover raster
 - Extract Ecological System Classes Evergreen Plantation or Managed Pine, Central and Southern Appalachian Montane Oak Forest, Central and Southern Appalachian Northern Hardwood Forest, Southern and Central Appalachian Oak

Forest, Appalachian Hemlock-Hardwood Forest, Southern and Central Appalachian Cove Forest, South-Central Interior Large Floodplain - Forest Modifier, South-Central Interior Small Stream and Riparian, Southern and Central Appalachian Bog and Fen, South-Central Interior Large Floodplain - Herbaceous Modifier, Pasture/Hay.

- Convert Raster to Polygon
- Intersect with Geomorphon/Wetland/Soils union layer data
- Layer selection justification:
 - Bunched arrowhead is associated with water seepage areas of bogs, wooded swamps, and deciduous woodlands. Specific natural communities include the Swamp Forest-Bog Complex (Typic Subtype) and Southern Appalachian Bog (Southern Subtype). Gap communities associated with the eight known North Carolina EO's included the communities listed above. These included GAP landcover communities that overlapped documented North Carolina Southern Bog and Swamp Forest-Bog Complex communities (Extrapolated from NHP Tier II Data).
- "Habitat" versus "Nonhabitat" designations:
 - Potential habitat includes specific GAP landcover communities as listed above.

Layer 6

- Layer name: NHD_Water_Line
- Layer description:
 - National Hydrography Dataset line features.
 - Select all intersected Geomorphon/Wetland/Soil/GAP layers located within 150 feet of NHD Water Lines
- Layer selection justification:
 - Bunched arrowhead is associated with water seepage areas of bogs, wooded swamps, and deciduous woodlands. Small seeps areas are often found in the drainage/floodplain of small streams. These areas may not be mapped as hydric soils and small wetland features may not be captured by NWI mapping.
- "Habitat" versus "Nonhabitat" designations:
 - Potential habitat may occur near small stream and drainage features.

List of Delivered Model Products

- *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 (shapefiles) and word document*

References

(NCNHP) North Carolina Natural Heritage Program. 2017. Natural Heritage Program List of Rare Plant Species of North Carolina. <https://files.nc.gov/dncr-nhp/documents/files/2016-nhp-list-of-rare-plants-of-nc-revised-02-24-2017.pdf>. (Accessed April 18, 2018).

North Carolina Natural Heritage Program. 2018. Biotics Database. Division of Land and Water Stewardship. Department of Natural and Cultural Resources, Raleigh, North Carolina.

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.

(USFWS) U.S. Fish and Wildlife Service. 1979. Determination that *Sagittaria fasciculata* is an Endangered Species. 44 FR43700-43701.

USFWS. 1983. Recovery Plan for the Bunched Arrowhead (*Sagittaria fasciculata*). https://ecos.fws.gov/docs/recovery_plan/Bunched%20arrowhead%20RP.pdf. (Accessed April 18, 2018).

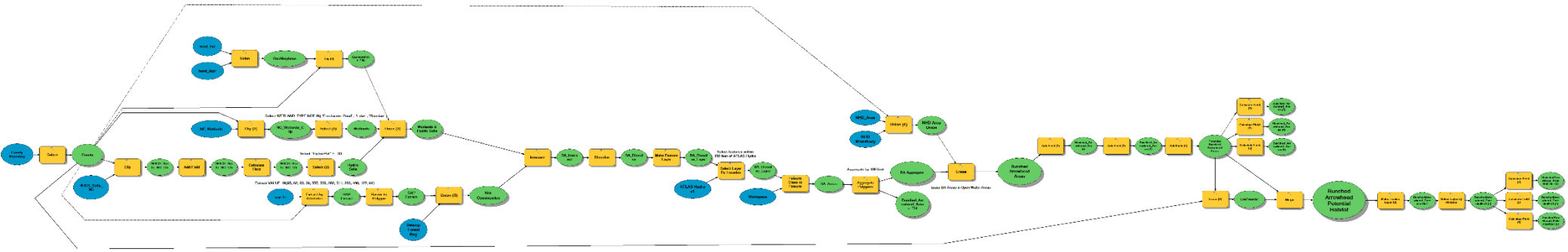
USFWS. 2011. Bunched arrowhead, *Sagittaria fasciculata* Factsheet. <https://www.fws.gov/southeast/pdf/fact-sheet/bunched-arrowhead.pdf>. (Accessed April 18, 2018).

USFWS. 2014. Bunched arrowhead (*Sagittaria fasciculata*), 5-year Review: Summary and Evaluation. <https://www.fws.gov/southeast/pdf/five-year-reviews/bunched-arrowhead.pdf>. (Accessed September 7, 2018).

USFWS. 2018. Bunched Arrowhead (*Sagittaria fasciculata*). https://www.fws.gov/raleigh/species/es_bunched_arrowhead.html. (Accessed April 18, 2018).

Appendix 1: Bunched Arrowhead Expert Model

Bunched Arrowhead



Appendix 2: Reviewer Documentation

Project Information

- Species: Bunched Arrowhead (*Sagittaria fasciculata*)
- Team Contact: Eric Black (e.black@sncgrp.com) 919-612-2591; Matt Cobb (matt.cobb@stantec.com), 919-325-4773
- Reviewer names:
 1. Suzanne Mason (NCNHP)
 2. Jame Amoroso (NCNHP)
 3. Rebekah Reid (USFWS – West)
 - Suzanne Mason (NCNHP) – Suzanne is a data manager for the North Carolina Natural Heritage Program. She has been with the NCNHP since 2005 and specializes in maintaining conservation data for federally protected species. Suzanne previously studied the genetic diversity of Schweinitz’s sunflower (*Helianthus schweinitzii*) for her Master of Science thesis.
 - 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.
 - 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 239,840 acres
- ATLAS Range 9,881 acres

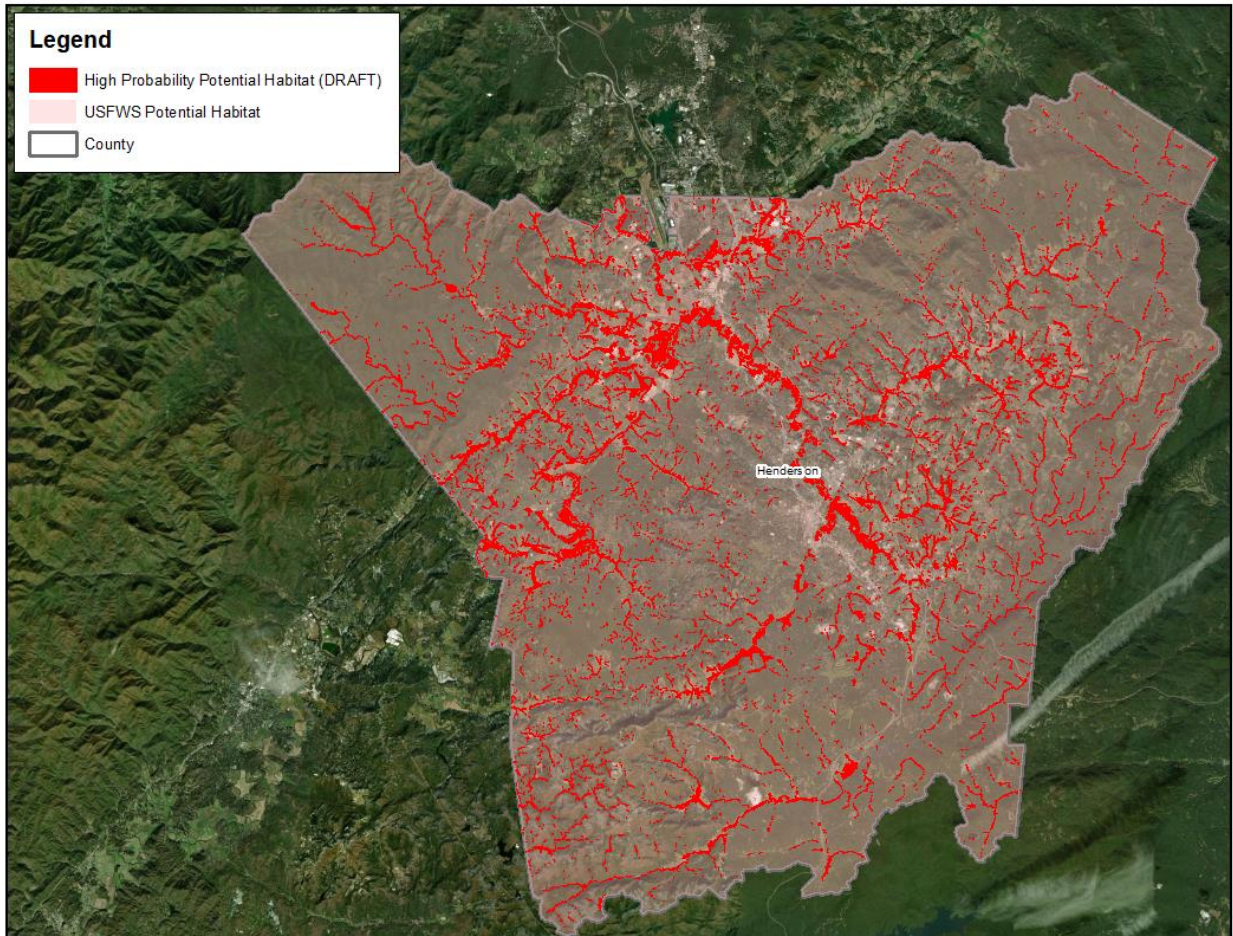


Figure 2. Range Map and High Probability Potential Habitat (DRAFT)

Summary of Model (DRAFT)

Environmental data layers used included county boundary, NWI wetlands, NRCS soil data (hydric soils), and Henderson County flats and depressions (geomorphon analysis), GAP land cover, and NHD water lines.

- Summary of model steps
 - Selected North Carolina counties where plant is known to occur
 - Union NWI wetlands, NRCS hydric soils, and Henderson county flats and depressions data to encompass all potential habitat areas.
 - Intersect result file with GAP landcover data
 - Select areas from resulting file located within 150 feet of NHD water lines.

- Response Rate
 - Reviewer Response Rate: 73%
 - 21 judgement points placed by modeler.
 - # Additional Comments (placed by reviewers): 15

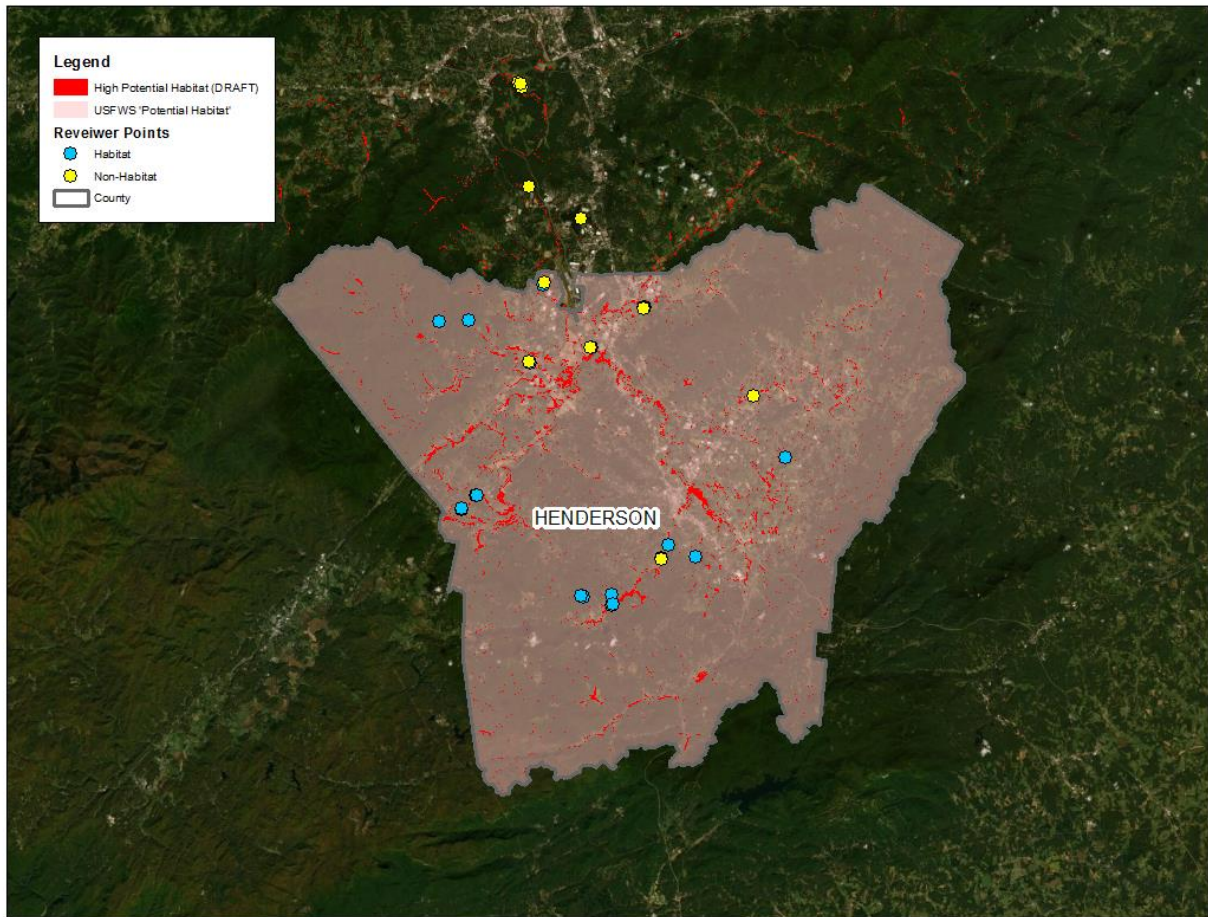


Figure 3. Reviewer Points High Probability Potential Habitat (DRAFT)

Reviewer Responses

- 21 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 BA habitat. Reviewers provided a total of 54 responses consisting of 46 responses (73% response rate) for flagged location accuracy, and 8 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). Reviewer responses regarding model over prediction (False Positive) was primarily attributed to the prediction of BA habitat in open water or river systems. Reviewer response regarding model False Negatives was attributed to patchy under prediction and projection errors. Analysis of model layers used showed that incorrectly classified GAP landcover data (2011) did affect model prediction. 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:

- Cultivated Cropland (code 556) was added to GAP landcover data (2011), replaced the NHD water lines layer with ATLAS Hydro layer version 1, and added Swamp Forest Bog layer to generate version 1 of the model.
- Version 1 of the potential habitat model includes an additional 735 acres of for a total range of 6,949 acres

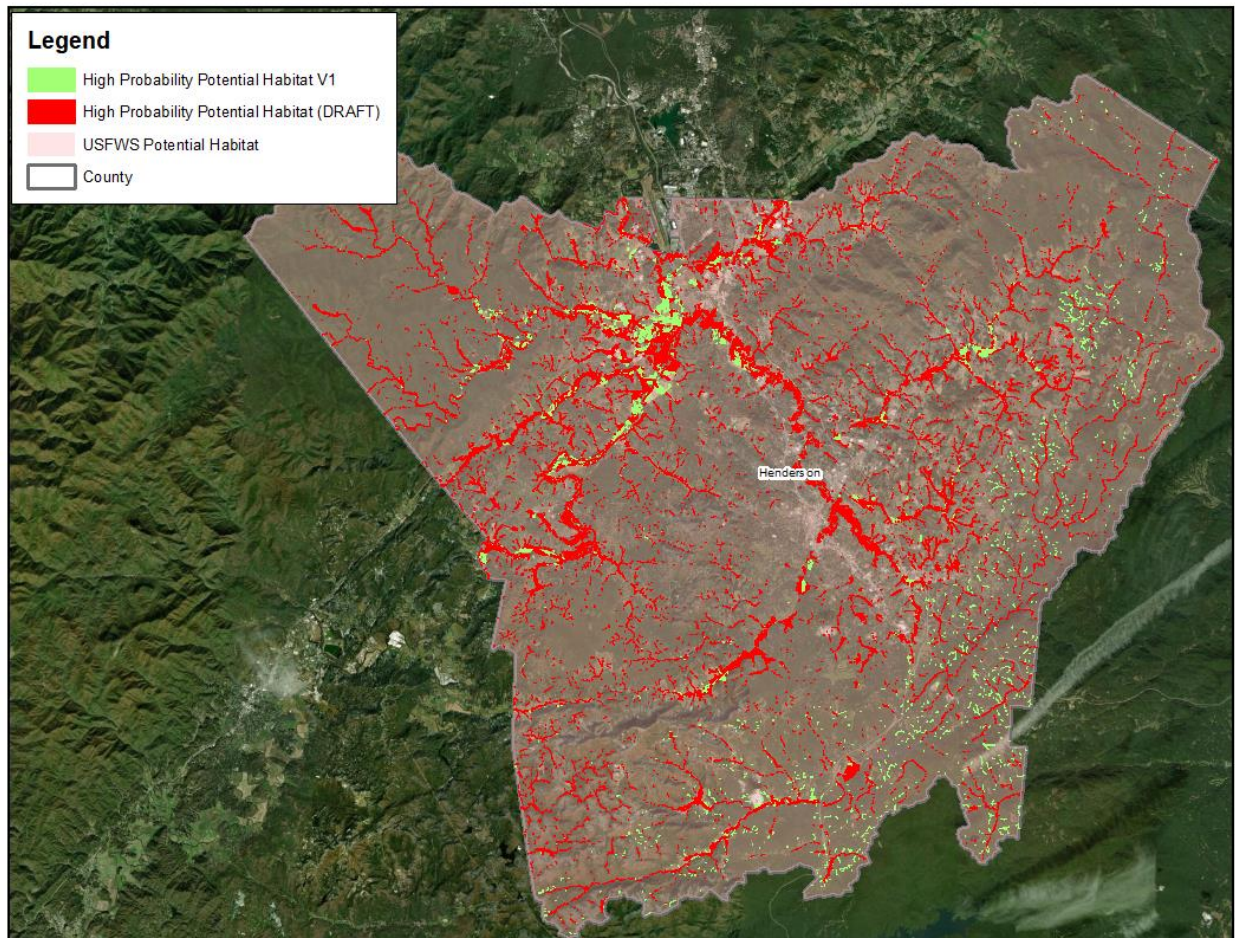


Figure 4. Range Map and High Probability Potential Habitat Version 1

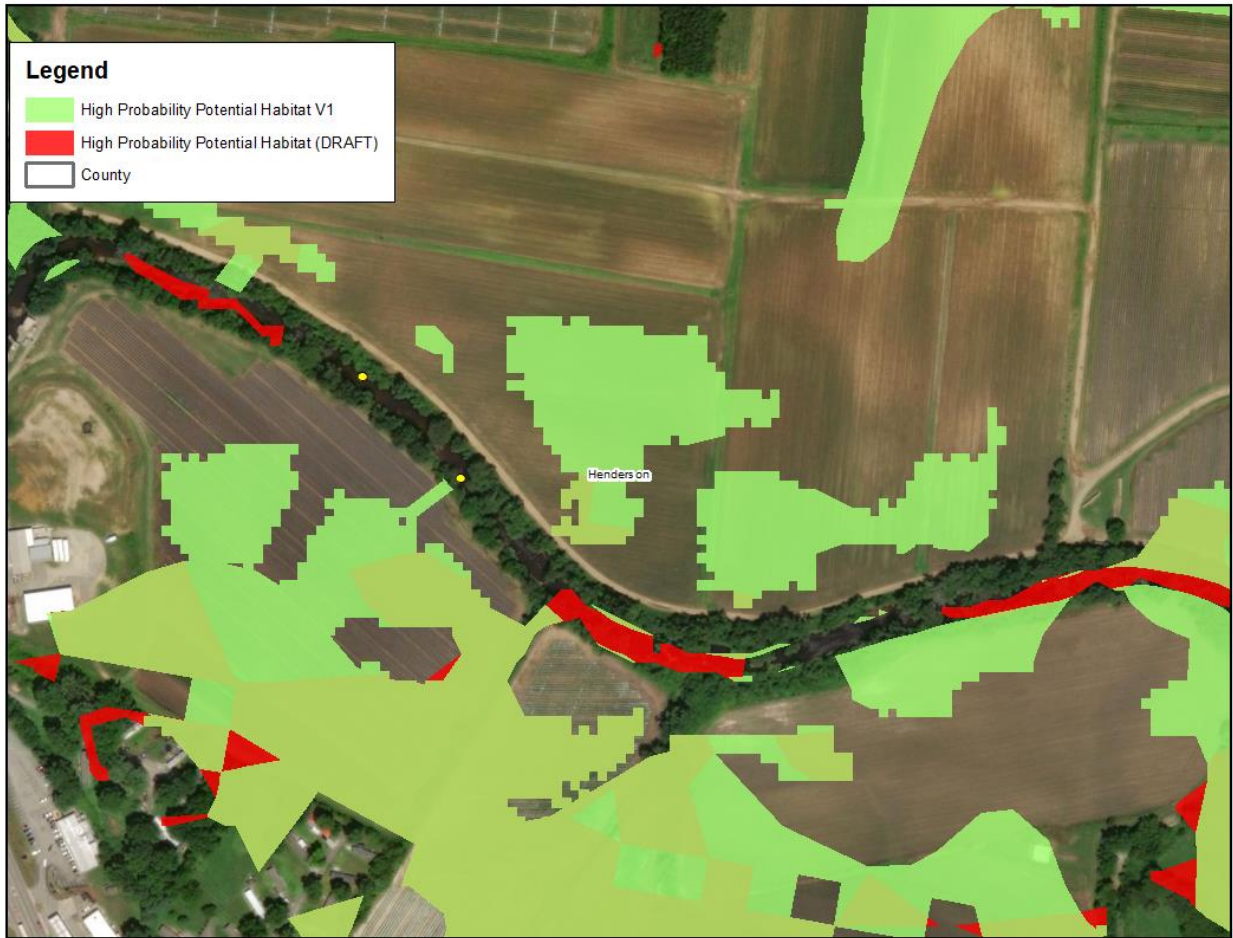


Figure 5. High Probability BA habitat (No habitat in rivers) following model revision (Version 1)

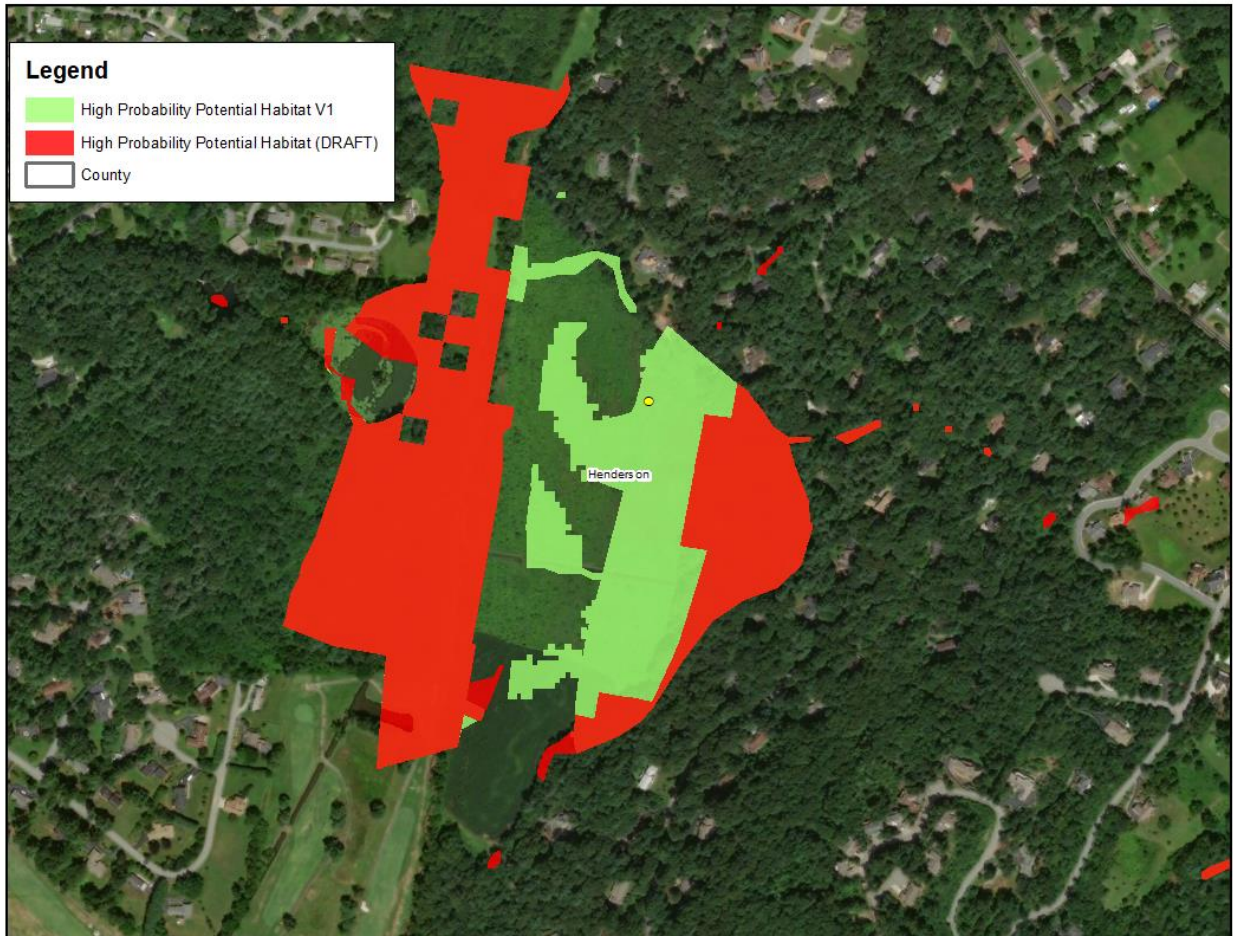


Figure 6. High Probability BA habitat (Increased footprint in documented hydric soils) following model revision (Version 1)

Model Field Assessment and Accuracy Statistics

Habitat model field assessments performed in 20 locations across the “current” USFWS listed county, Henderson County in 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

- Eric Black is a Senior Environmental Project Manager with Scenic Consulting Group with experience in federally protected plant and animal surveys in both the private and public environmental sectors. He served as western plant coordinator for the ATLAS project.

- Logan Williams is a Senior Environmental Project Manager with Scenic Consulting Group with 30+ years' experience in federally protected plant and animal surveys in both the private and public environmental sectors.

Figure 7. Accuracy summary based on field assessment of Version 1 model. (units in the confusion matrix are polygons drawn by biologists)

	Field "Actual" Potential Habitat	Field "Actual" Non-Habitat
Predicted Potential Habitat	True Positive 7	False Positive 9
Predicted Non- Habitat	False Negative 0	True Negative 6

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

- Percent correctly classified was 59%
- Sensitivity was 1
- Specificity was 0.4

The biologists' summarized their observations as follows:

- The model generally predicts known habitat (e.g. roadside seeps/ditches, low velocity stream associated seeps excludes unlikely habitat (e.g. upland forests, upland pastures, parking lots, regularly maintained properties, urban areas, ridgelines, hilltops).
- False positives were located in areas where the floodplain hydrology has been altered or high velocity streams.
- The model generally had more areas of false positives in agriculturally impacted floodplains as well as greater than first order streams.