Expert-based Model Guidance and Documentation (Version 1)

Project Information

- Species: Green Pitcher Plant (*Sarracenia oreophila*)
- 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: late April-October

The habitat of green pitcher plant (GPP), found in the North Carolina Blue Ridge Province, varies from moderately to steeply sloped seepage bogs (Southern Appalachian Bog-Southern Subtype) and boggy stream banks in North Carolina and Alabama to poorly drained oak and oak-pine flatwoods with a high-water table during the winter months in Georgia. Soils of all known occurrences are generally acidic and derived from sandstones or shales. Soils of the flatwood and seepage bog habitat sites are sandy clays or loams, while those of the stream bank habitat sites are almost pure sand. This carnivorous herb is dependent on some form of disturbance, often periodic fire, to keep its habitat in an early successional stage and reduce competition. Flooding also appears to maintain, and perhaps create, the plant's suitable habitat in its stream bank environment by eliminating competing species.

Additional Species Information

GPP known populations and associated habitats include: 1) **Alabama** (14 Populations) - 10 extant colonies on streambanks, 1 extant colony in shallow drainage, and 11 extant colonies in seepage bogs; 2) **Georgia** (1 Population shared w/ North Carolina) – 1 colony in seepage bog; and 3) **North Carolina** (1 Population shared with Georgia) – 1 colony in seepage bog. Soils associated with these habitats are moist, not subject to regular flooding or saturation. GPP grows away from the wet slough in seepage bogs. Per the Green Pitcher Plant Recovery Plan, streambank colonies are restricted to the Lookout Mountain area.

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

County Information

- NHP listed counties: Clay
- FWS listed counties: Clay
- Additions proposed by reviewers: NA

Environmental Data Information

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

Layer 1

- Layer name: County_Boundary
- Layer description:
  - Select Clay County from County Boundary shapefile
- Layer selection justification:
  - Species only listed in Clay County
- "Habitat" versus "Nonhabitat" designations:
  - Habitat listed as Clay County.

Layer 2

- Layer name: NRCS_Soils_NC
- Layer description:
  - SSURGO Map Unit Polygon feature class of soil type and hydric percentage.
  - Clip polygon to Clay County extent
  - Select soils with Hydric Percentage 1-100 %.
- Layer selection justification:
  - NCNHP data showed the single NC colony occurs in wetland bog habitat. Wetlands are associated with hydric soils, or upland soils with hydric inclusions.
- "Habitat" versus "Nonhabitat" designations:
  - Potential habitat soils must have some hydric percentage $\geq$ 1%.

Layer 3

- Layer name: NC_Wetlands
- Layer description:
  - NWI Wetlands Polygon
  - Clip polygon to Clay County extent
  - Select Wetland Types of Freshwater Emergent Wetland & Freshwater Forested/Shrub Wetland
- Layer selection justification:
  - GPP is associated with the Southern Appalachian Bog community. NWI mapping data showed overlap between the Southern Appalachian Bog Community, and

Freshwater Forested/Shrub Wetlands (PFO1A) and Freshwater Emergent Wetlands (PEM1A).

- "Habitat" versus "Nonhabitat" designations:
    - Potential habitat may be associated with NWI mapped wetlands described above.

Layer 4

- Layer name: nc_ph1t
- Layer description:
    - SSURGO soil pH raster
    - Clip to Clay County extent
    - Select pH values between 3.0 and 6.0
    - Convert selection to polygon
- Layer selection justification:
    - GPP habitat is associated with highly acidic soils. The NRCS divides soil pH into common soil classes that range from Extremely acidic 3.5-4.4 to Strongly alkaline 8.5-9.0. Soils classes used to capture highly acidic soils included: Strongly acid 5.1-5.5, Very strongly acid 4.5-5.0, and Extremely acid 3.5-4.4.
- "Habitat" versus "Nonhabitat" designations:
    - Potential habitat included soils with pH ranging from 3.0 to 6.0.

Layer 5

- Layer name: nc_sand
- Layer description:
    - SSURGO soil sand percentage raster
    - Clip to Clay County extent
    - Select values sand percentage $\geq$ 50%
    - Convert selection to polygon
- Layer selection justification:
    - Soils of the flatwood and seepage bog habitat sites are sandy clays or loams, while those of the stream bank habitat sites are almost pure sand. Sand percentage was selected to identify soils having greater than or equal to 50% sand composition.
- "Habitat" versus "Nonhabitat" designations:
    - Potential habitat includes soils with sand percentage of $\geq$ 50%.

Layer 6

- Layer name: Gap_lc
- Layer description:
    - USGS GAP Land Cover raster
    - Extract NVI Classes Appalachian Hemlock-Hardwood Forest, Disturbed/Successional – Grass/Forb Regeneration, Disturbed/Successional - Shrub Regeneration; Evergreen Plantation or Managed Pine, Harvested Forest-Shrub Regeneration, Harvested Forest – Grass/Forb Regeneration, Pasture/Hay,

South-Central Interior Small Stream and Riparian, Southern and Central Appalachian Bog and Fen, and Southern and Central Appalachian Oak Forest.
    - Convert Raster to Polygon
- Layer selection justification:
    - GPP habitat in North Carolina is associated with Southern Appalachian Bogs, but is found to grow more successfully in open, sunny areas with little competition. Gap communities associated with two known North Carolina EO's include disturbed areas (i.e. Pasture/Hay etc.) on hydric soils, or GAP communities that overlapped documented North Carolina Southern Bog communities (Extrapolated from NHP Tier II Data).
- "Habitat" versus "Nonhabitat" designations:
    - Potential habitat included the GAP communities listed above.

Known Issues with Model Data Layers

- Overall Habitat: Selection of layers used in the proposed model were based on limited habitat data for GPP in North Carolina. Generalized data from the USFS Recovery plan and data (i.e. landcover, soils, NWI data) from the two North Carolina GPP EO's was used to generate the proposed habitat model. Stream layers were not used to identify GPP habitat in the North Carolina model. The rationale for this decision is based on the fact that ALL known stream bank populations for GPP have occurred in the Lookout Mountain Region of Alabama.
- Landfire Fire Regime: Fire Regime Group Data was evaluated for model usage. The data showed good correlation between more frequent fire return intervals (<35 years) and the two known green pitcher plant EO's. This data excluded potential habitat that fell within floodplains and valleys having less frequent fire returns (35-200 years). While appropriate habitat has naturally been maintained through flooding and fire events, human disturbance may create secondary habitat such as open grassy areas/disturbed areas. A comparison between Fire Regime Group data and GAP Landcover data (i.e. disturbed/successional, pastures etc.) showed better coverage of potential GPP habitat with the landcover data because it included both areas of more frequent fire return and areas of human disturbance. Subsequently, it is likely that omission of the Fire Regime Group Data will have no overall effect on predicting potential GPP habitat in North Carolina.
- Gap Landcover: GAP data (2011) included buildings, roads, and other structures within vegetative landcover classes which 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:
        - Select North Carolina county where plant is known to occur
        - Select relevant data for NRCS hydric soils and NWI wetlands.
        - Union NRCS hydric soils and NWI wetlands data to encompass all potential habitat areas.
        - Extract relevant data for soil pH, soil percent sand, and GAP landcover data.
        - Intersect result files.
        - Aggregate intersected files by 100 feet.
        - Remove polygons with area less than 25 square feet.
- 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 result – NHP element occurrences intersected predicted habitat.

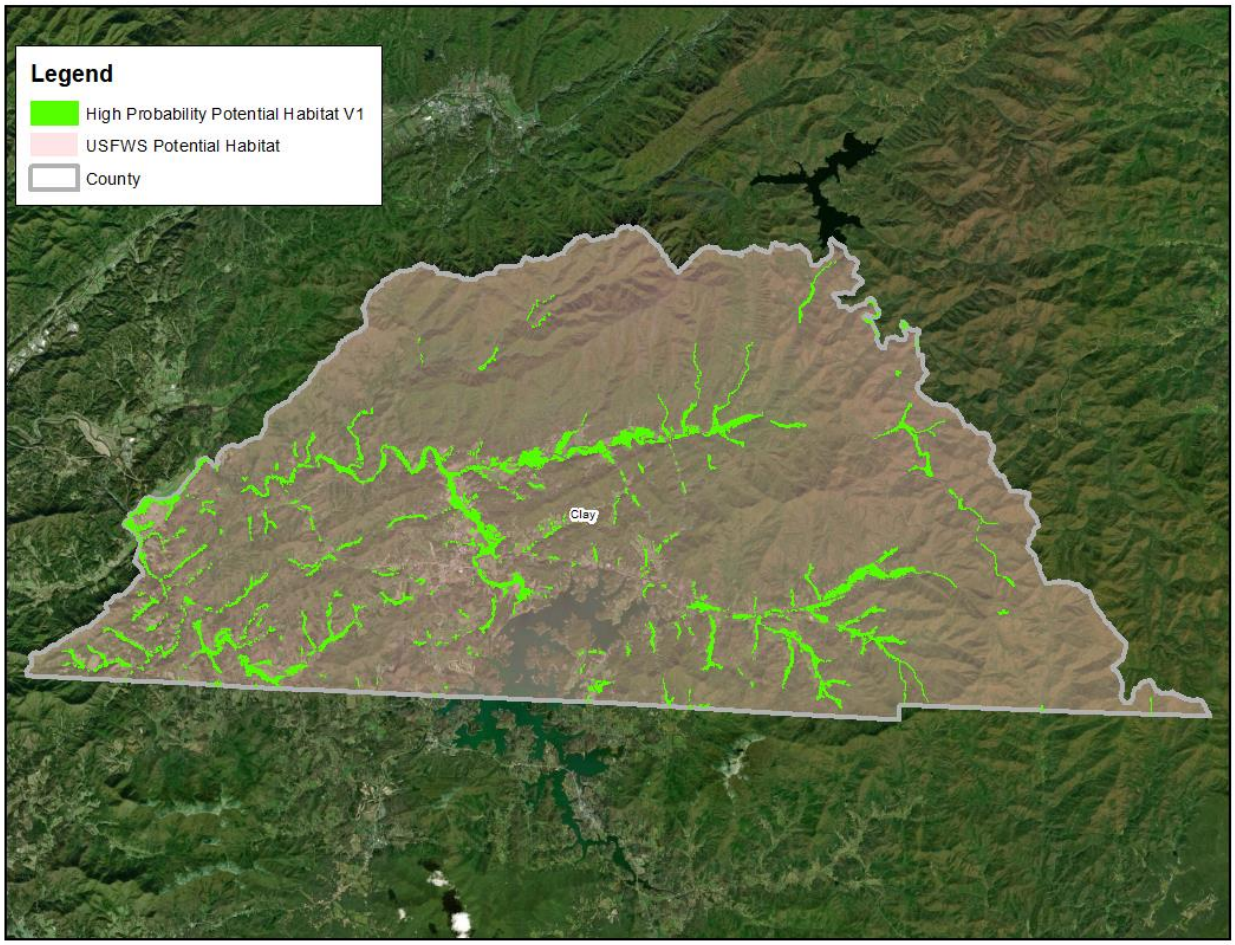


Figure 1. Range Map and High Probability Potential Habitat Version 1

Previous Model Versions (DRAFT)

The previous version of the model was developed in 2018. The hydric soils layer was modified between versions. No new additional layers were added or deleted after its review in 2019.

Layer 2

- Layer name: NRCS_Soils_NC
- Layer description:
    - SSURGO Map Unit Polygon feature class of soil type and hydric percentage.
    - Clip polygon to Clay County extent
    - Select soils with Hydric Percentage >=1 %, occasionally flooded, rarely flooded, or no flooding designation.
- Layer selection justification:
    - NCNHP data showed the single NC colony occurs in wetland bog habitat. Wetlands are associated with hydric soils, or upland soils with hydric inclusions.
- "Habitat" versus "Nonhabitat" designations:

- Potential habitat soils must have some hydric percentage higher than 1% and occur in areas that are not regularly flooded or have constantly saturated soils.

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 comments and general model recommendations.*
- *Version 1 Model prediction file(s) (shapefile)*
- *AGOL reviewer comments (shapefile)*
- *Field reviewer comments (shapefiles) and word document*

References

Nature Serve. 2018. *Sarracenia oreophila* - (Kearney) Wherry, Green Pitcher Plant. http://explorer.natureserve.org/servlet/NatureServe?searchName=Sarracenia+oreophila. (Accessed August 27, 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.

Troup, R. L., & McDaniel, S. T. 1980. Current status report on *Sarracenia oreophila*. US Fish and Wildlife Service, Atlanta, GA.

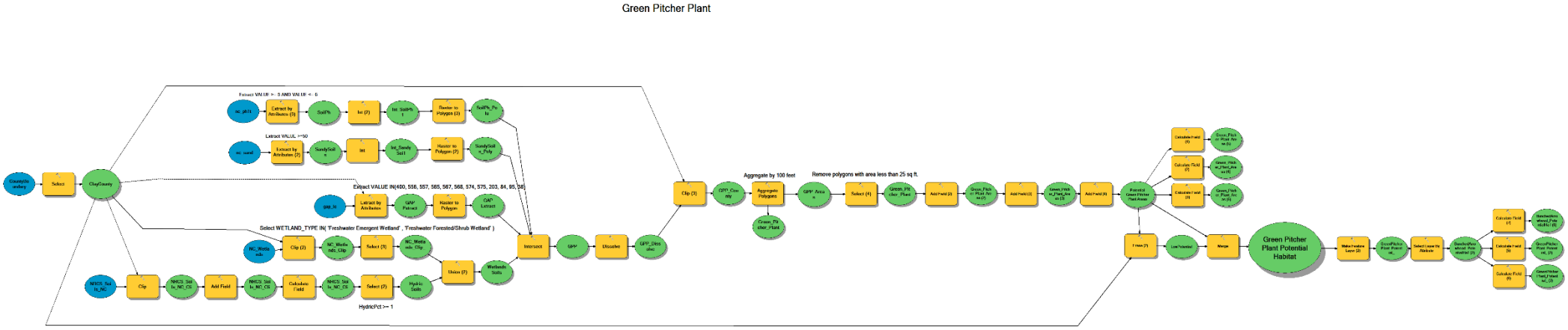
(USFWS) US Fish and Wildlife Service. 1994. Green Pitcher Plant (*Sarracenia oreophila*) Recovery Plan. https://projects.ncsu.edu/cals/plantbiology/ncsc/rare/Recovery_Sarracenia_oreophila.pdf. Accessed April 25, 2018).

USFWS. 2011. Green pitcher plant (*Sarracenia oreophila*) Factsheet. https://www.fws.gov/southeast/pdf/fact-sheet/green-pitcher-plant.pdf. (Accessed April 25, 2018).

USFWS. 2013. Green pitcher plant (*Sarracenia oreophila*): 5-Year Review: Summary and Evaluation. https://www.fws.gov/southeast//pdf/five-year-reviews/green-pitcher-plant.pdf. (Accessed September 6, 2018).

USFWS. 2017. Green Pitcher Plant (*Sarracenia oreophila*). https://www.fws.gov/asheville/htmls/listed_species/green_pitcher_plant.html. (Accessed April 25, 2018).

Appendix 1: Green Pitcher Plant Expert Model



Appendix 2: Reviewer Documentation

Project Information

- Species: Green Pitcher Plant (*Sarracenia oreophila*)
- Lead modeler: 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 141,260 acres
- ATLAS Range 1,752 acres

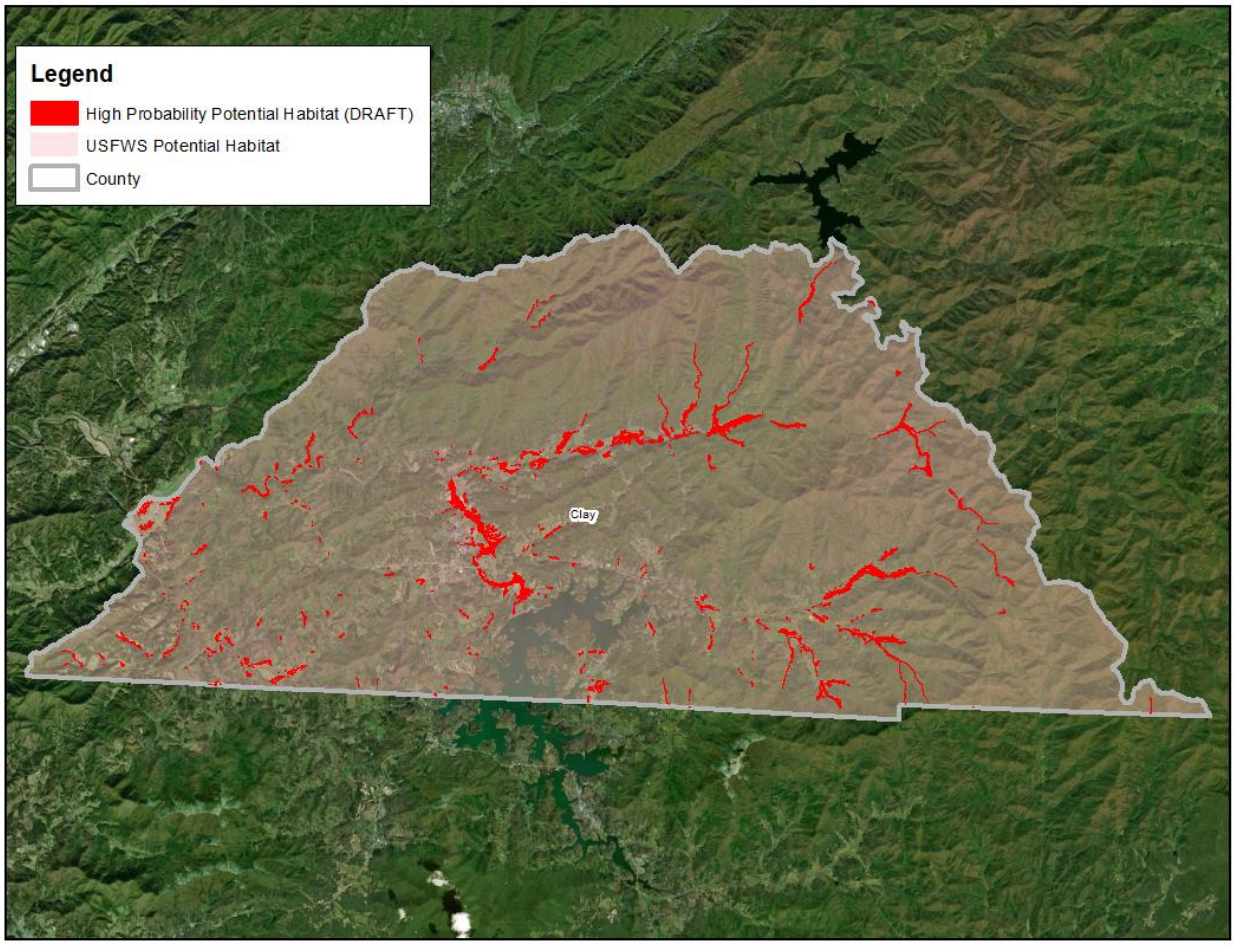


Figure 2. Range Map and High Probability Potential Habitat (DRAFT).

Summary of Model (DRAFT)

Environmental data layers used included county boundary, NRCS soil data, NWI wetlands, soil pH, soil sand percentage, and GAP land cover.

- Summary of model steps
    - Selected North Carolina county where plant is known to occur
    - Select relevant data for NRCS hydric soils and NWI wetlands.
    - Union NRCS hydric soils and NWI wetlands data to encompass all potential habitat areas.
    - Extract relevant data for soil pH, soil percent sand, and GAP landcover data.
    - Intersect result files.
    - Aggregate intersected files by 100 feet.
    - Remove polygons with area less than 50 square feet.

- Response Rate
    - Reviewer Response Rate: 75%
        - 21 judgement points placed by modeler.

- # Additional Comments (placed by reviewers): 15

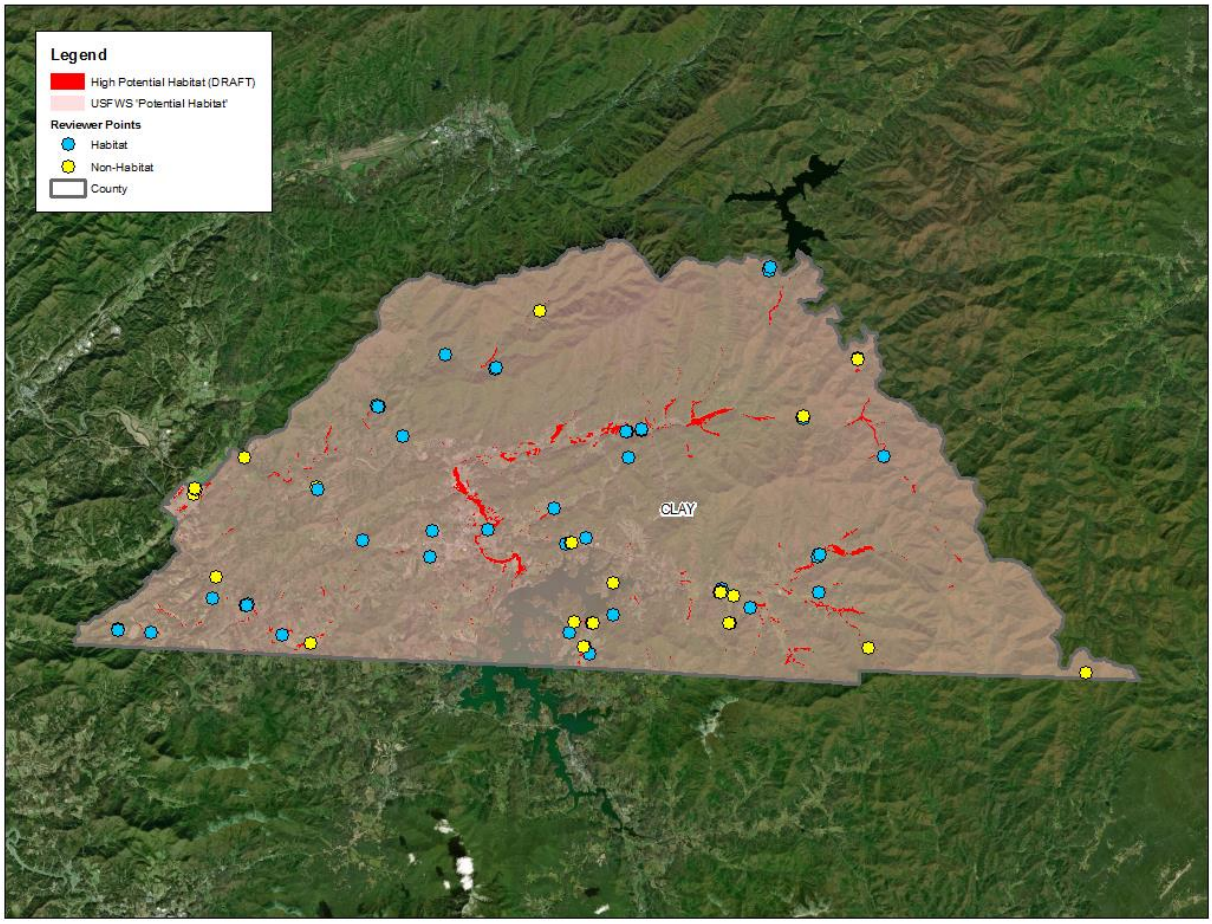


Figure 3. Reviewer Points High Probability Potential Habitat (DRAFT)

- Twenty-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 GPP habitat. Reviewers provided a total of 78 responses consisting of 47 responses (75% response rate) for flagged location accuracy, and 31 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. Reviewer responses regarding model under prediction due to False Negative comprised the majority of comments. Analysis of model layers used showed that incorrectly classified GAP landcover data (2011), exclusion of soils classified as 33-99% hydric and/or frequently flooded, and exclusion of soils mapped as <50% sand composition resulted in reviewer perceived habitat under prediction for both True Positive and False Negative judgement classes. 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:

- All soils classified as ≥ 1 percent hydric were used for model generation.
- GAP land cover data will be updated following GAP landfire updates in 2020.
- Version 1 of the potential habitat model includes an additional 1,868 acres for a total range of 3,620 acres.

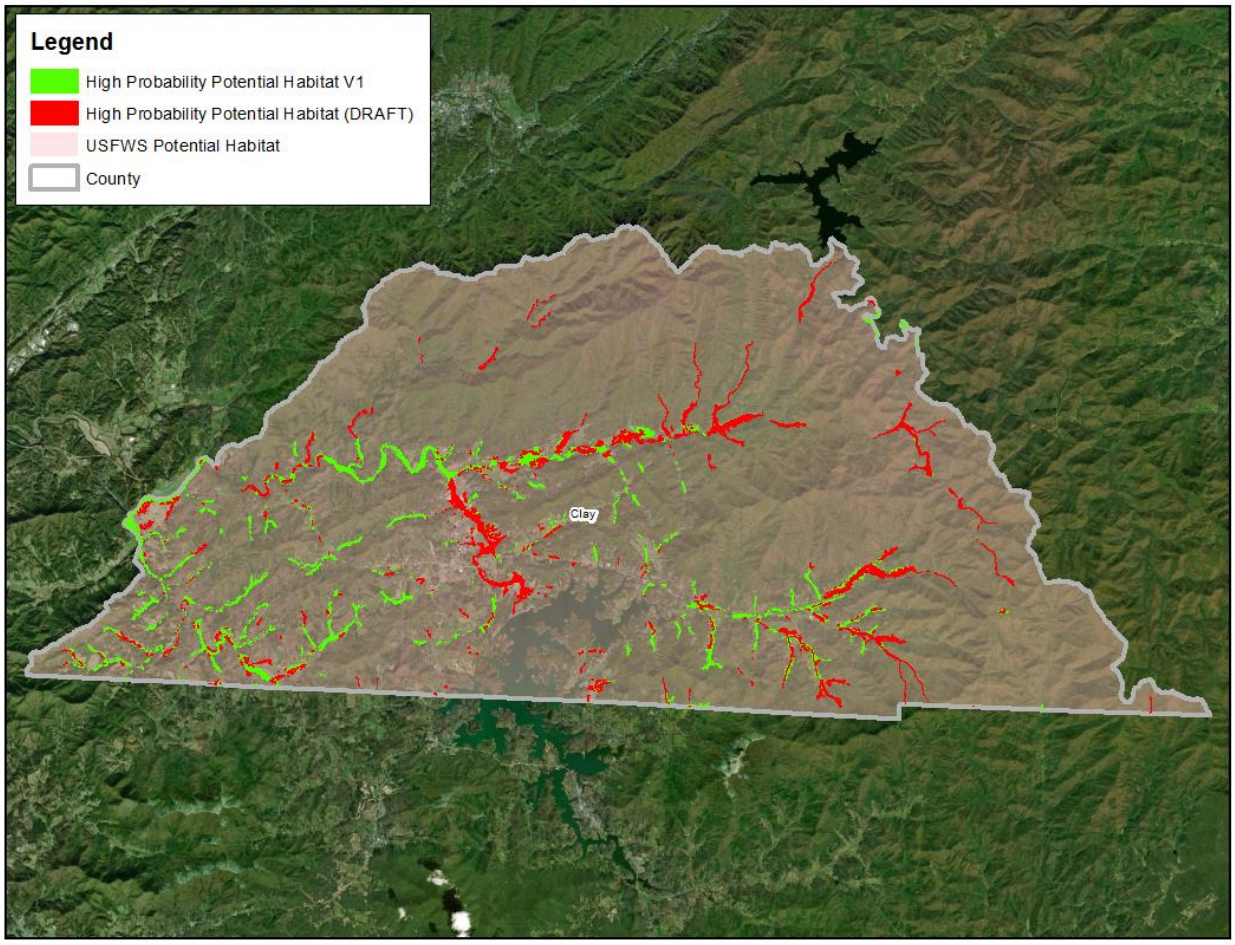


Figure 4. Range Map and High Probability Potential Habitat Version 1

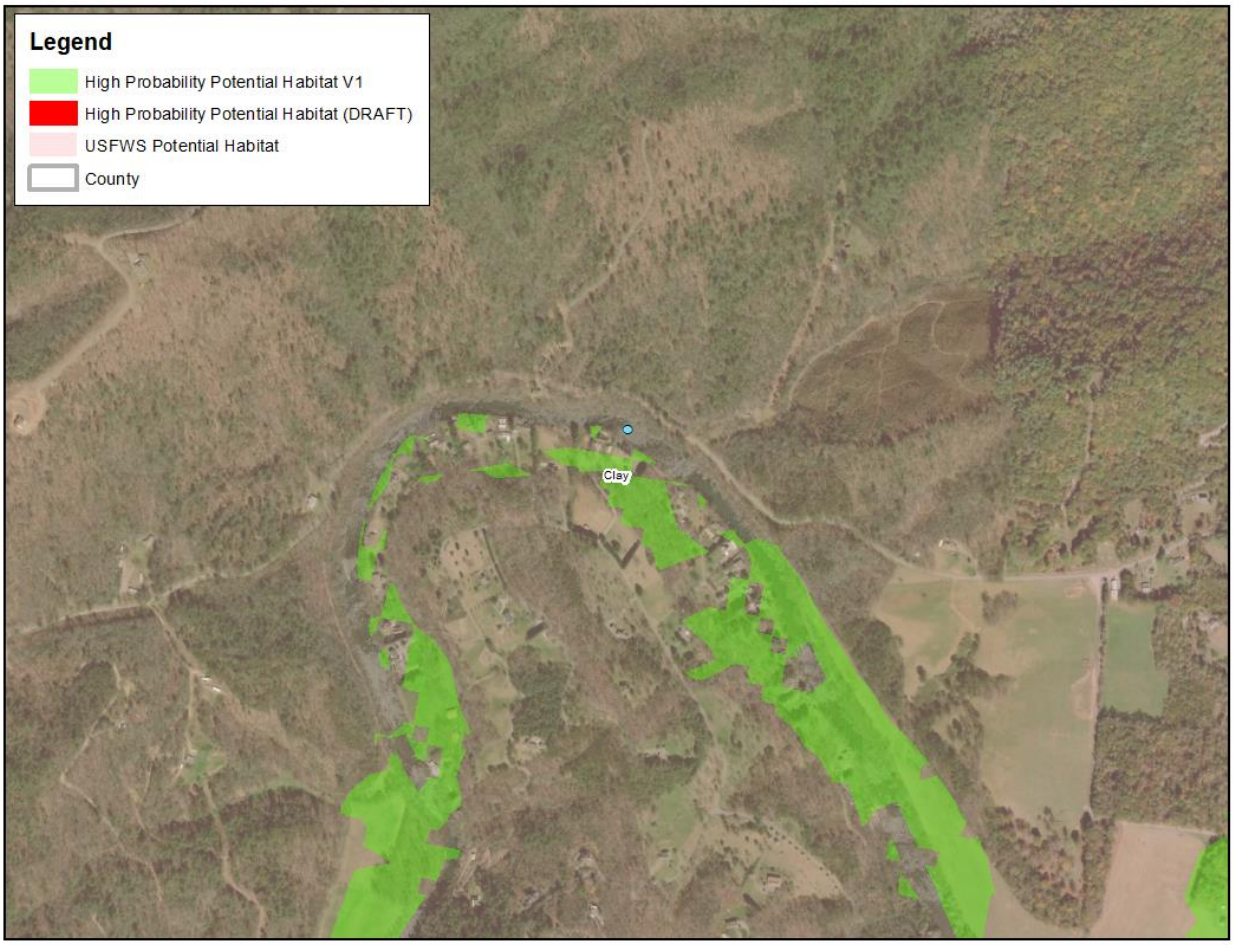


Figure 5. High Probability GPP habitat (Using ALL Hydric Soils) following model revision (Version 1)

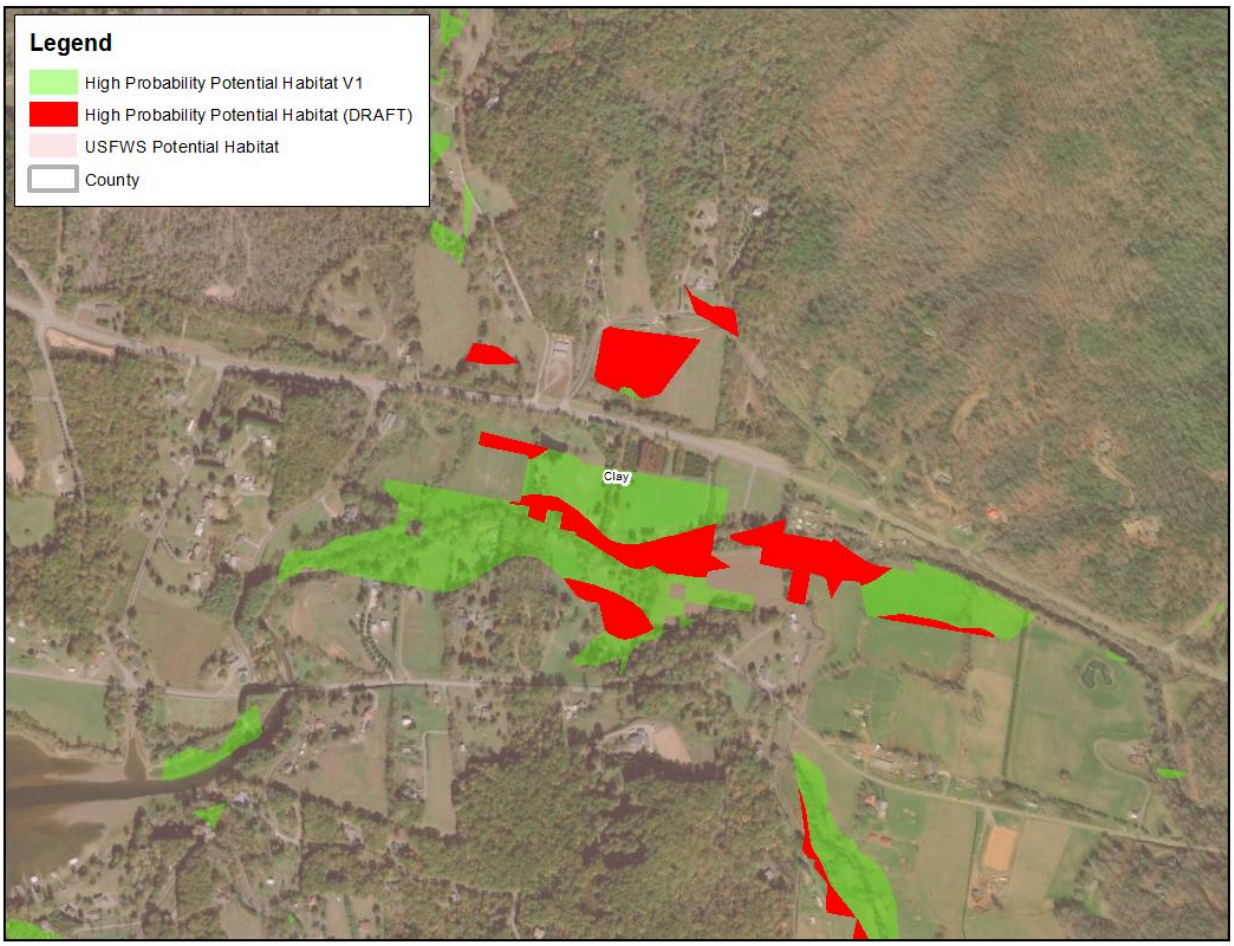


Figure 6. High Probability GPP Habitat following model revision (Version 1)

Model Field Assessment and Accuracy Statistics

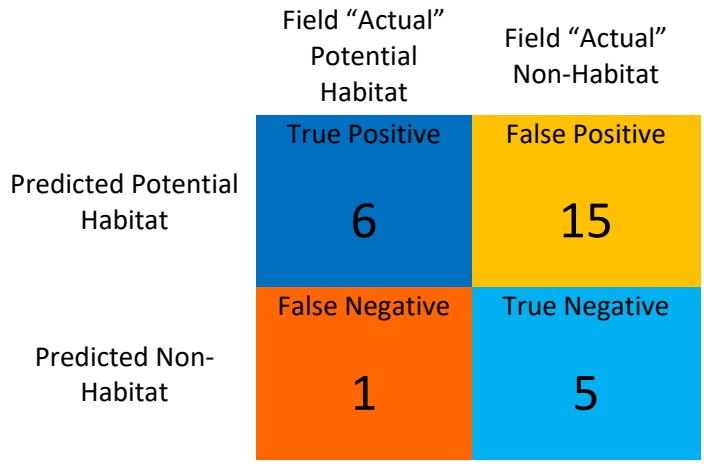
Habitat model field assessments performed in 20 locations across the "current" USFWS listed county, Clay County, in December 2019 assisted to clarify model strengths and weaknesses. A stratified sample of points were generated on "accessible lands" (generally public lands and right-of-ways) and biologists 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)



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

- Percent correctly classified was 41%
- Sensitivity was 0.857143
- Specificity was 0.25

The biologists' summarized their observations as follows:

- Generally predicts known habitat (e.g. spring seepages, swamp forest, and bogs) and excludes unlikely habitat (e.g. upland forests, pastures, parking lots, regularly maintained properties, urban areas, ridgelines, hilltops, hillsides).
- False positives located in floodplain hydrology that has been altered or currently in in agriculture (e.g. drain or fill, incised stream, or existing vegetation was too thick)
- False negatives located in areas adjacent to predicted habitat and may have been attributed to pixel size, or mapped soil characteristics (e.g. sand percentage).