

Expert-based Model Guidance and Documentation (Version 1)

Project Information

- Species: Pondberry (*Lindera melissifolia*)
- Team Contacts: Alicia Jackson, Dr. J.H. Carter III and Associates, Inc. (ajackson@jhcarterinc.com) and Ryan Dugger, HDR (Ryan.Dugger@hdrinc.com)
- Date started: June 2018
- Date completed: March 2020

Species Information

NCDOT Natural Resource Technical Report Habitat Description

USFWS Optimal Survey Window: February - March and September - October

Pondberry occurs in seasonally flooded wetlands, sandy sinks, pond margins, and swampy depressions. This deciduous, aromatic shrub occurs in bottomland hardwood forests with perched water tables along inland areas of the southeastern United States. In the Coastal Plain of the Carolinas, the species occurs at the margins of limestone sinks and ponds and in undrained, shallow depressions of longleaf pine and pond pine forests. Known occurrences in North Carolina occur in the Small Depression Pocosin natural community, grow in soils with sandy sediments and high water table, contain high peat content in the subsurface, and include a prevalence of shrubs due to historically frequent or intense fires. It generally grows in somewhat shaded areas, but can tolerate full sun.

Additional Species Information

There are currently six known element occurrences (EOs) in NC, three of which are extant:

- Cumberland County (1)
- Sampson County (2)
- Onslow County (2). Note: One of the two Onslow County records is mapped with low accuracy.
- Bladen County: One Historical EO last seen in 1987 and believed to be destroyed (NC Natural Heritage Program (NHP) 2020). This county was excluded from the final model extent because of its' USFWS Historic status.
- One additional EO in Orange County is documented in NHP data based on a herbarium specimen from 1822. Site and surrounding areas have been surveyed extensively by experts on the species, and no potential habitat has been located (personal communication, J. Moore, U.S. Fish and Wildlife Service (USFWS)).

County Information

- NHP listed counties: Cumberland, Onslow, and Sampson (Bladen and Orange are Historic)
- FWS listed counties: Cumberland, Onslow, and Sampson (Bladen is Historic)

Environmental Data Information

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

Data Layer 1

- Layer name: County Boundaries
- File name: CountyBoundary.shp
- Layer description:
 - Selected Bladen, Cumberland, Onslow and Sampson Counties
- Layer selection justification:
 - The four counties listed contain the only recent occurrences of pondberry in the state according to NHP and USFWS data (see Species Information above)
- “Habitat” versus “Non-habitat” designations:
 - Potential habitat will be within the 3 listed USFWS Current counties.

Data Layer 2

- Layer name: GAP/Landfire National Terrestrial Ecosystems 2011
- File name: l48_eslf_v3_NCProj.tif
- Layer description:
 - The GAP/Landfire National Terrestrial Ecosystems 2011 landcover data, version 3.0. developed by the U.S. Gap Analysis Program (GAP). 2017. Attributes include NatureServe’s Ecological Systems Classification.
 - Clipped/extracted raster to the selected counties from Layer 1
 - Converted raster to a shapefile (polygon)
 - Selected from the “gridcode” field: 9118, 9121, 9128 and 9305 and exported as a shapefile (see below for additional details)
- Layer selection justification:

The GAP/Landfire National Terrestrial Ecosystems 2011 was chosen because it had the finest-level habitat mapping of the available datasets and its attribute data could be cross-referenced with vegetative community and rare species data available from NatureServe, the NHP, the Carolina Vegetation Survey, and VegBank.
- “Habitat” versus “Non-habitat” designations:
 - Since so few populations occur in NC, habitat information from South Carolina (SC) populations was also considered when identifying potential habitat in the model.
 - Beckley and Gramling (2013) studied habitats within pondberry populations in the southeastern US and described the following four vegetative communities, each found in NC and/or SC: Swamp Tupelo Depression Pond, Successional Swamp Forest, Pond-Cypress Pond and Pocosin, and Limestone Sink Forest. Using their habitat descriptions and various other sources, equivalent or similar NatureServe Ecological Systems were identified that could support pondberry.

- The following Ecological Systems were selected to represent pondberry habitat:
 - Atlantic Coastal Plain Clay-based Bay Wetland (Ecological System Lifeform (ESLF) code 9128, Community Ecological System (CES) 203.245): This community is mapped at Big Pond Bay in Cumberland County (GAP/Landfire 2011, NCNHP 2018) and has been reported to contain pondberry (Schafale et al. 2015a). Of the landcover types mapped in the GAP/Landfire 2011 data, this habitat also most closely resembled the Swamp Tupelo Depression Pond community described by Beckley and Gramling (2013).
 - Atlantic Coastal Plain Peatland Pocosin and Canebrake (ESLF code 9121): This community covers most bays in NC not mapped as Atlantic Coastal Plain Clay-based Bay Wetland, including an extant pondberry EO in Sampson Co. (Pondberry Bay) (GAP/Landfire 2011, NCNHP 2018). Like the previous community, pondberry has been documented in Peatland Pocosin and Canebrake habitat (Schafale et al. 2015b). High Pocosin and Pond Pine Woodland communities fall within this Ecological System (Schafale 2012, Schafale et al. 2015b), habitats which surround some known pondberry populations in SC (Beckley and Gramling 2013).
 - Central Atlantic Coastal Plain Wet Longleaf Pine (ESLF code 9118): Much of the area mapped as this predominantly savanna and flatwoods Ecological System is not suitable habitat for pondberry; however, some small, suitable depressions are included in this mapping unit, including one extant EO in Sampson County (Newkirk Bay) (GAP/Landfire 2011, NCNHP 2018). Other rare species associated with bays have been documented within this community, including awned meadowbeauty (*Rhexia aristosa*) and Canby's dropwort (*Oxypolis canbyi*) (Schafale et al. 2014a).
 - Southern Atlantic Coastal Plain Depression Pond (ESLF code 9305, CES203.262): This community consists of wetlands in small basins formed in unconsolidated sediments (Schafale and Evans 2007). Found from southeastern Virginia to Florida, these ponds typically have sandy soils, with mucky surfaces in the wettest portions. Many of the small depression NVCS associations are listed in this Ecological System. Limesink depressions tend to fall in this system (Schafale and Evans 2007), as well as Small Depression Pocosins, which are known habitat for pondberry (Schafale and Weakley 1990). Note: Communities of this type in NC are currently mapped as inclusions within the other three communities listed, likely because they did not meet the minimum mapping unit used for the national map. This code was left in the model selection in case future landcover datasets include this community.
- The following riparian and tidal Ecological Systems were selected to remove unsuitable pondberry habitat added from the soil series in Data Layer 3:
 - Southern Atlantic Coastal Plain Tidal Wooded Swamp (ESLF code 9194):
 - Southern Atlantic Coastal Plain Salt and Brackish Tidal Marsh (ESLF code 9236)
 - Atlantic Coastal Plain Small Brownwater River Floodplain Forest (ESLF code 9315)
 - Atlantic Coastal Plain Small Blackwater River Floodplain Forest (ESLF code 9318)
 - Atlantic Coastal Plain Brownwater Stream Floodplain Forest (ESLF code 9320)

- Atlantic Coastal Plain Blackwater Stream Floodplain Forest (ESLF code 9322)
- Southern Atlantic Coastal Plain Fresh and Oligohaline Tidal Marsh (ESLF code 9413)

Data Layer 3

- Layer name: Soils
- File name: PondberrySoils.shp
- Layer description:
 - Soil Survey Geographic (SSURGO) database for Bladen, Cumberland, Onslow and Sampson Counties
- Layer selection justification
 - Soils are another way of identifying areas that could support pondberry; particularly where landcover does not adequately represent all potential habitat.
- “Habitat” versus “Non-habitat” designations:
 - Carolina Vegetation Survey plot summaries (2018), US National Vegetation Classification (NVCS) Association descriptions, VegBank (Peet et al. 2013) plot data, and NHP data were utilized to determine predominant soil series in vegetative communities known to support pondberry populations (CEGL codes 3733, 4441, and 4475). Soils listed in these sources, but described as being well drained, were excluded.
 - Potential habitat was defined as the following soil map units: Byars, Chipley, Goldsboro, Leon, Lynn Haven, Lynn Haven and Torhunta, Torhunta and Lynn Haven, McColl, Murville, Rains or Woodington.

Data Layer 4

- Layer name: National Land Cover Database (NLCD) (2016 edition)
- File name: nlcd.tif
- Layer description:
 - Landcover dataset produced by the Multi-Resolution Land Characteristics (MRLC) Consortium. Landcover is classified into 15 broad categories.
- Layer selection justification
 - Landcover categories are more generalized in this dataset than in the GAP/Landfire dataset (Layer 2), but the areas classified as disturbed were more current than those in Layer 2.
- “Habitat” versus “Non-habitat” designations:
 - The following “Land_Cover” categories were considered to be non-habitat and were removed from the combination of the previous 2 layers: Developed, High Intensity; Developed, Medium Intensity; Developed, Low Intensity; Developed, Open Space; Cultivated Crops; Hay/Pasture; Barren Land; Open Water; and Emergent Herbaceous Wetlands.

Known Issues with Model Data Layers

- The soils within many of the Carolina bays in Bladen County are mapped as Croatan, Pamlico or Dorovan muck, which were not found to be associated with pondberry in the data sources researched. However, the selected landcover codes identify the majority of these bays as potential habitat, thus overpredicting areas that could actually support pondberry. However, Bladen County has been excluded from the final model because of its USFWS Historic status.

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 representing potential habitat within the 3 listed and current counties
- ArcGIS Model Builder
 - Created using ArcGIS 10.5.1
 - Graphical depiction of model included in Appendix 1.
 - Summary of model steps:
 - Select the four counties where the species is listed (Bladen, Cumberland, Onslow and Sampson), export as a shapefile.
 - “Clip” (Extract by Mask) GAP/Landfire and NLCD landcover rasters to the selected counties, convert to shapefiles
 - Select suitable landcover and soils, Union and Dissolve
 - Select developed, agricultural and other disturbed areas from NLCD data, export as a shapefile, and Dissolve
 - Erase disturbed areas from the Union of soils and suitable landcovers.
 - Select unsuitable wetland Ecological Systems from the GAP/Landfire data, export as a shapefile, and Dissolve.
 - Erase unsuitable wetland vegetative communities.
 - Extract data from the three Current counties, add fields, and Dissolve by Potential Habitat (High and Low).
- ArcGIS Online (AGOL) Review
 - A model prediction file was shared with select subject matter experts for review on AGOL. Points were placed within the USFWS potential habitat (county range map) as well as the modeled potential habitat in order to solicit feedback. Reviewers could place additional comments for consideration by the modeler.
 - AGOL review was completed in February 2019 on a draft version of this model (See Appendix 2).

- Independent Data Review
 - Data sources: NC Natural Heritage Program element occurrence data, NatureServe Ecological System data, VegBank plot data, United States National Vegetation Classification Database, NCNHP community classifications, and county soil surveys.
 - Methods: Literature searches and reviews of available environmental GIS data were conducted to determine how best to represent potential habitat for pondberry.
 - NatureServe ecosystems and soil series were found to be the best choices for identifying potential pondberry habitat.
 - The model was independently reviewed using NHP EO data and field survey results from recent natural resource investigations for NCDOT projects.

USFWS Range Acreage Compared to Modeled Predicted Habitat - Version 1

- USFWS Range 1,549,435.09 acres
- ATLAS Range 299,561.97 acres

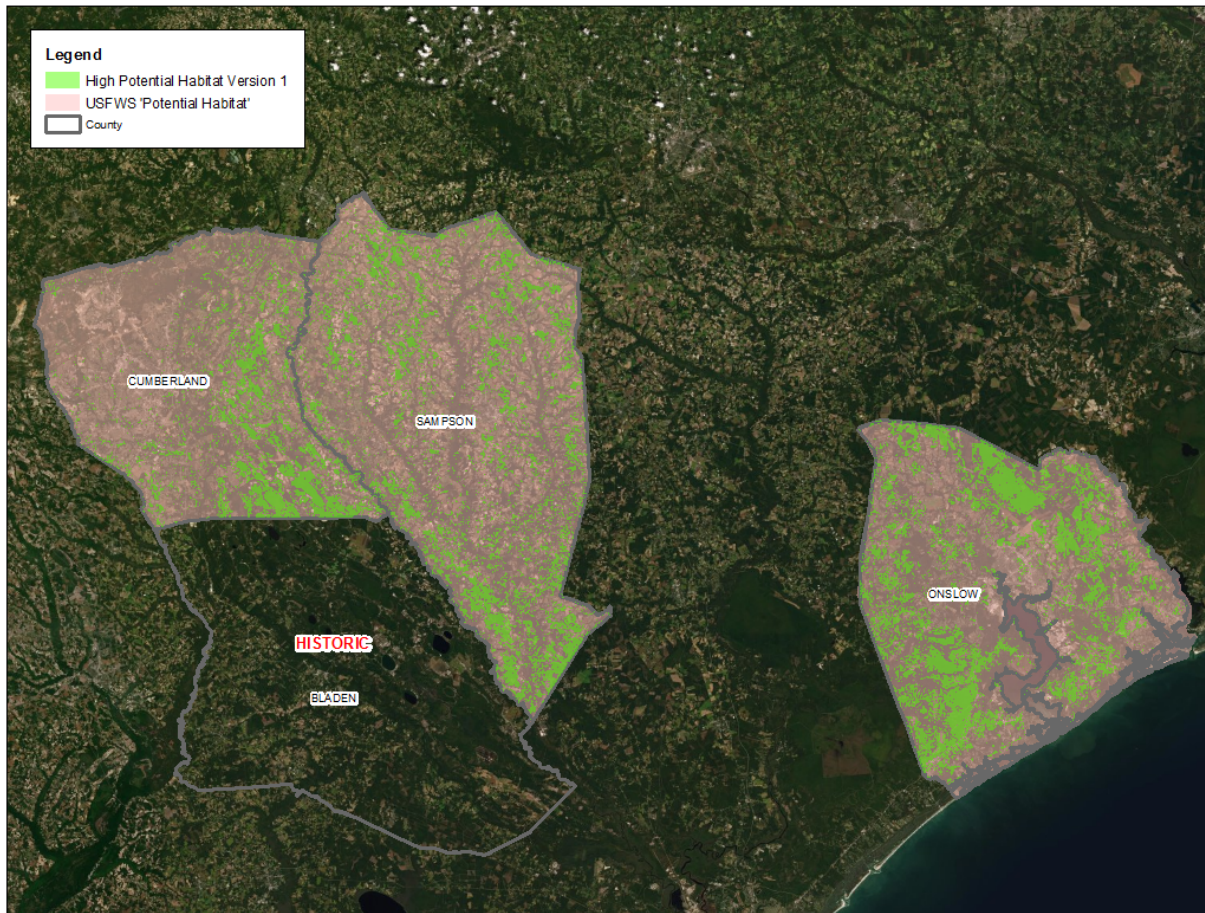


Figure 1. USFWS Range Map and Modeled Potential Habitat - Version 1

Previous Model - (Draft 1 and 2)

Draft 1 of this model was developed in November 2018, which was used for the AGOL review. For Draft 2, the 2011 version of the NLCD layer was updated with the 2016 version, and one additional landcover category was added to the selection from this layer. No other layers were added, removed, or changed from the Drafts to Version 1; therefore, the layer descriptions above are applicable to all versions.

Draft layers changed for Version 1:

- Layer name: National Land Cover Database (NLCD) (2011 edition)
- Layer description:
 - Landcover dataset produced by the Multi-Resolution Land Characteristics (MRLC) Consortium. Landcover is classified into 15 broad categories.
- Layer selection justification
 - Landcover categories are more generalized in this dataset than in the GAP/Landfire dataset (Layer 2), but the areas classified as disturbed were slightly more current than those in Layer 2.
- “Habitat” versus “Nonhabitat” designations:
 - The following “Land_Cover” categories were previously considered to be nonhabitat and were removed from the combination of the previous 2 layers: Developed, High Intensity; Developed, Medium Intensity; Developed, Low Intensity; Developed, Open Space; Cultivated Crops; Hay/Pasture; Barren Land; and Open Water.

List of Delivered Model Products

- *This summary document*
- *Version 1 Model prediction file(s) (shapefile)*
- *Model builder file (toolbox) and model screenshots (Appendix 1)*
- *Reviewer documentation (Appendix 2) – summary of comments and general model recommendations*
- *AGOL reviewer comment file*
- *Field reviewer comments (shapefiles) and word document*

References

Beckley, A.C. and J.M. Gramling. 2013. Description and Classification of *Lindera melissifolia* Habitat in the Southeastern Coastal Plain. *Castanea* 78(4): 277-289. December.

Carolina Vegetation Survey. 2018. Vegetation of the Carolinas Project CEGL search tool. Accessed November 2018 at <http://cvs.bio.unc.edu/data/comm/index.htm>

North Carolina Natural Heritage Program. 2020. Element Occurrence Database. Division of Land and Water Stewardship. Department of Natural and Cultural Resources, Raleigh, North Carolina. GIS data accessed online March 2020.

Peet, R.K., M.T. Lee, M.D. Jennings, D. Faber-Langendoen (eds). 2013. VegBank: The vegetation plot archive of the Ecological Society of America. Accessed 28 August 2018 at <http://vegbank.org>.

Schafale, M.P., R. Evans and C. Nordman. 2014a. NatureServe Explorer Ecological System Comprehensive Report: Central Atlantic Coastal Plain Wet Longleaf Pine Savanna and Flatwoods. 21 May 2014. Accessed 14 November 2018 at http://explorer.natureserve.org/servlet/NatureServe?searchSystemUid=ELEMENT_GLOBAL.2.723221

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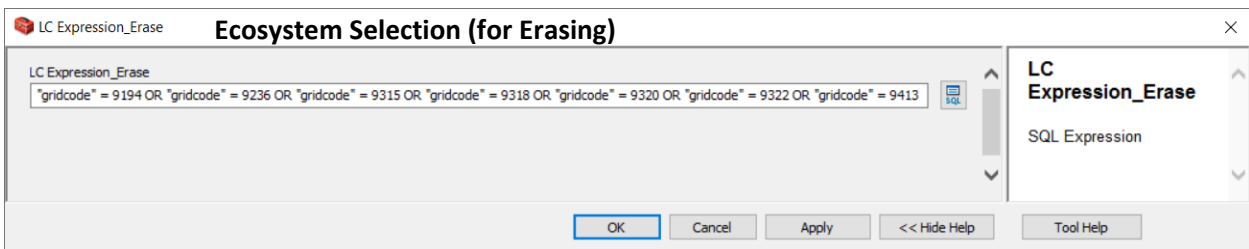
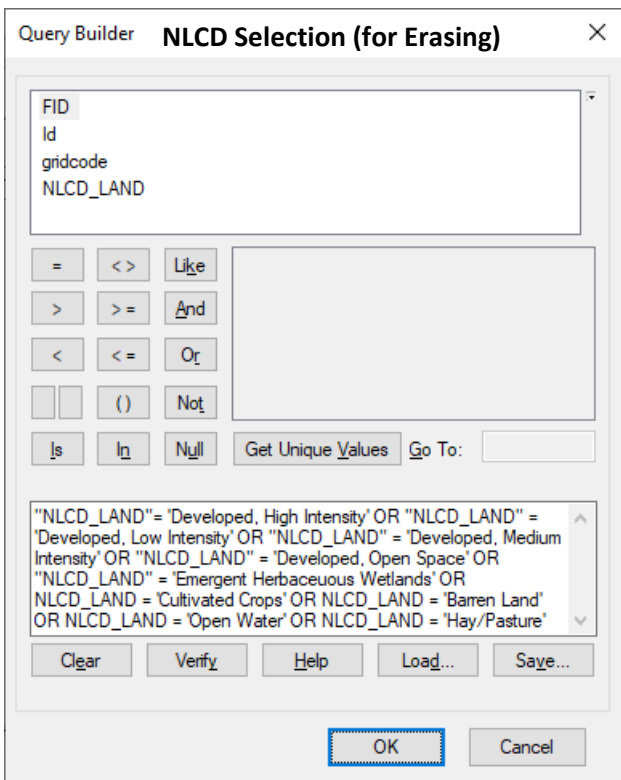
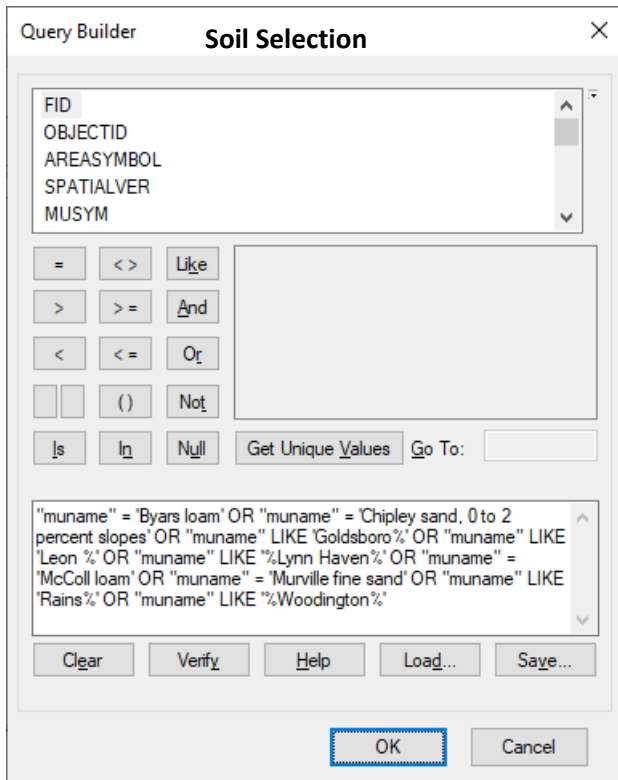
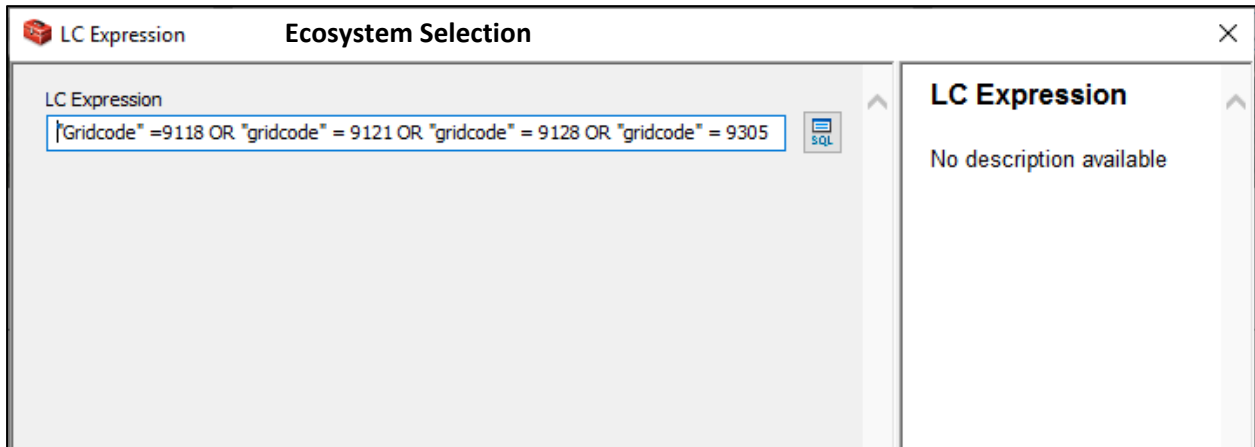
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Schafale, M. P. and A. S. Weakley. 1990. Classification of the Natural Communities of North Carolina: Third Approximation. Natural Heritage Program, Division of Parks and Recreation, N.C. Department of Environment, Health and Natural Resources. Raleigh,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

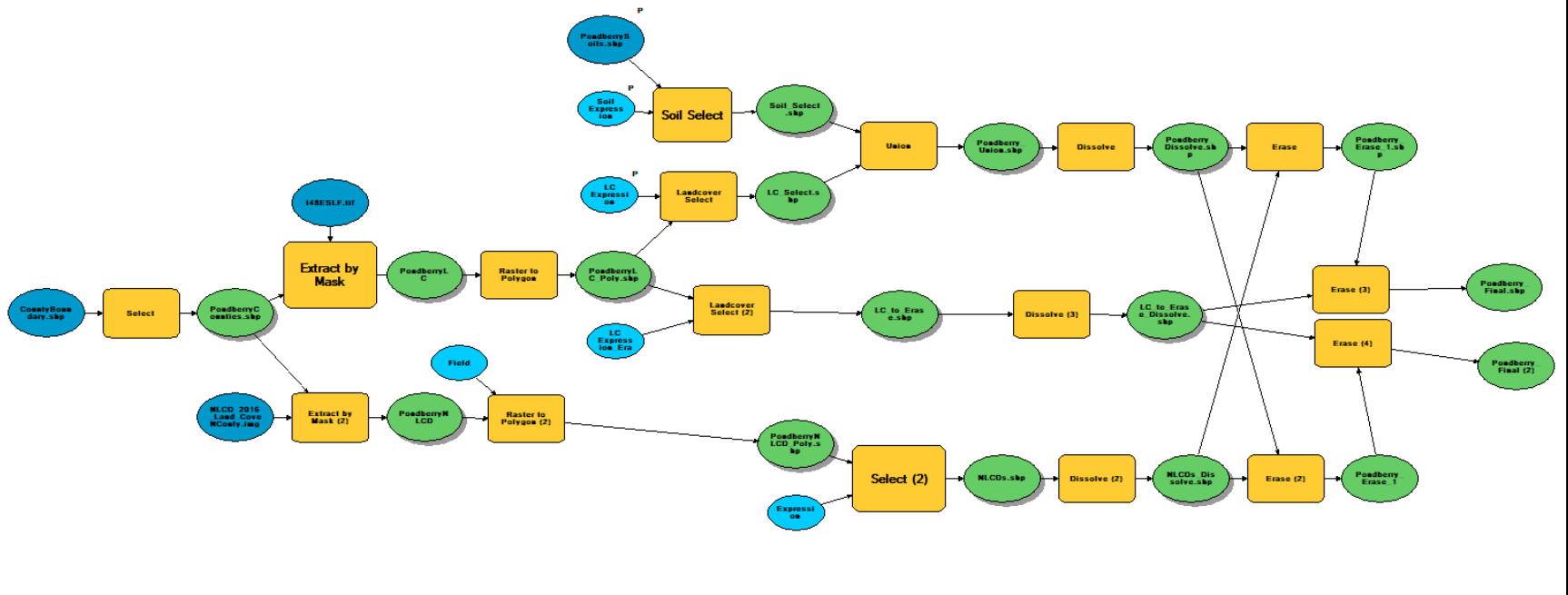
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Appendix 1. Model (Version 1) Screenshots



Model Schematic



Appendix 2: Reviewer Documentation

Project Information

- Species: Pondberry (*Lindera melissifolia*)
- Lead modeler: Alicia Jackson, Dr. J.H. Carter III & Associates, Inc. (ajackson@jhcarterinc.com) 910 695-1043
- Reviewer names:
 1. Dale Suiter (USFWS)
 2. Lesley Starke (NC Plant Conservation Program)
 3. Kevin Markham (Environmental Services, Inc.)
 - Dale Suiter has worked as a biologist with the U.S. Fish and Wildlife Service in Raleigh, NC since 2000. He has the recovery lead for several petitioned and at risk species. He monitors and conducts surveys for rare plants throughout eastern NC and in neighboring states.
 - Lesley Starke is the Plant Conservation Program Manager with NC Department of Agriculture and Consumer Services. She has worked with North Carolina's imperiled plant species through her work at the Plant Conservation Program since 2010 and has a strong background in remote sensing and species distribution modeling.
 - Kevin Markham – 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.

USFWS Range Acreage Compared to Modeled Predicted Habitat - Draft 1

- USFWS Range 2,084,461 acres
- ATLAS Range 501,941 acres

Summary of Model - Draft 1

- Environmental data layers used included soils, county boundaries, 2011 GAP/Landfire Terrestrial Ecosystems landcover data, and 2011 National Land Cover Database landcover data
- Selected soils and ecosystems known to support pondberry, then removed (Erased) unsuitable landcover categories using the NLCD dataset.

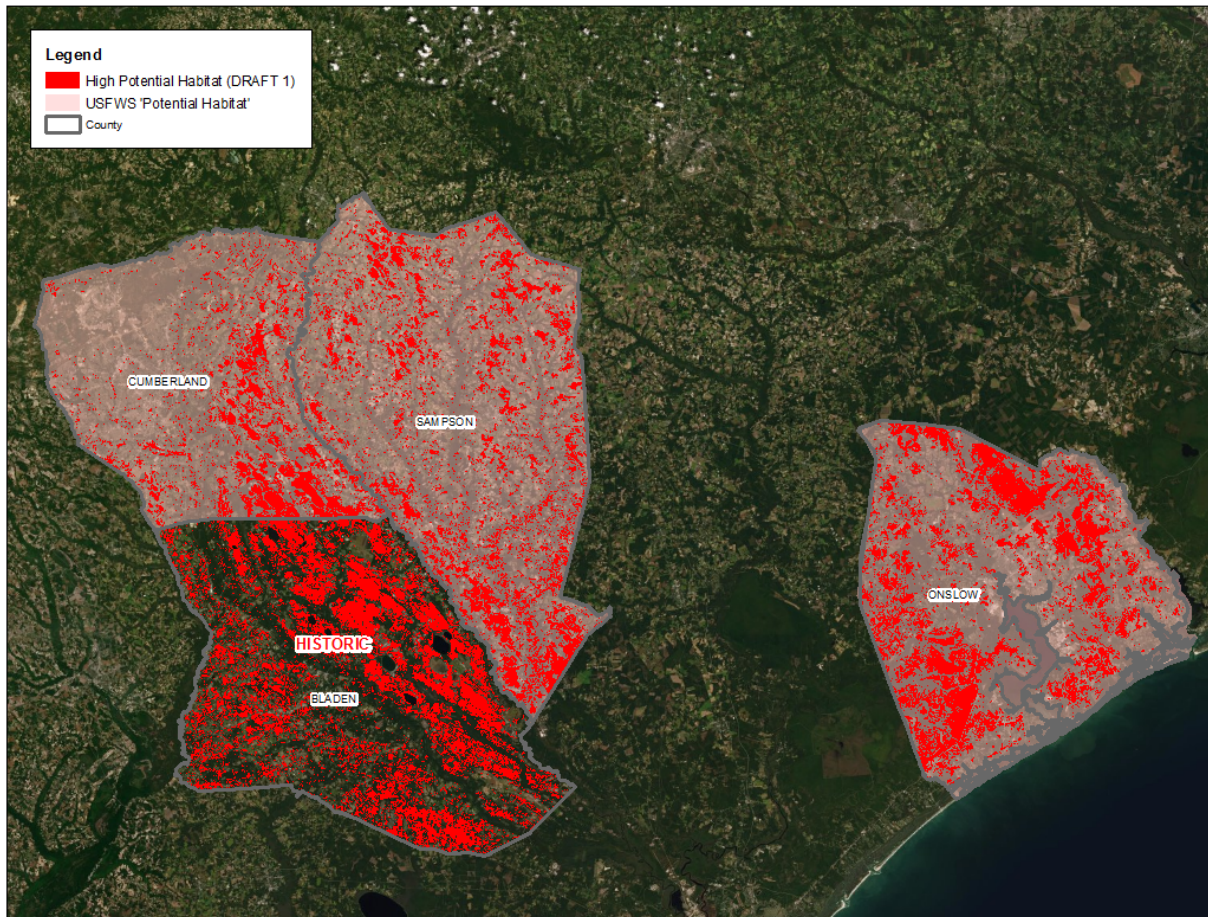


Figure 2. USFWS Range Map and Predicted Potential Habitat – Draft 1

Reviewer Response Rate

- Reviewer Response Rate: 94%
 - 21 reviewer points placed by modeler
 - # Additional Comments (placed by reviewers): 46

Reviewer Responses

- 13 (12%) of the comments stated that the model underpredicted habitat. At 5 of these points, habitat was predicted in the general area, just not at the specific comment points. Four of the points conflicted with other modelers' comments at the same location, and four comments could not be supported with environmental data or literature.

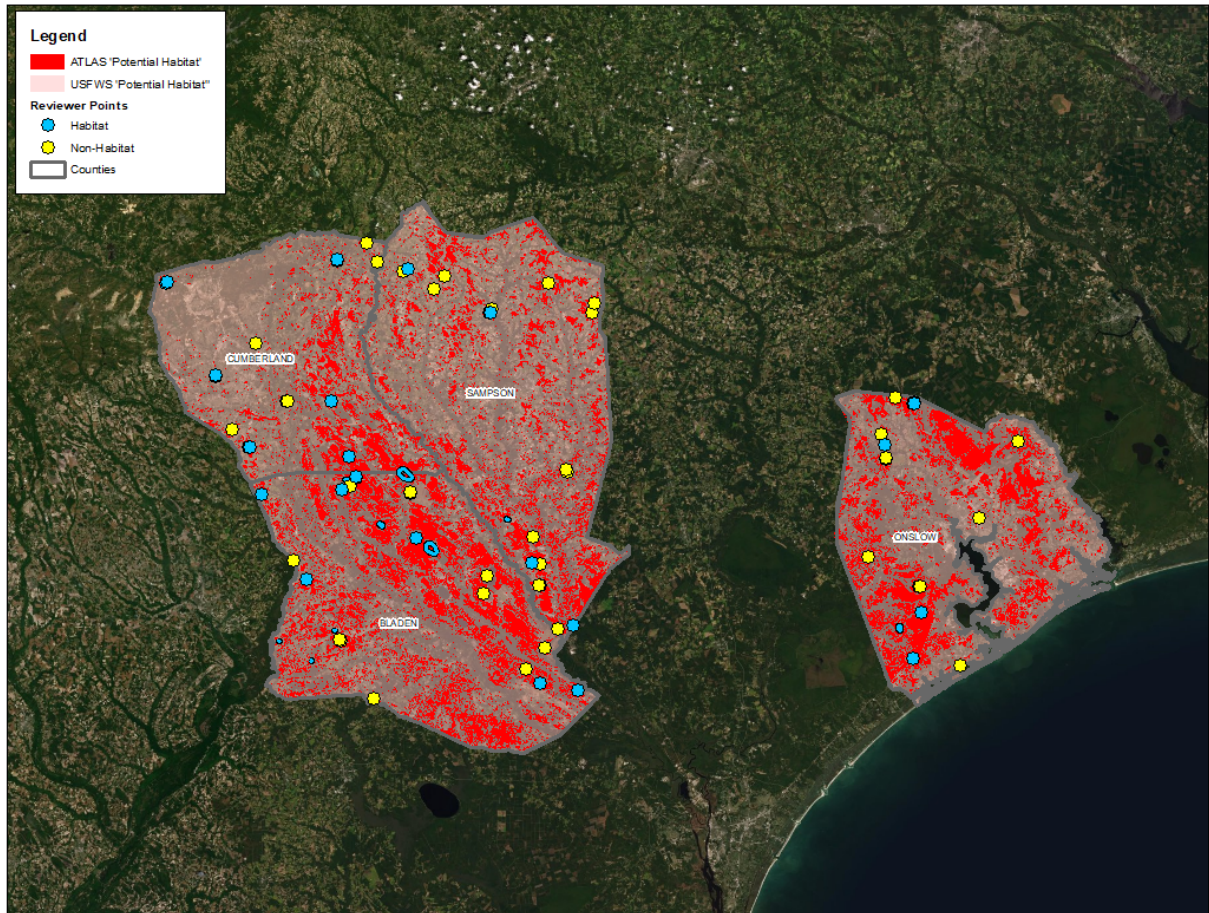


Figure 3. Reviewer Points High Probability Potential Habitat Draft 1

Summary of Model - Draft 2

In order to address comments made during ArcGIS Online reviews, the following changes were made to the model:

- The 2011 NLCD layer was replaced with the newly-available 2016 dataset. This update either resolved or decreased the amount of predicted habitat around approximately 10 of the comments regarding outdated land use (obviously disturbed, unsuitable areas on current aerial photography being incorrectly represented in the model as potential habitat).
- One additional NLCD category, “Emergent Herbaceous Wetlands,” was added to the categories that are erased from the combination (“Union”) of suitable soils and ecosystems. Thirteen of the comments suggesting overprediction of habitat were resolved or improved by this addition.
- Many comments referred to habitat being overpredicted in managed pine plantations. These habitats are challenging since they could be classified in the landcover data anywhere from “Herbaceous” to “Shrub/Scrub” to “Evergreen Forest,” depending where they are in the timber rotation. Many of the transitional landcover categories include known populations of pondberry; therefore, these could not be excluded from

the model. No additional GIS layers could be found that would more accurately reflect rotational forests or disturbance related to bedding or ditching. The addition of “Emergent Herbaceous Wetlands” to the areas to be erased helped to reduce the amount of predicted habitat in many plantations.

- Similarly, no layers or tools could be found that would eliminate habitat within a certain distance from disturbance without also eliminating known pondberry populations.
- Draft 2 of the model reduced the predicted habitat within current counties from the 317,493.74 acres to 305,719.05 acres.
- From the reviewed Draft 1 to Draft 2, the percentage of commenters’ habitat determinations that were in agreement with the model predictions increased from 88% (Draft 1) to 89% (Draft 2) (Figure 4).

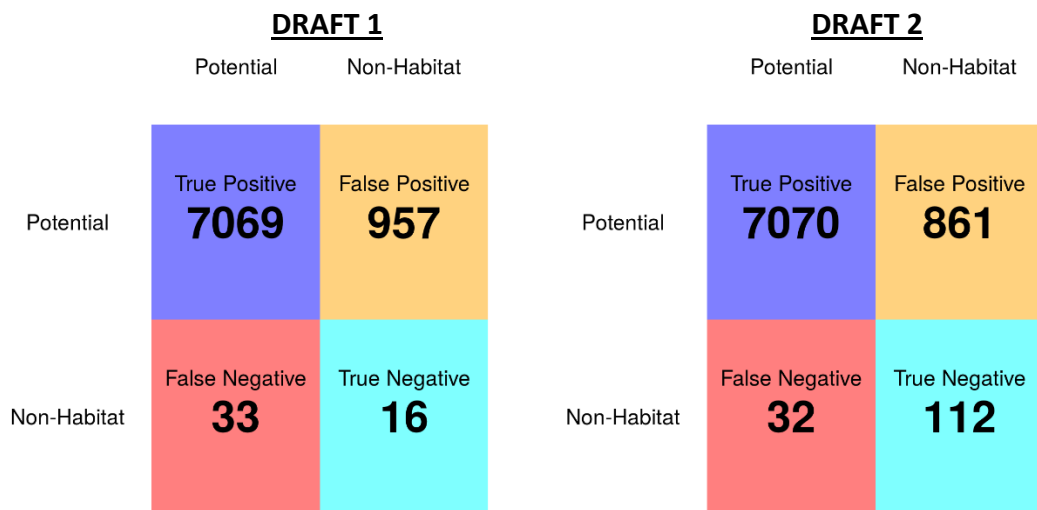


Figure 4. Reviewer responses to Draft 1 (left) and Draft 2 (right) model output

Model Field Assessment and Accuracy Statistics

Habitat model field assessments performed in 32 locations across the “current” USFWS listed counties, in December 2019 and January 2020 assisted to clarify model strengths and weaknesses. A stratified sample of points were generated on “accessible lands” (generally public lands and rights-of-way) and biologists surveyed 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

- Alicia Jackson is a botanist and Certified Wildlife Biologist® with Dr. J.H. Carter III and Associates, Inc. She has over 20 years of experience surveying for rare plants in the

coastal plain and sandhills and with red-cockaded woodpecker monitoring, surveys, and management.

- Pam Ferral is an environmental scientist and Certified Wildlife Biologist® with Stantec with more than 25 years of experience in conservation and consulting. She spent most of her career as a biologist with the U.S. Forest Service and conservation ecologist with The Nature Conservancy, specializing in the management and monitoring of endangered species in coastal plain ecosystems. She now conducts rare plant and animal surveys for a variety of private sector clients.

	True Positive	False Positive
Predicted Potential Habitat	6	20
	False Negative	True Negative
Predicted Non-Habitat	0	6

Figure 7. Accuracy summary based on field assessment of Draft 2 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 37.5%
- Sensitivity was 1
- Specificity was 0.230769

The biologists summarized their observations as follows:

- In general, the model overpredicted potential habitat. Many Carolina Bays and other isolated wetlands were likely historically suitable, but had been ditched for pine plantations and were too densely vegetated to support pondberry. Pondberry does not require full sunlight and may actually prefer somewhat shaded habitat, but still depends on periodic flooding and/or fire to reduce competition from other species. Stands with a very dense midstory were determined to be non-habitat, regardless of soils or vegetative community.
- No suitable habitat was found to be predicted as non-habitat (no false negatives).

Proposed Version 1 Model

In order to address comments made during ArcGIS Online and field reviews, the following changes were made to the model:

- During field review, it was noted that many of the wetland areas modeled as potential habitat were riparian areas, a wetland type not known to support pondberry populations in the Atlantic Coastal Plain. Additionally, a few AGOL comments pointed out tidally influenced wetlands being incorrectly identified as habitat. For Version 1, seven unsuitable riparian and tidal wetland ecosystems were selected from the GAP/Landfire data and erased from the modeled habitat (listed in Data Layer 2 above).
- Version 1 of the model reduces the predicted habitat within current counties from 305,719 acres (Draft 2) to 299,562 acres.

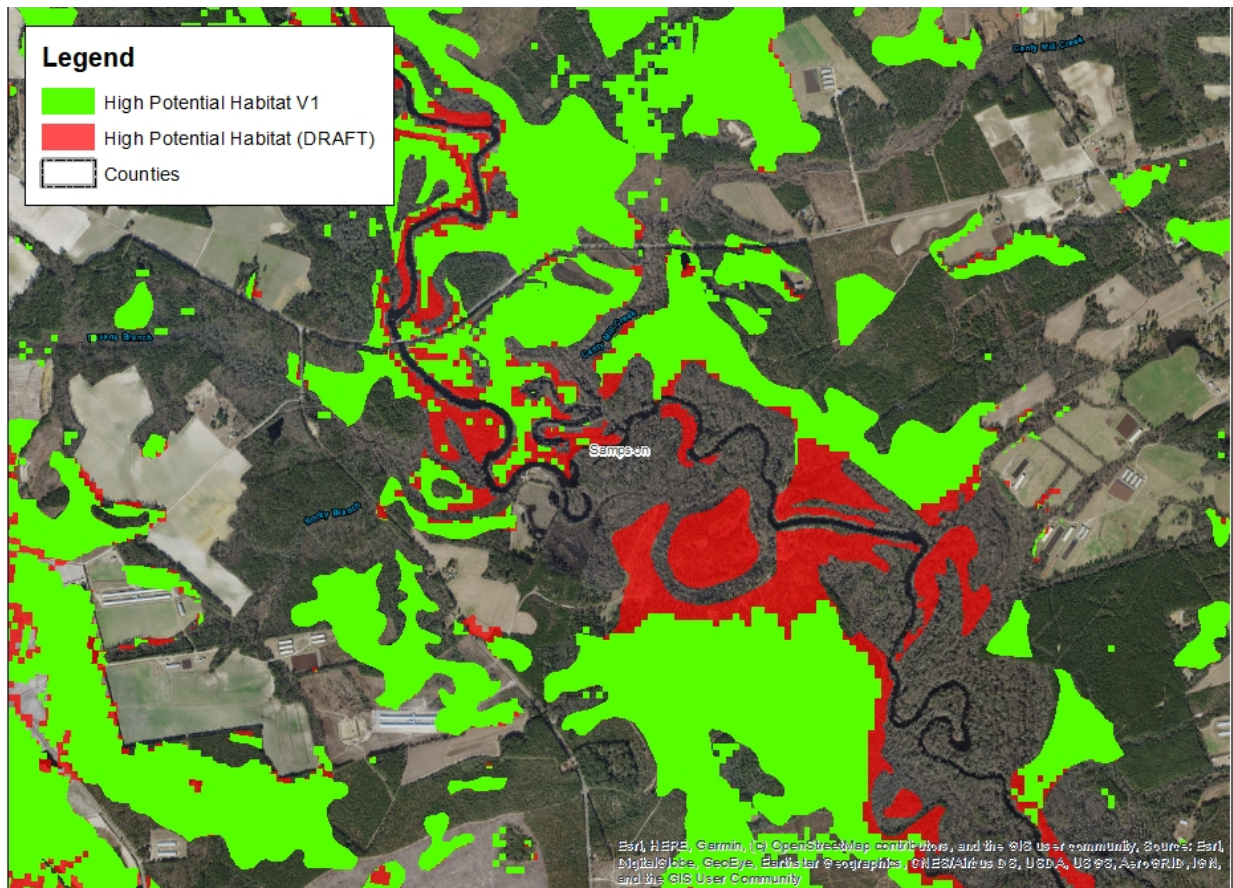


Figure 5. Examples of changes in predicted habitat from the Draft 2 model to Version 1.

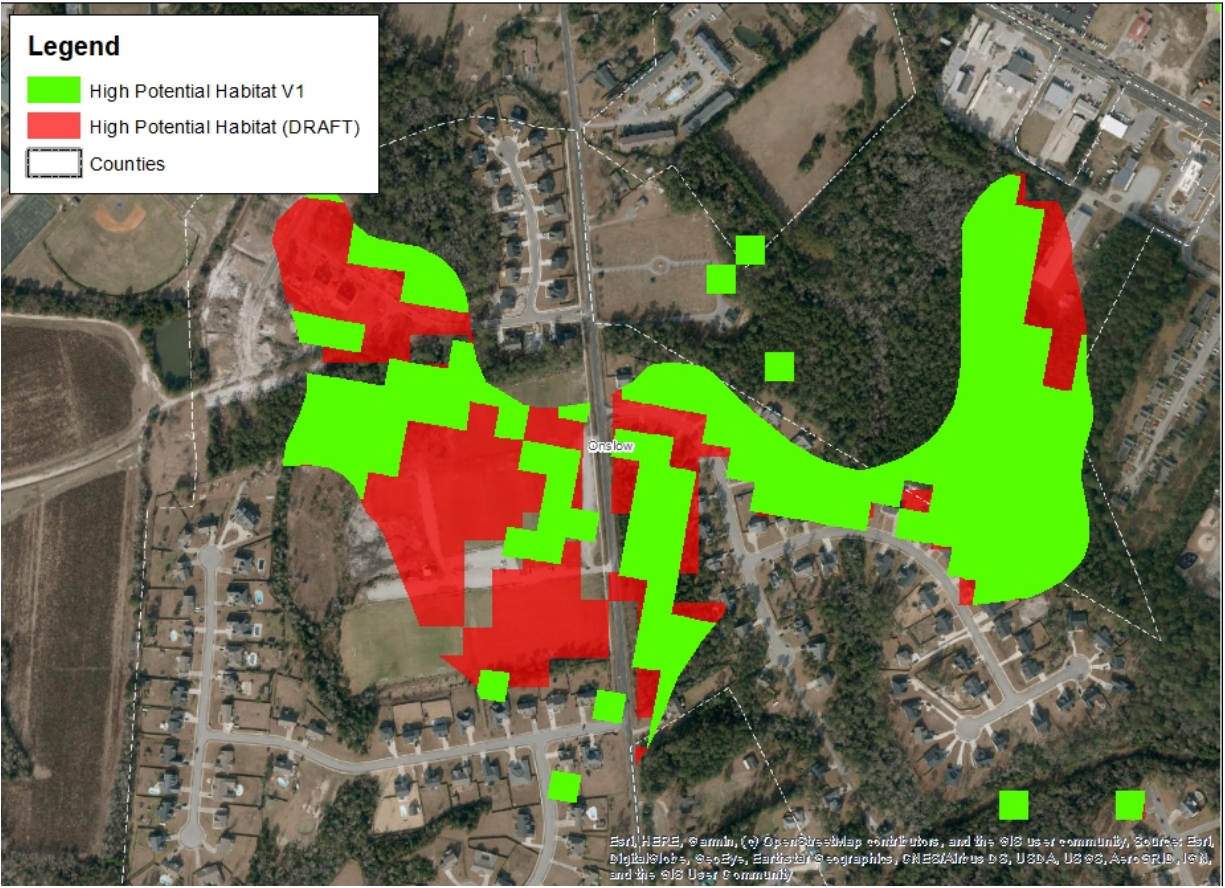


Figure 6. Examples of changes in predicted habitat from the Draft 2 model to Version 1.