# Blueprint 2.1 Development Process

## August 12, 2016

### Last revised September 7, 2016 to clarify mapping steps for indicators that have not changed since Blueprint 2.0, add known issues, correct typos, and update links

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# Ecosystems

## Beach & Dune

### Ecosystem Map

The beach and dune ecosystem was defined by the 2011 National Land Cover Database (NLCD) (Homer et al. 2015) barren land cover classification within 300 m of the ocean shoreline defined by Himmelstoss et al. (2010). The 300 m buffer preserved beaches, but excluded sediments along the estuaries. An additional 100 m shoreline buffer defined narrow beaches where no barren classification existed due to data resolution. The beach shoreline length was 1,668 km (1,036 miles).

During the process of rescaling data to a 200 m resolution, ecosystems were overlaid and overlaps were handled by ordering them from high (never excluded by another ecosystem) to low (always excluded by another ecosystem). To avoid data loss, linear features, such as maritime forests, were ranked relatively high. The ranking proceeded as: 10) maritime forest, 9) beaches and dunes, 8) estuaries, 7) major waterbodies, 6) localized data on pine land cover, 5) forested wetlands, 4) freshwater marsh, 3) longleaf pine range, 2) upland hardwoods, 1) marine. At the end of this process, there were still pixels left unclassified. We filled in these pixels using the following classes from Landfire Biophysical Settings data: Southern Atlantic Coastal Plain Dune and Maritime Grassland, Northern Atlantic Coastal Plain Dune and Swale, and East Gulf Coastal Plain Dune and Coastal Grassland.

#### *Known Issues*

-- Some dune areas heavily altered by humans are likely misclassified. Once they have been altered, it is challenging to identify what the naturally occurring ecosystem would be.

#### *Literature Cited*

Himmelstoss, E. A., M. Kratzmann, C. Hapke, E. R. Thieler, and J. List. 2010. The national assessment of shoreline change: A GIS compilation of vector shorelines and associated shoreline change data for the New England and Mid-Atlantic Coasts: U.S. Geological Survey Open-File Report 2010-1119. <http://pubs.usgs.gov/of/2010/1119>.

Homer, C.G., Dewitz, J.A., Yang, L., Jin, S., Danielson, P., Xian, G., Coulston, J., Herold, N.D., Wickham, J.D., and Megown, K., 2015, Completion of the 2011 National Land Cover Database for the conterminous United States-Representing a decade of land cover change information. Photogrammetric Engineering and Remote Sensing, v. 81, no. 5, p. 345-354.

U.S. Geological Survey, Earth Resources Observation and Science (EROS) Center. 2010. LANDFIRE Biophysical Settings: LANDFIRE 2012 (LF 1.3.0). <http://www.landfire.gov>.

### Ecosystem-Specific Indicators

The South Atlantic ecosystem indicators serve as the South Atlantic LCC's metrics of success and drive the identification of priority areas for shared action in the Conservation Blueprint. To learn more about

the indicators and how they are being used, please visit the indicator page. Check out the Blueprint page for more information on the development of the Blueprint, a living spatial plan to conserve our natural and cultural resources.

## *Unaltered Beach*

This layer is one of the South Atlantic LCC indicators in the beach and dune ecosystem. It is an index of altered beaches capturing impacts from hardened structures like jetties, groins, and infrastructure.

### Reason for Selection

Altered beaches (including human developments along shorelines, jetties, groins, seawalls, revetments, and other structures) provide a measure of overall habitat alteration. Human infrastructure along shorelines generally stabilizes barrier islands, and thereby impedes beach migration and barrier island rollover processes. Additionally, seawalls are difficult to locate on aerial photography, and developed shorelines may act as a surrogate for unmapped shoreline armoring.

Groins, seawalls, jetties, and revetments have resulted in narrowing of beaches, or greater beach loss, compared to unstructured beaches (Dugan et al. 2008, Hall and Pilkey 1991, Mohanty et al. 2012, Pilkey and Wright III 1988). Jetties alter sand transport and may result in downdrift erosion, although effects are dependent on the context of the structure (Bruun 1995). Bruun (1995) showed examples ranging from 5-13 km.

### Input Data

-- Hard structures were digitally mapped with guidance from recent ocean shoreline evaluations (Rice 2012a,b). Shoreline parallel structures (e.g., revetments) were mapped by length and perpendicular structures (e.g., jetties, groins) were mapped as points. Overall, shoreline parallel structures totaled 22.3 km, and 148 perpendicular structures were mapped.

-- Spatial designations of the Coastal Barrier Resources System, as a result of the Coastal Barrier Resources Act (1982) and its update (1990), were used to set boundaries of undeveloped beaches (U.S. Fish and Wildlife Service 2013, accessed 15 May 2014). The Act designated relatively undeveloped barrier island segments as ineligible for Federal expenditures, such as Federal flood insurance.

### Mapping Steps

Indicators that have not changed since Blueprint 2.0 were initially computed, or in the case of existing data, resampled to 1 ha spatial resolution using the nearest neighbor method. For computational reasons, we then used the ArcGIS Spatial Analyst-Aggregate function to rescale the resolution to 200 m. The aggregate function avoided loss of detail by taking the maximum value of each cell in the conversion (e.g., species presence).

1) Beaches outside of the Coastal Barrier Resources System were considered vulnerable to alteration.

2) We buffered perpendicular structures by 5 km and considered shoreline within this radius altered.

3) All beaches outward from parallel structures were considered altered.

Data were reclassified into the following rankings:

0 = Low (vulnerable to alteration, with/without nearby jetties/groins)

1 = Medium (less vulnerable with nearby jetties/groins)

2 = High (less vulnerable without nearby jetties/groins)

## Defining the Spatial Extent of Ecosystems

This indicator has been clipped to the beach and dune ecosystem, as defined in the Ecosystem Map section under Beach & Dune.

## Known Issues

-- The effect of perpendicular structures (e.g., groins, jetties) on beaches is not straightforward. We used a 5 km radius around these structures to consider beaches altered, but the effect on beaches may be directional and may be lesser or much greater than the 5 km radius we selected.

-- Data were digitized from known sources, but should be considered a minimum amount of hard structures in the region. Further mapping and checking for known structures is warranted.

-- We have considered all beaches outside of the Coastal Barrier Resources System to be altered by human development, which may not necessarily be true.

-- Changes to the designations continue annually, including further additions to the system. The Coastal Barrier Resources System dataset used in this indicator is from 2013 and a 2016 version is now available.

-- Beach renourishment negatively affects some beach and dune species, and is not captured by this indicator.

## Data Disclaimer

Coastal Barrier Resources System (CBRS) digital boundaries in this mapper are only representations of the official CBRS boundaries and are not to be considered authoritative. In general, these digital boundaries can be considered accurate to within approximately 150 ft of the actual CBRS boundaries as shown on the official maps. Additionally, because CBRS units extend seaward out to either the 20- or 30-ft bathymetric contour (depending on the location of the unit), the true seaward extent of the units is not shown in this mapper. The Service is not responsible for any misuse or misinterpretation of this digital data set, including use of the data to determine eligibility for Federal financial assistance such as Federal flood insurance. Click here for information on obtaining an official determination of whether or not an area or specific property is located within the CBRS. Visit this link for information on project consultations. For information on the horizontal accuracy of this digital data set, please read the metadata.

## Literature Cited

Bruun, P., 1995. The development of downdrift erosion. J. Coast. Res., 1242-1257.

Dugan, J.E., Hubbard, D.M., Rodil, I.F., Revell, D.L., Schroeter, S., 2008. Ecological effects of coastal armoring on sandy beaches. Marine Ecology 29, 160-170.

Hall, M.J., Pilkey, O.H., 1991. Effects of hard stabilization on dry beach width for New Jersey. J. Coast. Res., 771-785.

Mohanty, P.K., Patra, S.K., Bramha, S., Seth, B., Pradhan, U., Behera, B., Mishra, P., Panda, U.S., 2012. Impact of groins on beach morphology: a case study near Gopalpur Port, east coast of India. J. Coast. Res. 28, 132-142.

Pilkey, O.H., Wright III, H.L., 1988. Seawalls versus beaches. J. Coast. Res., 41-64.

Rice, T.M., 2012a. Inventory of Habitat Modifications to Tidal Inlets in the Continental U.S. Coastal Migration and Wintering Range of the Piping Plover (*Charadrius melodus*). Appendix 1b, in Comprehensive Conservation Strategy for the Piping Plover (*Charadrius melodus*) in its Coastal Migration and Wintering Range in the Continental United States. U.S. Fish and Wildlife Service, East Lansing, Michigan.

Rice, T.M., 2012b. The Status of Sandy, Oceanfront Beach Habitat in the Continental U.S. Coastal Migration and Wintering Range of the Piping Plover (*Charadrius melodus*), Appendix 1c in Comprehensive Conservation Strategy for the Piping Plover (*Charadrius melodus*) in its Coastal Migration and Wintering Range in the Continental United States. U.S. Fish and Wildlife Service, East Lansing, Michigan

U.S. Fish and Wildlife Service. December 2013. John H. Chafee Coastal Barrier Resources System Approximate Polygons Vector Digital Data Set. Falls Church, VA. <https://www.fws.gov/ecological-services/habitat-conservation/cbra/Maps/Boundaries.html>. (May 15, 2014).

## *Beach Birds*

This layer is one of the South Atlantic LCC indicators in the beach and dune ecosystem. It is an index capturing observed abundance of four shorebird species.

### Reason for Selection

This index represents a variety of ecosystem features and the species selected are already being monitored for the entire region by state and Federal agencies.

### Input Data

#### *Wilson's Plover and American Oystercatcher*

Betsy Von Holle (University of Central Florida) led a project that included state waterbird biologists in the South Atlantic: Tim Keyes, Felicia Sanders, Sara Schweitzer, and Janell Brush. They mapped habitat suitability based on nest, or breeding pair, density per beach segment, as was used for Von Holle et al.'s sea turtle research. The following nesting years were used for the analysis:

--American oystercatcher: FL (2005-2011), GA (2010-2011), SC (2008), NC (2007)

--Wilson's plover: FL (2005-2011), GA (2010-2011), SC (2009-2011), NC (2007)

### *Least Tern*

The point locations and number of least tern nests, or breeding pairs, were provided by waterbird biologists from each state's natural resource department (Tim Keyes, Felicia Sanders, Sara Schweitzer, and Janell Brush). All least tern locations were buffered by 1 km. Although least tern do not actively forage on the beach itself, the buffer characterizes habitat selected by least tern (i.e., beach width, predator abundance, etc.) and accounts for interannual variability in nesting locations. Among years, data showed least tern often shifted the location of nests in the general vicinity of previous years.

### *Piping Plover (Winter Distribution)*

The 2011 winter population census of piping plover was provided by the U.S. Geological Survey, as the international census is repeated every five years. Locations were buffered with a 2 km radius. Although home range estimates exist for piping plover, (Cohen et al. 2008, Drake et al. 2001) these measures depict primarily linear habitats. We used a 2 km buffer, as this is similar to the mean linear distance of 4.2 km that piping plover moved during winter in Texas (Drake et al. 2001). The resulting buffer was also substantiated by maps in Cohen et al. (2008).

## Mapping Steps

Indicators that have not changed since Blueprint 2.0 were initially computed, or in the case of existing data, resampled to 1 ha spatial resolution using the nearest neighbor method. For computational reasons, we then used the ArcGIS Spatial Analyst-Aggregate function to rescale the resolution to 200 m. The aggregate function avoided loss of detail by taking the maximum value of each cell in the conversion (e.g., species presence).

1) Von Holle et al. used a categorical habitat suitability ranking based on six quantiles of nest density, or breeding pair density, for each species on the Atlantic Coast. We converted these to numeric rankings ranging from 0 (absent) to 6 (high density). We expanded the approach by ranking least tern nest abundance in the South Atlantic LCC based on quantiles (0–6). Piping plover individuals were also ranked by quantile (0–6).

2) The beach bird index was developed by using the software program Zonation with the core-area algorithm and without the edge removal option (edge removal = 0). Zonation starts with all potential beach habitats and iteratively removes each cell that results in the least loss of species. The rankings (0–6) described above were used as a measure of relative abundance for all species; no connectivity options were used. The values in this layer represent relative use of habitat for beach nesting birds in the South Atlantic. Fundamentally, areas with higher values in this layer have greater abundance of beach nesting birds in the index than areas with lower values.

The index is scaled from 1 (low) to 10 (high) as follows:

1 = Below the 10th percentile of importance for beach bird index species (low)

2 = 10th-20th percentile of importance

3 = 20th-30th percentile of importance

4 = 30th-40th percentile of importance

5 = 40th-50th percentile of importance

6 = 50th-60th percentile of importance

7 = 60th-70th percentile of importance

8 = 70th-80th percentile of importance

9 = 80th-90th percentile of importance

10 = Above the 90th percentile of importance for beach bird index species (American oystercatcher, Wilson's plover, least tern, and piping plover) (high)

## Defining the Spatial Extent of Ecosystems

This indicator has been clipped to the beach and dune ecosystem, as defined in the Ecosystem Map section under Beach & Dune.

## Known Issues

-- Beach bird survey data are summarized by beach segment and do not account for variations in density within those segments.

-- Volunteers often collect beach bird data in discrete time frames and survey effort may differ by location. Some areas may not have been surveyed or nests may have been missed. Therefore, this data does not imply absence of species.

-- Because we did not have the exact quantile breaks used for habitat suitability on the Atlantic coast, different methods between Atlantic and Gulf regions of this indicator may cause issues when comparing scores.

-- Red knot is not included due to lack of data.

-- This indicator does not capture variations in beach bird use of dune areas inland of beach segments.

## Literature Cited

Cohen, J.B., Karpanty, S.M., Catlin, D.H., Fraser, J.D., Fischer, R.A., 2008. Winter Ecology of Piping Plovers at Oregon Inlet, North Carolina. Waterbirds 31, 472-479.

Drake, K.R., Thompson, J.E., Drake, K.L., Zonick, C., 2001. Movements, habitat use, and survival of nonbreeding Piping Plovers. The Condor 103, 259-267.

## Integrity Scores

This data represents the Blueprint 2.1 ecosystem integrity scores for the beach and dune ecosystem within the South Atlantic LCC geography. To read more about the indicators, please see the Indicators section under each ecosystem heading.

### *Input Data and Mapping Steps*

Indicators (200 m resolution) were spatially modeled, tested, reviewed, and used as inputs to derive high integrity areas. The integrity scores for this system are based on the beach and dune indicators and some landscapes indicators. These indicators served as inputs into Zonation, a conservation planning framework and software that produces a hierarchal prioritization of the landscape. Zonation employs an algorithm that proceeds by removing cells of lowest conservation value, minimizing marginal loss to produce a spatial prioritization at a fine scale.

#### Zonation Parameters and Inputs

-- Inputs: Beach and dune indicators (beach birds and unaltered beach) and some landscapes indicators (low road density and low-urban historic landscapes).

-- Removal rule = 1 (basic core-area Zonation): In basic core-area Zonation (commonly CAZ), cell removal is done in a manner that minimizes biological loss by picking the cell that has the smallest occurrence for the most valuable feature over all biodiversity features in the cell. In other words, the cell gets a high value if even one species has a relatively important occurrence there.

-- Warp factor = 1: The warp factor defines how many cells are removed at a time per iteration. A lower warp factor provides a finer resolution, but requires a longer model run time. A higher warp factor reduces the time required to run a model, but results in a coarser resolution.

-- Boundary length penalty = 0 (not used): Boundary length penalty (BLP) is a method to induce aggregation of high priority areas. Using a BLP, the hierarchy of cell removal is based upon the conservation value of the cell and the increase/decrease of boundary length that results from the removal of a cell.

-- Edge removal = 1: Determines whether the program removes cells from the edges of remaining landscape (value = 1) or anywhere from the landscape (value = 0). Note that setting this parameter to 0 will increase the running times with large landscapes.

-- Indicator weights = 1 for all indicators. All indicators were weighted equally in the Zonation run.

For more information on the reasoning behind the Zonation settings used for each ecosystem, please refer to the Blueprint 2.1 section under Indicator Analysis.

### *Literature Cited*

Moilanen, A., L. Meller, J. Leppänen, F.M. Pouzols, H. Kujala, A. Arponen. 2014. Zonation Spatial Conservation Planning Framework and Software V4.0, User Manual.

# Estuarine

## Ecosystem Map

Estuarine marshes and estuarine open water were defined by the National Wetlands Inventory (NWI) (U.S. Fish and Wildlife Service 2014) for the Florida Gulf Coast. NWI broadly classified the estuarine zone as "Estuarine and Marine Wetland" (estuarine marsh) and "Estuarine and Marine Deepwater" (estuarine open water). Similarly, for the Atlantic Coast, we used an NWI update by The Nature Conservancy's South Atlantic Marine Bight Assessment. Their classifications of salt marsh, salt marsh impoundments, and tidal flat classifications corresponded to the estuarine marsh ecosystem.

During the process of rescaling data to a 200 m resolution, ecosystems were overlaid and overlaps were handled by ordering them from high (never excluded by another ecosystem) to low (always excluded by another ecosystem). To avoid data loss, linear features, such as maritime forests, were ranked relatively high. The ranking proceeded as: 10) maritime forest, 9) beaches and dunes, 8) estuaries, 7) major waterbodies, 6) localized data on pine land cover, 5) forested wetlands, 4) freshwater marsh, 3) longleaf pine range, 2) upland hardwoods, 1) marine. At the end of this process, there were still pixels left unclassified. We filled in these pixels using the following classes from Landfire Biophysical Settings data: Open Water.

### *Known Issues*

-- The ability of National Wetland Inventory (NWI) data to distinguish estuarine marsh from freshwater marsh is relatively unknown.

-- Some small areas of estuarine open water near the coast may be misclassified as marine.

### *Literature Cited*

Conley, Mary and Netwon, Robert. 2015. Coastal Ecosystems. in Conley, M, M.G. Anderson, L. Geselbracht, eds. The South Atlantic Bight Marine Ecoregional Assessment. The Nature Conservancy, Eastern U.S. Division, Boston, MA. <http://easterndivision.s3.amazonaws.com/Marine/SABMA/FINAL_DRAFT_SABMA_coastal_ecosystems_090415.pdf>.

U.S. Fish and Wildlife Service 2014. National Wetlands Inventory - Wetlands. <http://www.fws.gov/wetlands/>.

U.S. Geological Survey, Earth Resources Observation and Science (EROS) Center. 2010. LANDFIRE Biophysical Settings: LANDFIRE 2012 (LF 1.3.0). <http://www.landfire.gov>.

## Ecosystem-Specific Indicators

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## *Coastal Condition*

This layer is one of the South Atlantic LCC indicators in the estuarine ecosystem. It is an index of coastal condition capturing water quality, sediment quality, and benthic community condition.

### Reason for Selection

This index measures the overall abiotic condition of the system, is well monitored, and is synthesized by the Environmental Protection Agency (EPA) every five years. It integrates measures of water quality, sediment quality, and benthic habitat quality.

### Input Data

-- The EPA Coastal Condition Index (CCI) is a ranking derived from a water quality index, sediment quality index, benthic index, coastal habitat index, and fish tissue contaminants index (US EPA 2012). The coastal habitat index and fish tissue contaminants are region-wide measures and were not included in the indicator. For our objectives, we only used the indices derived from point sampling (water quality index, sediment quality index, benthic index), and the data were scored in the same way as EPA's scoring: 1 = poor, 3 = fair, and 5 = good.

-- Both the 2010 (sampling conducted in 2010) and 2006 (sampling conducted from 2003-2006) data were used in the Blueprint 2.1 update of the indicator. In calculating the overall rank for each point, the mean of the three indices was taken for each sampling period.

### Mapping Steps

1) The 2006 data and the 2010 point data were converted to separate rasters with 200 m pixel cell size using interpolation. Interpolation of point data from the CCI was conducted with the ArcGIS Spatial Analyst-Inverse Distance Weighted function. This function interpolates among points by weighting a specified number of nearby points as having a large influence if they are in close proximity and a declining influence as they are farther away. We used a power function of 5 to emphasize local samples (> 5 had little influence), the 3 nearest points were used in interpolation, and a maximum distance to points of 36 km was used. CCI scores ranged continuously from 1-5.

2) The 2006 and 2010 raster data were averaged together to create the final score.

The final indicator is continuous, with values ranging from:

High: 5 (good water quality, sediment quality, and benthic community condition)

Low: 1.13 (poor water quality, sediment quality, and benthic community condition)

### Defining the Spatial Extent of Ecosystems

This indicator has been clipped to the estuarine ecosystem, as defined in the Ecosystem Map section under Estuarine.

### Known Issues

-- Estimates for areas not near monitoring points used in the Coastal Condition Index are highly uncertain. This is particularly true for most areas along the Gulf where there are few points within the South Atlantic region.

-- Uses only two snapshots in time in a highly dynamic system.

### Disclaimer: Comparing with Older Indicator Versions

While this indicator has changed since the version of estuarine marsh coastal condition used in Blueprint 2.0 and the version of estuarine open water coastal condition used in Blueprint 2.0, this only reflects differences in the way it was calculated and should not be compared to measure change over time.

### Literature Cited

U.S. Environmental Protection Agency (EPA). 2012. National Coastal Condition Report IV. Office of Research and Development/Office of Water. Washington D.C. EPA-842-R-10-003. June 2014. <http://water.epa.gov/type/oceb/assessmonitor/nccr/upload/0_NCCR_4_Report_508_bookmarks.pdf>.

## *Wetland Patch Size*

This layer is one of the South Atlantic LCC indicators in the estuarine ecosystem. It is an index based on the size of estuarine patches.

### Reason for Selection

Larger, better connected wetlands are positively associated with fish (Meynecke et al. 2008), shrimp (Turner 1977), and marsh birds. In particular, seaside sparrow (Benoit and Askins 2002, Rush et al. 2009), saltmarsh sharp-tailed sparrow (Benoit and Askins 2002), and marsh wren (Rush et al. 2009) have been associated with marsh area effects. Other species are expected to be limited based on home range size. In addition, wave attenuation is increased with wetland area (Shepard et al. 2011). Over time, a decrease in patch size will correspond to marsh degradation and wetland loss. As a wide variety of marsh patch sizes correspond to species and ecosystem services (noted above), the quantile index is a simple, objective way of quantifying the functional value of different patch sizes. Since the index is dependent on the NLCD, future monitoring will be relatively easy. A decrease in patch size will be an early sign of marsh degradation.

### Input Data

-- National Wetlands Inventory (NWI) (accessed 15 May 2014) - "Estuarine and Marine Wetland" class

-- National Land Cover Database 2011 (NLCD 2011) - "Emergent Wetland" class

-- For the Atlantic coast, we used an NWI update by The Nature Conservancy's South Atlantic Marine Bight Assessment. Salt marsh, salt marsh impoundments, and tidal flats corresponded to estuarine marsh.

### Mapping Steps

Indicators that have not changed since Blueprint 2.0 were initially computed, or in the case of existing data, resampled to 1 ha spatial resolution using the nearest neighbor method. For computational

reasons, we then used the ArcGIS Spatial Analyst-Aggregate function to rescale the resolution to 200 m. The aggregate function avoided loss of detail by taking the maximum value of each cell in the conversion (e.g., species presence).

1) The NLCD emergent wetland class was masked with NWI's "Estuarine and Marine Wetland" category to distinguish estuarine marshes from freshwater marshes.

2) The ArcGIS Spatial Analyst-Region Group function was used to delineate individual patches using an 8-neighbor rule. The method defines patches by clumping into individual patches all wetland cells directly adjacent or diagonal to each other.

3) The wetland patches were reclassified into five quantiles of wetland sizes (in hectares):

0 = 1-328 ha (low)

1 = 329-1,228 ha

2 = 1,229-3,087 ha

3 = 3,088-6,088 ha

4 = 6,088-15,154 ha (high)

## Defining the Spatial Extent of Ecosystems

This indicator has been clipped to the estuarine ecosystem, as defined in the Ecosystem Map section under Estuarine.

## Known Issues

-- Does not account for variations in marsh vegetation composition.

-- The ability of National Wetland Inventory (NWI) data to distinguish estuarine marsh from freshwater marsh is relatively unknown.

-- This indicator has not been expanded to cover areas newly added to estuarine marsh with the improved ecosystem maps of Blueprint 2.1. This resulted in a small number of no data pixels, < 37 total, throughout the coastal area of the South Atlantic.

## Literature Cited

Benoit, L.K., Askins, R.A., 2002. Relationship between habitat area and the distribution of tidal marsh birds. The Wilson Bulletin 114, 314-323.

Conley, Mary and Netwon, Robert. 2015. Coastal Ecosystems. in Conley, M, M.G. Anderson, L. Geselbracht, eds. The South Atlantic Bight Marine Ecoregional Assessment. The Nature Conservancy, Eastern U.S. Division, Boston, MA. <http://easterndivision.s3.amazonaws.com/Marine/SABMA/FINAL_DRAFT_SABMA_coastal_ecosystems_090415.pdf>.

Homer, C.G., Dewitz, J.A., Yang, L., Jin, S., Danielson, P., Xian, G., Coulston, J., Herold, N.D., Wickham, J.D., and Megown, K., 2015, Completion of the 2011 National Land Cover Database for the conterminous United States-Representing a decade of land cover change information. Photogrammetric Engineering and Remote Sensing, v. 81, no. 5, p. 345-354.

Meynecke, J.O., Lee, S.Y., Duke, N., 2008. Linking spatial metrics and fish catch reveals the importance of coastal wetland connectivity to inshore fisheries in Queensland, Australia. Biological Conservation 141, 981-996.

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Shepard, C.C., Crain, C.M., Beck, M.W., 2011. The protective role of coastal marshes: a systematic review and meta-analysis. PLoS One 6.

Turner, R.E., 1977. Intertidal vegetation and commercial yields of penaeid shrimp. Transactions of the American Fisheries Society 106, 411-416.

U.S. Fish and Wildlife Service 2014. National Wetlands Inventory - Wetlands. <http://www.fws.gov/wetlands/>.

## *Water-Vegetation Edge*

This layer is one of the South Atlantic LCC indicators in the estuarine ecosystem. It is an index capturing the length of the edge between open water and estuarine vegetation.

### Reason for Selection

The density and abundance of shrimp, crab, fish, and other nekton are strongly correlated with the open water-vegetation edges (Minello et al. 2003). In a review of nekton species and coastal habitats, open water-vegetation edge was cited as having the second most dense nekton populations (i.e., first being submerged aquatic vegetation, or SAV) (Minello et al. 2003). In particular, the first 1 m of open water near wetlands is often noted as having the highest density of nekton (Minello and Rozas 2002). For marsh birds, clapper rail (Rush et al. 2009) and king rail (Pickens and King 2013)—as well as least bittern, American bittern, sora, and Virginia rail (Rehm and Baldassarre 2007)—use open water-vegetation edge habitats. Wood storks also use tidal creeks (Gaines et al. 1998), which are depicted by the edge characteristic.

### Input Data

-- National Wetlands Inventory (NWI) (accessed 15 May 2014) - "Estuarine and Marine Wetland" and "Estuarine and Marine Deepwater" classes

-- For the Atlantic coast, we used an NWI update by The Nature Conservancy's South Atlantic Marine Bight Assessment. Salt marsh, salt marsh impoundments, and tidal flats corresponded to estuarine marsh.

## Mapping Steps

Indicators that have not changed since Blueprint 2.0 were initially computed, or in the case of existing data, resampled to 1 ha spatial resolution using the nearest neighbor method. For computational reasons, we then used the ArcGIS Spatial Analyst-Aggregate function to rescale the resolution to 200 m. The aggregate function avoided loss of detail by taking the maximum value of each cell in the conversion (e.g., species presence).

1) We used the NWI's "estuarine and marine wetlands" and "estuarine and marine deepwater" as the inputs for this indicator. This categorization included coastal marsh and tidal creeks, plus distinguished estuarine marshes from freshwater marshes.

2) We converted the vector data to 30 m raster cells (which preserved tidal creeks), and used the ArcGIS Filter function (Spatial Analyst-Neighborhood) with a 3x3 high pass filter to extract the open water-marsh edge. The layer was reclassified to depict all open water-marsh interfaces as edge, and then the raster layer was converted to a polyline of "edge."

3) We used ArcGIS Spatial Analyst-Focal Statistics to summarize the length of edge within a 500 m radius of each cell.

4) Length of edge within 500 m was reclassified into five quantiles (km/sq km), excluding open water itself from the ranking:

0 = 0-0.61 km/sq km (low)

1 = 0.61-1.68 km/sq km

2 = 1.68-2.82 km/sq km

3 = 2.82-4.27 km/sq km

4 = 4.27-19.42 km/sq km (high)

## Defining the Spatial Extent of Ecosystems

This indicator has been clipped to the estuarine ecosystem, as defined in the Ecosystem Map section under Estuarine.

## Known Issues

-- Does not account for variations in marsh vegetation composition.

-- The ability of National Wetland Inventory (NWI) data to distinguish estuarine marsh from freshwater marsh is relatively unknown.

-- This indicator has not been expanded to cover areas newly added to estuarine marsh with the improved ecosystem maps of Blueprint 2.1. This resulted in a small number of no data pixels, < 37 total, throughout the coastal area of the South Atlantic.

### Literature Cited

Conley, Mary and Netwon, Robert. 2015. Coastal Ecosystems. in Conley, M, M.G. Anderson, L. Geselbracht, eds. The South Atlantic Bight Marine Ecoregional Assessment. The Nature Conservancy, Eastern U.S. Division, Boston, MA. <http://easterndivision.s3.amazonaws.com/Marine/SABMA/FINAL_DRAFT_SABMA_coastal_ecosystems_090415.pdf>.

Gaines, K.F., Bryan Jr, A.L., Dixon, P.M., Harris, M.J., 1998. Foraging habitat use by wood storks nesting in the coastal zone of Georgia, USA. Colonial Waterbirds, 43-52.

Minello, T.J., Able, K.W., Weinstein, M.P., Hays, C.G., 2003. Salt marshes as nurseries for nekton: testing hypotheses on density, growth and survival through meta-analysis. Marine Ecology Progress Series 246, 39-59.

Minello, T.J., Rozas, L.P., 2002. Nekton in Gulf Coast wetlands: fine-scale distributions, landscape patterns, and restoration implications. Ecol. Appl. 12, 441-455.

Pickens, B.A., King, S.L., 2013. Microhabitat selection, demography, and correlates with home range size for the king rail (*Rallus elegans*). Waterbirds 36, 319-329.

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Rush, S.A., Soehren, E.C., Woodrey, M.S., Graydon, C.L., Cooper, R.J., 2009. Occupancy of select marsh birds within northern Gulf of Mexico tidal marsh: current estimates and projected change. Wetlands 29, 798-808.

U.S. Fish and Wildlife Service 2014. National Wetlands Inventory - Wetlands. <http://www.fws.gov/wetlands/>.

## Integrity Scores: Estuarine Open Water

This data represents the Blueprint 2.1 ecosystem integrity scores for the estuarine open water portion of the estuarine ecosystem within the South Atlantic LCC geography. To read more about the indicators, please see the Indicators section under each ecosystem heading.

### *Input Data and Mapping Steps*

Indicators (200 m resolution) were spatially modeled, tested, reviewed, and used as inputs to derive high integrity areas. The integrity scores for this system are based on the only indicator that covers the estuarine open water area (coastal condition), so it was not necessary to use Zonation to prioritize this area. Because of this, the open water part of estuaries was treated differently than the other ecosystems. Instead of using Zonation, we used the ArcGIS Slice function to bin the coastal condition indicator into 100 equal area classes. Each of these classes covers roughly the same area (1% of the open water estuaries). This allowed us to use this layer in the same way as the Zonation outputs.

### *Literature Cited*

Moilanen, A., L. Meller, J. Leppänen, F.M. Pouzols, H. Kujala, A. Arponen. 2014. Zonation Spatial Conservation Planning Framework and Software V4.0, User Manual.

## Integrity Scores: Estuarine Marsh

This data represents the Blueprint 2.1 ecosystem integrity scores for the estuarine marsh portion of the estuarine ecosystem within the South Atlantic LCC geography. To read more about the indicators, please see the Indicators section under each ecosystem heading.

### *Input Data and Mapping Steps*

Indicators (200 m resolution) were spatially modeled, tested, reviewed, and used as inputs to derive high integrity areas. The integrity scores for this system are based on the estuarine marsh indicators, freshwater aquatic indicators, waterscapes indicators, and some landscapes indicators. Because some of the estuarine indicators did not extend into the open water, the estuarine ecosystem was broken down into two spatially distinct areas: estuarine marsh and open water estuaries. These indicators served as inputs into Zonation, a conservation planning framework and software that produces a hierarchal prioritization of the landscape. Zonation employs an algorithm that proceeds by removing cells of lowest conservation value, minimizing marginal loss to produce a spatial prioritization at a fine scale.

#### Zonation Parameters and Inputs

-- Inputs: Estuarine indicators (wetland patch size, water-vegetation edge, and coastal condition), some landscapes indicators (low road density and low-urban historic landscapes), freshwater aquatic indicators (imperiled aquatic species, permeable surface, and riparian buffers), and waterscapes indicators (migratory fish connectivity and network complexity).

-- Removal rule = 1 (basic core-area Zonation): In basic core-area Zonation (commonly CAZ), cell removal is done in a manner that minimizes biological loss by picking the cell that has the smallest occurrence for the most valuable feature over all biodiversity features in the cell. In other words, the cell gets a high value if even one species has a relatively important occurrence there.

-- Warp factor = 1: The warp factor defines how many cells are removed at a time per iteration. A lower warp factor provides a finer resolution, but requires a longer model run time. A higher warp factor reduces the time required to run a model, but results in a coarser resolution.

-- Boundary length penalty = 0 (not used): Boundary length penalty (BLP) is a method to induce aggregation of high priority areas. Using a BLP, the hierarchy of cell removal is based upon the conservation value of the cell and the increase/decrease of boundary length that results from the removal of a cell.

-- Edge removal = 1: Determines whether the program removes cells from the edges of remaining landscape (value = 1) or anywhere from the landscape (value = 0). Note that setting this parameter to 0 will increase the running times with large landscapes.

-- Indicator weights = 1 for all indicators. All indicators were weighted equally in the Zonation run.

For more information on the reasoning behind the Zonation settings used for each ecosystem, please refer to the Blueprint 2.1 section under Indicator Analysis.

## *Literature Cited*

Moilanen, A., L. Meller, J. Leppänen, F.M. Pouzols, H. Kujala, A. Arponen. 2014. Zonation Spatial Conservation Planning Framework and Software V4.0, User Manual.

# Forested Wetland

## Ecosystem Map

Forested wetlands were defined by the 2011 NLCD (Homer et al. 2015) classification of "woody wetlands" (value 90).

During the process of rescaling data to a 200 m resolution, ecosystems were overlaid and overlaps were handled by ordering them from high (never excluded by another ecosystem) to low (always excluded by another ecosystem). To avoid data loss, linear features, such as maritime forests, were ranked relatively high. The ranking proceeded as: 10) maritime forest, 9) beaches and dunes, 8) estuaries, 7) major waterbodies, 6) localized data on pine land cover, 5) forested wetlands, 4) freshwater marsh, 3) longleaf pine range, 2) upland hardwoods, 1) marine. At the end of this process, there were still pixels left unclassified. We filled in these pixels using the following classes from Landfire Biophysical Settings data: Atlantic Coastal Plain Mesic Hardwood Forest, Atlantic Coastal Plain Peatland Pocosin and Canebrake, Atlantic Coastal Plain Streamhead Seepage Swamp-Pocosin-Baygall, Central Atlantic Coastal Plain, Nonriverine Swamp and Wet Hardwood Forest, Central Interior and Appalachian Floodplain Systems, Central Interior and Appalachian Riparian Systems, Central Interior and Appalachian Swamp Systems, Floridian Highlands Freshwater Marsh, Gulf and Atlantic Coastal Plain Floodplain Systems, Gulf and Atlantic Coastal Plain Small Stream Riparian Systems, Gulf and Atlantic Coastal Plain Swamp Systems, South-Central Interior Mesophytic Forest, Southern Coastal Plain Mesic Slope Forest, Southern Coastal Plain Nonriverine Cypress Dome, and Southern Coastal Plain Seepage Swamp and Baygall.

### *Known Issues*

-- Some forested wetland areas that have been drained and heavily altered by humans are likely misclassified. Once they have been altered, it is challenging to identify what the naturally occurring ecosystem would be.

### *Literature Cited*

Homer, C.G., Dewitz, J.A., Yang, L., Jin, S., Danielson, P., Xian, G., Coulston, J., Herold, N.D., Wickham, J.D., and Megown, K., 2015, Completion of the 2011 National Land Cover Database for the conterminous United States-Representing a decade of land cover change information. Photogrammetric Engineering and Remote Sensing, v. 81, no. 5, p. 345-354.

U.S. Geological Survey, Earth Resources Observation and Science (EROS) Center. 2010. LANDFIRE Biophysical Settings: LANDFIRE 2012 (LF 1.3.0). <http://www.landfire.gov>.

## Ecosystem-Specific Indicators

The South Atlantic ecosystem indicators serve as the South Atlantic LCC's metrics of success and drive the identification of priority areas for shared action in the Conservation Blueprint. To learn more about the indicators and how they are being used, please visit the indicator page. Check out the Blueprint page for more information on the development of the Blueprint, a living spatial plan to conserve our natural and cultural resources.

## *Forested Wetland Birds*

This layer is one of the South Atlantic LCC indicators in the forested wetland ecosystem. It is an index of habitat suitability for six forested wetland bird species.

### Reason for Selection

This index represents a variety of ecosystem features and is already being modeled and monitored for the entire region by the Atlantic Coast Joint Venture.

### Input Data

-- Select models from the South Atlantic Migratory Bird Initiative (SAMBI) Designing Sustainable Landscapes (DSL) avian habitat project:

Black-throated green warbler (bBTNW)

Chuck-will's widow (bCWWI)

Northern parula (bNOPA)

Red-headed woodpecker (bRHWO)

Prothonotary warbler (bPROW)

Swainson's warbler (bSWWA)

-- Southeast GAP species models

### Mapping Steps

The index of forested wetland birds is based on scores representing increasingly restrictive limitations of potential habitat for a suite of species. Species-based constraints are:

1) Northern parula (70 ha minimum patch), black-throated green warbler (100 ha minimum patch), red-headed woodpecker (interior patch within 500 m of early successional habitat), Chuck-will's widow (interior patch within 500 m of early successional habitat)

2) Prothonotary warbler (70 ha minimum patch within 120 m of water)

3) Swainson's warbler (350 ha minimum patch within 250 m of water)

Species models from the Avian Habitat Modeling for the SAMBI Designing Sustainable Landscapes Project were used for the majority of the South Atlantic area. Ten HUC8 watersheds in the South Atlantic geography were not covered (or not fully covered) by these models. To fill in the missing areas, Southeast GAP species models were used in the following HUC8 watersheds: 3130003 (Middle Chattahoochee-Walter F), 3140201 (Upper Choctawhatchee), 3140301 (Upper Conecuh), 3140202 (Pea), 3140203 (Lower Choctawhatchee), 3130004 (Lower Chattahoochee), 3130011 (Apalachicola), 3150110 (Lower Tallapoosa), 3140101 (St. Andrew-St. Joseph Bays), 3130012 (Chipola).

1) If a pixel was identified in the red-headed woodpecker, Chuck-will's widow, black-throated green warbler, or Northern parula models, it was given a value of 1. If not it was give a value of 0.

2) If a pixel was identified in the prothonotary warbler model, it was given a value of 2. If not, it retained the value from step 1.

3) If a pixel was identified in the Swainson's warbler model, it was give a value of 3. If not, it retained the value from step 2.

4) The results were limited to the forested wetland ecosystem.

5) The results were converted from 30 m pixels to 200 m pixels using a majority resample.

The resulting index appears below:

0 = Less potential for presence of forested wetland bird index species (low)

1 = Potential for presence of Northern parula, black-throated green warbler, red-headed woodpecker, or Chuck-will's widow

2 = Potential for additional presence of prothonotary warbler

3 = Potential for additional presence of Swainson's warbler (high)

## Defining the Spatial Extent of Ecosystems

This indicator has been clipped to the forested wetland ecosystem, as defined in the Ecosystem Map section under Forested Wetland.

## Known Issues

-- GAP models used in Apalachicola basin use different methods and predict slightly less habitat than the SERAP models used in the rest of the area.

-- Bird models are based on 2001 GAP land cover data.

-- Thresholds used in this indicator focus primarily on species presence and larger patches are likely needed for source populations of any of these species.

## Disclaimer: Comparing with Older Indicator Versions

While this indicator has changed since the version of forested wetland birds used in Blueprint 2.0, this only reflects differences in the way it was calculated and should not be compared to measure change over time.

## Literature Cited

Williams SG, Rubino MJ. 2012. Designing Sustainable Landscapes Project. Biodiversity and Spatial Information Center, North Carolina State University. Available: http://www.basic.ncsu.edu/dsl/hab.html (April 2014).

Southeast Gap Analysis Project. SE-GAP Vertebrate Predicted Habitat. <http://www.basic.ncsu.edu/segap/DataServer.html>.

## *Forested Wetland Extent*

Forested wetland is already captured through the ecosystem map, so we did not use it an input to Zonation. Please see the Ecosystem Map section under Forested Wetland for more information on how this indicator was developed.

## *Forested Wetland Amphibians*

This layer is one of the South Atlantic LCC indicators in the forested wetland ecosystem. It captures Priority Reptile and Amphibian Conservation Areas within forested wetlands.

### Reason for Selection

Amphibians provide an indicator of the condition and arrangement of embedded isolated wetlands.

### Input Data

South Atlantic LCC Priority Amphibian and Reptile Conservation Areas (PARCAs) served as input data for this indicator. PARCAs are a nonregulatory designation established to raise public awareness and spark voluntary action by landowners and conservation partners to benefit amphibians and/or reptiles. Areas are nominated using scientific criteria and expert review, drawing on the concepts of species rarity, richness, regional responsibility, and landscape integrity. Modeled in part after the Important Bird Areas program developed by BirdLife International, PARCAs are intended to be nationally coordinated but locally implemented at state or regional scales. Importantly, PARCAs are not designed to compete with existing landscape biodiversity initiatives, but to complement them, providing an additional spatially explicit layer for conservation consideration.

PARCAs are intended to be established in areas:

-- capable of supporting viable amphibian and reptile populations,

-- occupied by rare, imperiled, or at-risk species, and

-- rich in species diversity or endemism.

Species used in identifying the forested wetland PARCAs include: alligator snapping turtle, Barbour's map turtle, one-toed amphiuma, Savannah slimy salamander, Mabee's salamander, dwarf waterdog, Neuse river waterdog, chicken turtle, spotted turtle, tiger salamander, rainbow snake, and lesser siren.

There are four major implementation steps:

1) Regional PARC task teams or state experts can use the criteria and modify them when appropriate to designate potential PARCAs in their area of interest.

2) Following the identification of all potential PARCAs, the group then reduces these to a final set of exceptional sites that best represent the area of interest.

3) Experts and stakeholders in the area of interest collaborate to produce a map that identifies these peer-reviewed PARCAs.

4) Final PARCAs are shared with the community to encourage the implementation of voluntary habitat management and conservation efforts. PARCA boundaries can be updated as needed.

### Mapping Steps

This indicator was converted from a vector to a 200 m pixel raster using the Feature to Raster function in ArcGIS. We clipped PARCAs to the forested wetland ecosystem.

Indicator values were assigned as follows:

0 = Not a Priority Amphibian and Reptile Conservation Area (PARCA) within forested wetlands

1 = Priority Amphibian and Reptile Conservation Area (PARCA) within forested wetlands

### Defining the Spatial Extent of Ecosystems

This indicator has been clipped to the forested wetland ecosystem, as defined in the Ecosystem Map section under Forested Wetland.

### Known Issues

-- The mapping of this indicator is relatively coarse and doesn't always capture differences in pixel-level quality in the outer edge of PARCAs.

-- This indicator is binary and doesn't capture the full continuum of value across the South Atlantic.

-- The methods of combining expert knowledge and data in this indicator may have caused some areas that are poorly known and/or under-surveyed to be scored too low.

### Disclaimer: Comparing with Older Indicator Versions

While this indicator has changed since the version of forested wetland amphibians used in Blueprint 2.0, this only reflects differences in the way it was calculated and should not be compared to measure change over time.

### Literature Cited

Sutherland and deMaynadier. 2012. Model Criteria and Implementation Guidance for a Priority Amphibian and Reptile Conservation Area (PARCA) System in the USA. Partners in Amphibian and Reptile Conservation, Technical Publication PARCA-1. 28 pp. <http://www.parcplace.org/images/stories/documents/PARCA_System_Criteria_and_Implementation_Guidance_FINAL.pdf>.

## Integrity Scores

This data represents the Blueprint 2.1 ecosystem integrity scores for the forested wetland ecosystem within the South Atlantic LCC geography. To read more about the indicators, please see the Indicators section under each ecosystem heading.

## *Input Data and Mapping Steps*

Indicators (200 m resolution) were spatially modeled, tested, reviewed, and used as inputs to derive high integrity areas. The integrity scores for this system are based on some forested wetland indicators and the landscapes indicators, freshwater aquatic indicators, and waterscapes indicators. These indicators served as inputs into Zonation, a conservation planning framework and software that produces a hierarchal prioritization of the landscape. Zonation employs an algorithm that proceeds by removing cells of lowest conservation value, minimizing marginal loss to produce a spatial prioritization at a fine scale. Forested wetland extent is already captured through the ecosystem map, so we did not use it an input to Zonation.

### Zonation Parameters and Inputs

-- Inputs: Forested wetland indicators (forested wetland birds and forested wetland amphibians), landscapes indicators (low road density, resilient biodiversity hotspots, and low-urban historic landscapes), freshwater aquatic indicators (imperiled aquatic species, permeable surface, and riparian buffers) and waterscapes indicators (migratory fish connectivity and network complexity).

-- Removal rule = 1 (basic core-area Zonation): In basic core-area Zonation (commonly CAZ), cell removal is done in a manner that minimizes biological loss by picking the cell that has the smallest occurrence for the most valuable feature over all biodiversity features in the cell. In other words, the cell gets a high value if even one species has a relatively important occurrence there.

-- Warp factor = 10: The warp factor defines how many cells are removed at a time per iteration. A lower warp factor provides a finer resolution, but requires a longer model run time. A higher warp factor reduces the time required to run a model, but results in a coarser resolution.

-- Boundary length penalty = 0 (not used): Boundary length penalty (BLP) is a method to induce aggregation of high priority areas. Using a BLP, the hierarchy of cell removal is based upon the conservation value of the cell and the increase/decrease of boundary length that results from the removal of a cell.

-- Edge removal = 1: Determines whether the program removes cells from the edges of remaining landscape (value = 1) or anywhere from the landscape (value = 0). Note that setting this parameter to 0 will increase the running times with large landscapes.

-- Indicator weights = 0.1 for low-urban historic landscapes, 1 for all other indicators. We began ecosystem runs with all indicators weighted equally. Due to the small extent of the low-urban historic landscapes indicator, the Zonation results included the full extent of the indicator in the top 10% of the prioritization. This meant that even areas with the lowest indicator values and no overlap with other high indicator values would end up in the highest priority class. To resolve this, we reduced the indicator weight until some areas with lower indicator values were outside of the top 10%. We tested weights of 0.75, 0.6, 0.5, 0.25, and 0.1. All other indicators were weighted equally in the final Zonation run.

For more information on the reasoning behind the Zonation settings used for each ecosystem, please refer to the Blueprint 2.1 section under Indicator Analysis.

## *Literature Cited*

Moilanen, A., L. Meller, J. Leppänen, F.M. Pouzols, H. Kujala, A. Arponen. 2014. Zonation Spatial Conservation Planning Framework and Software V4.0, User Manual.

# Freshwater Marsh

## Ecosystem Map

Tidal and nontidal freshwater marsh classifications included emergent marsh inland of estuarine marsh, defined by the 2011 NLCD "emergent herbaceous wetlands" class, excluding the defined estuarine ecosystem (see above).

During the process of rescaling data to a 200 m resolution, ecosystems were overlaid and overlaps were handled by ordering them from high (never excluded by another ecosystem) to low (always excluded by another ecosystem). To avoid data loss, linear features, such as maritime forests, were ranked relatively high. The ranking proceeded as: 10) maritime forest, 9) beaches and dunes, 8) estuaries, 7) major waterbodies, 6) localized data on pine land cover, 5) forested wetlands, 4) freshwater marsh, 3) longleaf pine range, 2) upland hardwoods, 1) marine. At the end of this process, there were still pixels left unclassified. We filled in these pixels using the following classes from Landfire Biophysical Settings data: Gulf and Atlantic Coastal Plain Tidal Marsh Systems.

### *Known Issues*

-- The ability of National Wetland Inventory (NWI) data to distinguish estuarine marsh from freshwater marsh is relatively unknown.

### *Literature Cited*

Homer, C.G., Dewitz, J.A., Yang, L., Jin, S., Danielson, P., Xian, G., Coulston, J., Herold, N.D., Wickham, J.D., and Megown, K., 2015, Completion of the 2011 National Land Cover Database for the conterminous United States-Representing a decade of land cover change information. Photogrammetric Engineering and Remote Sensing, v. 81, no. 5, p. 345-354.

U.S. Geological Survey, Earth Resources Observation and Science (EROS) Center. 2010. LANDFIRE Biophysical Settings: LANDFIRE 2012 (LF 1.3.0). <http://www.landfire.gov>.

## Ecosystem-Specific Indicators

The South Atlantic ecosystem indicators serve as the South Atlantic LCC's metrics of success and drive the identification of priority areas for shared action in the Conservation Blueprint. To learn more about the indicators and how they are being used, please visit the indicator page. Check out the Blueprint page for more information on the development of the Blueprint, a living spatial plan to conserve our natural and cultural resources.

### *Freshwater Marsh Extent*

Freshwater marsh extent is already captured through the ecosystem map, so we did not use it an input to Zonation. Please see the Ecosystem Map section under Freshwater Marsh for more information on how this indicator was developed.

## *Freshwater Marsh Birds*

This layer is one of the South Atlantic LCC indicators in the tidal and nontidal freshwater marsh ecosystem. It is an index of potential habitat for five freshwater marsh bird species.

### Reason for Selection

Patch sizes of fresh marsh were ranked with knowledge of marsh bird habitat relationships. Over time, a decrease in patch size will correspond to marsh degradation and wetland loss. Brown and Dinsmore (1986) tested bird responses to wetland patch size in interior fresh marshes. They showed 10 species were not present in wetland patches of < 5 ha, but were included in greater patch sizes. Examples of these species include least bittern, northern pintail, and northern shoveler. Several other species had strongly increased abundance with patches > 5 ha. The patch size class > 5 ha and ≤ 20 ha is inclusive of marsh bird home ranges: King rail in fresh marsh have known home ranges of 7.7-16 ha (Pickens and King 2013); least bittern home ranges are highly variable, but Bogner and Baldassarre (2002) reported a mean of 9.7 ha and Moore (2009) showed a mean wetland area of 10.9 ha where least bittern were detected. Brown and Dinsmore (1986) showed a species richness– wetland area relationship with the greatest species richness near 20-30 ha. For king rail, Drew and Collazo (2014) also had support for a model with a patch size class of > 20 ha for predicting species occupancy. Similarly, Pickens and King (2014a, 2014b) showed water-level management, often at a scale > 20 ha, and habitat measured at a 100 ha scale, corresponded to king rail abundance. Since the indicator is dependent on the NLCD, future monitoring is feasible. A decrease in patch size will be an early sign of marsh degradation and/or wetland loss.

### Input Data

-- 2011 National Land Cover Database (2011 NLCD)

### Mapping Steps

1) Pull out emergent herbaceous wetland class from 2011 NLCD.

2) Calculate patch size using the ArcGIS Spatial Analyst-Region Group function with a 4-neighbor rule. The 4-neighbor approach best quantified fragmentation around patches and this rule helped eliminate misclassifications of fresh marsh (< 5 ha).

3) Convert 30 m data to 200 m data using majority resample.

4) Clip results down to the South Atlantic LCC freshwater marsh ecosystem.

The final indicator is continuous, with values ranging as follows:

High: 11,907 ha patch (likely to support least bittern, Northern pintail, Northern shoveler, and king rail)

Low: 0 (< 1 ha patch not likely to support freshwater marsh bird index species)

### Defining the Spatial Extent of Ecosystems

This indicator has been clipped to the freshwater marsh ecosystem, as defined in the Ecosystem Map section under Freshwater Marsh.

## Known Issues

-- The distinction between fresh and estuarine marsh was determined by the National Wetlands Inventory (NWI), but the accuracy of this data has not been documented. Other misclassifications of freshwater marsh appear to include wet pastures or grasslands and wet areas planted with winter wheat.

-- The amount of open water within freshwater marsh (i.e., open water-vegetation edge) and the wetland's hydroperiod are critical to wildlife, but the ephemeral nature of water in this ecosystem makes it difficult to measure with currently available GIS data.

## Disclaimer: Comparing with Older Indicator Versions

While this indicator has changed since the version of freshwater marsh birds used in Blueprint 2.0, this only reflects differences in the way it was calculated and should not be compared to measure change over time.

## Literature Cited

Bogner, H. E., and G. A. Baldassarre. 2002. Home range, movement, and nesting of least bitterns in western New York. Wilson Bulletin 114:297-308.

Brown, M., and J. J. Dinsmore. 1986. Implications of marsh size and isolation for marsh bird management. The Journal of wildlife management:392-397.

Drew, C. A., and J. A. Collazo. 2014. Bayesian networks as a framework to step-down and support Strategic Habitat Conservation of data-poor species: A case study with king rail (*Rallus elegans*) in Eastern North Carolina and Southeastern Virginia, Prepared for the United States Fish and Wildlife Service Raleigh Field Office.

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Moore, S., J. R. Nawrot, and J. P. Severson. 2009. Wetland-scale habitat determinants influencing least bittern use of created wetlands. Waterbirds 32:16-24.

Pickens, B. A., and S. L. King. 2013. Microhabitat selection, demography, and correlates with home range size for the king rail (*Rallus elegans*). Waterbirds 36:319-329.

Pickens, B. A., and S. L. King. 2014a. Linking multi-temporal satellite imagery to coastal wetland dynamics and bird distribution. Ecological Modelling 285:1-12.

Pickens, B. A., and S. L. King. 2014b. Multiscale habitat selection of wetland birds in the northern Gulf Coast. Estuaries and Coasts 37:1301-1311.

## Integrity Scores

This data represents the Blueprint 2.1 ecosystem integrity scores for the freshwater marsh ecosystem within the South Atlantic LCC geography. To read more about the indicators, please see the Indicators section under each ecosystem heading.

### *Input Data and Mapping Steps*

Indicators (200 m resolution) were spatially modeled, tested, reviewed, and used as inputs to derive high integrity areas. The integrity scores for this system are based on a freshwater marsh indicator and the landscapes indicators, freshwater aquatic indicators, and waterscapes indicators. These indicators served as inputs into Zonation, a conservation planning framework and software that produces a hierarchal prioritization of the landscape. Zonation employs an algorithm that proceeds by removing cells of lowest conservation value, minimizing marginal loss to produce a spatial prioritization at a fine scale. Freshwater marsh extent is already captured through the ecosystem map, so we did not use it an input to Zonation.

#### Zonation Parameters and Inputs

-- Inputs: Freshwater marsh indicator (freshwater marsh birds), landscapes indicators (low road density, resilient biodiversity hotspots, and low-urban historic landscapes), freshwater aquatic indicators (imperiled aquatic species, permeable surface, and riparian buffers), and waterscapes indicators (migratory fish connectivity and network complexity).

-- Removal rule = 1 (basic core-area Zonation): In basic core-area Zonation (commonly CAZ), cell removal is done in a manner that minimizes biological loss by picking the cell that has the smallest occurrence for the most valuable feature over all biodiversity features in the cell. In other words, the cell gets a high value if even one species has a relatively important occurrence there.

-- Warp factor = 1: The warp factor defines how many cells are removed at a time per iteration. A lower warp factor provides a finer resolution, but requires a longer model run time. A higher warp factor reduces the time required to run a model, but results in a coarser resolution.

-- Boundary length penalty = 0 (not used): Boundary length penalty (BLP) is a method to induce aggregation of high priority areas. Using a BLP, the hierarchy of cell removal is based upon the conservation value of the cell and the increase/decrease of boundary length that results from the removal of a cell.

-- Edge removal = 1: Determines whether the program removes cells from the edges of remaining landscape (value = 1) or anywhere from the landscape (value = 0). Note that setting this parameter to 0 will increase the running times with large landscapes.

-- Indicator weights = 1 for all indicators. All indicators were weighted equally in the Zonation run.

For more information on the reasoning behind the Zonation settings used for each ecosystem, please refer to the Blueprint 2.1 section under Indicator Analysis.

## *Literature Cited*

Moilanen, A., L. Meller, J. Leppänen, F.M. Pouzols, H. Kujala, A. Arponen. 2014. Zonation Spatial Conservation Planning Framework and Software V4.0, User Manual.

# Marine

## Ecosystem Map

The marine extent of Blueprint 2.1 includes portions of the Atlantic Ocean. The Gulf portions were not included due to the small extent of the Gulf marine environment in the South Atlantic geography, the lack of defined boundaries in any direction, and the extensive spatial planning efforts already ongoing in the Gulf of Mexico (e.g., the Ocean Conservancy). The U.S. Exclusive Economic Zone (EEZ), which extends 200 miles into the ocean, delineates the eastern boundary of the marine ecosystem. The northern and southern boundaries were delineated by extending parallel lines out from the coast at roughly 30 degrees latitude (southern boundary) and 37 degrees latitude (northern boundary). In Blueprint 1.0, the use of Outer Continental Shelf lease block layers as the marine spatial extent produced a gap between the marine and inland components of the Blueprint. To fill this gap in Blueprint 2.1, the western boundary of the marine ecosystem was delineated by buffering the marine extent of Blueprint 1.0 by 7 miles, then removing all pixels already classified as an inland ecosystem.

During the process of rescaling data to a 200 m resolution, ecosystems were overlaid and overlaps were handled by ordering them from high (never excluded by another ecosystem) to low (always excluded by another ecosystem). To avoid data loss, linear features, such as maritime forests, were ranked relatively high. The ranking proceeded as: 10) maritime forest, 9) beaches and dunes, 8) estuaries, 7) major waterbodies, 6) localized data on pine land cover, 5) forested wetlands, 4) freshwater marsh, 3) longleaf pine range, 2) upland hardwoods, 1) marine.

### *Known Issues*

-- Some small areas of estuarine open water near the coast may be misclassified as marine.

## Ecosystem-Specific Indicators

The South Atlantic ecosystem indicators serve as the South Atlantic LCC's metrics of success and drive the identification of priority areas for shared action in the Conservation Blueprint. To learn more about the indicators and how they are being used, please visit the indicator page. Check out the Blueprint page for more information on the development of the Blueprint, a living spatial plan to conserve our natural and cultural resources.

### *Potential Hardbottom Condition*

This layer is one of the South Atlantic LCC indicators in the marine ecosystem. It is an index of the potential condition of deepwater corals and other hardbottom habitats.

#### Reason for Selection

Hardbottom (including corals and livebottom) extent and condition is particularly important for a variety of marine species, is impacted by landscape scale stressors (e.g., water quality degradation, mining, dredging, and beach renourishment), can be monitored and modeled with existing information, and is widely used and understood by diverse partners.

## Input Data

-- The Nature Conservancy's (TNC) South Atlantic Bight Marine Assessment. For more details on the seafloor habitats analysis, please refer to this pdf.

-- South Atlantic Fishery Management Council (SAFMC) Deepwater Coral Habitat Areas of Particular Concern (Coral HAPCs)

-- Commercial Vessel Density (2009 - 2010)

-- Ocean dredge disposal sites for FL, GA, SC, and NC

## Mapping Steps

Indicators that have not changed since Blueprint 2.0 were initially computed, or in the case of existing data, resampled to 1 ha spatial resolution using the nearest neighbor method. For computational reasons, we then used the ArcGIS Spatial Analyst-Aggregate function to rescale the resolution to 200 m. The aggregate function avoided loss of detail by taking the maximum value of each cell in the conversion (e.g., species presence).

We combined hardbottom predictions, areas of high commercial shipping traffic, dredge disposal sites, and SAFMC Deepwater Coral HAPCs to classify three types of potential hardbottom condition: areas likely stressed by human activity (category 1, those overlapping with high shipping traffic or dredge disposal sites), areas less likely stressed by human activities (category 2, comprised of areas not part of category 1, but lacking the additional protections in the next category), and areas likely in best condition due to additional protections (category 3, those that are part of the Deepwater Coral HAPCs and have additional restrictions on fishing gear and coral harvest). We defined high commercial shipping traffic as 501 vessels and above (classification code 7 and above).

Data were classified as described above into the following rankings:

0 = Hardbottom not predicted

1 = Hardbottom likely stressed by human activities

2 = Hardbottom less likely stressed by human activities

3 = Hardbottom likely in best condition due to additional protections

## Defining the Spatial Extent of Ecosystems

This indicator has been clipped to the marine ecosystem, as defined in the Ecosystem Map section under Marine.

## Known Issues

-- Underpredicts hardbottom in many areas.

-- Hardbottom under protection can take a long time to recover. Protected status may not always indicate hardbottom currently in good condition and may also include areas likely to be in good condition in the future if current protections continue.

-- This indicator only considers commercial shipping traffic and dredge disposal sites as threats. Other threats, such as fishing gear, energy exploration/production, and impacts to water quality are not included.

### Literature Cited

Anderson, M.G., A. Barnett, M, Conley, K. Goodin, J. Prince and K. Weaver. 2015. Seafloor Habitats of the South Atlantic Bight Marine Region. in Conley, M, M.G. Anderson, L. Geselbracht, eds. The South Atlantic Bight Marine Ecoregional Assessment. The Nature Conservancy, Eastern U.S. Division, Boston, MA. <http://easterndivision.s3.amazonaws.com/Marine/SABMA/FINAL_DRAFT_SABMA_seafloor_habitats_090415.pdf>.

Department of Commerce, National Oceanic and Atmospheric Administration (NOAA), National Ocean Service, Coastal Services Center. 2012. 2010 United States Automatic Identification System Database, Commercial Vessel Density (2009 - 2010). NOAA's Ocean Service, Coastal Services Center. Available: http://gsaaportal.org/explore/catalog#commercial-vessel-density-2009-2010-links.

Florida Fish and Wildlife Conservation Commission (FWC), Fish and Wildlife Research Institute (FWRI). 2008. Deepwater Coral HAPCs. South Atlantic Fishery Management Council (SAFMC). Available: http://www.safmc.net/ecosystem-management/mapping-and-gis-data.

U.S. Army Corps of Engineers. 2010-2013. Ocean dredged material disposal sites for the state of North Carolina, South Carolina, Georgia, Florida. Available: http://gsaaportal.org/explore/catalog#ocean-dredge-material-disposal-areas-links.

## *Marine Mammals*

This layer is one of the South Atlantic LCC indicators in the marine ecosystem. It is an index of highly productive areas for dolphins and whales. It uses monthly density predictions for ten species of cetaceans and yearly density predictions for three rarer cetacean species.

### Reason for Selection

Marine mammals help identify key areas of ocean productivity and overall ocean health, are regularly monitored, and resonate with a variety of audiences. Marine mammals are often used as ocean health indicators due to their long life spans, feeding at a high trophic levels, and large blubber stores that can serve as repositories for anthropogenic chemicals and toxins (Bossart 2011).

### Input Data

Input data for this indicator was provided by the Duke Marine Lab. These habitat-based density models cover the entire U.S. Atlantic. They use aggregated survey information, distance-sampling, and oceanographic variables to predict cetacean density throughout the region. Species with monthly

models used in this indicator are: North Atlantic Right Whale, Sperm Whale, Sei Whale, Humpback Whale, Fin Whale, Bottlenose Dolphin, Short-Beaked Common Dolphin, Risso's Dolphin, Harbor Porpoise, and Atlantic White-Sided Dolphin. Species with yearly models used in this indicator are: Pilot Whale, Beaked Whale, and Striped Dolphin. Additional species not included (e.g., minke whale) lacked sufficient data to produce detailed models for the entire South Atlantic area.

For additional information, please visit the project page.

### Mapping Steps

1) To identify high quality areas for each species during each month, we used the core area algorithm in Zonation. We included each monthly density layer for each species as a separate input and weighted them equally. We used the information gap uncertainty option on the coefficient of variation with an alpha of 1 ensure robustness to the spatial uncertainty in each model. To account for boundary effects, we ran all the models across the entire U.S. Atlantic.

2) We then clipped down the results to the South Atlantic region.

The final indicator is continuous, with values ranging from:

High: 100 (most important for seasonal density of marine mammal index species)

Low: 0 (least important for seasonal density of marine mammal index species)

### Defining the Spatial Extent of Ecosystems

This indicator has been clipped to the marine ecosystem, as defined in the Ecosystem Map section under Marine.

### Known Issues

-- North Atlantic right whale models are underpredicting densities in the calving grounds, likely due to the limited amount of sighting data available at the time the models were run. An updated version of the right whale input data using far more sighting information is in production.

### Literature Cited

Roberts JJ, Best BD, Mannocci L, Fujioka E, Halpin PN, Palka DL, Garrison LP, Mullin KD, Cole TVN, Khan CB, McLellan WM, Pabst DA, Lockhart GG (2016) Habitat-based cetacean density models for the U.S. Atlantic and Gulf of Mexico. Scientific Reports 6: 22615. doi: 10.1038/srep22615.

Bossart, G. D. "Marine Mammals as Sentinel Species for Oceans and Human Health." Veterinary Pathology Online 48, no. 3 (May 1, 2011): 676–90. doi:10.1177/0300985810388525.

## Integrity Scores

This data represents the Blueprint 2.1 ecosystem integrity scores for the marine ecosystem within the South Atlantic LCC geography. To read more about the indicators, please see the Indicators section under each ecosystem heading.

## *Input Data and Mapping Steps*

Indicators (200 m resolution) were spatially modeled, tested, reviewed, and used as inputs to derive high integrity areas. The integrity scores for this system are based on the marine indicators. These indicators served as inputs into Zonation, a conservation planning framework and software that produces a hierarchal prioritization of the landscape. Zonation employs an algorithm that proceeds by removing cells of lowest conservation value, minimizing marginal loss to produce a spatial prioritization at a fine scale.

## *Zonation Parameters and Inputs*

-- Inputs: Marine indicators (marine mammals, potential hardbottom condition). Depth zones were also used in an attempt to stratify the results (deep circalittoral, deep mesobenthic, infralittoral, shallow circalittoral, shallow mesobenthic, bathybentic, not classified by SABMA project). Spatial depictions of depth zones came from The Nature Conservancy's (TNC) South Atlantic Bight Marine Assessment (SAMBA).

-- Removal rule = 1 (basic core-area Zonation): In basic core-area Zonation (commonly CAZ), cell removal is done in a manner that minimizes biological loss by picking the cell that has the smallest occurrence for the most valuable feature over all biodiversity features in the cell. In other words, the cell gets a high value if even one species has a relatively important occurrence there.

-- Warp factor = 1000: The warp factor defines how many cells are removed at a time per iteration. A lower warp factor provides a finer resolution, but requires a longer model run time. A higher warp factor reduces the time required to run a model, but results in a coarser resolution.

-- Boundary length penalty = 0 (not used): Boundary length penalty (BLP) is a method to induce aggregation of high priority areas. Using a BLP, the hierarchy of cell removal is based upon the conservation value of the cell and the increase/decrease of boundary length that results from the removal of a cell.

-- Edge removal = 1: Determines whether the program removes cells from the edges of remaining landscape (value = 1) or anywhere from the landscape (value = 0). Note that setting this parameter to 0 will increase the running times with large landscapes.

-- Indicator weights = 0.1 for potential hardbottom condition, 0.1 for marine depth zones, 1 for all other indicators. We began ecosystem runs with all indicators weighted equally. Due to the small extent of the potential hardbottom condition indicator and marine depth zones, the Zonation results included the full extent of these Blueprint inputs in the top 10% of the prioritization. This meant that even areas with the lowest indicator values and no overlap with other high indicator values would end up in the highest priority class. To resolve this, we reduced the indicator weight until some areas with lower indicator values were outside of the top 10%. We tested weights of 0.75, 0.6, 0.5, 0.25, 0.1. All other indicators were weighted equally in the final Zonation run.

For more information on the reasoning behind the Zonation settings used for each ecosystem, please refer to the Blueprint 2.1 section under Indicator Analysis.

## *Literature Cited*

Moilanen, A., L. Meller, J. Leppänen, F.M. Pouzols, H. Kujala, A. Arponen. 2014. Zonation Spatial Conservation Planning Framework and Software V4.0, User Manual.

# Maritime Forest

## Ecosystem Map

Maritime forest distribution was obtained from each state:

-- VA: Berman, M.R. and H. Berquist, 2007. Coastal Maritime Forests in Virginia - Delineation and Distribution. Final report submitted to Virginia Coastal Zone Management Program, Department of Environmental Quality, Richmond, Virginia, pp. 15. <http://ccrm.vims.edu/gis_data_maps/data/maritimeforest/index.html>. Accessed 1 April 2014.

-- NC: Hall, Stephen. 2008. Statewide Assessment of Conservation Priorities at the Landscape Level. North Carolina Natural Heritage Program.

-- SC: SC GAP Analysis Program. Accessed 1 April 2014. Since the data layer was from the early 1990s, we removed all maritime forest areas now classified as developed.

-- GA: Nongame Conservation Section, Wildlife Resources Division, GA DNR. <http://www.georgiawildlife.org/node/2011/>.

-- FL: Florida Natural Areas Inventory. 2012. Florida Cooperative Land Cover Map, Version 2.3. Tallahassee, Florida. <http://www.fnai.org/LandCover.cfm>. Accessed 1 April 2014.

Virginia, North Carolina, and Georgia data were originally in vector format; South Carolina data was at a 30 m resolution and Florida data was a 15 m resolution. To combine layers without losing narrow segments of maritime forests, we resampled data to 10 m and then used the ArcGIS Spatial Analyst-Aggregate function to use the maximum value within 1 ha cells. To update the entire layer to 2011, we removed maritime forest that was classified as "developed" (classes 21-24) in the 2011 National Land Cover Database (NLCD) (resampled to 100 m).

During the process of rescaling data to a 200 m resolution, ecosystems were overlaid and overlaps were handled by ordering them from high (never excluded by another ecosystem) to low (always excluded by another ecosystem). To avoid data loss, linear features, such as maritime forests, were ranked relatively high. The ranking proceeded as: 10) maritime forest, 9) beaches and dunes, 8) estuaries, 7) major waterbodies, 6) localized data on pine land cover, 5) forested wetlands, 4) freshwater marsh, 3) longleaf pine range, 2) upland hardwoods, 1) marine. At the end of this process, there were still pixels left unclassified. We filled in these pixels using the following classes from Landfire Biophysical Settings data: Central Atlantic Coastal Plain Maritime Forest, East Gulf Coastal Plain Maritime Forest, Northern Atlantic Coastal Plain Maritime Forest, and Southern Atlantic Coastal Plain Maritime Forest.

### *Known Issues*

-- Maritime forests are poorly mapped in South Carolina, while the other states have relatively recent distribution maps derived with the help of ground-truthing.

### *Literature Cited*

Berman, M.R. and H. Berquist, 2007. Coastal Maritime Forests in Virginia - Delineation and Distribution. Final report submitted to Virginia Coastal Zone Management Program, Department of Environmental Quality, Richmond, Virginia, pp. 15. <http://ccrm.vims.edu/gis_data_maps/data/maritimeforest/index.html>. Accessed 1 April 2014.

Florida Natural Areas Inventory. 2012. Florida Cooperative Land Cover Map, Version 2.3. Tallahassee, Florida. <http://www.fnai.org/LandCover.cfm>. Accessed 1 April 2014.

Georgia Department of Natural Resources. 2013. Nongame Conservation Section Biotics Database. Wildlife Resources Division, Social Circle, GA. Available: http://www.georgiawildlife.org/node/2011/ (April 2014).

Hall, Stephen. 2008. Statewide Assessment of Conservation Priorities at the Landscape Level. North Carolina Natural Heritage Program.

Homer, C.G., Dewitz, J.A., Yang, L., Jin, S., Danielson, P., Xian, G., Coulston, J., Herold, N.D., Wickham, J.D., and Megown, K., 2015, Completion of the 2011 National Land Cover Database for the conterminous United States-Representing a decade of land cover change information. Photogrammetric Engineering and Remote Sensing, v. 81, no. 5, p. 345-354.

South Carolina Cooperative Fish and Wildlife Research Unit, USGS Biological Resources Division. 2001. South Carolina 27-Class Land Cover, GAP Analysis Program. Clemson, SC. Available: <http://www.dnr.sc.gov/GIS/gap/mapping.html> (April 2014).

U.S. Geological Survey, Earth Resources Observation and Science (EROS) Center. 2010. LANDFIRE Biophysical Settings: LANDFIRE 2012 (LF 1.3.0). <http://www.landfire.gov>.

## Ecosystem-Specific Indicators

The South Atlantic ecosystem indicators serve as the South Atlantic LCC's metrics of success and drive the identification of priority areas for shared action in the Conservation Blueprint. To learn more about the indicators and how they are being used, please visit the indicator page. Check out the Blueprint page for more information on the development of the Blueprint, a living spatial plan to conserve our natural and cultural resources.

### *Maritime Forest Extent*

Maritime forest extent is the only ecosystem-specific indicator in the maritime forest ecosystem. It is already captured through the ecosystem map, so we did not use it an input to Zonation. Please see the Ecosystem Map section under Maritime Forest for more information on how this indicator was developed.

## Integrity Scores

This data represents the Blueprint 2.1 ecosystem integrity scores for the maritime forest ecosystem within the South Atlantic LCC geography. To read more about the indicators, please see the Indicators section under each ecosystem heading.

### *Input Data and Mapping Steps*

Indicators (200 m resolution) were spatially modeled, tested, reviewed, and used as inputs to derive high integrity areas. The integrity scores for this system are based on some landscape indicators and a freshwater aquatic indicator. These indicators served as inputs into Zonation, a conservation planning framework and software that produces a hierarchal prioritization of the landscape. Zonation employs an algorithm that proceeds by removing cells of lowest conservation value, minimizing marginal loss to produce a spatial prioritization at a fine scale. Maritime forest extent is the only ecosystem-specific indicator in the maritime forest ecosystem. It is already captured through the ecosystem map, so we did not use it an input to Zonation.

#### Zonation Parameters and Inputs

-- Inputs: Landscapes indicators (low road density, low-urban historic landscapes) and a freshwater aquatic indicator (permeable surface).

-- Removal rule = 1 (basic core-area Zonation): In basic core-area Zonation (commonly CAZ), cell removal is done in a manner that minimizes biological loss by picking the cell that has the smallest occurrence for the most valuable feature over all biodiversity features in the cell. In other words, the cell gets a high value if even one species has a relatively important occurrence there.

-- Warp factor = 1: The warp factor defines how many cells are removed at a time per iteration. A lower warp factor provides a finer resolution, but requires a longer model run time. A higher warp factor reduces the time required to run a model, but results in a coarser resolution.

-- Boundary length penalty = 0 (not used): Boundary length penalty (BLP) is a method to induce aggregation of high priority areas. Using a BLP, the hierarchy of cell removal is based upon the conservation value of the cell and the increase/decrease of boundary length that results from the removal of a cell.

-- Edge removal = 1: Determines whether the program removes cells from the edges of remaining landscape (value = 1) or anywhere from the landscape (value = 0). Note that setting this parameter to 0 will increase the running times with large landscapes.

-- Indicator weights = 1 for all indicators. All indicators were weighted equally in the Zonation run.

For more information on the reasoning behind the Zonation settings used for each ecosystem, please refer to the Blueprint 2.1 section under Indicator Analysis.

### *Literature Cited*

Moilanen, A., L. Meller, J. Leppänen, F.M. Pouzols, H. Kujala, A. Arponen. 2014. Zonation Spatial Conservation Planning Framework and Software V4.0, User Manual.

# Pine & Prairie

## Ecosystem Map

The pine woodland, savanna, and prairie ecosystem was defined by current pine/pine flatwoods/longleaf pine communities combined with uplands within the historic range of longleaf pine as defined by Little's range (Climate Change Atlas: Landscape Change Research Group 2014). Little's tree range boundaries were originally published in the 1970s, and data were based on field surveys, herbarium records, and expert knowledge. We expanded this range map with historical accounts of longleaf pine in Virginia (Frost 1993). Due to NLCD (Homer et al. 2015) misclassifications between woody wetlands and mesic longleaf pine communities, we further defined the pine ecosystem with state-level land cover data and with RCW locations in known pine habitats (for FL, GA, SC). The following classifications were considered within the pine zone:

1) Florida (Florida Natural Areas Inventory 2012): wet coniferous plantation, wet flatwoods, and tree plantations.

2) Georgia (Georgia Department of Natural Resources 2013): longleaf pine-scrub oak woodlands, longleaf pine-scrub oak woodlands/longleaf pine-wiregrass savannas, longleaf pine-wiregrass savannas, pine flatwoods, pine flatwoods/wet pine savannas/herbaceous and shrub bogs, wet pine savannas/herb and shrub bogs.

3) North Carolina (Hall 2008): wet-xeric longleaf pine woodlands/ephemeral pools, wet-xeric longleaf-wiregrass woodlands, xeric-mesic longleaf pine and mixed oak woodland.

4) South Carolina GAP land cover (accessed 1 April 2014): closed canopy evergreen forest/woodland, open canopy/recently cleared forest, and pine woodland. In addition, we used the Okefenokee National Wildlife Refuge conservation plan (Fish and Wildlife Service 2006) to identify uplands.

During the process of rescaling data to a 200 m resolution, ecosystems were overlaid and overlaps were handled by ordering them from high (never excluded by another ecosystem) to low (always excluded by another ecosystem). To avoid data loss, linear features, such as maritime forests, were ranked relatively high. The ranking proceeded as: 10) maritime forest, 9) beaches and dunes, 8) estuaries, 7) major waterbodies, 6) localized data on pine land cover, 5) forested wetlands, 4) freshwater marsh, 3) longleaf pine range, 2) upland hardwoods, 1) marine. At the end of this process, there were still pixels left unclassified. We filled in these pixels using the following classes from Landfire Biophysical Settings data: Atlantic Coastal Plain Dry and Dry-Mesic Oak Forest, Atlantic Coastal Plain Fall-line Sandhills Longleaf Pine Woodland, Atlantic Coastal Plain Upland Longleaf Pine Woodland, Central Atlantic Coastal Plain Wet Longleaf Pine Savanna and Flatwoods, Central Florida Pine Flatwoods, East Gulf Coastal Plain Interior Upland Longleaf Pine Woodland, East Gulf Coastal Plain Near-Coast Pine Flatwoods, East Gulf Coastal Plain Northern Dry Upland Hardwood Forest, Florida Longleaf Pine Sandhill, Northern Atlantic Coastal Plain Hardwood Forest, Southeastern Interior Longleaf Pine Woodland, Southern Atlantic Coastal Plain Wet Pine Savanna and Flatwoods, Southern Coastal Plain Blackland Prairie and Woodland, and Southern Coastal Plain Dry Upland Hardwood Forest.

### *Known Issues*

-- The historic longleaf range used to delineate the boundary between upland hardwood and pine and prairie is relatively coarse and likely misclassified some areas near the boundary.

### *Literature Cited*

Climate change atlas: Landscape Change Research Group 2014. Climate change atlas. <http://www.nrs.fs.fed.us/atlas> (Accessed 15 May 2014).

Fish and Wildlife Service. 2006. Okefenokee National Wildlife Refuge Comprehensive Conservation Plan, U.S. Department of the Interior, Fish and Wildlife Service, Southeast Region.

Florida Natural Areas Inventory. 2012. Florida Cooperative Land Cover Map, Version 2.3. Tallahassee, Florida. <http://www.fnai.org/LandCover.cfm>. Accessed 1 April 2014.

Frost, C. C. 1993. Four centuries of changing landscape patterns in the longleaf pine ecosystem, p. 17-43. Proceedings of the Tall Timbers fire ecology conference. Tall Timbers Research Station, Tallahassee, FL.

Georgia Department of Natural Resources. 2013. Nongame Conservation Section Biotics Database. Wildlife Resources Division, Social Circle, GA. Available: http://www.georgiawildlife.org/node/2011/ (April 2014).

Hall, Stephen. 2008. Statewide Assessment of Conservation Priorities at the Landscape Level. North Carolina Natural Heritage Program.

South Carolina Cooperative Fish and Wildlife Research Unit, USGS Biological Resources Division. 2001. South Carolina 27-Class Land Cover, GAP Analysis Program. Clemson, SC. Available: http://www.dnr.sc.gov/GIS/gap/mapping.html (April 2014).

U.S. Geological Survey, Earth Resources Observation and Science (EROS) Center. 2010. LANDFIRE Biophysical Settings: LANDFIRE 2012 (LF 1.3.0). <http://www.landfire.gov>.

## Ecosystem-Specific Indicators

The South Atlantic ecosystem indicators serve as the South Atlantic LCC's metrics of success and drive the identification of priority areas for shared action in the Conservation Blueprint. To learn more about the indicators and how they are being used, please visit the indicator page. Check out the Blueprint page for more information on the development of the Blueprint, a living spatial plan to conserve our natural and cultural resources.

### *Regularly Burned Habitat*

This layer is one of the South Atlantic LCC indicators in the pine woodland, savanna and prairie ecosystem. It captures acres of fire-maintained, open canopy pine and prairie habitat.

#### Reason for Selection

This indicator represents the overall structure and condition of the habitat, is regularly monitored, and is widely used and understood by diverse partners. LANDFIRE is regularly updated.

## Input Data

-- Data from the LANDFIRE program (also known as the Landscape Fire and Resource Management Planning Tools) were used to quantify fire distribution. LANDFIRE is a cooperative project from The Nature Conservancy, the USDA Forest Service, Department of the Interior, and other agencies. Specifically, vegetation disturbance data for 1999–2010 derived from Landsat satellite imagery, local agency data contributions, and ancillary data (Ryan and Opperman 2013, Vogelmann et al. 2011).

-- 2011 National Land Cover Database (NLCD): Used to define urban areas as described in mapping steps

## Mapping Steps

Indicators that have not changed since Blueprint 2.0 were initially computed, or in the case of existing data, resampled to 1 ha spatial resolution using the nearest neighbor method. For computational reasons, we then used the ArcGIS Spatial Analyst-Aggregate function to rescale the resolution to 200 m. The aggregate function avoided loss of detail by taking the maximum value of each cell in the conversion (e.g., species presence).

1) From the disturbance data, we only used disturbances from fires, which excluded mechanical, chemical, and unknown disturbances.

2) The ArcGIS Spatial Analyst-Aggregate (maximum) function was used to rescale data to a 1 km resolution.

3) From the 1 km grid size, we then removed all areas classified as human development in the 2011 NLCD (100 m resolution; classifications categories 21-24) and resampled the data to 200 m resolution to be consistent with other data sources. The data were classified as follows:

0 = Not recently burned or not open canopy

1 = Recently burned open canopy

## Defining the Spatial Extent of Ecosystems

This indicator has been clipped to the pine and prairie ecosystem, as defined in the Ecosystem Map section under Pine & Prairie.

## Known Issues

-- Data used only depict fires from 1999-2010 and do not fully capture the full fire history of the site. A site burned only once during this period still received the highest score.

-- Predictions are relatively coarse to account for underprediction of fire in moderate (30%-100%) canopy cover areas. This indicator tends to underpredict fire in the northern part of the South Atlantic region, as canopy cover is naturally higher there and therefore more likely to hide the presence of fire.

-- This indicator has not been expanded to cover areas newly added to pine and prairie with the improved ecosystem maps of Blueprint 2.1. These areas are classified as no data in this indicator. Most

of these no data pixels are near the North Carolina coast in areas previously classified as “other” in Blueprint 2.0.

### Literature Cited

Homer, C.G., Dewitz, J.A., Yang, L., Jin, S., Danielson, P., Xian, G., Coulston, J., Herold, N.D., Wickham, J.D., and Megown, K., 2015, Completion of the 2011 National Land Cover Database for the conterminous United States-Representing a decade of land cover change information. Photogrammetric Engineering and Remote Sensing, v. 81, no. 5, p. 345-354.

Ryan, K.C., Opperman, T.S., 2013. LANDFIRE–A national vegetation/fuels data base for use in fuels treatment, restoration, and suppression planning. Forest Ecology and Management 294, 208-216.

Vogelmann, J.E., Kost, J.R., Tolk, B., Howard, S., Short, K., Chen, X., Huang, C., Pabst, K., Rollins, M.G., 2011. Monitoring landscape change for LANDFIRE using multi-temporal satellite imagery and ancillary data. Selected Topics in Applied Earth Observations and Remote Sensing, IEEE Journal of 4, 252-264.

## *Pine and Prairie Birds*

This layer is one of the South Atlantic LCC indicators in the pine woodland, savanna and prairie ecosystem. It is an index combining species distribution and census data for three pine and prairie bird species.

### Reason for Selection

This species index represents the structure and function of pine ecosystems in the Southeast.

### Input Data

The distribution of red-cockaded woodpecker (*Picoides borealis*), Northern bobwhite (*Colinus virginianus*), and Bachman's sparrow (*Aimophila aestivalis*) are included in the index.

#### *Northern Bobwhite*

To model the distribution of bobwhite, the National Bobwhite Technical Committee used an extensive series of initial and revision workshops, where a multitude of experts conducted a spatially explicit habitat ranking based on GIS data and local expert knowledge (The National Bobwhite Technical Committee 2011). Bobwhite habitat suitability was ranked from low to high; for our purposes, we used the highest ranking, "high," as a conservation target (i.e., 0/1).

#### *Red-Cockaded Woodpecker (RCW)*

RCW data were primarily obtained from NatureServe (2014) with cooperation from state Natural Heritage programs of Virginia, North Carolina, South Carolina, Georgia, Alabama, and Florida. Important supplemental data were supplied by Francis Marion National Forest in South Carolina and Tall Timbers Research Station in Florida. We removed records classified as "extirpated" and records with > 2 km of potential location error. Of the remaining locations, we used RCW data when the last recorded observation was 1990 or later. This long timeframe was necessary because private land surveys are often not repeated, Federal and state agreements with landowners may restrict data access, and there is often a substantial lag time for reporting monitoring data on public lands. Locations where RCWs were

last observed from 1970-1989 were often noted as inactive nest cavities or had been surveyed later without finding evidence of RCWs. In contrast, post-1990 data were typically active clusters, although many had not been surveyed regularly. Since the extent of habitat was not always recorded, we also used the point locations, or plotted a point at the center of RCW polygons, and placed a 2 km radius buffer around each point. An 800 m buffer has been suggested and used for RCW locations (James et al. 2001, U.S. Fish and Wildlife Service 2003), but here, we wanted to extend this to account for location errors. We did not include RCW locations within the forested wetland ecosystem east of the Suffolk Scarp of North Carolina (i.e., pocosin habitat), as indicators were restricted to the historic range of the longleaf pine savanna.

### *Bachman's Sparrow*

Bachman's sparrow locations were recorded in three distinct survey projects conducted by the North Carolina Wildlife Resources Commission (NCWRC) (n = 544; 2006-2013), Paul Tallie et al. (2015) (n = 99; 2012), and a Virginia Tech study in cooperation with the U.S. Marine Corps at Camp Lejeune (n = 84; 2010). Paul Taillie (NCWRC), Jeffrey Marcus (The Nature Conservancy), Scott Anderson (NCWRC), and John Carpenter (NCWRC) collected data and summarized existing data sources. Data were collected as part of species-specific point count surveys with call-backs, general point counts, and as incidental observations. Points within 250 m of another presence location were removed from the dataset. Fires were quantified from the LANDFIRE program (also known as the Landscape Fire and Resource Management Planning Tools). The National Land Cover Database (NLCD) classifications of evergreen forest and a combined layer of shrub/scrub and grassland/herbaceous depicted coarse land cover classes. Tree canopy cover was quantified with NLCD. All of these variables were calculated with 3x3 and 9x9 neighborhood statistics. Connectivity was quantified using local connectedness from The Nature Conservancy's Southeastern Terrestrial Resilience dataset (Anderson et al. 2014). This connectivity measure emphasized fragmentation caused by agriculture and urban development. After initial model development, we calculated the amount of habitat within a 5 km radius and included this result in the model.

A resource selection function (RSF) modeling approach was used (Boyce et al. 2002) with pseudo-absences dispersed throughout the survey extent; row crop agriculture and urban classifications (NLCD land cover classes 21-24) were excluded. A logistic regression compared Bachman's sparrow presence with pseudo-absence points. This compared Bachman's sparrow habitat use vs. availability. As results of logistic regression are not directly relevant to assessing a resource selection function, data were divided into training data (60%) and validation data (40%). RSFs are relative measures of habitat use, but we wanted to determine a threshold for estimating presence/absence. Similar to other studies (Wilson et al. 2013, Fedy et al. 2014) we determined the optimal classification threshold with the training data, and applied it to the validation data. We were primarily interested in how well the model performed in predicting presence and the proportion of area predicted.

The results showed canopy cover, evergreen land cover, canopy cover SD, fires, and connectedness were related to Bachman's sparrow. After projection of these variables, we also discovered an association with habitat within a 5 km radius of a cell. The confusion matrix of the validation results

showed 90% classification accuracy. The RSF model predicted 9% of North Carolina as Bachman's sparrow "present" and captured 87% of known Bachman's sparrow presence locations in North Carolina.

Questions about Bachman's sparrow modeling may be directed to Bradley Pickens, bapicken@ncsu.edu.

## Mapping Steps

Models used as inputs to this indicator were initially computed, or in the case of existing data, resampled to 1 ha spatial resolution using the nearest neighbor method. For computational reasons, we then used the ArcGIS Spatial Analyst-Aggregate function to rescale the resolution to 200 m. The aggregate function avoided loss of detail by taking the maximum value of each cell in the conversion (e.g., species presence).

The final pine bird index was derived by summing the number of species in each 200 m cell.

The indicator is classified as follows:

0 = Pine index birds absent (low)

1 = 1 pine index bird present

2 = 2 pine index birds present

3 = 3 pine index birds present (Bachman's sparrow, bobwhite quail, and red-cockaded woodpecker) (high)

## Defining the Spatial Extent of Ecosystems

This indicator has been clipped to the pine and prairie ecosystem, as defined in the Ecosystem Map section under Pine & Prairie.

## Known Issues

-- The model only incorporated Bachman's sparrow presence data from North Carolina and used it to predict the indicator for the whole South Atlantic geography. More data is needed to validate this extrapolation. However, habitat variables were chosen with specific reference to Bachman's sparrow ecology. Fires, canopy cover, evergreen trees, and fragmentation are all known to be factors affecting Bachman's sparrow throughout the Southeast. Definitive absence data would be helpful for verifying the presence/absence threshold chosen here. The 90% accuracy of the model in North Carolina shows that the model is of high quality, but 10% error is still expected. The data should not be treated as a complete census.

-- For RCWs, data is near census level, but data from private lands may be limited in a few localities. Some locations post-1990 could use a more recent verification. Additionally, some data on RCW locations post-1990 are likely still missing from this indicator.

-- The Northern bobwhite model does not provide quantitative abundance estimates. The bobwhite model is based on expert opinion and likely has issues in places where consulted experts had less experience.

## Data Disclaimer

Data are not to be interpreted for legal or regulatory actions. The indicators are intended for conservation planning purposes and to depict the ecological condition of the landscape.

## Disclaimer: Comparing with Older Indicator Versions

While this indicator has changed since the version of pine and prairie birds used in Blueprint 2.0, this only reflects differences in the way it was calculated and should not be compared to measure change over time.

## Literature Cited

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## *Pine and Prairie Amphibians*

This layer is one of the South Atlantic LCC indicators in the pine woodland, savanna and prairie ecosystem. It captures Priority Amphibian and Reptile Conservation Areas in the pine and prairie ecosystem.

### Reason for Selection

Amphibians provide an indicator of the condition and arrangement of embedded isolated wetlands.

### Input Data

South Atlantic LCC Priority Amphibian and Reptile Conservation Areas (PARCAs) served as input data for this indicator. PARCAs are a nonregulatory designation established to raise public awareness and spark voluntary action by landowners and conservation partners to benefit amphibians and/or reptiles. Areas are nominated using scientific criteria and expert review, drawing on the concepts of species rarity, richness, regional responsibility, and landscape integrity. Modeled in part after the Important Bird Areas program developed by BirdLife International, PARCAs are intended to be nationally coordinated but locally implemented at state or regional scales. Importantly, PARCAs are not designed to compete with existing landscape biodiversity initiatives, but to complement them, providing an additional spatially explicit layer for conservation consideration.

PARCAs are intended to be established in areas:

-- capable of supporting viable amphibian and reptile populations,

-- occupied by rare, imperiled, or at-risk species, and

-- rich in species diversity or endemism.

Species used in identifying the pine and prairie PARCAs include: gopher frog, Eastern diamondback rattlesnake, Southern hognose snake, pinesnake, flatwoods salamander, gopher tortoise, striped newt, pine barrens treefrog, and indigo snake.

There are four major implementation steps:

1) Regional PARC task teams or state experts can use the criteria and modify them when appropriate to designate potential PARCAs in their area of interest.

2) Following the identification of all potential PARCAs, the group then reduces these to a final set of exceptional sites that best represent the area of interest.

3) Experts and stakeholders in the area of interest collaborate to produce a map that identifies these peer-reviewed PARCAs.

4) Final PARCAs are shared with the community to encourage the implementation of voluntary habitat management and conservation efforts. PARCA boundaries can be updated as needed.

### Mapping Steps

This indicator was converted from a vector to a 200 m pixel raster using the Feature to Raster function in ArcGIS. PARCAs were clipped to pine woodland, savanna and prairie ecosystem. Indicator values were assigned as follows:

0 = Not a Priority Amphibian and Reptile Conservation Area (PARCA) within pine and prairie

1 = Priority Amphibian and Reptile Conservation Area (PARCA) within pine and prairie

### Defining the Spatial Extent of Ecosystems

This indicator has been clipped to the pine and prairie ecosystem, as defined in the Ecosystem Map section under Pine & Prairie.

### Disclaimer: Comparing with Older Indicator Versions

While this indicator has changed since the version of pine and prairie amphibians used in Blueprint 2.0, this only reflects differences in the way it was calculated and should not be compared to measure change over time.

### Known Issues

-- The mapping of this indicator is relatively coarse and doesn't always capture differences in pixel-level quality in the outer edge of PARCAs.

-- This indicator is binary and doesn't capture the full continuum of value across the South Atlantic.

-- The methods of combining expert knowledge and data in this indicator may have caused some areas that are poorly known and/or under-surveyed to be scored too low.

### Literature Cited

Sutherland and deMaynadier. 2012. Model Criteria and Implementation Guidance for a Priority Amphibian and Reptile Conservation Area (PARCA) System in the USA. Partners in Amphibian and Reptile Conservation, Technical Publication PARCA-1. 28 pp. <http://www.parcplace.org/images/stories/documents/PARCA_System_Criteria_and_Implementation_Guidance_FINAL.pdf>.

## Integrity Scores

This data represents the Blueprint 2.1 ecosystem integrity scores for the pine and prairie ecosystem within the South Atlantic LCC geography. To read more about the indicators, please see the Indicators section under each ecosystem heading.

### *Input Data and Mapping Steps*

Indicators (200 m resolution) were spatially modeled, tested, reviewed, and used as inputs to derive high integrity areas. The integrity scores for this system are based on the pine and prairie indicators,

landscapes indicators, freshwater aquatic indicators, and waterscapes indicators. These indicators served as inputs into Zonation, a conservation planning framework and software that produces a hierarchal prioritization of the landscape. Zonation employs an algorithm that proceeds by removing cells of lowest conservation value, minimizing marginal loss to produce a spatial prioritization at a fine scale.

### Zonation Parameters and Inputs

-- Inputs: Pine and prairie indicators (pine and prairie birds, pine and prairie amphibians, and regularly burned habitat), landscapes indicators (low road density, resilient biodiversity hotspots, and low-urban historic landscapes), freshwater aquatic indicators (imperiled aquatic species, permeable surface, and riparian buffers), and waterscapes indicators (migratory fish connectivity and network complexity).

-- Removal rule = 1 (basic core-area Zonation): In basic core-area Zonation (commonly CAZ), cell removal is done in a manner that minimizes biological loss by picking the cell that has the smallest occurrence for the most valuable feature over all biodiversity features in the cell. In other words, the cell gets a high value if even one species has a relatively important occurrence there.

-- Warp factor = 10: The warp factor defines how many cells are removed at a time per iteration. A lower warp factor provides a finer resolution, but requires a longer model run time. A higher warp factor reduces the time required to run a model, but results in a coarser resolution.

-- Boundary length penalty = 0 (not used): Boundary length penalty (BLP) is a method to induce aggregation of high priority areas. Using a BLP, the hierarchy of cell removal is based upon the conservation value of the cell and the increase/decrease of boundary length that results from the removal of a cell.

-- Edge removal = 1: Determines whether the program removes cells from the edges of remaining landscape (value = 1) or anywhere from the landscape (value = 0). Note that setting this parameter to 0 will increase the running times with large landscapes.

-- Indicator weights = 0.25 for low-urban historic landscapes, 1 for all other indicators. We began ecosystem runs with all indicators weighted equally. Due to the small extent of the low-urban historic landscapes indicator, the Zonation results included the full extent of the indicator in the top 10% of the prioritization. This meant that even areas with the lowest indicator values and no overlap with other high indicator values would end up in the highest priority class. To resolve this, we reduced the indicator weight until some areas with lower indicator values were outside of the top 10%. We tested weights of 0.75, 0.6, 0.5, 0.25, and 0.1. All other indicators were weighted equally in the final Zonation run.

For more information on the reasoning behind the Zonation settings used for each ecosystem, please refer to the Blueprint 2.1 section under Indicator Analysis.

## *Literature Cited*

Moilanen, A., L. Meller, J. Leppänen, F.M. Pouzols, H. Kujala, A. Arponen. 2014. Zonation Spatial Conservation Planning Framework and Software V4.0, User Manual.

# Upland Hardwood

## Ecosystem Map

The upland hardwood ecosystem included the Piedmont region; upland hardwoods were defined as this region minus forested wetlands and NLCD 2011 freshwater emergent wetlands (Homer et al. 2015).

During the process of rescaling data to a 200 m resolution, ecosystems were overlaid and overlaps were handled by ordering them from high (never excluded by another ecosystem) to low (always excluded by another ecosystem). To avoid data loss, linear features, such as maritime forests, were ranked relatively high. The ranking proceeded as: 10) maritime forest, 9) beaches and dunes, 8) estuaries, 7) major waterbodies, 6) localized data on pine land cover, 5) forested wetlands, 4) freshwater marsh, 3) longleaf pine range, 2) upland hardwoods, 1) marine. At the end of this process, there were still pixels left unclassified. We filled in these pixels using the following classes from Landfire Biophysical Settings data: Allegheny-Cumberland Dry Oak Forest and Woodland, Appalachian (Hemlock-)Northern Hardwood Forest, Central and Southern Appalachian Montane Oak Forest, Central Appalachian Alkaline Glade and Woodland, Central Appalachian Dry Oak-Pine Forest, Central Appalachian Pine-Oak Rocky Woodland, East Gulf Coastal Plain Interior Shortleaf Pine-Oak Forest, Northeastern Interior Dry-Mesic Oak Forest, Southern and Central Appalachian Cove Forest, Southern Appalachian Low-Elevation Pine Forest, Southern Appalachian Montane Pine Forest and Woodland, Southern Appalachian Northern Hardwood Forest, Southern Appalachian Oak Forest, Southern Piedmont Dry Oak(-Pine) Forest, Southern Piedmont Mesic Forest, and Southern Ridge and Valley/Cumberland Dry Calcareous Forest.

### *Known Issues*

-- The historic longleaf range used to delineate the boundary between upland hardwood and pine and prairie is relatively coarse and likely misclassified some areas near the boundary.

-- Limiting upland hardwood to the Piedmont resulted in a small amount of naturally occurring upland hardwood forest in the Coastal Plain being misclassified as pine and prairie.

### *Literature Cited*

Homer, C.G., Dewitz, J.A., Yang, L., Jin, S., Danielson, P., Xian, G., Coulston, J., Herold, N.D., Wickham, J.D., and Megown, K., 2015, Completion of the 2011 National Land Cover Database for the conterminous United States-Representing a decade of land cover change information. Photogrammetric Engineering and Remote Sensing, v. 81, no. 5, p. 345-354.

U.S. Geological Survey, Earth Resources Observation and Science (EROS) Center. 2010. LANDFIRE Biophysical Settings: LANDFIRE 2012 (LF 1.3.0). <http://www.landfire.gov>.

## Ecosystem-Specific Indicators

The South Atlantic ecosystem indicators serve as the South Atlantic LCC's metrics of success and drive the identification of priority areas for shared action in the Conservation Blueprint. To learn more about the indicators and how they are being used, please visit the indicator page. Check out the Blueprint page

for more information on the development of the Blueprint, a living spatial plan to conserve our natural and cultural resources.

## *Upland Hardwood Birds*

This layer is one of the South Atlantic LCC indicators in the upland hardwood forest ecosystem. It is an index of potential habitat for seven upland hardwood bird species.

### Reason for Selection

This index represents a variety of ecosystem features and is already being modeled and monitored for the entire region by the Atlantic Coast Joint Venture.

### Input Data

-- Designing Sustainable Landscapes models: Swainson's warbler

-- Southeast GAP models: Wood thrush, hooded warbler, Acadian flycatcher, Kentucky warbler

### Mapping Steps

Indicators that have not changed since Blueprint 2.0 were initially computed, or in the case of existing data, resampled to 1 ha spatial resolution using the nearest neighbor method. For computational reasons, we then used the ArcGIS Spatial Analyst-Aggregate function to rescale the resolution to 200 m. The aggregate function avoided loss of detail by taking the maximum value of each cell in the conversion (e.g., species presence).

The index of upland hardwood birds is based on scores representing increasingly restrictive limitations of potential habitat for a suite of species.

Species-based constraints are:

1) Wood thrush (1 ha minimum patch), whip-poor-will (no more than 250 m into forest interior)

2) Hooded warbler (15 ha minimum patch), American woodcock (within 125 m of ecotone edge)

3) Acadian flycatcher (40 ha minimum patch), Kentucky warbler (17 ha minimum patch in wet hardwoods)

4) Swainson’s warbler (350 ha minimum patch within 250 m of water)

The Southeast GAP models (for all species other than Swainson’s warbler) and Designing Sustainable Landscapes models (for Swainson’s warbler) were scored based on the constraints above. All models were then combined so that locations retained the maximum score (e.g. if a location was identified by both the wood thrush and the Swainson’s warbler models, it was given a value of 4).

SE GAP and Designing Sustainable Landscapes models use different approaches for defining a patch. In the case of the upland hardwood bird index, the SE GAP models provided a more useful (and restrictive) definition of a patch for all species except for Swainson’s warbler. For Swainson’s warbler, the less restrictive definition in the Designing Sustainable Landscapes model was a better fit for the index and

also maintained consistency with the Swainson's warbler model in the forested wetland bird index (which also used the Designing Sustainable Landscapes model).

The resulting index appears below:

0 = Less potential for presence of upland hardwood bird index species (low)

1 = Potential for presence of wood thrush or whip-poor-will

2 = Potential for additional presence of hooded warbler or American woodcock

3 = Potential for additional presence of Acadian flycatcher or Kentucky warbler

4 = Potential for additional presence of Swainson's warbler (high)

### Defining the Spatial Extent of Ecosystems

This indicator has been clipped to the upland hardwood ecosystem, as defined in the Ecosystem Map section under Upland Hardwood.

### Known Issues

-- Thresholds used in this indicator focus primarily on species presence, and larger patches are likely needed for source populations of any of these species.

-- Bird models are based on 2001 GAP land cover data.

-- This indicator has not been expanded to cover areas newly added to upland hardwood with the improved ecosystem maps of Blueprint 2.1. This resulted in a small number of no data pixels in two areas of the upland hardwood ecosystem as defined in Blueprint 2.1. There are 2 pixels of no data west of Petersburg, VA near the Dinwiddie County Airport and 101 pixels of no data North of Macon, GA near the Jones county line. These no data pixels make up < 0.00004% of the upland hardwoods ecosystem.

### Literature Cited

Williams SG, Rubino MJ. 2012. Designing Sustainable Landscapes Project. Biodiversity and Spatial Information Center, North Carolina State University. Available: http://www.basic.ncsu.edu/dsl/hab.html (April 2014).

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## *Urban Open Space*

This layer is one of the South Atlantic LCC indicators in the upland hardwood forest ecosystem. It is an index based on the distance of urban areas from open space.

## Reason for Selection

This indicator represents the ability of this ecosystem to connect urban residents and nature through nearby open space. It is easily modeled and monitored, and is widely understood by diverse partners.

## Input Data

-- 2011 National Land Cover Database (NLCD)

-- The Nature Conservancy's (TNC) 2014 External Secured Lands Database

-- 2010 Census Urban Area National

## Mapping Steps

This indicator was calculated using 30 m pixel cells, then resampled to 200 m using majority resample.

1) Protected areas were identified using TNC's Secured Lands Database. All areas in the database were treated in the same way, regardless of ownership or GAP level protection status

2) Distance from secured areas was calculated using the Euclidean Distance function in ArcGIS.

3) Areas that were not classified as any of the four developed classes from the 2011 NLCD were given values based on distance from protected areas. Non-urban areas that are not currently close to existing protected lands are given a higher value. The assumption is to prioritize areas that are not already near existing protected lands

4) The final output was clipped down to include only areas inside or within a 3 mile buffer around the 2010 Census urban areas. Indicator values were assigned as follows:

0 = Existing development (low)

1 = Undeveloped area < 400 m from protected land

2 = Undeveloped area 400-800 m from protected land

3 = Undeveloped area 800-1600 m from protected land

4 = Undeveloped area > 1600 m from protected land

5 = Protected land (high)

The values above were all based on impacts of open space on property values in the peer-reviewed literature:

-- 1 mile: Acharya and Bennett (2001), Breffle et al. (1998), Geoghegan (2002), Geoghegan et al. (2003)

-- 0.5 mile: Breffle et al. (1998)

-- 400 m: Acharya and Bennett (2001), Irwin and Bockstael (2001), Ready and Abdalla (2005), Walsh (2004)

## Defining the Spatial Extent of Ecosystems

This indicator has been clipped to the upland hardwood ecosystem, as defined in the Ecosystem Map section under Upland Hardwood.

## Known Issues

-- There are inconsistencies in the representation of urban secured areas across states. This leads to many urban secured areas, particularly in Georgia and South Carolina, not being incorporated into this indicator.

-- Does not incorporate size of secured area, amenities, public safety, or other factors beyond distance that might limit access.

-- Using a hard line at the 3 mile buffer around census urban areas does not account for the more continuous decline in the value of open space as a secured area gets farther from the urban core.

## Disclaimer: Comparing with Older Indicator Versions

While this indicator has changed since the version of urban open space used in Blueprint 2.0, this only reflects differences in the way it was calculated and should not be compared to measure change over time.

## Literature Cited

Acharya, Gayatri, and Lynne Lewis Bennett. 2001. Valuing open space and land-use patterns in urban watersheds. Journal of Real Estate Finance and Economics 22:221-237.

Breffle, William S., Edward R. Morey and Tymon S. Lodder. 1998. Using contingent valuation to estimate a neighborhood's willingness to pay to preserve undeveloped land. Urban Studies 35(4):715-727.

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## Integrity Scores

This data represents the Blueprint 2.1 ecosystem integrity scores for the upland hardwood ecosystem within the South Atlantic LCC geography. To read more about the indicators, please see the Indicators section under each ecosystem heading.

### *Input Data and Mapping Steps*

Indicators (200 m resolution) were spatially modeled, tested, reviewed, and used as inputs to derive high integrity areas. The integrity scores for this system are based on the upland hardwood indicators, landscapes indicators, freshwater aquatic indicators, and waterscapes indicators. These indicators served as inputs into Zonation, a conservation planning framework and software that produces a hierarchal prioritization of the landscape. Zonation employs an algorithm that proceeds by removing cells of lowest conservation value, minimizing marginal loss to produce a spatial prioritization at a fine scale.

#### Zonation Parameters and Inputs

-- Inputs: Upland hardwood indicators (upland hardwood birds and urban open space), landscapes indicators (low road density, resilient biodiversity hotspots, and low-urban historic landscapes), freshwater aquatic indicators (permeable surface, riparian buffers, and imperiled aquatic species), and waterscapes indicators (migratory fish connectivity and network complexity).

-- Removal rule = 1 (basic core-area Zonation): In basic core-area Zonation (commonly CAZ), cell removal is done in a manner that minimizes biological loss by picking the cell that has the smallest occurrence for the most valuable feature over all biodiversity features in the cell. In other words, the cell gets a high value if even one species has a relatively important occurrence there.

-- Warp factor = 10: The warp factor defines how many cells are removed at a time per iteration. A lower warp factor provides a finer resolution, but requires a longer model run time. A higher warp factor reduces the time required to run a model, but results in a coarser resolution.

-- Boundary length penalty = 0 (not used): Boundary length penalty (BLP) is a method to induce aggregation of high priority areas. Using a BLP, the hierarchy of cell removal is based upon the conservation value of the cell and the increase/decrease of boundary length that results from the removal of a cell.

-- Edge removal = 1: Determines whether the program removes cells from the edges of remaining landscape (value = 1) or anywhere from the landscape (value = 0). Note that setting this parameter to 0 will increase the running times with large landscapes.

-- Indicator weights = 0.5 for urban open space, 0.1 for low-urban historic landscapes, 1 for all other indicators. We began ecosystem runs with all indicators weighted equally. Due to the small extent of the low-urban historic landscapes indicator, the Zonation results included the full extent of the indicator in the top 10% of the prioritization. This meant that even areas with the lowest indicator values and no overlap with other high indicator values would end up in the highest priority class. To resolve this, we reduced the indicator weight until some areas with lower indicator values were outside of the top 10%. We tested weights of 0.75, 0.6, 0.5, 0.25, and 0.1. With urban open space, high values had little overlap with high values of other indicators. That indicated strong trade-offs between that indicator and all others. We reduced the weight of that indicator until at least some of the pixels with the highest indicator value dropped below the top 10% of the prioritization. We tested weights of 0.75, 0.5, 0.25, and 0.1. All other indicators were weighted equally in the final Zonation run.

For more information on the reasoning behind the Zonation settings used for each ecosystem, please refer to the Blueprint 2.1 section under Indicator Analysis.

## *Literature Cited*

Moilanen, A., L. Meller, J. Leppänen, F.M. Pouzols, H. Kujala, A. Arponen. 2014. Zonation Spatial Conservation Planning Framework and Software V4.0, User Manual.

# Habitat Aggregates

## Landscapes

### Cross-Ecosystem Indicators

The South Atlantic ecosystem indicators serve as the South Atlantic LCC's metrics of success and drive the identification of priority areas for shared action in the Conservation Blueprint. To learn more about the indicators and how they are being used, please visit the indicator page. Check out the Blueprint page for more information on the development of the Blueprint, a living spatial plan to conserve our natural and cultural resources.

Landscapes and waterscapes are "habitat aggregates" intended to capture connections across all terrestrial and aquatic ecosystems. For the purposes of the Blueprint, the freshwater aquatic ecosystem functions as a habitat aggregate because freshwater aquatic condition is so heavily influenced by the surrounding landscape. Landscapes and waterscapes indicators apply to the entire South Atlantic geography; freshwater aquatic indicators apply to all parts of the South Atlantic LCC geography not classified as marine or estuarine. As a result, no refined ecosystem extent was needed, and no ecosystem map is defined, for these systems. In addition, we do not run a Zonation analysis specific to these systems, so they do not have individual ecosystem integrity scores. Instead, the freshwater aquatic, landscapes, and waterscapes indicators serve as inputs to Zonation within defined ecosystems, as described in the Integrity Scores sections above.

#### *Resilient Biodiversity Hotspots*

This layer is one of the South Atlantic LCC indicators in the landscapes "habitat aggregate", which is intended to capture connections across all terrestrial ecosystems. It is an index of mostly natural, high-diversity areas potentially resilient to climate change.

##### Reason for Selection

Resilience scores quantify a combination of landscape diversity and local connectedness. These measures represent the number of microclimates available to species and the current state of the landscape. This builds on research from Anderson and Ferree (2010), who showed geophysical diversity and elevation range were associated with biodiversity in the Eastern United States. Resilience emphasizes diverse landscapes where species are likely to be able to move and adjust to changing conditions.

##### Input Data

-- Resilient biodiversity hotspots were quantified using The Nature Conservancy's (TNC) Southeastern Terrestrial Resilience dataset (Anderson and Prince 2014). Terrestrial resilience was derived as a normalized combination of two datasets: Local Connectedness and Landscape Diversity. These two datasets were standardized by ecoregion and geophysical setting, so rankings were relative across similar ecosystems.

-- 2011 National Land Cover Database (NLCD): Used to define urban areas as described in mapping steps

## Mapping Steps

Analysis on this indicator was performed using 30 m pixels. It was then converted to 200 m pixels using majority resample.

Landscape diversity ranked sites using the variety of landforms, elevation range, and wetland density (for very flat areas). Local connectedness measured natural land cover types within a 3 km radius of each cell.

1) We use TNC's SE Resilience data where it was available. Where it was not available, we filled in with TNC's NE resilience data.

2) To target specific areas for conservation, we reclassified the original continuous data layer into the seven standard deviation-based classes that TNC uses in display of the data.

3) We used the coastal zone data layer provided by TNC to remove areas in the 0-3 ft elevation zone not well captured by this dataset. These areas were changed to NoData.

4) We used 2011 NLCD to change existing urban areas to 0.

Indicator values were assigned as follows:

0 = Urban

1 = Final Resilience Score: Far below average (< -2 SD)

2 = Final Resilience Score: Below average (-1 to -2 SD)

3 = Final Resilience Score: Slightly below average (-0.5 to -1 SD)

4 = Final Resilience Score: Average (0.5 to -0.5 SD)

5 = Final Resilience Score: Slightly above average (0.5 to 1 SD)

6 = Final Resilience Score: Above average (1 to 2 SD)

7 = Final Resilience Score: Far above average (> 2 SD)

## Defining the Spatial Extent of Ecosystems

Landscapes and waterscapes indicators were defined as features that applied across all terrestrial and aquatic ecosystems and no refined extent was needed.

## Known Issues

-- Does not explicitly account for threats from sea-level rise; therefore, following the recommendation of the data developers, we removed areas in the 0-3 ft elevation zone.

-- Does not account for the occurrence and timing of natural disturbance processes, particularly fire. Without fire, resilient sites in many ecosystems will not serve as biodiversity hotspots. This is particularly problematic in the pine and prairie ecosystem and the shortleaf pine/Piedmont prairie component of the upland hardwood ecosystem.

### Disclaimer: Comparing with Older Indicator Versions

While this indicator has changed since the version of resilient biodiversity hotspots used in Blueprint 2.0, this only reflects differences in the way it was calculated and should not be compared to measure change over time.

### Literature Cited

Anderson, M.G., A. Barnett, M. Clark, C. Ferree, A. Olivero Sheldon, and J., Prince., 2014. Resilient Sites for Terrestrial Conservation in the Southeast Region. The Nature Conservancy, Eastern Conservation Science. 127 pp.

Anderson, M.G., Ferree, C.E., 2010. Conserving the stage: climate change and the geophysical underpinnings of species diversity. PLoS One 5, e11554.

Homer, C.G., Dewitz, J.A., Yang, L., Jin, S., Danielson, P., Xian, G., Coulston, J., Herold, N.D., Wickham, J.D., and Megown, K., 2015, Completion of the 2011 National Land Cover Database for the conterminous United States-Representing a decade of land cover change information. Photogrammetric Engineering and Remote Sensing, v. 81, no. 5, p. 345-354.

## *Low-Urban Historic Landscapes*

This layer is one of the South Atlantic LCC indicators in the landscapes “habitat aggregate”, which is intended to capture connections across all terrestrial ecosystems. It is an index of National Historic Register sites surrounded by limited urban development.

### Reason for Selection

Low-urban historic landscapes indicate significant cultural landscapes whose cultural context has been less impacted by urban growth. Cultural landscapes are “properties [that] represent the combined works of nature and of man" (UNESCO 2012). Reductions in natural habitat within these cultural landscapes reduce their overall historic and cultural value.

### Input Data

-- National Register of Historic Places: The National Register of Historic Places reflects what Americans value in their historic built environment. It is the collection of our human imprint on the landscape that records through time our changing relationship with the landscape, bridging between modern life and our history by providing, as closely as possible, experiences that evoke our empathy and understanding of previous eras. National Register of Historic Places point and polygon features were obtained in April 2014, and the features were last updated in 2012. We used feature polygons whenever possible (rather than points). If no polygon feature was available, the points were buffered by 100 m. The resulting layers were combined and converted to a 200 m raster representing historic places using the methods described below.

-- 2011 National Land Cover Database (NLCD): Used to define urban areas as described in mapping steps

## Mapping Steps

This indicator was analyzed using 30 m pixels, then converted to 200 m pixels using majority resampling.

1) Urban areas were defined using the following classes from the 2011 National Land Cover Database (NLCD) - Developed, High Intensity; Developed, Medium Intensity; Developed, Low Intensity; Developed, Open Space. All urban pixels were classified as 1 and all other pixels were classified as 0.

2) The percent urban in a 270 m radius circle was calculated for each pixel using focal statistics in ArcGIS. Since the NLCD data resolution is 30 m pixels, we used 270 m (9 pixels) to approximate a 250 m radius. All pixels that were < 50% urban within a 270 m radius were retained.

3) The historic places raster was then used to remove areas that fall outside of the historic places. We removed six polygons from the Historic Register that appeared to have errors in the geospatial data. These features (Andalusia, Eric Vernon Folds house, Hampton-Ellis farm, Laurelwood cemetery, Pacific Community Association building, and Locust Hill) were described in the text as small properties, but were represented in the spatial data as long linear features. These errors caused problems in the connectivity analysis of the Blueprint. We are pursuing updates to the National Historic Register to correct them. Indicator values were assigned as follows:

0 = Not in the National Register of Historic Places (low)

1 = Historic place with nearby high-urban buffer

2 = Historic place with nearby low-urban buffer (high)

## Defining the Spatial Extent of Ecosystems

Landscapes and waterscapes indicators were defined as features that applied across all terrestrial and aquatic ecosystems and no refined extent was needed.

## Known Issues

-- There are spatial mapping errors for some of the historic areas.

-- Some historic areas with cultural importance are not necessarily captured in the National Register of Historic Places.

-- The approach to measuring urban growth doesn't capture degradation to historic places that were historically in larger cities (e.g., courthouses and other downtown buildings).

## Disclaimer: Comparing with Older Indicator Versions

While this indicator has changed since the version of low-urban historic landscapes used in Blueprint 2.0, this only reflects differences in the way it was calculated and should not be compared to measure change over time.

### Literature Cited

Homer, C.G., Dewitz, J.A., Yang, L., Jin, S., Danielson, P., Xian, G., Coulston, J., Herold, N.D., Wickham, J.D., and Megown, K., 2015, Completion of the 2011 National Land Cover Database for the conterminous United States-Representing a decade of land cover change information. Photogrammetric Engineering and Remote Sensing, v. 81, no. 5, p. 345-354.

Stutts M. 2014. National Register of Historic Places. National Register properties are located throughout the United States and their associated territories around the globe.

UNESCO (2012) Operational Guidelines for the Implementation of the World Heritage Convention [1]. UNESCO World Heritage Centre. Paris. Page 14.

## *Low Road Density*

This layer is one of the South Atlantic LCC indicators in the landscapes "habitat aggregate", which is intended to capture connections across all terrestrial ecosystems. It is an index of areas with few roads.

### Reason for Selection

Large areas with few roads are favorable for conservation of numerous species, including reptiles and amphibians, birds, and large mammals. Roads can cause negative impacts by promoting dispersal of invasive species and inhibiting water flow. Road density, as well as urban expansion in areas of low road density, are straightforward to measure and monitor. Road density has been used in other broad-scale conservation planning efforts and is widely used and understood by diverse partners.

### Input Data

-- We obtained TIGER (Topologically Integrated Geographic Encoding and Referencing) road files of the South Atlantic LCC region from The Nature Conservancy.

-- We developed a mask to exclude estuaries, large lakes, and reservoirs from the analysis. More specifically, the mask excluded the areas of waterbodies mapped from a 1: 1 million scale (National Atlas of the United States 2014).

-- Estuarine open water was excluded based on National Wetlands Inventory (NWI) data.

### Mapping Steps

Analysis was performed using 200 m pixels. The line density calculation used vector roads and output density in a 200 m pixel raster.

1) All TIGER roads were included in the analysis. The ArcGIS Spatial Analyst-Line Density function was used to estimate road density within a 2 km radius of each cell (km of road per sq km of area). Importantly, the area in the calculation included large waterbodies, and the following steps explain how we accounted for this.

2) Road density was multiplied by the area of the 2 km radius circle (12.56636 sq km). The result was road length within each 2 km radius.

3) Focal statistics were used to sum the terrestrial area (see mask description in the “Input Data” section) within a 2 km radius of each cell.

4) The road length was then divided by the terrestrial area within a 2 km radius. The result was: road density = road length (km) within a 2 km radius/terrestrial area (sq km) within a 2 km radius. Steps 2-4 above helped depict barrier islands and coastal areas where the radius of circles included large bodies of open water.

5) “Low road density areas" were classified as those with < 1.5 km/sq km. Areas with a road density > 1.5 km/sq km have been correlated with skewed sex ratios in turtles (Steen and Gibbs 2004), as excessive female mortality may occur when they are seeking nest sites. We used the ArcGIS Spatial Analyst-Region Group function to calculate low road density patch sizes by connecting patches of cells directly adjacent to each other (4-neighbor rule). A minimum low road density patch size of > 4,050 ha (10,000 acres) was targeted for conservation.

Indicator values were assigned as follows:

0 = High road density (≥ 1.5 km/sq km) or low road density patches smaller than 4,050 ha

1 = Low road density (< 1.5 km/sq km) patches greater than 4,050 ha

## Defining the Spatial Extent of Ecosystems

Landscapes and waterscapes indicators were defined as features that applied across all terrestrial and aquatic ecosystems and no refined extent was needed.

## Known Issues

-- Roads are a significant factor in habitat fragmentation in our region, but they are not the only factor. Natural habitat can also be fragmented with anthropogenic land uses. This indicator does not address that type of fragmentation.

-- Future changes will be difficult to predict. Road shapefiles are updated regularly but lack of standardization in road digitizing across our area may make it difficult to track changes over time.

## Disclaimer: Comparing with Older Indicator Versions

While this indicator has changed since the version of low road density used in Blueprint 2.0, this only reflects differences in the way it was calculated and should not be compared to measure change over time.

## Literature Cited

National Atlas of the United States, 2014. 1:1,000,000-Scale Waterbodies and Wetlands of the United States. Rolla, MO. <http://nationalatlas.gov/atlasftp-1m.html>.

Steen, D. A. and Gibbs, J. P. (2004), Effects of Roads on the Structure of Freshwater Turtle Populations. Conservation Biology, 18: 1143–1148. doi: 10.1111/j.1523-1739.2004.00240.x <http://noss.cos.ucf.edu/papers/Steen%20and%20Gibbs%202004.pdf>.

The Nature Conservancy, Eastern Division Maps & Spatial Data. 2012. TIGER road linework for all TNC Eastern Division states. <http://www.conservationgateway.org/ConservationByGeography/NorthAmerica/UnitedStates/edc/reportsdata/mapsdata/Pages/default.aspx>.

U.S. Fish and Wildlife Service 2014. National Wetlands Inventory - Wetlands. <http://www.fws.gov/wetlands/> .

# Waterscapes

## Cross-Ecosystem Indicators

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Landscapes and waterscapes are "habitat aggregates" intended to capture connections across all terrestrial and aquatic ecosystems. For the purposes of the Blueprint, the freshwater aquatic ecosystem functions as a habitat aggregate because freshwater aquatic condition is so heavily influenced by the surrounding landscape. Landscapes and waterscapes indicators apply to the entire South Atlantic geography; freshwater aquatic indicators apply to all parts of the South Atlantic LCC geography not classified as marine or estuarine. As a result, no refined ecosystem extent was needed, and no ecosystem map is defined for these systems. In addition, we do not run a Zonation analysis specific to these systems, so they do not have individual ecosystem integrity scores. Instead, the freshwater aquatic, landscapes, and waterscapes indicators serve as inputs to Zonation within defined ecosystems, as described in the Integrity Scores sections above.

### *Migratory Fish Connectivity*

This layer is one of the South Atlantic LCC indicators in the waterscapes "habitat aggregate", which is intended to capture connections across all aquatic ecosystems. It is an index capturing how far upstream different migratory fish species have been observed.

#### Reason for Selection

Aquatic connectivity, which benefits diadromous fish, is considered a high priority for the integrity of aquatic ecosystems.

#### Input Data

-- Southeast Aquatic Connectivity Assessment Project (SEACAP)

#### Mapping Steps

1) We used HUC 12 watershed boundary dataset polygons to dissect the polygons representing functional catchments. We did this by using the intersect function in ArcGIS. This sliced up the functional catchments into HUC12 sized pieces and reduced the area selected in step 2.

2) We performed the following spatial intersections to associate the linework representing presence/absence for diadromous species with the sliced up functional network catchments:

4 = All HUC12 sliced functional catchments that intersected with the linework depicting presence of Gulf or Atlantic Sturgeon

3 = All HUC12 sliced functional catchments that intersected with the linework depicting presence of Alabama shad, Blueback herring or Striped bass (and that were not already identified as Gulf or Atlantic Sturgeon presence)

2 = All HUC12 sliced functional catchments that were adjacent to the diadromous fish associated catchments listed above

1 = All remaining HUC12 sliced functional catchments

3) We converted the polygon layer created above to a raster with 200 m cell size using the ArcGIS Polygon to Raster tool with a cell assignment type of "maximum combined area".

4) We intersected the above raster with the Active River Area raster to limit the results to the Active River Area associated with each functional network.

Indicator values were assigned as follows:

1 = Migratory fish connectivity index species not adjacent/not observed (low)

2 = Adjacent to presence of migratory fish connectivity index species

3 = Presence of Alabama shad, American shad, blueback herring, or striped bass

4 = Presence of Gulf or Atlantic sturgeon (high)

## Defining the Spatial Extent of Ecosystems

Landscapes and waterscapes indicators were defined as features that applied across all terrestrial and aquatic ecosystems and no refined extent was needed.

## Definitions

### *Functional Network:*

SEACAP developed linear spatial data on the presence of priority diadromous species. These layers are modified versions of the NHDPlus Version 2. These data were altered to contain presence of Alabama Shad using data from the Atlantic States Marine Fisheries Commission (produced for the ASMFC by the Biodiversity and Spatial Information Center (BaSIC) at North Carolina State University, Alexa Mckerrow), and expert knowledge of the SEACAP Workgroup.

### *Functional Catchments:*

SEACAP also developed a functional river network layer (final SEACAP report, page 9). A functional river network is a network is defined by those stream reaches that are accessible to a hypothetical fish within that network. The functional river network is defined by lines (streams). SEACAP also calculated “functional catchments,” which are polygons that represent the catchment area that is associated with each of those functional networks.

### *Active River Area:*

SEACAP developed an Active River Area layer (final SEACAP report, page 21):

"The Active River Area (ARA) is a 'spatially explicit framework for modeling rivers and their dynamic interaction with the land through which they flow' (Smith et al. 2008). Key features of the ARA include the meander belt, riparian wetlands, floodplains, terraces, material contribution areas. The ARA is different from, but was calibrated to and compared against, the FEMA 100-year floodplain. SEACAP used the ARA as a unit within which various landcover metrics, such as forest cover and impervious surface, were summarized. For the SEACAP area, we delineated the ARA for each of the seven size classes described in Section 2.1.3, using a seamless mosaic of 10m DEM data from the National Elevation Dataset (Gesch 2007; Gesch et al. 2002) as well as stream polylines, waterbody polygons, and stream area polygons from the NHDPlus v2 dataset. We selected and resampled wetflat landforms from a 30m landform model developed for the Southeastern United States (Anderson et al. 2014) to identify ARA components that occurred on wetflats and where longer-term storage of water is expected to occur. In addition, we obtained 100-yr floodplain polygons from the FEMA National Flood Hazard Layer (NFHL) in spring 2013 and used this data to inform cost distance threshold selection in the ARA delineation. Any FEMA 100-yr floodplain areas that were not captured by the ARA delineation were gridded at 10m resolution and merged underneath the ARA components in the final product. The final 10m ARA was resampled to 30m for use in the SEACAP metric calculations due to the resolution of other key input datasets (i.e., landcover). 22 The methods used to calculate all metrics was automated and documented via ArcGIS Model Builder models and custom Python scripts. Contact the authors for more information on the methods used to calculate metrics."

### Known Issues

-- Does not account for smaller dams/culverts.

-- Overestimates species ranges in some areas (e.g., above Blewett Falls and High Rock Dam in the Pee Dee, upstream of Rocky Mount, NC).

-- In certain cases when calculating adjacency to presence of migratory fish connectivity index species, GIS processing steps may erroneously include nearby but not hydrologically connected stream segments in a species range.

### Literature Cited

Martin, E. H, Hoenke, K., Granstaff, E., Barnett, A., Kauffman, J., Robinson, S. and Apse, C.D. 2014. SEACAP: Southeast Aquatic Connectivity Assessment Project: Assessing the ecological impact of dams on Southeastern rivers. The Nature Conservancy, Eastern Division Conservation Science , Southeast Aquatic Resources Partnership. <maps.tnc.org/seacap>.

## *Network Complexity*

This layer is one of the South Atlantic LCC indicators in the waterscapes “habitat aggregate”, which is intended to capture connections across all aquatic ecosystems. It depicts the number of connected stream classes in a river network.

### Reason for Selection

River networks with a variety of connected stream classes help retain aquatic biodiversity in a changing climate by allowing species to access climate refugia and move between habitats.

## Input Data

Input data for this indicator was provided by the Southeast Aquatic Connectivity Assessment Project (SEACAP). SEACAP identifies this metric within the category of "size/system type". It measures the number different stream size classes in each functional network. To be counted, the stream size must be > 0.5 miles long (final SEACAP report, page 97). To create the spatial component of this layer, the number of stream sizes is applied to the Active River Area inside the functional network. Stream size classes are defined as:

1a: Headwaters (< 3.861 sq mi)

1b: Creeks (≥ 3.861 and < 38.61 sq mi)

2: Small Rivers (≥ 38.61 and < 200 sq mi)

3a: Medium Tributary Rivers (≥ 200 and < 1000 sq mi)

3b: Medium Mainstem Rivers (≥ 1000 and < 3861 sq mi)

4: Large Rivers (≥ 3861 and < 9653 sq mi)

5: Great Rivers (≥ 9653 sq mi)

## Mapping Steps

1) SEACAP calculated this measure by counting the number of different stream size classes in each functional network.

2) We intersected the functional network layer with the Active River Area layer in order to spatially apply this metric to the Active River Area.

3) We converted to 200 m cell size using the ArcGIS Resample function with the "majority" resampling technique.

Indicator values were assigned as follows:

1 = 1 connected stream class (low)

2 = 2 connected stream classes

3 = 3 connected stream classes

4 = 4 connected stream classes

5 = 5 connected stream classes

6 = 6 connected stream classes

7 = 7 connected stream classes (high)

## Defining the Spatial Extent of Ecosystems

Landscapes and waterscapes indicators were defined as features that applied across all terrestrial and aquatic ecosystems and no refined extent was needed.

## Definitions

### *Functional Network:*

SEACAP developed linear spatial data on the presence of priority diadromous species. These layers are modified versions of the NHDPlus Version 2. These data were altered to contain presence of Alabama Shad using data from the Atlantic States Marine Fisheries Commission (produced for the ASMFC by the Biodiversity and Spatial Information Center (BaSIC) at North Carolina State University, Alexa Mckerrow), and expert knowledge of the SEACAP Workgroup.

### *Functional Catchments:*

SEACAP also developed a functional river network layer (final SEACAP report, page 9). A functional river network is a network is defined by those stream reaches that are accessible to a hypothetical fish within that network. The functional river network is defined by lines (streams). SEACAP also calculated "functional catchments," which are polygons that represent the catchment area that is associated with each of those functional networks.

### *Active River Area:*

SEACAP developed an Active River Area layer (final SEACAP report, page 21):

"The Active River Area (ARA) is a 'spatially explicit framework for modeling rivers and their dynamic interaction with the land through which they flow' (Smith et al. 2008). Key features of the ARA include the meander belt, riparian wetlands, floodplains, terraces, material contribution areas. The ARA is different from, but was calibrated to and compared against, the FEMA 100-year floodplain. SEACAP used the ARA as a unit within which various landcover metrics, such as forest cover and impervious surface, were summarized. For the SEACAP area, we delineated the ARA for each of the seven size classes described in Section 2.1.3, using a seamless mosaic of 10m DEM data from the National Elevation Dataset (Gesch 2007; Gesch et al. 2002) as well as stream polylines, waterbody polygons, and stream area polygons from the NHDPlus v2 dataset. We selected and resampled wetflat landforms from a 30m landform model developed for the Southeastern United States (Anderson et al. 2014) to identify ARA components that occurred on wetflats and where longer-term storage of water is expected to occur. In addition, we obtained 100-yr floodplain polygons from the FEMA National Flood Hazard Layer (NFHL) in spring 2013 and used this data to inform cost distance threshold selection in the ARA delineation. Any FEMA 100-yr floodplain areas that were not captured by the ARA delineation were gridded at 10m resolution and merged underneath the ARA components in the final product. The final 10m ARA was resampled to 30m for use in the SEACAP metric calculations due to the resolution of other key input datasets (i.e., landcover). 22 The methods used to calculate all metrics was automated and documented via ArcGIS Model Builder models and custom Python scripts. Contact the authors for more information on the methods used to calculate metrics."

## Known Issues

-- Does not account for smaller dams/culverts.

-- May not include other smaller scale attributes of complexity (e.g., sinuosity, mixtures of riffles/pools/runs).

## Literature Cited

Martin, E. H, Hoenke, K., Granstaff, E., Barnett, A., Kauffman, J., Robinson, S. and Apse, C.D. 2014. SEACAP: Southeast Aquatic Connectivity Assessment Project: Assessing the ecological impact of dams on Southeastern rivers. The Nature Conservancy, Eastern Division Conservation Science , Southeast Aquatic Resources Partnership. <maps.tnc.org/seacap>.

# Freshwater Aquatic

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Landscapes and waterscapes are "habitat aggregates" intended to capture connections across all terrestrial and aquatic ecosystems. For the purposes of the Blueprint, the freshwater aquatic ecosystem functions as a habitat aggregate because freshwater aquatic condition is so heavily influenced by the surrounding landscape. Landscapes and waterscapes indicators apply to the entire South Atlantic geography; freshwater aquatic indicators apply to all parts of the South Atlantic LCC geography not classified as marine or estuarine. As a result, no refined ecosystem extent was needed, and no ecosystem map is defined for these systems. In addition, we do not run a Zonation analysis specific to these systems, so they do not have individual ecosystem integrity scores. Instead, the freshwater aquatic, landscapes, and waterscapes indicators serve as inputs to Zonation within defined ecosystems, as described in the Integrity Scores sections above.

### *Imperiled Aquatic Species*

This layer is one of the South Atlantic LCC indicators in the freshwater aquatic ecosystem. It illustrates the total number of rare aquatic species within each watershed.

#### Reason for Selection

This indicator identifies areas with abundant rare and endemic aquatic species that would benefit from conservation actions.

#### Input Data

Input data for this indicator was provided by NatureServe and the Environmental Protection Agency (EPA) EnviroAtlas. This EnviroAtlas dataset includes analysis by NatureServe of species associated with aquatic habitat that are listed as G1 (globally critically imperiled), G2 (globally imperiled), or listed under the U.S. Endangered Species Act (ESA). The analysis results are for use and publication by both the LandScope America website and by EnviroAtlas. Results are provided for the total number of Aquatic Associated G1-G2/ESA species, the total number of Wetland Associated G1-G2/ESA species, the total number of Terrestrial Associated G1-G2/ESA species, and the total number of Unknown Habitat Association G1-G2/ESA species in each 12-digit hydrologic unit (HUC12). NatureServe is a non-profit organization dedicated to developing and providing information about the world's plants, animals, and ecological communities. NatureServe works in partnership with 82 independent Natural Heritage programs and Conservation Data Centers that gather scientific information on rare species and ecosystems in the United States, Latin America, and Canada (the Natural Heritage Network). NatureServe is a leading source for biodiversity information that is essential for effective conservation

action. This dataset was produced by NatureServe to support research and online mapping activities related to EnviroAtlas. EnviroAtlas allows the user to interact with an easy-to-use web-based mapping application to view and analyze multiple ecosystem services for the contiguous United States. The dataset is available as downloadable data or as an EnviroAtlas map service. Additional descriptive information about each attribute in this dataset can be found in its associated EnviroAtlas Facts Sheet.

This indicator includes data for the following species: Broad River Stream Crayfish, Greensboro Burrowing Crayfish, Piedmont Blue Burrower, Lean Crayfish, Oconee Burrowing Crayfish, Chauga Crayfish, Sandhills Spiny Crayfish, Piedmont Prairie Burrowing Crayfish, Mimic Crayfish, Saluda Burrowing Crayfish, Newberry Burrowing Crayfish, Ochlockonee Crayfish, Santa Fe Cave Crayfish, Big Blue Springs Cave Crayfish, Woodville Karst Cave Crayfish, Pallid Cave Crayfish, Black Creek Crayfish, Florida Longbeak Crayfish, Spider Cave Crayfish, Gulf Sturgeon, Alabama Shad, Bluestripe Shiner, Altamaha Shiner, Thinlip Chub, Cape Fear Shiner, Carolina Redhorse, Robust Redhorse, Carolina Madtom, Orangefin, Broadtail Madtom, Stippled Studfish, Waccamaw Killifish, Waccamaw Silverside, Carolina Pygmy Sunfish, Bluebarred Pygmy Sunfish, Waccamaw Darter, Halloween Darter, Roanoke Logperch, Altamaha Arcmussel, Dwarf Wedgemussel, Carolina Elktoe, Apalachicola Floater, Delicate Spike, Pod Lance, Brother Spike, Brown Elliptio, Yellow Lance, St. Johns Elephantear, Inflated Spike, Altamaha Spinymussel, Tar River Spinymussel, Waccamaw Spike, Purple Bankclimber, Atlantic Pigtoe, Finelined Pocketbook, Waccamaw Fatmucket, Carolina Fatmucket, Carolina Heelsplitter, Ochlockonee Moccasinshell, Suwannee Moccasinshell, James Spinymussel, Oval Pigtoe, Tallapoosa Orb, Florida Mapleleaf, Savannah Lilliput, Peninsular Floater, Carolina Creekshell, Magnificent Ramshorn, Squaremouth Amnicola, Cobble Sprite, Suwannee Hydrobe, Slough Hydrobe, Creek Siltsnail, Green Cove Siltsnail, Ichetucknee Siltsnail, Ocmulgee Siltsnail, Emily's Siltsnail, Halcyon Marstonia, Pumpkin Siltsnail, Reverse Pebblesnail, Flint Pebblesnail, Savannah Pebblesnail, Panhandle Pebblesnail, Flaxen Elimia, Pup Elimia, Slanted Elimia, Gem Elimia, Oak Elimia, and Timid Elimia.

## Mapping Steps

1) We downloaded the watershed boundary dataset and the national metric tables in Esri FileGeodatabse format from the EPA's EnviroAtlas and joined the tabular and spatial data.

2) We identified the field depicting total number of Aquatic Associated G1-G2 or ESA species in each HUC12.

3) We used the above field to convert the vector HUC12 layer to a raster with 200 m cell size using ArcGIS Polygon to Raster tool with a cell assignment type of "maximum combined area".

4) We clipped the resulting raster to the Active River Area layer from the Southeast Aquatic Connectivity Assessment Project (SEACAP).

5) We reclassified the values depicting the total number of Aquatic Associated G1-G2 or ESA species in each HUC12 as follows:

0 = No aquatic associated G1-G2 or ESA species

1 = 1 aquatic associated G1-G2 or ESA species

2 = 2 aquatic associated G1-G2 or ESA species

3 = 3 aquatic associated G1-G2 or ESA species

4 = 4 or more aquatic associated G1-G2 or ESA species

## Defining the Spatial Extent of Ecosystems

Freshwater aquatic indicators were applied to all parts of the South Atlantic LCC geography not classified as marine or estuarine, so no refined extent was needed.

## Definitions

### *Active River Area:*

SEACAP developed an Active River Area layer (final SEACAP report, page 21):

"The Active River Area (ARA) is a 'spatially explicit framework for modeling rivers and their dynamic interaction with the land through which they flow' (Smith et al. 2008). Key features of the ARA include the meander belt, riparian wetlands, floodplains, terraces, material contribution areas. The ARA is different from, but was calibrated to and compared against, the FEMA 100-year floodplain. SEACAP used the ARA as a unit within which various landcover metrics, such as forest cover and impervious surface, were summarized. For the SEACAP area, we delineated the ARA for each of the seven size classes described in Section 2.1.3, using a seamless mosaic of 10m DEM data from the National Elevation Dataset (Gesch 2007; Gesch et al. 2002) as well as stream polylines, waterbody polygons, and stream area polygons from the NHDPlus v2 dataset. We selected and resampled wetflat landforms from a 30m landform model developed for the Southeastern United States (Anderson et al. 2014) to identify ARA components that occurred on wetflats and where longer-term storage of water is expected to occur. In addition, we obtained 100-yr floodplain polygons from the FEMA National Flood Hazard Layer (NFHL) in spring 2013 and used this data to inform cost distance threshold selection in the ARA delineation. Any FEMA 100-yr floodplain areas that were not captured by the ARA delineation were gridded at 10m resolution and merged underneath the ARA components in the final product. The final 10m ARA was resampled to 30m for use in the SEACAP metric calculations due to the resolution of other key input datasets (i.e., landcover). 22 The methods used to calculate all metrics was automated and documented via ArcGIS Model Builder models and custom Python scripts. Contact the authors for more information on the methods used to calculate metrics."

## Known Issues

-- As this indicator is based on occurrence records, poorly surveyed areas may be scored too low. Therefore, this data does not imply absence of species.

-- The data in this indicator was last updated in 2011. Subwatersheds with fewer than four imperiled aquatic species in 2011 that subsequently had new imperiled species discovered after 2011 would be scored too low.

### Literature Cited

Martin, E. H, Hoenke, K., Granstaff, E., Barnett, A., Kauffman, J., Robinson, S. and Apse, C.D. 2014. SEACAP: Southeast Aquatic Connectivity Assessment Project: Assessing the ecological impact of dams on Southeastern rivers. The Nature Conservancy, Eastern Division Conservation Science , Southeast Aquatic Resources Partnership. <maps.tnc.org/seacap>.

U.S. Environmental Protection Agency (USEPA) Office of Research & Development (ORD) - National Exposure Research Laboratory (NERL) and NatureServe. 2013. EnviroAtlas - NatureServe Analysis of Imperiled or Federally Listed Species by HUC-12 for the Conterminous United States. <https://edg.epa.gov/data/Public/ORD/EnviroAtlas/National>.

## *Permeable Surface*

This layer is one of the South Atlantic LCC indicators in the freshwater aquatic ecosystem. It is an index of impervious surface within each watershed.

### Reason for Selection

Impervious cover is easy to monitor and model, and is widely used and understood by diverse partners. It is also strongly linked to water quality, estuary condition, eutrophication, and freshwater inflow (Schueler et al. 2009, Wenger et al. 2008, Uphoff et al. 2011).

### Input Data

-- National Land Cover Database 2011 (NLCD 2011): Percent developed imperviousness

-- National Hydrography Dataset Plus Version 2 (NHD Plus Version 2)

### Mapping Steps

1) We calculated percent impervious for each NHD Plus catchment using the NLCD 2011 impervious surface layer and the ArcGIS Zonal Statistics as Table tool.

2) We converted percent impervious to percent permeable using the formula [percent permeable = 100 - percent impervious] to maintain consistent scoring across South Atlantic LCC indicators (high values indicate better ecological condition) and joined the resulting table back to NHD Plus catchment layer.

3) We converted vector catchments to a raster with 200 m cell size using the ArcGIS Polygon to Raster tool with a cell assignment type of "maximum combined area". The final indicator is continuous, with values ranging as follows:

High: 100% of catchment permeable

Low: 9% of catchment permeable

### Defining the Spatial Extent of Ecosystems

Freshwater aquatic indicators were applied to all parts of the South Atlantic LCC geography not classified as marine or estuarine, so no refined extent was needed.

### Known Issues

-- May not account for differences in permeability between different types of soils and land uses.

### Disclaimer: Comparing with Older Indicator Versions

While this indicator has changed since the version of permeable surface used in Blueprint 2.0, this only reflects differences in the way it was calculated and should not be compared to measure change over time.

### Literature Cited

Schueler, T., Fraley-McNeal, L., and Cappiella, K. (2009). "Is Impervious Cover Still Important? Review of Recent Research." J. Hydrol. Eng. 14, SPECIAL ISSUE: Impervious Surfaces in Hydrologic Modeling and Monitoring, 309–315.

James H. Uphoff Jr., Margaret McGinty, Rudolph Lukacovic, James Mowrer & Bruce Pyle (2011): Impervious Surface, Summer Dissolved Oxygen, and Fish Distribution in Chesapeake Bay Subestuaries: Linking Watershed Development, Habitat Conditions, and Fisheries Management, North American Journal of Fisheries Management, 31:3, 554-566.

Wenger, S. J., J. T. Peterson, M. C. Freeman, B. J. Freeman, D. D. Homans. 2008. Stream fish occurrence in response to impervious cover, historic land use and hydrogeomorphic factors Canadian Journal of Fisheries and Aquatic Sciences 65, 1250-1264.

U.S. Environmental Protection Agency (USEPA) and the U.S. Geological Survey (USGS). 2012. National Hydrography Dataset Plus. 2.10. < http://www.horizon-systems.com/nhdplus/>

Xian, G., Homer, C., Dewitz, J., Fry, J., Hossain, N., and Wickham, J., 2011. The change of impervious surface area between 2001 and 2006 in the conterminous United States. Photogrammetric Engineering and Remote Sensing, Vol. 77(8): 758-762.

## *Riparian Buffers*

This layer is one of the South Atlantic LCC indicators in the freshwater aquatic ecosystem. It is a riparian buffer index capturing natural habitat near rivers and streams.

### Reason for Selection

Habitat near rivers and streams is strongly linked to water quality and instream flow (Naiman 1997), is easy to monitor and model, and is widely used and understood by diverse partners. These buffers provide a "front line defense" for aquatic systems.

### Input Data

-- Southeast Aquatic Connectivity Assessment Project (SEACAP)

-- National Land Cover Database 2011 (NLCD 2011)

-- National Hydrography Dataset Plus Version 2 (NHD Plus Version 2)

## Mapping Steps

1) We mapped riparian buffers using the SEACAP Active River Area layer.

2) Natural landcover was mapped using the following National Land Cover Data 2011 classes: open water, barren land, deciduous forest, evergreen forest, mixed forest, scrub/shrub, grassland/herbaceous, woody wetlands, and emergent wetlands.

3) The two layers listed above (riparian buffers and natural landcover) were intersected to capture the natural landcover classes that fell within the Active River Area.

4) We calculated the percent of riparian natural landcover inside each NHD Plus Version 2 catchment using the ArcGIS Zonal Statistics as Table tool and joined the resulting table back to the NHD Plus catchment layer.

5) We converted the percent riparian natural landcover by catchment vector layer to a raster with 200 m cell size using the ArcGIS Polygon to Raster tool with a cell assignment type of "maximum combined area". The final indicator is continuous, with values ranging as follows:

High: 100% natural habitat surrounding rivers and streams by catchment

Low: 0% natural habitat surrounding rivers and streams by catchment

## Defining the Spatial Extent of Ecosystems

Freshwater aquatic indicators were applied to all parts of the South Atlantic LCC geography not classified as marine or estuarine, so no refined extent was needed.

## Definitions

### *Active River Area:*

SEACAP developed an Active River Area layer (final SEACAP report, page 21):

"The Active River Area (ARA) is a 'spatially explicit framework for modeling rivers and their dynamic interaction with the land through which they flow' (Smith et al. 2008). Key features of the ARA include the meander belt, riparian wetlands, floodplains, terraces, material contribution areas. The ARA is different from, but was calibrated to and compared against, the FEMA 100-year floodplain. SEACAP used the ARA as a unit within which various landcover metrics, such as forest cover and impervious surface, were summarized. For the SEACAP area, we delineated the ARA for each of the seven size classes described in Section 2.1.3, using a seamless mosaic of 10m DEM data from the National Elevation Dataset (Gesch 2007; Gesch et al. 2002) as well as stream polylines, waterbody polygons, and stream area polygons from the NHDPlus v2 dataset. We selected and resampled wetflat landforms from a 30m landform model developed for the Southeastern United States (Anderson et al. 2014) to identify ARA components that occurred on wetflats and where longer-term storage of water is expected to occur. In addition, we obtained 100-yr floodplain polygons from the FEMA National Flood Hazard Layer (NFHL) in spring 2013 and used this data to inform cost distance threshold selection in the ARA delineation. Any FEMA 100-yr floodplain areas that were not captured by the ARA delineation were gridded at 10m

resolution and merged underneath the ARA components in the final product. The final 10m ARA was resampled to 30m for use in the SEACAP metric calculations due to the resolution of other key input datasets (i.e., landcover). 22 The methods used to calculate all metrics was automated and documented via ArcGIS Model Builder models and custom Python scripts. Contact the authors for more information on the methods used to calculate metrics."

## Known Issues

-- Does not account for accumulated impacts of upstream riparian buffers. Buffers at the headwaters are treated the same as those downstream.

-- Does not account for variation in buffer quality within the Active River Area at a scale below the catchment. This means that within the Active River Area, loss of natural habitat adjacent to the river is treated the same as loss farther away.

## Disclaimer: Comparing with Older Indicator Versions

While this indicator has changed since the version of riparian buffers used in Blueprint 2.0, this only reflects differences in the way it was calculated and should not be compared to measure change over time.

## Literature Cited

Homer, C.G., Dewitz, J.A., Yang, L., Jin, S., Danielson, P., Xian, G., Coulston, J., Herold, N.D., Wickham, J.D., and Megown, K., 2015, Completion of the 2011 National Land Cover Database for the conterminous United States-Representing a decade of land cover change information. Photogrammetric Engineering and Remote Sensing, v. 81, no. 5, p. 345-354.

Martin, E. H, Hoenke, K., Granstaff, E., Barnett, A., Kauffman, J., Robinson, S. and Apse, C.D. 2014. SEACAP: Southeast Aquatic Connectivity Assessment Project: Assessing the ecological impact of dams on Southeastern rivers. The Nature Conservancy, Eastern Division Conservation Science , Southeast Aquatic Resources Partnership. <maps.tnc.org/seacap>.

Naiman, Robert J., and Henri Decamps. “The Ecology of Interfaces: Riparian Zones.” Annual Review of Ecology and Systematics 28 (1997): 621–58.

U.S. Environmental Protection Agency (USEPA) and the U.S. Geological Survey (USGS). 2012. National Hydrography Dataset Plus. 2.10. <http://www.horizon-systems.com/nhdplus/>.

# Corridors 2.1

## Terrestrial Hubs

These are the hubs used in the Linkage Mapper-based connectivity analysis for the terrestrial portion of the South Atlantic area in Blueprint 2.1.

### Input Data

-- Ecosystem scores from Zonation for all inland ecosystems (beach and dune, estuarine marsh, forested wetland, freshwater marsh, maritime forest, pine and prairie, upland hardwood)

--The Nature Conservancy's Southeast Resilience Project and Northeast Resilience Project

-- The Nature Conservancy's Secured Lands Database (External Eastern Division 2014)

### Mapping Steps

1) Individual ecosystem integrity scores (Zonation outputs) for the inland ecosystems (beach and dune, estuarine marsh, forested wetland, freshwater marsh, maritime forest, pine and prairie, upland hardwood) were mosaiced together into one raster. The highest scoring 10% of the inland South Atlantic LCC area (based on ecosystem integrity scores) were identified as potential hubs.

2) Outside of the South Atlantic LCC geography, we used local connectedness from The Nature Conservancy's Southeast Resilience Project and Northeast Resilience Project. Areas ≥ 1 standard deviation above average were identified as potential hubs.

3) We selected polygons from TNC's Secured Lands (External Eastern Division 2014) that were in GAP Status 1 - Permanent Protection for Biodiversity, 2 - Permanent Protection to Maintain a Primarily Natural State, or 3 - Permanently Secured for Multiple Uses.

4) Since military-owned lands are often protected for training or defense rather than conservation, we removed any polygons that listed the Fee Owner as U.S. Department of the Army, U.S. Department of Defense, U.S. Air Force, or U.S. Department of the Navy.

5) We converted this polygon layer to a raster with a cell size of 200 m using a maximum combined area cell assignment. This allowed us to match the data from step 2, and also helped identify large patches of secured lands that are near one another, but separated by a narrow linear feature like a river or road. It also allowed us to combine tracts that are contiguous but differ in ownership.

6) We combined potential hubs from the ecosystem integrity scores (step 1), TNC Resilience Project (step 2), and Secured Lands (step 5).

7) Contiguous patches greater than 2,000 ha (5,000 acres) in size were kept as hubs. We identified these patches using the ArcGIS Spatial Analyst-Region Group function (8-neighbor). This size threshold from Hoctor et. al (2000) is also used by the neighboring LCC to the south for connectivity purposes.

8) The raster patches were converted to polygons.

9) All polygons either within the South Atlantic LCC geography or within 26.1 km of the South Atlantic LCC boundary were used as terrestrial hubs in the Linkage Mapper analysis. The distance of 26.1 km is based on dispersal distances of subadult black bears (White et al. 2000), a species that disperses from within the LCC into all other adjacent LCCs.

## Terrestrial Corridors

This is the corridor raster used in the terrestrial portion of the South Atlantic area in Blueprint 2.1.

### Input Data

-- Ecosystem integrity scores (from Zonation) for all inland ecosystems (beach and dune, estuarine marsh, forested wetland, freshwater marsh, maritime forest, pine and prairie, upland hardwood)

-- The Nature Conservancy's Southeast Resilience Project and Northeast Resilience Project

-- Blueprint 2.1 Terrestrial Hubs (created above)

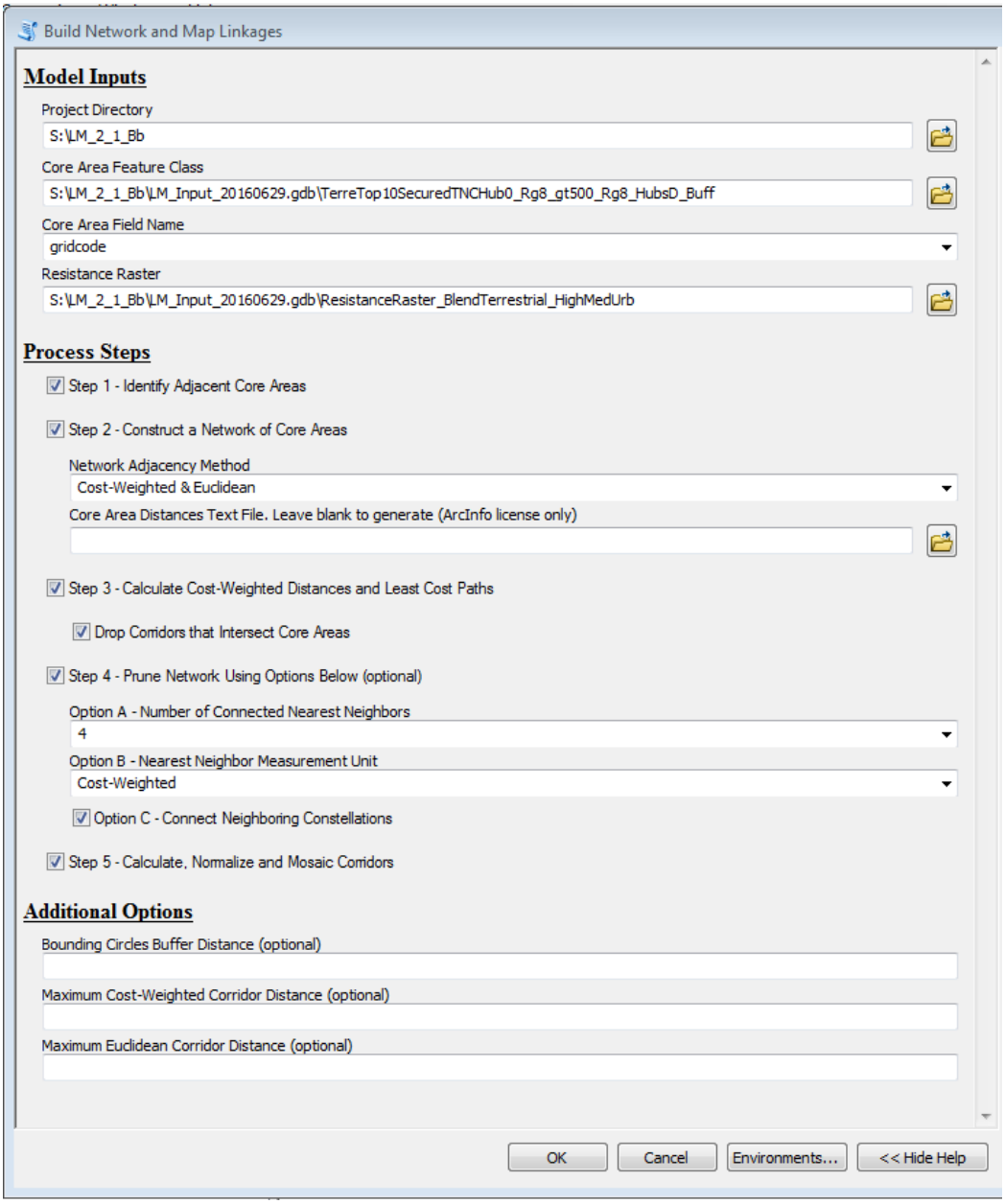
### Mapping Steps

1) All inland ecosystem integrity scores (beach and dune, estuarine marsh, forested wetland, freshwater marsh, maritime forest, pine and prairie, upland hardwood) were mosaiced to form a new raster.

2) We used the local connectedness layers from The Nature Conservancy's Southeast Resilience Project and Northeast Resilience Project to fill in a buffer area around the South Atlantic LCC geography. This allowed corridors to connect from inside the South Atlantic geography into the neighboring landscapes.

3) To create a single resistance layer, we rescaled and inverted the terrestrial ecosytem integrity scores (within the LCC boundaries) and the local connectedness metric (outside the LCC boundaries) to ensure they used the same scale and that high values represented high resistance.

4) We performed a Linkage Mapper corridor analysis using the following settings as pictured below:




5) Linkage Mapper outputs a corridor raster with a continuous surface. We used the ArcGIS Slice function to identify the top 20% of the corridor surface by area. This result is the terrestrial corridors component of the Corridors 2.1 layer. Terrestrial corridor pixels not already identified as highest, high or medium priority were incorporated into Blueprint 2.1 as the "corridor" class. We chose a 20% cutoff because it resulted in a corridor area of approximately 5% of the South Atlantic terrestrial area (not already covered by highest, high, or medium priority pixels).

## Marine Hubs

These are the hubs used in the Linkage Mapper-based corridor analysis for the marine portion of the South Atlantic area in Blueprint 2.1.

## Input Data

-- Marine ecosystem integrity scores

-- Estuarine open water component of the Blueprint 2.1 Ecosystem Maps

## Mapping Steps

1) The highest scoring 10% of the marine area (based on integrity scores) were identified as potential hubs in the marine ecosystem. We used the ArcGIS Spatial Analyst-Region Group function to identify patches of these top 10% areas. Contiguous patches greater than 2000 ha were kept as hubs. These patches were identified using the ArcGIS Spatial Analyst-Region Group function (4-neighbor).

2) All open water estuary pixels were considered potential hubs. We performed a Region Group analysis on the open water estuary ecosystem map to identify patches. Contiguous patches greater than 2000 ha were kept as hubs to encourage connectivity from all large estuaries to the highest priority marine hubs. These patches were identified using the ArcGIS Spatial Analyst-Region Group function (8-neighbor).

3) We converted the raster patches to polygons for use in Linkage Mapper.

# Marine Corridors

This is the corridor raster used in the marine portion of the South Atlantic area in Blueprint 2.1.

## Input Data

-- Marine ecosystem integrity score (from Zonation)

-- Estuarine coastal condition indicator

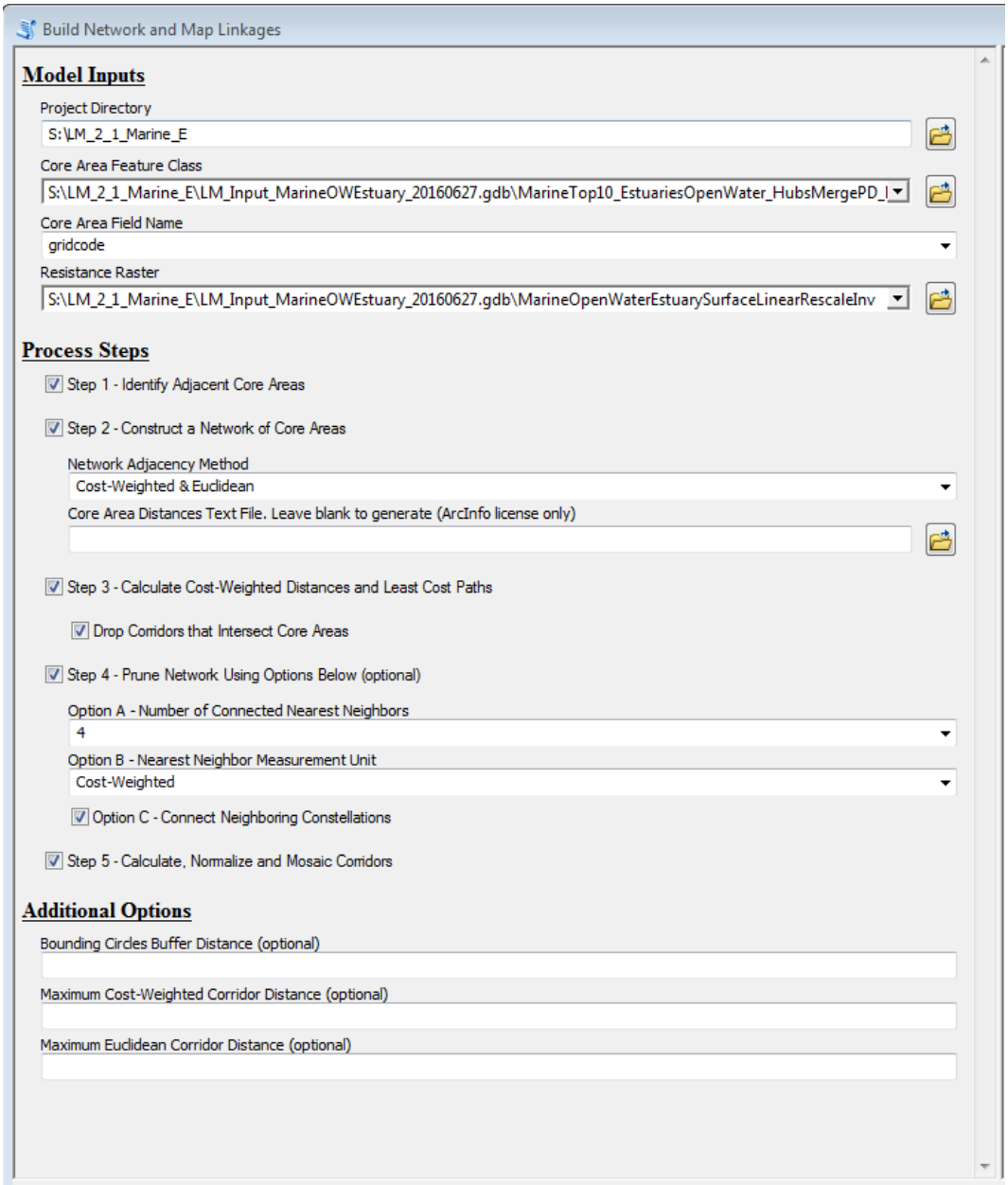
-- Blueprint 2.1 Marine Hubs (created above)

## Mapping Steps

1) The estuarine open water ecosystem is only covered by one indicator in Blueprint 2.1, coastal condition, which made it unnecessary to perform a Zonation run to prioritize open water estuaries. However, to perform a corridor analysis to connect open water estuaries with the marine ecosystem, we needed to create a layer comparable to the Blueprint 2.1 marine ecosystem integrity score. To do this, we clipped the coastal condition indicator to the estuarine open water ecosystem. Coastal condition has values ranging from 1.13 to 5. We rescaled these values to range from 0 - 1 using a linear transformation function.

2) To create a single resistance layer, we mosaiced, rescaled, and inverted the coastal condition indicator and the marine ecosystem integrity score so that high values represented high resistance.

3) We performed a Linkage Mapper corridor analysis using the following settings as pictured below:




4) Linkage Mapper outputs a corridor raster with a continuous surface. We used the ArcGIS Slice function to identify the top 35% of the corridor surface by area. This result is the marine corridors component of the Corridors 2.1 layer. Marine corridor pixels not already covered by highest, high or medium priority pixels were incorporated into Blueprint 2.1 as the corridor class. We chose a 35% cutoff because it resulted in a corridor area of approximately 5% of the South Atlantic marine environment (not already covered by highest, high, or medium priority pixels).

## Literature Cited

Anderson, M.G., A. Barnett, M. Clark, C. Ferree, A. Olivero Sheldon, and J., Prince., 2014. Resilient Sites for Terrestrial Conservation in the Southeast Region. The Nature Conservancy, Eastern Conservation Science. 127 pp.

McRae, B. and Kavanagh, D. Linkage Mapper User Guide: Version 1.0. 2014. <http://www.circuitscape.org/linkagemapper> .

Moilanen, A., Pouzols, F. M, Meller, L., Veach, V., Arponen, A., Leppänen, J. Kujala, H. Zonation Version 4 User Manual: Spatial conservation planning methods and software. <http://cbig.it.helsinki.fi/files/zonation/zonation_manual_v4_0.pdf> .

The Nature Conservancy. 2014. Secured Lands dataset. The Nature Conservancy, Eastern Conservation Science. Boston, MA. <http://www.conservationgateway.org/ConservationByGeography/NorthAmerica/UnitedStates/edc/reportsdata/terrestrial/secured/Pages/default.aspx>.

White, T.H., JR., J.L. Bowman, B.D. Leopold, H.A. Jacobson, W.P. Smith, and F.J. Vilella. 2000. Influence of Mississippi alluvial valley rivers on black bear movements and dispersal: Implications for Louisiana black bear recovery. Biological Conservation 95:323–331.

# Blueprint 2.1

The Blueprint is a living spatial plan for sustaining natural and cultural resources in the face of future change. It identifies opportunities for shared conservation action, prioritizing the lands and waters of the South Atlantic based on natural and cultural resource indicator models and a connectivity analysis. So far, more than 400 people from over 100 organizations have actively participated in developing the Blueprint. To learn more about the Blueprint, visit the Blueprint page. To learn more about the indicators, visit the indicator page.

## Priority Categories

Highest priority for shared action: the most important areas for natural and cultural resources based on indicator condition. This class covers 10% of the South Atlantic geography.

High priority for shared action: important areas for natural and cultural resources based on indicator condition. This class covers an additional 15% of the South Atlantic geography; together, the highest and high priority categories cover 25%.

Medium priority for shared action: above-average areas for natural and cultural resources based on indicator condition, capturing potential restoration opportunities. This class covers 20% of the South Atlantic geography; together, the highest, high, and medium priority categories cover 45%.

Corridors: connections between large patches of highest priority areas and secured lands, optimized for efficiency and indicator condition in a least cost path analysis. This category covers an additional 5% of the South Atlantic geography; in total, the Blueprint covers 50%.

## Input Data

-- Ecosystem Integrity Scores 2.1

-- Corridors 2.1

## Indicator Analysis

We used Zonation, an open-source spatial conservation planning framework software, to prioritize areas within Blueprint 2.1 using the individual indicator data layers. The Indicators 2.1 folder in the Blueprint 2.1 data gallery on the CPA contains the data layers for all natural and cultural resource indicators used to create Blueprint 2.1. Some indicators not used in the Blueprint due to data limitations are classified as “indicators not used in Blueprint”. Other data inputs that were used in the Blueprint, but are not indicators (such as marine depth zones) are classified as “additional Blueprint inputs”.

For more detail on the model parameters and specific indicators used in the Zonation analysis for each ecosystem, please read the Integrity Scores section under each ecosystem above.

## Selection Algorithm

For each ecosystem, except for the open water portion of estuaries, we used the core area Zonation algorithm. This algorithm focuses on minimizing indicator loss and maintaining a balanced representation across all indicators. It begins by including all potential cells in the Blueprint and iteratively removes cells that will result in the least relative indicator loss. The first cell removed is the lowest priority and the final cell retained is the highest.

According to the Zonation manual, core area Zonation "tries to retain core areas of all [indicators] until the end of cell removal, even if the feature is initially widespread and common. Thus, at first only cells with occurrences of common features are removed. Gradually, the initially common features become more rare, and cells with increasingly rare feature occurrences start disappearing. The last site to remain in the landscape is the cell with the highest (weighted) richness. This is the site that would be kept last if all else was to be lost" (Moilanen et al. 2014, page 32).

## Choosing Run Options

### *Indicator Weights*

We began ecosystem runs with all indicators weighted equally. Due to the small extent of some indicators (low-urban historic landscapes and marine hardbottom condition) and one input (marine depth zones), the Zonation results included the full extent of the indicator in the top 10% of the prioritization. This meant that even areas with the lowest indicator values and no overlap with other high indicator values would end up in the highest priority class. To resolve this, we reduced the indicator weight until some areas with lower indicator values were outside of the top 10%. We tested weights of 0.75, 0.6, 0.5, 0.25, and 0.1.

There was also a single indicator, urban open space, where high values had little overlap with high values of other indicators. That indicated strong trade-offs between that indicator and all others. We reduced the weight of that indicator until at least some of the pixels with the highest indicator value dropped below the top 10% of the prioritization. We used intervals 0.75, 0.5, 0.25, 0.1. All other indicators not discussed above were weighted equally in the final Zonation run.

### *Warp Factors*

Warp factor specifies how many cells will be removed at once during each iteration. We used warp 10 for forested wetland, pine and prairie, and upland hardwood to reduce overall run time. We used warp 1000 for the marine ecosystem to reduce run time and account for different spatial resolutions of indicators. For all other ecosystems, we used warp 1.

## Approach for Open Water Estuaries

The integrity scores for this system are based on the only indicator that covers the open water estuaries (coastal condition), so it was not necessary to use Zonation to prioritize this area. Because of this, the open water part of estuaries were treated differently than the other ecosystems. Instead of using Zonation, we used the ArcGIS Slice function to bin the coastal condition indicator into 100 equal area classes. Each of these classes covers roughly the same area (1% of the open water estuaries). This

allowed us to use this layer in the same way as the Zonation outputs. For more details on this approach, please read the Integrity Scores: Estuarine Open Water section under Estuaries above.

## Corridors 2.1

We generated the corridors through a connectivity analysis. For more details on the connectivity methods, including the model parameters used and an explanation of how hubs and resistance were defined, please read the Corridors 2.1 section above.

We used Linkage Mapper, an ArcGIS-based tool designed to support regional wildlife habitat connectivity analysis, to create corridors for Blueprint 2.1. In the terrestrial environment, we defined hubs as large areas of high ecosystem integrity scores from the Zonation analysis and large patches of secured land from TNC's Secured Lands Database. In the marine environment, we defined hubs as large areas of marine and estuarine ecosystem integrity. Linkage Mapper connected these hubs in a least-cost path analysis optimized for ecosystem integrity scores. To minimize edge effects with adjacent LCCs, we also used secured lands hubs and local connectedness data from The Nature Conservancy's Southeast Resilience Project and Northeast Resilience Project to incorporate corridors that connect to hubs outside the South Atlantic LCC boundary.

## Combining Ecosystem Integrity Scores and Connectivity

The final Blueprint covers 50% of the South Atlantic landscape, divided into priority categories as described in the Priority Categories section above. To combine the results of the Zonation indicator analysis and the Linkage Mapper corridor analysis into the final Blueprint, we followed the steps described below.

### Creating the Terrestrial Blueprint

1) We mosaiced the ecosystem integrity score layers to stitch together the results of the Zonation prioritization for each terrestrial ecosystem (beach and dune, estuarine marsh, forested wetland, freshwater marsh, maritime forest, pine and prairie, upland hardwood). In this mosaiced terrestrial Zonation output layer, each pixel in the South Atlantic terrestrial geography has a continuous value ranging from 0 to 1 according to its rank in its ecosystem's Zonation prioritization.

2) We used the ArcGIS Slice-Reclassify function to divide this mosaiced layer into 100 classes, grouping together pixels with the same score range across different ecosystems. Each class (ranging from 1 - 100) covers ~1% of the terrestrial area. The 1 class contains the lowest indicator scores across all terrestrial ecosystems collectively, while 100 contains the highest.

3) Pixels in classes above 90 are in the highest tier of indicator condition. We selected all slice classes > 90 and classified them as "highest priority for shared action".

4) Pixels in classes above 75 that aren't already classified as highest priority are in the second-highest tier of indicator condition. We selected all slice classes > 75 and ≤ 90 and classified them as "high priority for shared action".

5) Pixels in classes above 56 that aren't already classified as highest or high priority are in the third-highest tier of indicator condition. We selected all slice classes > 56 and ≤ 75 and classified them as "medium priority for shared action". This makes up the first portion of the medium priority class.

6) Any terrestrial hubs used in the connectivity analysis that that were not already classified as highest, high, or medium priority in the steps above were added to the medium priority class. This ensured that the large patches of secured lands used as hubs in the connectivity analysis can score no lower than medium priority in the Blueprint. This added an additional 1% of total area to the medium priority class.

7) The terrestrial corridors layer was then used to fill in corridors. Any pixel identified as a corridor in the terrestrial corridor analysis that was not already assigned to the highest, high or medium priority categories in the steps above was classified as “corridors” in Blueprint 2.1. This contributes an additional 5% to the total Blueprint area, ensuring the final Blueprint ultimately covers 50% of the South Atlantic landscape.

## Creating the Marine Blueprint

1) We mosaiced the marine ecosystem score layer with the open water estuarine ecosystem score layer. In this mosaiced marine layer, each pixel in the South Atlantic marine geography has a continuous value ranging from 0 to 1 according to its rank in its ecosystem's Zonation prioritization.

2) We used the ArcGIS Slice-Reclassify function to divide this mosaiced layer into 100 classes, grouping together pixels with the same score range across different ecosystems. Each class (ranging from 1 - 100) covers ~1% of the marine area. The 1 class contains the lowest indicator scores across all marine ecosystems collectively, while 100 contains the highest.

3) Pixels in classes above 90 are in the highest tier of indicator condition. We selected all slice classes > 90 and classified them as “highest priority for shared action”.

4) Pixels in classes above 75 that aren't already classified as highest priority are in the second-highest tier of indicator condition. We selected all slice classes > 75 and ≤ 90 and classified them as “high priority for shared action”.

5) Pixels in classes above 55 that aren't already classified as highest or high priority are in the third-highest tier of indicator condition. We selected all slice classes > 55 and ≤ 75 and classified them as "medium priority for shared action".

6) The marine corridors layer was then used to fill in corridors. Any pixel identified as a corridor in the marine corridor analysis that was not already assigned to the highest, high or medium priority categories in the steps above was classified as “corridors” in Blueprint 2.1. This step ensures that the final Blueprint ultimately covers 50% of the South Atlantic landscape.

## Combining the Terrestrial and Marine Components into Blueprint 2.1

1) The final step was to combine the terrestrial and marine results into a single raster representing the final Blueprint 2.1. We did this using the ArcGIS Cell Statistics-Maximum function.

## Known Issues

-- Some aquatic areas, particularly smaller rivers and streams, are over-prioritized. The new imperiled aquatic species indicator is at a subwatershed (HUC12) scale while the species hotspots it seeks to depict are often only a part of that subwatershed.

-- Some aquatic areas important for migratory fish are being under-prioritized in areas far upstream due to issues in the migratory fish connectivity indicator.

-- The eastern part of the right whale calving grounds (off the coast of Georgia and Florida) is under-prioritized. Current right whale models are under-predicting density in that area. Model improvements based on additional data are underway. New right whale models are expected by Fall/Winter 2016.

-- Piedmont prairie areas are under-prioritized. These are not well captured with current indicators and depicting condition and extent of this ecosystem continues to pose a challenge.

-- Urban open space is poorly captured in Georgia and South Carolina. The TNC Secured Lands database is currently missing many urban protected areas in these states. The 2015 update of the Secured Lands database, due for release later in 2016, will fill in many of these missing urban protected areas.

-- Congaree National Park is under-prioritized. This is likely due to the forested wetland bird indicator under-predicting Swainson's warbler in the area.

-- The low-urban historic landscapes indicator affects corridors too strongly in some areas. This leads some corridor routes to go through overly developed areas at the expense of slightly longer, but more suitable, routes.

## Background

The lands and waters of the South Atlantic are changing rapidly. Climate change, urban growth, and increasing human demands on resources are reshaping the landscape. While these forces cut across political and jurisdictional boundaries, the conservation community does not have a consistent cross-boundary, cross-organization plan for how to respond. The South Atlantic Conservation Blueprint is that plan.

In 2012, developing a Conservation Blueprint became the 3-5 year mission of the South Atlantic Landscape Conservation Cooperative (LCC). In 2013, the Cooperative adopted natural and cultural resource indicators as shared measures of success. In 2014, the Steering Committee approved Blueprint Version 1.0. This first version of the Blueprint was created by combining expert input from workshops with existing regional and state plans. Click here to access Blueprint 1.0 in the Conservation Planning Atlas (CPA). Blueprint 2.0, released in June 2015, was a completely data-driven plan that identified priority areas for shared conservation action based on ecosystem indicator condition and connectivity. Click here to access Blueprint 2.0 in the CPA. Blueprint 2.1, the current version, is a small data-driven update to the Blueprint that uses the same overall methods as Version 2.0, but incorporates improved data for some of the indicators.

## Intended Uses

Due to its coarse resolution and broad scope, the Blueprint is not intended for use in isolation of other more locally and/or resource-specific layers. Instead, it is designed to complement other more detailed information by identifying the best places for shared action at the ecosystem level. Intended uses include: finding places to pool resources, raising new conservation dollars, guiding infrastructure development, developing conservation incentives, showing how local actions fit into a larger strategy, and locating places to build resilience to major disasters. Conservation practitioners are already using using the Blueprint to inform conservation action and investment across the geography.

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