Model Name: Neotropical Migrant Passerines Habitat Suitability Index

Functional Area: Ecosystem Services / Upper Trophic Level

Model Proponents: Coastal Protection and Restoration Authority

Model Developer(s): Paul Leberg, University of Louisiana at Lafayette

Please note this is a working-draft document currently undergoing review and revision. The final version will be posted in March 2012 along with the final version of the 2012 Coastal Master Plan.

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1. Background

a. Purpose of Model

The purpose of this model is to compare the effects of various coastal protection and wetland restoration options on habitat quality for neotropical migrant passerines in coastal Louisiana. The model was created to provide information for consideration by the State of Louisiana in its preparation of the 2012 Coastal Master Plan. This model will assist the Coastal Protection and Restoration Authority (CPRA) and other water management agencies (e.g., U.S. Army Corps of Engineers) in evaluating the benefits and impacts of various protection and restoration projects. In addition, this model can be used to indicate habitat suitability in a scenario with no increased future action.

b. Model Description and Depiction

A Habitat Suitability Index (HSI) is defined as a numerical index that represents the capacity of a given habitat to support a selected fish or wildlife species. The HSI has a range of zero to one, with zero representing unsuitable habitat and one representing optimum habitat. This model does not consider or estimate population size, dynamics or recruitment; it only estimates suitable habitat.

Coastal Louisiana represents important stopover and breeding habitat for a large number of neotropical migrants. This group is also important from an economic perspective in that many bird watchers travel to coastal parishes to observe these species during migration; birding activities represent a contribution to the local economy.

Here we define neotropical migrant as a bird that breeds in the United States or Canada and winters primarily in the Neotropics (south of the tropic of Cancer). We focus on passerines (order *Passeriformes*) because the habitat requirements of other neotropical migrants are better addressed with separate models (such as shorebirds, raptors, some waterfowl).

Table 1. List of species (common name) used develop index values for neotropical migrants

Eastern Wood-Pewee	Swainson's Thrush	Swainson's Warbler
Acadian Flycatcher	Wood Thrush	Ovenbird
Alder/Willow Flycatcher	Gray Catbird	Northern Waterthrush
Least Flycatcher	Blue-winged Warbler	Louisiana Waterthrush
Great Crested Flycatcher	Golden-winged Warbler	Kentucky Warbler
Great Kiskadee	Tennessee Warbler	Mourning Warbler
Western Kingbird	Nashville Warbler	Common Yellowthroat
Eastern Kingbird	Northern Parula	Hooded Warbler
Scissor-tailed Flycatcher	Yellow Warbler	Wilson's Warbler
White-eyed Vireo	Chestnut-sided Warbler	Canada Warbler
Yellow-throated Vireo	Magnolia Warbler	Yellow-breasted Chat
Warbling Vireo	Black-throated Green Warbler	Eastern Towhee
Philadelphia Vireo	Blackburnian Warbler	Summer Tanager
Red-eyed Vireo	Yellow-throated Warbler	Scarlet Tanager
Purple Martin	Prairie Warbler	Rose-breasted Grosbeak

Northern Rough-winged Swallow	Bay-breasted Warbler	Blue Grosbeak
Tree Swallow	Black-and-white Warbler	Indigo Bunting
Bank Swallow	Blackpoll Warbler	Painted Bunting
Barn Swallow	Cerulean Warbler	Dickcissel
Cliff Swallow	American Redstart	Bobolink
Eastern Bluebird	Prothonotary Warbler	Orchard Oriole
Veery	Worm-eating Warbler	Baltimore Oriole
Gray-cheeked Thrush		

Published surveys of relative abundance of neotropical migrant species, conducted across the habitats of coastal Louisiana, could not be located. Instead of developing a standard HSI, which is typically done for a species or a community of species with similar habitat preferences, an index of habitat importance for this diverse group was developed. This index would have the highest values when sites contain most of the species in Table 1, (diversity) in the largest numbers (abundance). Rare species are weighed more heavily than common ones. Lower index values would occur if only a few members of a small number of common species were observed at a site. To obtain an index of habitat importance, data from the birding community were used. Reports on birds observed during birding trips to specific sites in southern Louisiana are recorded in a database maintained by the Cornell Laboratory of Ornithology and the National Audubon Society (ebird.org 2010). This data set was mined to obtain information on neotropical migrant use of habitats. There are a number of shortcomings to this approach, such as different levels of observer ability, reporting accuracy, and site homogeneity, but the benefits of having a large number of observations is assumed to minimize the bias and imprecision in individual surveys.

c. Contribution to Planning Effort

The model has potential application to any coastal planning activity that involves evaluation of projects that affect habitat types preferred by neotropical migrants. The model can be used to evaluate effects on neotropical migrant habitat suitability for a variety of coastal protection and restoration projects, including ridge creation, marsh creation, and others.

d. Description of Input Data

Vegetation types are used as model input. These input data are produced by the master plan Vegetation Model.

e. Description of Output Data

The model output data is a number ranging from 0 to 1 that represents the suitability of the habitat in each 500 x 500 m cell per year to provide habitat for neotropical migrants, where 1 is highly suitable habitat and 0 is unsuitable habitat.

f. Statement on the capabilities and limitations of the model

This model provides a habitat suitability index for each 500 x 500 m cell for 67 species of neotropical passerines. As vegetation cover changes in coastal wetlands, this model should be able to provide an indication of how those changes will affect habitat that is suitable for neotropical migrants.

The model is limited to assessing responses for a combined group of species. Since each species has different habitat requirements, individual species may increase or decrease and have little effect on the overall model predictions. The model is also limited by the vegetation types modeled. Bottomland forests and forested ridges are important habitats for these species but they were not included as part of the vegetation modeling efforts due to lack of data.

g. Description of model development process including documentation on testing conducted (Alpha and Beta tests)

CPRA identified neotropical migrants as important for inclusion in the 2012 Coastal Master Plan. Because there were no previously developed HSI's available for this group of species, a new HSI model was developed.

2. Technical Quality

a. Theory

The development of a suitable model for multiple species was difficult because the measure needed to include weights for abundance in a cell and relative rarity across the landscape. In brief, a measure assigned a higher index value if a location had larger numbers of rare species than if it had large numbers of common species. Following a literature review, it was determined that the hierarchical richness (HRI) index of French (1994) best addressed these needs because it incorporated both abundance and diversity and could be used with the available data (reports of numbers of individuals for a large number of species). This index incorporates both diversity of species at a site and the numbers of individuals in those species that are present. This index is the sum of (s_i x i) were i is the species rank by abundance and s_i is the abundance of the ith species (French 1994). Rarer species have higher ranks, so a site that has a large number of species that are typically rare in Louisiana will have a high HRI, especially if those species are abundant.

The following procedure was used to develop the index:

- Based on migratory patterns, it was determined that 67 species clearly fit a definition of passerines that were neotropical migrants (Table 1).
- Ebird reports for sites in coastal zone of southern Louisiana were collected from the ebird database (ebird.org 2010).
- Sites were then identified from the Cornell database which were dominated by one of the habitat types used in coastal modeling (fresh, intermediate, brackish, saline, ridges, maritime forests, and swamp) for which there were survey data. Reports from sites that could not be clearly assigned to a habitat type where eliminated. We identified 80 sites which had been surveyed a total of 945 times. This number included only surveys conducted between the months of March and October. Winter months were excluded because our goal was to examine occurrences of neotropical migrants, not birds wintering in the area. Because fresh, intermediate and brackish marshes were surveyed less frequently, we combined these samples to get a better estimate of relative abundance of different neotroprical migrants. Note: This model only represents one variable, which is wetland type. This occurred because it was the only feature in the available data sets that could be readily assigned to the sites in the ebird reports. However, this is perhaps not much of a liability because vegetation cover is probably the most important factor in determining the use of a site by migrating songbirds.

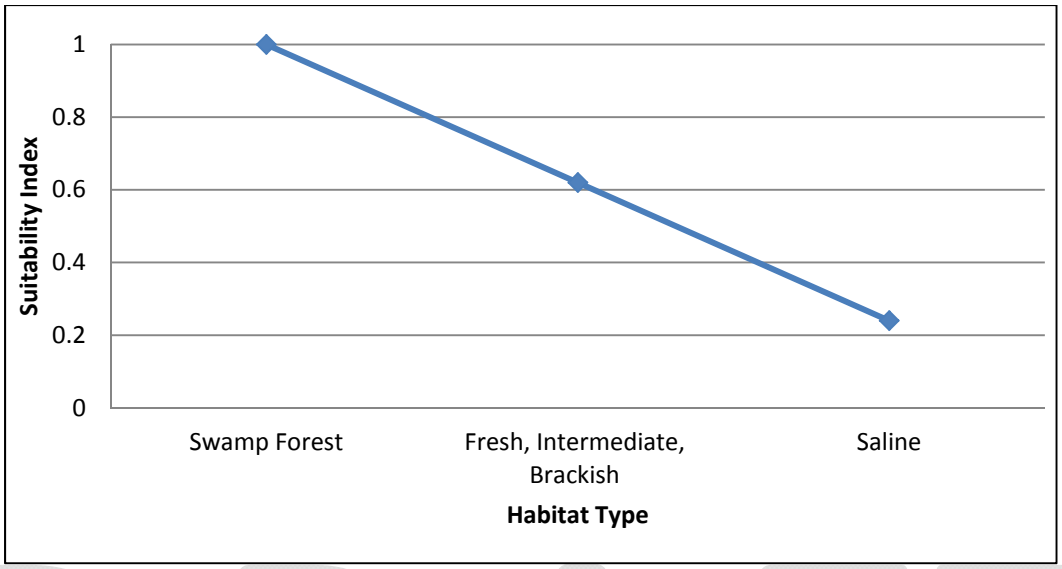
- For each ebird report (which represents a visit to a site by an observer), the number of individuals of each neotropical species that were observed was determined. These numbers were standardized by the amount of time an observer spent at a site.
- The numbers of each species in table 1 that were observed per hour were averaged across all the reports of a site.
- The values of s_i and i, defined above were determined for each site and used to estimate the HRI.
- Average HRI values were determined for each habitat type, based on all the sites where that habitat was dominant. Once we determined the vegetation type that had the highest average HRI value, we divided all values of the other habitat types by that average value, setting the highest relative value as 1, and setting the other values relative to the highest value. The relative values of the HRI are referred to as the habitat importance index (HI). The original model included relative importance values for ridges, maritime forests and bottomland hardwood forests. These forests had higher HRI and thus HI values than the wetland types included in the final mode. However, ridges, maritime forests and bottomland hardwood forests where removed from the final model because they were not modeled in the vegetation model due to lack of data on these habitat types. Thus, the relative values of HI were determined based on the most modeled vegetation type (swamp) that had the highest HRI. Other habitats evaluated were fresh, intermediate, brackish, and saline marsh. The HI values were used to assign relative important values using the following model.

Neotropical Migrant: Habitat Type, SI_1
HSI is sum of proportions of habitat types represented in a 500 x 500 m cell by relative values of each habitat type to neotropical migrants (1 * V1B + 0.63* V1C + 0.24* V1D).

V1B= percentage of cell that is Swamp Forest.
Weight = 1.0.

V1C = percentage of cell that is sum of Fresh + Intermediate Habitat+ Brackish Habitat.
Weight = 0.63.

V1D= percentage of cell that is Saline Habitat.
Weight = 0.24.



b. Description of system being represented by the model

This model is an attempt to model species richness, weighted by rarity for neotropical migrant passerines in the wetlands of southern Louisiana. This system is different from most species-specific models, since there is no attempt to incorporate the biology of individual species. The model is simulating how species richness, weighted by rarity, will change based on changes in wetland type, based on dominant vegetation types. These changes are represented by changes in the HI index value.

Results should not be taken to reflect individual species patterns. Because the model is based on a large number of species, individual taxa could be extirpated from the landscape with little effect on model outputs. Any uncertainty in the vegetation cover model will result in uncertainty in this model. Other limitations of the model are described in section 5.

c. Analytical requirements

The Neotropical Migrant HSI has the following analytical requirements: habitat type within a 500 x 500 m cell per year. The HSI value for each cell is the sum of the proportional weighting of each habitat type.

d. Assumptions

This model assumes that reports to the ebird database accurately reflect bird use in different habitat types. There is almost certainly error introduced by the lack of data resulting from rigorous sampling protocols. However, in the absence of such data (see sections 5 and 6), use of survey reports from a large number of observers should provide a relative measure of the species richness in different habitats. This assumption is supported by the observation that the HSI values assigned to different habitats are similar to what the author would assign based on 20 years of experience in studying bird habitats.

e. Identification of formulas used in the model and proof that the computations are appropriate and done correctly

The model decision rules that were coded are provided in section 2.a. above. Quality review was performed by both the model coders and CPRA to ensure formulas and computations were correct.

3. System Quality

a. Description and rationale for selection of supporting software tool/programming language and hardware platform

Building on the ecological modeling application development performed for the Everglades modeling community, Java was used as the programming language inside the Eclipse RCP environment which supports plug-in software development. This approach facilitated the construction of software suites which execute the specific decision rules provided by subject matter experts allowing an end-user to choose which of the ecosystem services models to run.

b. Proof that the programming was done correctly

All software products are the result of multiple programmers working in concert. As part of the code development process, code classes are either team developed which ensures multiple individuals real-time code review or when individually coded are spot checked prior to production builds and exports. After final model coding was performed, an independent review was performed to ensure that the model code exactly matched the decision rules contained in the documentation provided to the model coder.

c. Availability of software and hardware required by model

The choice of Java as the development platform ensures the broadest execution platform. These software suites can run on desktops with the following operating systems: Windows XP, 7 (32 and 64 bit), Apple OSX (32 and 64 bit), Linux. Furthermore, these Java executables could be easily re-compiled to run on Windows or Linux Application Servers.

d. Description of process used to test and validate model

The model was tested prior to production release with fabricated data built according to the data descriptions provided by the various teams. The absence of "real" data made pre-production testing less effective than it could have been had there been high quality test data.

Ideally, model outputs would be validated by comparing the model predictions to observations made in the field, but that is not possible with this model. The second best validation is based upon comparison of modeled predictions to what is expected given the known inputs. The latter approach was followed and known spatial patterns and temporal patterns in input were used to predict output patterns for neotropical migrants.

e. Discussion of the ability to import data into other software analysis tools (interoperability issue)

Being standards compliant with international modeling data standards ensures rather broad interoperability. Unidata actively supports netCDF read/write libraries for C++, Java, C# and Fortran programming languages across multiple operating systems. Additionally, netCDF is natively consumable by commercial software product such as ESRI ArcMAP and MatLab. Furthermore, the Everglades Joint Ecologic Modeling community has backed a USGS software

development effort resulting in EverVIEW which brings an open-source visualization platform solution to the complex realm of binary modeling data.

4. Usability

a. Availability of input data necessary to support the model

The input data are simulated by other master plan models: habitat type. The input files that were produced by master plan modeling teams for use in this model are available through the CPRA.

b. Formatting of output in an understandable manner

The output data is a suitability index ranging from zero to one that represents neotropical migrant habitat suitability of each 500 x 500 m model grid cell across the coast. The output files are in netCDF format and can be viewed using EverVIEW or ESRI ArcGIS.

c. Usefulness of results to support project analysis

In general, this model responds to projects which result in changes in neotropical migrant habitat suitability. Therefore, projects such as marsh creation, ridge creation, diversions, or hydrologic restoration that change habitat type would drive changes in model results for a particular area.

d. Ability to export results into project reports

The model output is in netCDF format, which provides both a graphical and tabular representation of the model results that can be incorporated into reports. Model outputs can also be imported into ESRI ArcMap.

e. Training availability

Training for model usage can be provided through CPRA.

f. Users documentation availability and whether it is user friendly and complete

There are currently no user's guides or technical manuals to support the model; however, the model does have a help screen that explains how to convert model inputs into the necessary format as well as which files are necessary to run the model.

g. Technical support availability

Access to technical support for this model can be provided through CPRA.

h. Software/hardware platform availability to all or most users

The ecosystem services modeling suite, being coded in Java, will run on most operating systems.

i. Accessibility of the model

Access to the modeling software package can be made available through CPRA.

j. Transparency of model and how it allows for easy verification of calculations and outputs

Model decision rules are documented in section 2a. Model HSI values must be between zero and one.

5. *Sources of model uncertainty*

Potential sources of uncertainty include errors in data submitted to the ebird database, low sampling intensity for some vegetation types in the ebird database, and errors in assigning the correct habitat types to the spatial locations in the ebird database. This would lead to uncertainty in relative sizes of the HI values assigned to different habitats. These errors are probably relatively small because HI values conform to observations the model developer has made over 20 years of field work in southern Louisiana.

Another potential source of uncertainty includes uncertainty associated with modeling changing vegetation conditions over time; see the Vegetation Model appendix for a description of those potential issues.

6. *Suggested model improvements*

This model would have benefited by the inclusion of bottomland hardwoods in the vegetation modeling effort. This is an important wetland habitat for neotropical migrants. Ridge habitats located in wetlands are also critical for many of these species, but were not included as ridges were treated as unchanging upland habitats in the vegetation modeling effort. If ridges are included in future efforts, efforts should be made to model human development of those habitats.

The model would have benefited from a systematic sampling of neotropical bird species in the different vegetation types that were modeled. Although using observations from the ebird database provided general trends and reasonable estimates of the relative importance vegetation types to neotropical migrants, studies designed to quantify abundance in each vegetation cover type would provide greater resolution.

7. *Quality review*

Specific quality review procedures for the Neotropical Migrant HSI included comparison of modeled predictions with expected outcomes given the known inputs. The model developer as well as internal CPRA staff used known and observed spatial patterns and temporal patterns in input data to predict habitat suitability for neotropical migrants.

8. *Uncertainty analysis*

No uncertainty analysis was conducted for this model.

9. *References*

French, D. D. 1994. Hierarchical richness index (HRI): A simple procedure for scoring [] richness', for use with grouped data. Biological Conservation. 69:207-212.

eBird. 2010. eBird: An online database of bird distribution and abundance [web application]. Version 2. eBird, Ithaca, New York. Available: http://www.ebird.org. (Accessed: July 15, 2010).