

Model Name: Roseate Spoonbill Habitat Suitability Index

Functional Area: Ecosystem Services / Upper Trophic Level

Model Proponents: Coastal Protection and Restoration Authority

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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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Table of Contents

1.	<i>Background</i>	4
a.	Purpose of Model	4
b.	Model Description and Depiction	4
c.	Contribution to Planning Effort	4
d.	Description of Input Data	5
e.	Description of Output Data	5
f.	Statement on the capabilities and limitations of the model	5
g.	Description of model development process including documentation on testing conducted (Alpha and Beta tests)	5
2.	<i>Technical Quality</i>	5
a.	Theory	5
b.	Description of system being represented by the model	9
c.	Analytical requirements	10
d.	Assumptions	10
e.	Identification of formulas used in the model and proof that the computations are appropriate and done correctly	10
3.	<i>System Quality</i>	10
a.	Description and rationale for selection of supporting software tool/programming language and hardware platform	10
b.	Proof that the programming was done correctly	10
c.	Availability of software and hardware required by model	10
d.	Description of process used to test and validate model	11
e.	Discussion of the ability to import data into other software analysis tools (interoperability issue)	11
4.	<i>Usability</i>	11
a.	Availability of input data necessary to support the model	11
b.	Formatting of output in an understandable manner	11
c.	Usefulness of results to support project analysis-	11
d.	Ability to export results into project reports	11
e.	Training availability	11
f.	Users documentation availability and whether it is user friendly and complete	12
g.	Technical support availability	12
h.	Software/hardware platform availability to all or most users	12
i.	Accessibility of the model	12
j.	Transparency of model and how it allows for easy verification of calculations and outputs	12

5. *Sources of model uncertainty* 12

6. *Suggested model improvements* 12

7. *Quality review* 12

8. *Uncertainty analysis*..... 13

9. *References* 13

DRAFT

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 roseate spoonbills 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

The Roseate Spoonbill (*Platalea ajaja*) is a charismatic wading bird found throughout southern Louisiana. An HSI model already existed for this species (Lewis et al. 1983). This model was modified because some of the data inputs were not available through the master plan modeling process. For example, Lewis et al (1983) base part of their HSI on the average height of vegetation at a site and on the use of a site by other avian species. We did not have access to this type of information on the scale of this modeling effort. As noted below, we also have incorporated information from studies that occurred after Lewis et al. (1983) published into their HSI.

Roseate Spoonbills are dependent on trees or shrubs, in or surrounded by water, for nesting sites (Dumas 2000). Almost all foraging occurs in water at depths less than 12 cm (Dumas 2000, Draugelis-Dale 2007). The amount of land/water edge has also been shown to affect wading bird foraging (O'Connell 2010). In addition to natural wetlands, agricultural wetlands have been shown to be important foraging sites (Fleury and Sherry 1995). This can be important in assessing whether a potential nest site has suitable foraging habitat nearby. Lack of suitable foraging habitat near nest sites may be one of the primary reasons for nesting colony abandonment (Leberg et al 2007).

Because this species uses different wetlands for foraging and nesting, this model features a component for nesting habitat and a component for foraging habitat. Nest sites depend on the presence of woody vegetation surrounded by deep water; however foraging occurs in shallow water habitats. Because good foraging habitat is not usually good nesting habit, these components were separated in this model. Each cell is assessed for its HSI under each of these components. After determining the two HSI values, the higher value was assigned to a cell. We used the highest value of the HSI from the two components because birds can readily fly from one area to another to accomplish both foraging and nesting. Thus, just because a site is not useful for foraging, it might have great value for nesting.

c. Contribution to Planning Effort

The model has potential application to any coastal planning activity that involves evaluation of projects that affect the landscape setting, vegetation type, water depth, and edge preferred by roseate spoonbills. The model can be used to evaluate effects on roseate spoonbill habitat suitability for a variety of coastal protection and restoration projects, including marsh creation, diversions, and others.

d. Description of Input Data

This model requires data on landscape setting (whether cells are surrounded by water or not), vegetation types, water depth, the portion of the cell that is edge (land/water interface) as its input. Vegetation types are provided by the Vegetation model; water depth is calculated from outputs from both the Eco-hydrology and Wetland Morphology models; and edge is provided by the Wetland Morphology 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 roseate spoonbills, 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 cell based on the habitat use data available for the target species. As vegetation cover changes in coastal wetlands, this model should be able to provide an indication of how those changes will affect the suitability of the habitat of the target species.

The model is limited by the lack of detailed assessments of habitat use by the target species in southern Louisiana. The model is also limited by the vegetation types modeled. Bottomland forests and agricultural wetlands are important habitats for these species, but they were not included because they were not produced by the Vegetation model due to lack of data on these habitats. Likewise, the Eco-Hydrology model provided input data to this model at a very coarse spatial scale.

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

CPRA identified the roseate spoonbill as an important species for inclusion in the 2012 Coastal Master Plan. A literature review was conducted for the species, identifying studies that had examined habitat use and suitability especially in areas located in the southeastern United States. Relationships identified in the literature survey were developed into a series of equations describing habitat suitability. These equations were scaled so that 0 represented unsuitable habitat and 1 represented optimal habitat. The geometric means of HSI values were obtained for each cell. Relative values of the HSI were developed into an equation, based on habitat conditions in a cell. These equations were delivered to CPRA for development of the model code.

2. Technical Quality**a. Theory**

This model uses methodologies taken from those traditionally applied to developing habitat suitability indices developed by the U.S. Fish and Wildlife Service (see USFS 1981 for details on the procedures). The model attempts to use available habitat utilization information to develop a habitat suitability index ranging from 0 (unsuitable habitat) to 1 (optimal habitat). In cases where the model contains multiple indices, the geometric mean of the indices is used to assign an overall index value to a cell.

As noted above (section 1b), to capture this diverse relationship between the bird use and habitat features, this model features a component for nesting habitat and a component for foraging habitat.

Nesting Habitat Suitability

Roseate spoonbills nest on either islands or in woody vegetation isolated in deep water. Following Lewis (1983) a separate index for nesting habitat was created for these two very different habitat types. If a site is on an island, the index for islands should be used. Otherwise the index for wetlands should be used.

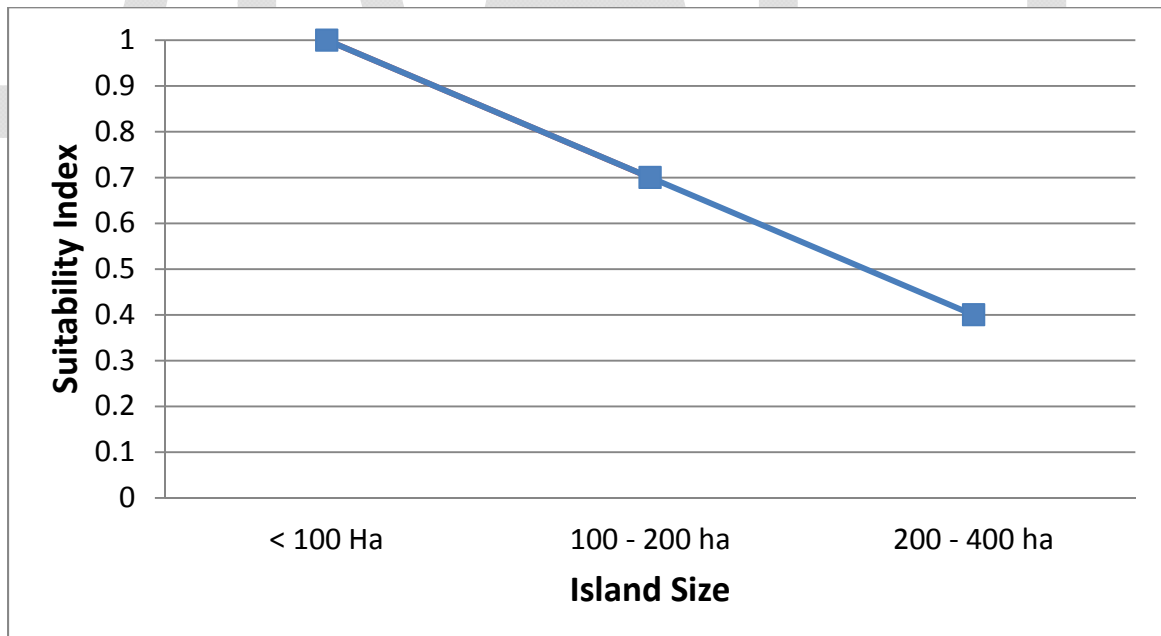
Nesting Habitat: Landscape Setting

V1: proportion of the 500 x 500 m cell that is near small, near-shore undeveloped island.

SI₁ = 1 when the focal cell or a portion of the cell, is part of a land mass < 100 hectares (ha) in size, and is surrounded completely by cells containing only water (with or without SAV).

SI₁ = 0.7 when the focal cell or a portion of the cell, is part of a land mass > 100 ha and ≤ 200 ha in size, and is surrounded completely by cells containing only water (with or without SAV).

SI₁ = 0.4 when the cell or a portion of the cell, is represented by “land,” and either singularly or as part of a contiguous patch of cells with land, is larger than 200 ha (8 cells) but not larger than 400 ha (16 cells), and is surrounded completely by cells containing only water (with or without SAV).



This treatment of island size was modified from Lewis (1983). It had to be modified because Lewis (1983) based the index on differences in island size that were beyond the spatial resolution of the data available in the CPRA data sets. However, the values above approximate

those used by Lewis (1983). Small islands are less likely to support predator populations or be utilized by humans and are thus more likely to support nesting populations of Roseate spoonbills than are larger island (Lewis 1983).

Notes: Current and future locations of Grand Isle, which is a developed island, have been removed from the HSI with a GIS mask. Current and future locations of islands that are too far off shore for regular use by the species (those that are both north of latitude 29.5 and east of longitude 89.1) have been removed from the HSI with a GIS mask.

Nesting Habitat: Vegetation Type

$$SI_2 = (1 * V2a + 0.6 * V2b + 0.2 * V2c)$$

Where:

V2a = Proportion of cell that is Swamp

V2b = proportion of the cell that is represented by Delta Splay + Wax Myrtle + Cutgrass + Maidencane + Cattail + Sawgrass + Bulltongue)

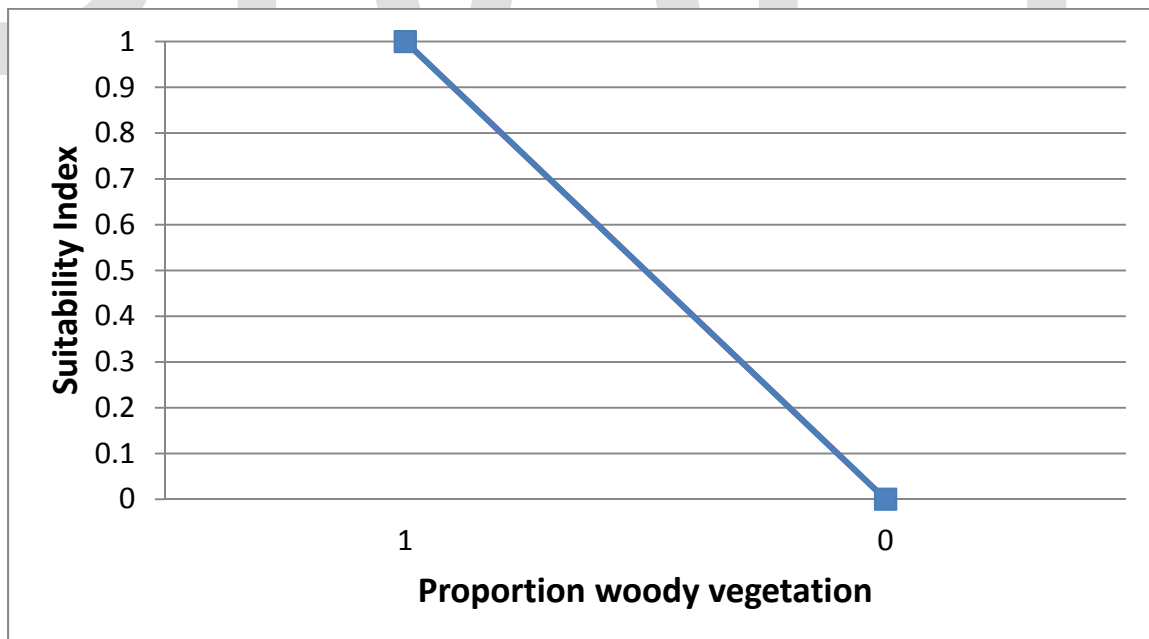
V2c = proportion of cell that is Intermediate, brackish or saline habitat

The relative values of these habitats are based on the number of occurrences of recent colonies based on surveys of Michot et al (2003) and Green et al. (2006) in different habitats divided by the abundance of those habitats in the survey area. The higher relative abundance of colonies in swamp is probably due to the tendency of the species to nest in tall, woody vegetation. It is not clear why fresh water habitats are preferred over brackish or saline or saline habitats, but the trend is quite clear from an examination of the survey data.

Nesting Habitat: Presence of Woody Vegetation

$$SI_3 = V3 / 100$$

V3 = (Swamp forest + Wax Myrtle + Mangrove + Shrub Scrub) in a cell.



Roseate Spoonbills are dependent on trees or shrubs for nesting sites (Lewis 1983,Dumas 2000).

Nesting Habitat: Availability of foraging habitat, based on water depths within 10 km of a cell containing possible nesting vegetation

V4 = the sum of the available foraging habitat from all cells in the 10-km radius of a focal cell divided by the total number of cells in the radius. Available foraging habitat is defined as the proportion of daily water depths for the period of Feb through July where the water depth is between 1 and 12 cm.

$$SI_4 = 1 \text{ if } V4 \geq 0.5$$

$$V3 * 2 \text{ if } V4 < 0.50$$

Note: Because there is no need to evaluate foraging habitat within 10 km of a cell that does not contain nesting habitat, this circle with a 10 km radius is only applied to cells where V3 > 0.

Lack of suitable foraging habitat may be one of the primary reasons for colony abandonment (Leberg et al 2007). This component is modified from Draugelis-Dale (2007) which focused on different wading birds. Season is based on timing of reproductive activity. Water depths are based on those commonly used by the species (see Dumas 2000); these birds do not use deep water. The 10km radius is based on Draugelis-Dale (2007) and represents the area over which nesting birds are likely to forage. While this might seem conservative for a species where adults can forage 30 km from a site, such long flights have energetic costs and it is critical that foraging areas be available near nesting sites. Previous waterbird HSIs (see Draugelis-Dale (2007)) used the proportion of the area rather than setting a threshold of 50%; however, those models contained less information on average water depths and personal observations suggest that only when foraging habitat becomes relatively uncommon does reproductive success decrease.

The following two indices should be used for islands, or other wetland habitats as appropriate to represent HSI_{nesting}.

$$HSI_{\text{island}} = (SI_1 * SI_2 * SI_3 * SI_4)^{1/4}$$

$$HSI_{\text{wetlands}} = (SI_2 * SI_3 * SI_4)^{1/3}$$

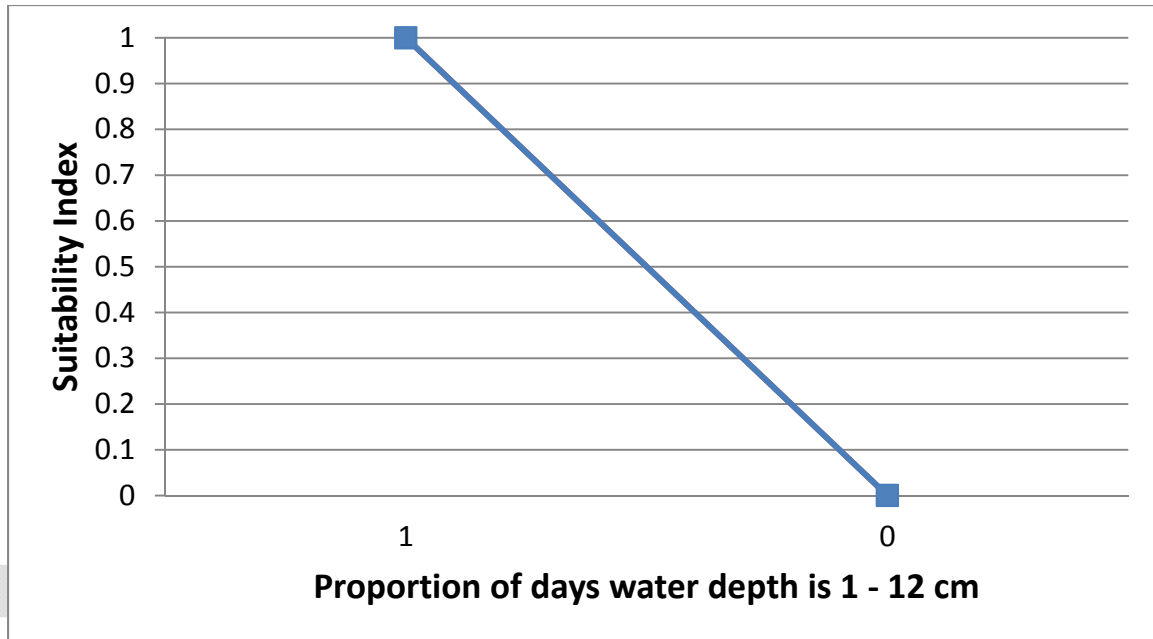
Foraging Habitat Suitability

Note : This portion of the model applies to individually modeled cells, unlike V4 which applies to the area around a cell.

Note : V₅ represents a HSI component that is no longer represented in the model. Because the programmer continued to use V₆ and V₇ in the model, with those variable designations, V₆ and V₇ are used here.

Foraging Habitat: Depth

SI₆ = V₆ where V₆ is the proportion of days in a year the water depth is 1 - 12 cm.



Almost all foraging occurs in water at depths less than 12 cm (Dumas 2000, Draugelis-Dale 2007). Because daily water depth inputs could be provided, the proportion of days depths occurred within a given range of values was used to influence the HSI.

Foraging Habitat: Edge

$SI_7 = v_7 * 0.0065 + 0.35$ where V_7 is the proportion of the of cell that is edge (the area of water projecting 10 m from the land/water interface)

This metric is based on the work of O'Connell (2010) that found increased foraging of wading birds near land/water edges. The regression model in that work is approximated above, relative values created by dividing the predicted value by the largest possible predicted value (obtained when $V_7 = 1$). Roseate spoonbills use edge habitat during foraging. Although this area needs more research, this model tries to capture the importance of edge habitat based on the slope of the relationship between the amount of edge in open water habitat. Such edge habitat is not applicable to cypress swamps, so the value for cypress swamp is an estimate based on personal observations of foraging in these habitats, relative to marsh edges.

The following index should be used for foraging habitat.

$$HSI_{\text{foraging}} = (SI_6 * SI_7)^{1/2}$$

As noted in section 1b, birds can readily fly between foraging and nesting sites. Even though a site may be poor habitat for one component of the species' needs, it might be critical for another. Therefore, a cell should be assigned the highest value of HSI_{foraging} or HSI_{nesting}

b. Description of system being represented by the model

This model is an attempt to predict relative habitat suitability for roseate spoonbills in the wetlands of southern Louisiana. Because this species uses wetlands differently for foraging and reproduction and is capable of moving between habitats, the suitability of a cell as both foraging

and nesting habitat is modeled. The cell is then assigned a relative suitability index based on the higher value of either foraging or nesting habitat.

c. Analytical requirements

The Roseate Spoonbill HSI has the following analytical requirements: landscape setting, vegetation type, presence of woody vegetation, water depths in proximity to each cell, proportion of days in a year the water depth is 1 - 12 cm, and edge. The first four variables are designated as important for nesting habitat, while the last two are important for foraging habitat. The geometric mean of the variables for nesting habitat is compared to the geometric mean of the variables for foraging habitat, and the higher value is designated as the HSI value for each 500 x 500 m cell.

d. Assumptions

This model assumes habitat relationships for this species obtained from the literature, often based on work in Texas and Florida, are valid for Louisiana. It also assumes that the Eco-Hydrology and Vegetation models have low rates of error.

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 roseate spoonbills.

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: landscape configuration, vegetation type, presence of woody vegetation, water depths in proximity to each cell, proportion of days in a year the water depth is 1 - 12 cm, and wetland edge. 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 roseate spoonbill 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 roseate spoonbill habitat suitability. Therefore, projects such as marsh creation, ridge creation, diversions, or hydrologic restoration that change habitat type, landscape configuration, or water depths 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 upper trophic level and ecosystem services modeling suites, 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 the low spatial resolution of the Eco-Hydrology model output. The lack of bottomland hardwoods model output from the Vegetation model also could influence the results of this model. Another potential source of uncertainty includes uncertainty associated with modeling changing vegetation conditions over time. Finally, this model represents a hypothesis about habitat suitability for the target species. This hypothesis should be tested in the field to quantify the degree of uncertainty and to see if it varies with geographic location.

6. Suggested model improvements

The land use/land cover base data set used in the modeling effort does not distinguish between rice/crayfish agriculture and other forms of agriculture. Although some forms of cultivated agriculture, such as rice/crayfish ponds provide high quality foraging sites, others do not. Because of uncertainty about which agricultural lands are classified as "cultivated agriculture" this variable is not listed as foraging habitat. However, if these agricultural types can be distinguished in the future, crawfish and rice agriculture should be included as foraging habitat in the estimation of SI4.

During the review of model output, it seemed possible that the low level of spatial resolution of the Eco-Hydrology model might be reducing the predictive ability of the habitat suitability estimates. Increasing resolution would enhance the outputs of this model. This is especially true in flooded forests such as bottomland hardwoods. Including bottomland hardwoods in the Vegetation modeling effort would be beneficial as these forests are sometimes used as nesting and foraging sites.

7. Quality review

Specific quality review procedures for the Roseate Spoonbill 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 roseate spoonbills.

8. Uncertainty analysis

No uncertainty analysis was conducted for this model.

9. References

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