Model Name: Gadwall 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 gadwall 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 gadwall (*Anas strepera*) is a migratory species, occurring most commonly in Louisiana in the fall, winter, and spring. Although there is a habitat suitability model (HSI) for the species on its nesting ground (Sousa, 1985), a HSI for wintering sites like Louisiana was not found.

This model is based on three variables, to be more fully described in section 2a. These variables are based on three relationships. First, on winter grounds, gadwalls use intermediate marsh more than fresh or brackish marsh (Bolduc 2002). Saline marsh is used less frequently than other marsh types (Gray 2010). It also uses flooded forested areas (Fredrickson and Heitmeyer 1987), but the use is more limited than that of marshes. Paulus (1984) noted that natural marshes provided better foraging habitats than did impoundments in Louisiana, but this conclusion was not supported by Bodluc (2002) so impoundment was not included in this model.

Second, compared to the other ducks being modeled, the gadwall tends to forage on submerged aquatic vegetation (SAV (White 1975, Leschack et al. 1997). And finally, Gadwall tend to require fairly deep water, compared to other dabbling ducks, for foraging (Bolduc 2002).

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, and water depth preferred by gadwall. The model can be used to evaluate effects on gadwall 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, and water depth as its input. Landscape setting is provided by the Wetland Morphology model; vegetation types are provided by the Vegetation model; and water depth is calculated using output both from the Eco-Hydrology and Wetland Morphology models.

e. Description of Output Data

The model output data is a number ranging from 0 to 1 that represents the suitability of each 500 x 500 m cell per year to provide habitat for gadwall, 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 landscape configuration and vegetation type change in coastal wetlands over the years modeled, this model should be able to provide an indication of how those changes will affect habitat suitability of the target species.

The model is limited by the lack of detailed assessments of habitat use by the target species along the northern coast of the Gulf of Mexico. The model is also limited by the vegetation types modeled. Likewise, the Eco-Hydrology modeling completed for this effort was provided at a coarse spatial scale.

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

CPRA identified gadwall 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 suitably, especially in areas located in the southeastern US. 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 the CPRA for development of the model.

2. Technical Quality

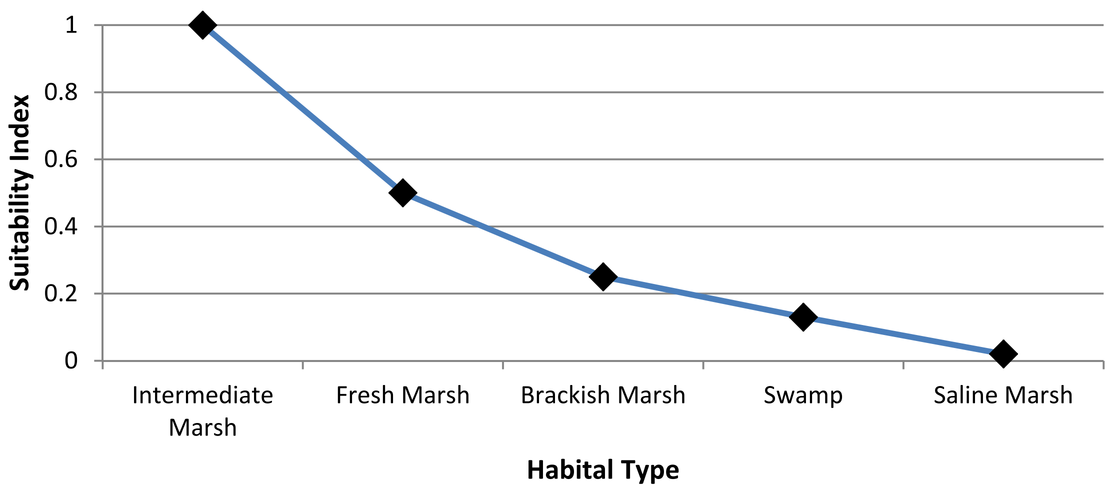
a. Theory

This model uses methodologies taken from those traditionally applied to developing habitat suitability indices developed by the US 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.

<u>V1 – Proportion of Cell Occupied by Gadwall Habitat</u>

$SI_1 = 1.0 * V1a + 0.5 * V1b + 0.25 * V1c + 0.13 * V1d + 0.02 * V1e$

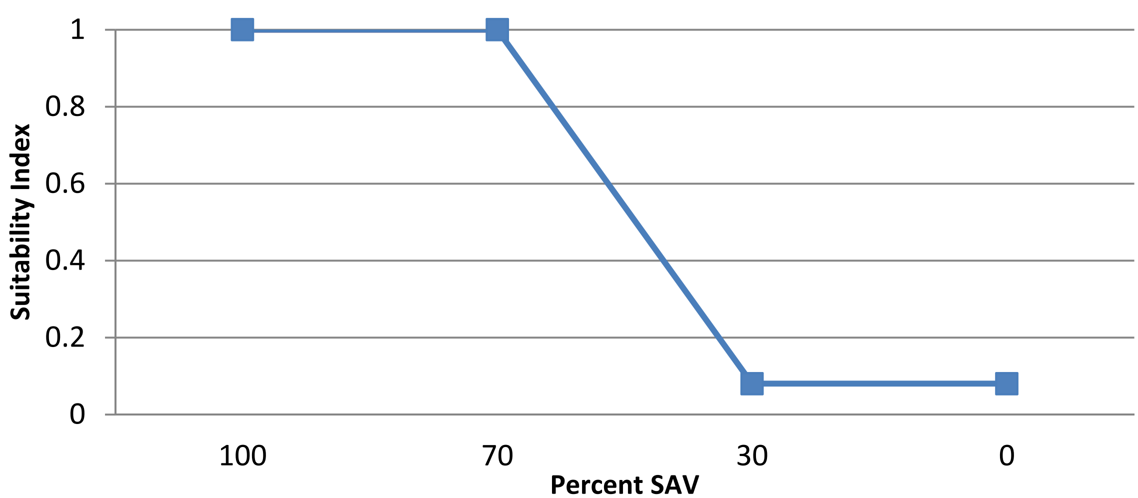
When:
V1a = intermediate marsh (weight = 1.0)
V1b = fresh marsh (weight = 0.5)
V1c = brackish marsh (weight = 0.25)
V1d = swamp (weight = 0.13)
V1e = saline marsh (weight = 0.02)



This index represents the average relative habitat use based on two studies in Louisiana. The first is based on densities of the species estimated by Bolduc (2002) in fresh, intermediate and brackish marsh. The second is based on estimates of proportional habitat use in fresh, intermediate, brackish and saline marsh (Gray 2010). In each case, the highest level of relative use was assigned a value of 1 prior to averaging; values from Gray 2010 were also averaged across years. Neither Bolduc nor Gray estimated use in flooded forest. We used a value of 0.13 that Foret et al. (2004) used for the value of swamps for all dabbling ducks. This seems reasonable for this species because it uses flooded forests for portions of the winter (Fredrickson and Heitmeyer 1987); however, investigation of the relative habitat use of marsh and forested wetlands is needed.

<u>V2 - Percent of the Cell that is Water with submerged aquatic vegetation (SAV)</u>

SI_2=	1.0	for 70 <=V2 <=100
	V2 * 0.23 - 0.61	for 30 <=V2 < 70
	0.08	for V2 < 30

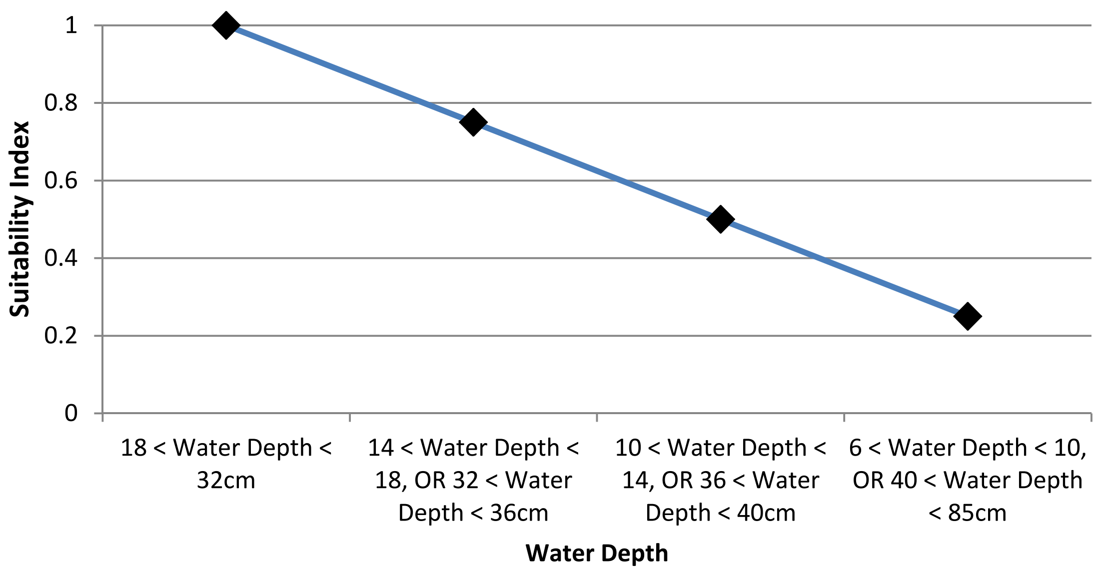


This index is developed by observations from White (1975) and is based on the distribution of gadwall foraging in Texas wetlands. The distribution of percent SAV was divided into classes and the most utilized class (70-100%) was assigned an index of one. Classes that were used to a lesser extent received proportionally lower values of V2. The change of the index value was then converted into a linear function to de-emphasize the influence of small changes in the environmental variable on the index value.

<u>V3 – Proportion of Days September-March that the Water Depth (cm) Provides Suitable Foraging Habitat</u>

$SI_3 = 1 * V3a + 0.75 * V3b + 0.5 * V3c + 0.25 * V3d$

When:
V3a is the proportion of days Sept-March that a cell's water depth (wd) is 18 ≤ depth ≤ 32 cm (weight = 1.0)
V3b is the proportion of days Sept-March that 14 ≤ wd < 18 or 32 < wd ≤ 36 cm (weight = 0.75)
V3c is the proportion of days Sept-March that 10 ≤ wd < 14 or 36 < wd ≤ 40 cm (weight = 0.50)
V3d is the proportion of days Sept-March that 6 ≤ wd < 10 or 40 < wd ≤ 85 cm (weight = 0.25)



This index is based on the nonparametric regressions developed by Bolduc (2002) of use of Gadwall of areas with different water. Depth was divided into classes and the most utilized class was assigned an index of one. Depths that were used to a lesser extent received proportionally lower values of SI3. The assessment of water depth was limited to the fall, winter, and spring, when migrating gadwall would be most likely to be found in south Louisiana. Because water depth is being allowed to fluctuate in the hydrology model, we used the proportion of days that the depths occurred within a given range of values to influence the HSI.

Following Foret et al. (2004), the HSI for gadwall is computed as the geometric mean of the three factors:

$HSI = (S1 \times SI2 \times SI3)^{1/3}$

Where: 1 = highly suitable habitat and 0= unsuitable habitat for the species.

b. Description of system being represented by the model

This model is an attempt to model relative habitat suitability for gadwall in the wetlands of southern Louisiana over a 50 year time scale within 500 x 500 m cells per year and with and without implementation of different protection and restoration projects.

c. Analytical requirements

The Gadwall HSI has the following analytical requirements: landscape setting (whether cells are surrounded by water or not), vegetation types, and water depth within a 500 x 500 m cell per year. The geometric mean of these three variables provides the HSI for each cell.

d. Assumptions

This model assumes habitat relationships for this species obtained from the literature, including 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 gadwall.

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 setting, vegetation type, and water depths in proximity to each 500 x 500 m model grid cell. 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 gadwall habitat suitability of a 500 x 500 m model grid cell. 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 gadwall 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 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

One potential source of uncertainty is the low spatial resolution of the Eco-Hydrology modeling. Another potential source of uncertainty is uncertainty associated with modeling changing vegetation conditions over time. There is only limited information on the use of swamp forest by this species creating uncertainty in the assignment of the SI value for this habitat. 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

There is currently very little information on the use of forested wetlands by gadwall in Louisiana. A study of relative habitat use during winter months that included both marsh and swamp would provide information that could improve this model. In addition, the Eco-Hydrology model lacks fine scale resolution which adds uncertainty to estimates of water depth. Improving the resolution of the Eco-Hydrology model would improve estimates of habitat suitability.

7. Quality review

Specific quality review procedures for the Gadwall 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 gadwall.

8. Uncertainty analysis

No uncertainty analysis was conducted for this model.

9. References

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