

**Model Name:** Potential for Agriculture / Aquaculture

**Functional Area:** Ecosystem Service

**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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## 1. Background

### a. Purpose of Model

The Potential for Agriculture/Aquaculture Model was based on the concept of habitat suitability index (HSI) models. The model was designed to examine the potential for agriculture using the requirements for the two leading crops in south Louisiana, sugarcane and rice. This model is also being used as a predictor for aquaculture potential.

### b. Model Description and Depiction

The Potential for Agriculture/Aquaculture Suitability Index (SI) is intended to consider the possible effect of a project on potential for agriculture/aquaculture. It is based on 500 x 500m model grid cells and is calculated on an annual time step. The model combines salinity and flooding risk to produce a suitability index for potential for agriculture/aquaculture ranging from 0.0 to 1.0.

### c. Contribution to Planning Effort

The model provides a prediction of agriculture/aquaculture potential in coastal Louisiana for a 50-year time horizon.

### d. Description of Input Data

Data used as input are salinity (ppt) and flood depth (cm) for 50 and 100 year events, and both are output data from other 2012 Coastal Master Plan models. The salinity input data are outputs from the Eco-hydrology Model and are provided as monthly averages. The flood depth input data are outputs from the Risk Assessment Model.

### e. Description of Output Data

The output data is a suitability index ranging from 0.0 to 1.0 that represents the potential for agriculture/aquaculture of a 500 x 500m model grid cell. A value of 1.0 indicates the greatest potential (suitability) for agriculture/aquaculture and a value of 0.0 indicates no potential (suitability) for agriculture/aquaculture.

### f. Statement on the capabilities and limitations of the model

The model is capable of determining the potential of a model grid cell for agriculture/aquaculture in order to evaluate the differences between proposed projects.

The model is limited by the fact that it was based on the conditions for only sugarcane and rice production. It is further limited by its lack of meteorological and soil property inputs. This model is not intended to be a comprehensive quantitative model, but rather a broad planning-level model that predicts areas where agriculture/aquaculture is theoretically possible.

### g. Description of model development process including documentation on testing conducted

Because of the physiological needs of sugarcane and rice plants and the need for freshwater, a salinity component was included in the model. A flooding variable was put into the model because of the flood risk in south Louisiana. Each of these factors were developed as individual suitability indices, and combined geometrically to give a potential for agriculture/aquaculture suitability index. Because aquaculture has similar requirements, the model is also being used as a predictor for aquaculture potential.

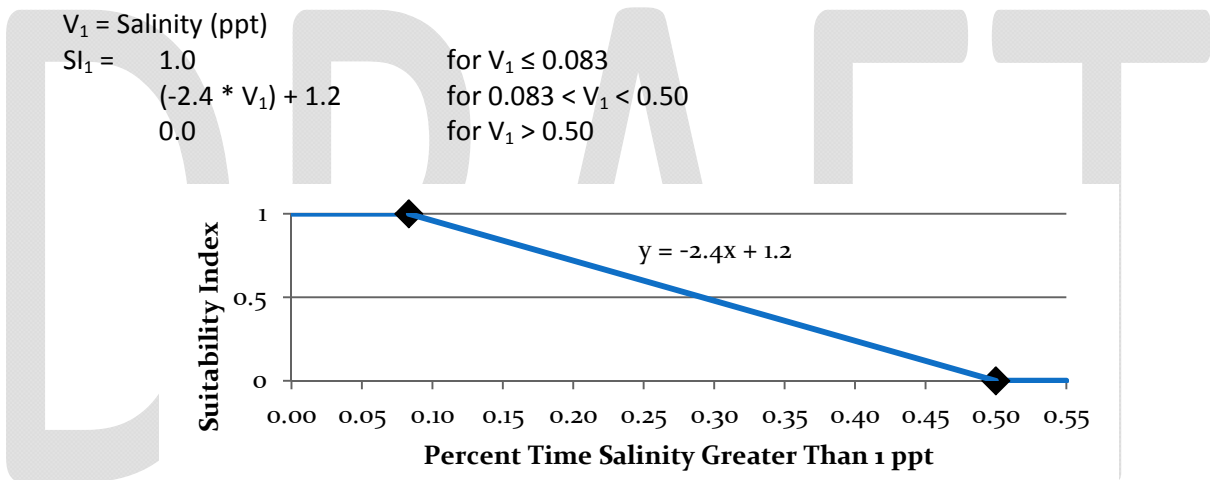
**2. Technical Quality**

**a. Theory**

This model was developed in a similar style to habitat suitability indices. The following factors are included in the Potential for Agriculture/Aquaculture SI Model:

**SI<sub>1</sub> - Suitability Index for Salinity**

Because of the sensitivity of both sugarcane and rice to salt, a salinity component of the model was designed. This variable measures the percent of time that the water within a given model grid cell is greater than 1.0 ppt (i.e.; not freshwater) per year based on monthly means. If the water is not fresh less than 8.3% of the time, then it receives a suitability index of 1.0. However if the water is not fresh more than 50% of the time, then it receives a suitability index for agriculture of 0.0. It is assumed that there is a linear relationship between suitability and time salinity is less than 1 ppt. The equation was calculated using by fitting a linear trend line between the two end points with the equation  $SI_1 = (-2.4 * V_1) + 1.2$ .



**SI<sub>2</sub> - Suitability Index for Inundation**

The risk of flooding the coastal areas of south Louisiana is of great concern for the agricultural industry. Since lands that are flooded frequently and deeply cannot support agriculture, an inundation component of the model was developed. The model is based on flooding under 100-yr and 50-yr events with a flood depth component. Lands that do not flood under a 100-yr event receive an SI of 1.0. If the land in a grid cell does not flood under a 50-yr event and floods less than 15cm for a 100-yr event, an SI of 0.8 is assigned. Areas that get between 0 and 15cm of flooding in a 50-yr event get an SI of 0.6. Lands that get 15cm or more flooding during a 50-yr event have an SI of 0.0.

$V_2 = \text{Depth of flooding}$

$SI_2 = \begin{cases} 1.0 & \text{for depth of flooding for 100 year event} = 0.0 \\ 0.8 & \text{for depth of flooding for 50 year event} = 0.0, \text{ AND depth for 100 year event} < 15\text{cm} \\ 0.6 & \text{for } 0.0 < \text{depth of flooding for 50 yr event} < 15\text{cm} \\ 0.0 & \text{for depth of flooding for 50 yr event} \geq 15\text{cm} \end{cases}$

**Potential for Agriculture SI**

The agriculture/aquaculture suitability index equation is a geometric relationship with both variables multiplied since both are essential components to the Potential for agriculture/aquaculture ecosystem service.

$$\text{Potential for Agriculture SI} = (\text{SI}_1 * \text{SI}_2)^{1/2}$$

**b. Description of system being represented by the model**

The agricultural industry is vital to the state of Louisiana because of its economic benefits and employment opportunities. Agriculture contributes about \$10 billion to Louisiana's economy (Coreil, 2010), and employs thousands of people (USDA NASS, 2007). The leading agricultural products statewide are sugarcane, rice, soybeans, corn, and cattle (USDA ERS, 2011). In the coastal zones of south Louisiana sugarcane and rice are the main crops (LSU AgCenter, 2010). Therefore, this modeling effort is based on the needs for those two coastal zone crops. In order to identify lands suitable for sugarcane and rice cultivation, the physiological limitations of each crop have been taken into account.

Both sugarcane and rice are sensitive to salt (LOCPR, 2011), so areas that experience extended periods of non-freshwater (> 1 ppt) are not suitable for raising them. Additionally, areas that are frequently flooded cannot support agriculture. Therefore, modeling of the flood frequency is an essential step for predicting suitable agricultural lands. This model was developed for agriculture. It is assumed that lands suitable for agriculture are suitable for aquaculture.

This model simulates the effects of salinity and inundation on habitat potential for agriculture/aquaculture. Each factor is defined as its own suitability index and both factors are combined as a potential for agriculture/aquaculture suitability index through a geometric mean.

**c. Analytical requirements**

In order to adequately investigate potential for agriculture/aquaculture, key factors were identified: salinity and inundation depth. These key factors were both included in the modeling effort, and combined depending on their importance to describing potential for agriculture/aquaculture. The agriculture/aquaculture suitability index equation is a geometric relationship with both variables multiplied since both are essential components to the Potential for agriculture/aquaculture ecosystem service.

**d. Assumptions**

The model was developed for agriculture in south Louisiana, and it is assumed that lands suitable for agriculture are suitable for aquaculture. It is further assumed that the conditions for sugarcane and rice harvest are representative for south Louisiana agriculture.

**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 upon 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.

#### 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

These models were 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 far 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 patterns in potential for agriculture/agriculture.

#### 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 files required to run this model are available through the CPRA.

**b. Formatting of output in an understandable manner**

The output data is a suitability index ranging from 0.0 to 1.0 that represents the potential for agriculture/aquaculture of a 500 x 500m model grid cell. The output files are in netCDF format and can be viewed using EverVIEW or ArcGIS.

**c. Usefulness of results to support project analysis**

In general, this model responds to projects which would result in increases or decreases in salinity or flood depth. Thus, hydrologic restoration or other water management projects or flood protection projects (possibly including large wetland building projects) 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 would 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 would 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 model and associated installation and execution files would be provided 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**

All relationships in this model are sources of potential uncertainty.

**6. Suggested model improvements**

This model could potentially be improved by incorporating additional variables, such as precipitation and evapo-transpiration. In addition, the model could be improved by additional research on salinity and inundation tolerances of rice and sugarcane. Finally, the model could be improved by adding other types of agricultural crops.

**7. Quality review**

Specific quality review procedures for the Agriculture/Aquaculture Model to support the 2012 Coastal Master Plan included comparison of modeled predictions with expected outcomes given the known inputs. The modeling team used known spatial patterns and temporal patterns in input to predict patterns in potential for agriculture/aquaculture.

**8. Uncertainty analysis**

No uncertainty analysis was performed for this model.

**9. References**

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