COASTAL WETLAND PLANNING, PROTECTION,

AND RESTORATION ACT

WETLAND VALUE ASSESSMENT METHODOLOGY

AND COMMUNITY MODELS

Developed by the Environmental Work Group,
Coastal Wetland Planning, Protection, and Restoration Act
Technical Committee

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COASTAL WETLAND PLANNING, PROTECTION AND RESTORATION ACT

Wetland Value Assessment Methodology and Community Models

I. INTRODUCTION

The Wetland Value Assessment (WVA) methodology is a quantitative habitat-based assessment methodology developed for use in prioritizing project proposals submitted for funding under the Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA) of 1990. The WVA quantifies changes in fish and wildlife habitat quality and quantity that are projected to be brought about as a result of a proposed wetland enhancement project. The results of the WVA, measured in Average Annual Habitat Units (AAHU's), can be combined with economic data to provide a measure of the effectiveness of a proposed project in terms of annualized cost per AAHU gained.

The WVA was developed by the Environmental Work Group (Group) assembled under the Planning and Evaluation Subcommittee of the CWPPRA Technical Committee; the Group includes members from each agency represented on the CWPPRA Task Force. The WVA was designed to be applied, to the greatest extent possible, using only existing or readily obtainable data.

The WVA has been developed strictly for use in ranking proposed CWPPRA projects; it is not intended to provide a detailed, comprehensive methodology for establishing baseline conditions within a project area. Some aspects of the WVA have been defined by policy and/or functional considerations of the CWPPRA; therefore, user-specific modifications may be necessary if the WVA is used for other purposes.

The WVA is a modification of the Habitat Evaluation Procedures (HEP) developed by the U.S. Fish and Wildlife Service (U.S. Fish and Wildlife Service 1980). HEP is widely used by the Fish and Wildlife Service and other Federal and State agencies in evaluating the impacts of development projects on fish and wildlife resources.

A notable difference exists between the two methodologies, however, in that HEP generally uses a species-oriented approach, whereas the WVA utilizes a community approach.

The WVA has been developed for application to the following coastal Louisiana wetland types: fresh marsh (including intermediate marsh), brackish marsh, saline marsh, and cypress-tupelo swamp. Future reference in this document to "wetland" or "wetland type" refers to one or more of those four communities.

II. WVA CONCEPT

The WVA operates under the assumption that optimal conditions for fish and wildlife habitat within a given coastal wetland type can be characterized, and that existing or predicted conditions can be compared to that optimum to provide an index of habitat quality. Habitat quality is estimated or expressed through the use of a mathematical model developed specifically for each wetland type. Each model consists of 1) a list of variables that are considered important in characterizing fish and wildlife habitat, 2) a Suitability Index graph for each variable, which defines the assumed relationship between habitat quality (Suitability Index) and different variable values, and 3) a mathematical formula that combines Suitability Index for each variable into a single value for wetland habitat quality; that single value is referred to as the Habitat Suitability Index, or HSI.

The Wetland Value Assessment models (Attachments 1-4) have been developed for determining the suitability of Louisiana coastal wetlands in providing resting, foraging, breeding, and nursery habitat to a diverse assemblage of fish and wildlife species. Models have been designed to function at a community level and therefore attempt to define an optimum combination of habitat conditions for <u>all</u> fish and wildlife species utilizing a given marsh type over a year or longer. Earlier attempts to capture other wetland functions and values such as storm-surge protection, flood water storage, water quality functions and nutrient import/export were abandoned due to the difficulty in defining unified model relationships and meaningful model outputs for such a variety of wetland benefits. However, the ability of a Louisiana coastal wetland to provide those functions and values may be generally assumed to be positively correlated with fish and wildlife habitat quality as predicted through the WVA.

The output of each model (the HSI) is assumed to have a linear relationship with the suitability of a coastal wetland system in providing fish and wildlife habitat.

III. COMMUNITY MODEL VARIABLE SELECTION

Habitat variables considered appropriate for describing habitat quality in each wetland type were selected according to the following criteria:

1) the condition described by the variable had to be important in characterizing fish and wildlife habitat quality in the wetland type under consideration;

2) values had to be easily estimated and predicted based on existing data (e.g., aerial photography, LANDSAT, GIS systems, water quality monitoring stations, and interviews with knowledgeable individuals); and

3) the variable had to be sensitive to the types of changes expected to be brought about by typical wetland projects proposed under the CWPPRA.

Variables for each model were selected through a two part procedure. The first involved a listing of environmental variables thought to be important in characterizing fish and wildlife habitat in coastal marsh or swamp systems.

The second part of the selection procedure involved reviewing variables used in species-specific HSI models published by the U.S. Fish and Wildlife Service. Review was limited to models for those fish and wildlife species known to inhabit Louisiana coastal wetlands, and included models for 10 estuarine fish and shellfish, 4 freshwater fish, 12 birds, 3 reptiles and amphibians, and 2 mammals (Attachment 7). The number of models included from each species group was dictated by model availability.

Selected HSI models were then grouped according to the wetland type(s) used by each species. Because most species for which models were considered are not restricted to one wetland type, most models were included in more than one wetland type group. Within each wetland type group, variables from all models were then grouped according to similarity (e.g., water quality, vegetation, etc.). Each variable was evaluated based on 1) whether it met the variable selection criteria; 2) whether another, more easily measured/predicted variable in the same or a different similarity group functioned as a surrogate; and 3) whether it was deemed suitable for the WVA application (e.g., some freshwater fish model variables dealt with riverine or lacustrine environments). Variables that did not satisfy those conditions were eliminated from further consideration. The remaining variables, still in their similarity groups, were then further eliminated or refined by combining similar variables and/or culling those that were functionally duplicated by variables from other models (i.e., some variables were used frequently in different models in only slightly different format, such as percent marsh coverage, salinity, etc.).

Variables selected from the HSI models were then compared to those identified in the first part of the selection procedure to arrive at a final list of variables to describe wetland habitat quality. That list includes six variables for each of the marsh types and three for the cypress-tupelo swamp (Attachments 1-4).

IV. SUITABILITY INDEX GRAPHS

Suitability Index graphs were constructed for each variable selected within a wetland type. A Suitability Index (SI) graph is a graphical representation of how fish and wildlife habitat quality or "suitability" of a given wetland type is predicted to change as values of the given variable change, and allows the model user to numerically describe, through a Suitability Index, the habitat quality of a wetland area for any variable value. Each Suitability

Index ranges from 0.0 to 1.0, with 1.0 representing the optimum condition for the variable in question.

A variety of resources were utilized to construct each Suitability Index (SI) graph, including personal knowledge of Group members, the species HSI models from which the final list of variables was partially derived, consultation with other professionals and researchers outside the Group, and published and unpublished data and studies. An important "non-biological" constraint on SI graph development was the need to insure that graph relationships were not counter to the purpose of the CWPPRA, that is, the long term creation, restoration, protection, or enhancement of coastal vegetated wetlands. That constraint was most operative in defining SI graphs for Variable 1 under each marsh model (see discussion below).

The process of graph development was one of constant evolution, feedback, and refinement; the form of each Suitability Index graph was decided upon through consensus among Group members.

V. SUITABILITY INDEX GRAPH ASSUMPTIONS

Suitability Index graphs were developed according to the following assumptions:

1. Fresh/Intermediate Marsh Model

Variable V_1- Percent of wetland covered by persistent emergent vegetation (≥ 10 percent canopy cover). Persistent emergent vegetation plays an important role in coastal wetlands by providing foraging, resting, and breeding habitat for a variety of fish and wildlife species; and by providing a source of detritus and energy for lower trophic organisms that form the basis for the food chain. An area with no marsh (i.e., shallow open water) is assumed to have minimal habitat suitability in terms of this variable, and is assigned an SI of 0.1.

Optimum vegetation coverage in a fresh/intermediate marsh is assumed to occur at 100 percent persistent emergent vegetation cover (SI=1.0). That assumption is dictated primarily by the constraint of not having graph relationships conflict with the CWPPRA's purpose of long term creation, restoration, protection, or enhancement of coastal vegetated wetlands. The Group had originally developed a strictly biologically-based graph defining optimum habitat conditions at marsh cover values between 60 and 80 percent, and sub-optimum habitat conditions at 100 percent cover. However, application of that graph, in combination with the time analysis used later in the evaluation process, often reduced project benefits or generated a net <u>loss</u> of habitat quality through time with the project. Those situations arose primarily when: existing (baseline) emergent vegetation cover exceeded the optimum (> 80 percent); the project was predicted to maintain baseline cover values; and without the project the marsh was predicted to degrade, with a concurrent decline in percent emergent vegetation cover into the optimum range (60-80 percent). The time factor aggravated the situation when the without-project degradation was not rapid enough to reduce marsh cover values significantly below the optimum range, or below the baseline SI, within the 20-year evaluation period. In those cases, the analysis would show net negative benefits for the project, and positive benefits for letting the marsh degrade rather than maintaining the existing marsh. Coupling that situation with the presumption that marsh conditions are not static, and that Louisiana will continue to lose coastal emergent marsh; and taking into account the purpose of the CWPPRA, the Group decided that, all other factors being equal, the WVA should favor projects that maximize emergent marsh creation, maintenance, and protection. Therefore, the Group agreed to deviate from a strict biologically-based habitat suitability graph for V_1 by setting optimum habitat conditions at 100 percent marsh cover.

Variable V_2- Percent of open water area dominated (> 50 percent canopy cover) by aquatic vegetation. Fresh and intermediate marshes often support diverse communities of floating-leaved and submerged aquatic plants that provide important food and cover to a wide variety of fish and wildlife species. A fresh/intermediate open water area with no aquatics is assumed to have low suitability (SI=0.1). Optimum condition (SI=1.0) is assumed to occur when 100 percent of the open water is dominated by aquatic vegetation. Habitat suitability may be assumed to decrease with aquatic plant coverage approaching 100 percent due to the potential for mats of aquatic vegetation to hinder fish and wildlife utilization; to adversely affect water quality by reducing photosynthesis by phytoplankton and other plant forms due to shading; and contribute to oxygen depletion spurred by warm-season decay of large quantities of aquatic vegetation. The Group recognized, however, that those affects were highly dependent on the dominant aquatic plants species, their growth forms, and their arrangement in the water column; thus, it is possible to have 100 percent cover of a variety of floating and submerged aquatic plants without the above-mentioned problems due to differences in plant growth form and stratification of plants through the water column. Because predictions of which species may dominate at any time in the future would be tenuous, at best, the Group decided to simplify the graph and define optimum conditions at 100 percent aquatic cover.

Variable V_3- Marsh edge and interspersion. This variable takes into account the relative juxtaposition of marsh and open water for a given marsh:open water ratio, and is measured by comparing the project area to sample illustrations (Attachment 5) depicting different degrees of interspersion. Interspersion is assumed to be especially important when considering the value of an area as foraging and nursery habitat for freshwater and estuarine fish and shellfish; the marsh/open water interface represents an ecotone where prey species often concentrate, and where post-larval and juvenile organisms can find cover. Isolated marsh ponds are often more productive in terms of aquatic vegetation than are larger ponds due to decreased turbidities, and, thus, may provide more suitable waterfowl habitat. However, interspersion can be indicative of marsh degradation, a factor taken into consideration in assigning suitability indices to the various Interspersion Types.

A relatively high degree of interspersion in the form of stream courses and tidal channels (Interspersion Type 1, Attachment 5) is assumed to be optimal (SI=1.0); streams and channels offer interspersion, yet are not indicative of active marsh deterioration. Areas exhibiting a high degree of marsh cover are also ranked as optimum, even though interspersion may be low, to avoid conflicts with the premises underlying the SI graph for variable V_1. Without such an allowance, areas of relatively healthy, solid marsh, or projects designed to create marsh, would be penalized with respect to interspersion. Numerous small marsh ponds (Interspersion Type 2) offer a high degree of interspersion, but are also usually indicative of the beginnings of marsh break-up and degradation, and are therefore assigned a more moderate SI of 0.6. Large open water areas (Interspersion Types 3 and 4) offer lower interspersion values and usually indicate advanced stages of marsh loss, and are thus assigned SI's of 0.4 and 0.2, respectively. The lowest expression of interspersion (i.e., no emergent marsh at all within the project area) is assumed to be least desirable and is assigned an SI=0.1.

Variable V_4- Percent of open water area ≤ 1.5 feet deep in relation to marsh surface. Shallow water areas are assumed to be more biologically productive than deeper water due to a general reduction in sunlight, oxygen, and temperature as water depth increases. Also, shallower water provides greater bottom accessibility for certain species of waterfowl, better foraging habitat for wading birds, and more favorable conditions for aquatic plant growth. Optimum depth in a fresh/intermediate marsh is assumed to occur when 80 to 90 percent of the open water area is less than or equal to 1.5 feet deep. The value of deeper areas in providing drought refugia for fish, alligators and other marsh life is recognized by assigning an SI=0.6 (i.e., sub-optimal) if all of the open water is less than or equal to 1.5 feet deep.

Variable V_5- Mean high salinity during the growing season. It is assumed that periods of high salinity are most detrimental in a fresh/intermediate marsh when they occur during the growing season (defined as March through November, based on dates of first and last frost contained in Soil Conservation Service soil surveys for coastal Louisiana). Mean high salinity is defined as the average of the upper 33 percent of salinity readings taken during a specified period of record. Optimum condition in fresh marsh is assumed to occur when mean high salinity during the growing season is less than 2 parts per thousand (ppt). Optimum condition in intermediate marsh is assumed to occur when mean high salinity during the growing season is less than 4 ppt.

Variable V_6- Aquatic organism access. Access by aquatic organisms, particularly estuarine fishes and shellfishes, is considered to be a critical component in assessing the "quality" or suitability of a given marsh system to provide habitat to those species. Additionally, a marsh with a relatively high degree of access by default also exhibits a relatively high degree of hydrologic connectivity with adjacent systems, and therefore may be considered to contribute more to nutrient exchange than would a marsh exhibiting a lesser degree of access. The Suitability Index for V_7 is determined by calculating an "Access Value" based on the interaction between the percentage of the project area wetlands considered accessible by estuarine organisms during normal tidal fluctuations, and the type of man-made structures (if any) across identified points of ingress/egress (bayous, canals, etc.). Standardized procedures for calculating the Access Value have been established (Attachment 6). Optimum condition is assumed to exist when all of the study area is accessible and the access points are entirely open and unobstructed. A fresh/intermediate marsh with no access is assigned an SI=0.3, reflecting the assumption that, while fresh/intermediate marshes are important to some species of estuarine fishes and shellfish, such a marsh lacking access continues to provide benefits to a wide variety of other wildlife and fish species, and is not without habitat value.

2. Brackish Marsh Model

Variable V_1- Percent of wetland covered by persistent emergent vegetation (≥ 10 percent canopy cover). Refer to the V_1 discussion under the fresh/intermediate marsh model for a discussion of the importance of persistent emergent vegetation in coastal marshes. The V_1 Suitability Index graph in the brackish marsh model is identical to that in the fresh/intermediate model.

Variable V_2- Percent of open water area dominated (> 50 percent canopy cover) by aquatic vegetation. Like fresh/intermediate marshes, brackish marshes have the potential to support aquatic plants that serve as important sources of food and cover for a wide variety of wildlife. However, brackish marshes generally do not support the amounts and kinds of aquatic plants that occur in fresh/intermediate marshes (although certain species, such as widgeon-grass, can occur abundantly under certain conditions). Therefore, a brackish marsh entirely lacking aquatic plants is assigned an SI=0.3. It is assumed that optimum open water coverage of aquatic plants in a brackish marsh occurs at 100 percent aquatic cover.

Variable V_3- Marsh edge and interspersion. The Suitability Index graph for edge and interspersion in the brackish marsh model is the same as that in the fresh/intermediate marsh model.

Variable V_4- Open water depth in relation to marsh surface. As in the fresh/intermediate model, shallow water areas in brackish marsh habitat are assumed to be important. However, brackish marsh generally exhibits deeper open water areas than fresh marsh due to tidal scouring. Therefore, the SI graph is constructed so that lower percentages of shallow water receive higher SI values relative to fresh/intermediate marsh. Optimum open water depth condition in a brackish marsh is assumed to occur when 70 to 80 percent of the open water area is less than or equal to 1.5 feet deep.

Variable V_5- Average annual salinity. The suitability index graph is constructed to represent optimum average annual salinity condition at between 0 ppt and 10 ppt. The Group acknowledges that average annual salinites below 6 ppt will effectively define a marsh as fresh or intermediate, not brackish. However, the suitability index graph makes allowances for lower salinities (i.e., < 6 ppt) to account for occasions when there is a trend of decreasing salinities through time toward a more intermediate condition. Implicit in keeping the graph at optimum for salinites less than 6 ppt is the assumption that lower salinites are not detrimental to a bracksih marsh. However, average annual salinites greater than 10 ppt are assumed to be progressively more harmful to brackish marsh vegetation, as illustrated in the downward sloping right leg of the suitability index graph. Average annual salinities greater than 16 ppt are assumed to be representative of those found in a saline marsh, and thus are not considered in the brackish marsh model.

Variable V_6- Aquatic organism access. The general rational and procedure behind the V_6 Suitability Index graph for the brackish marsh model is identical to that established for the fresh/intermediate model. However, brackish marshes are assumed to be more important as providers of habitat to estuarine fish and shellfish than fresh/intermediate marshes. Therefore, a brackish marsh providing no access is assigned an SI of 0.1.

3. Saline Marsh Model

Variable V_1- Percent of wetland covered by persistent emergent vegetation (≥ 10 percent canopy cover). Refer to the V_1 discussion under the fresh/intermediate marsh model for a discussion of the importance of persistent emergent vegetation in coastal marshes. The V_1 Suitability Index graph in the saline marsh model is identical to that in the fresh/intermediate and brackish models.

Variable V_2- Percent of open water area dominated (> 50 percent canopy cover) by aquatic vegetation. Refer to the V_2 discussion under the brackish marsh model for a discussion of persistent emergent vegetation in more saline coastal marshes. The V_2 Suitability Index graph in the saline marsh model is identical to that in the brackish model.

Variable V_3- Marsh edge and interspersion. The Suitability Index graph for edge and interspersion in the saline marsh model is the same as that in the fresh/intermediate and brackish marsh models.

Variable V_4– Open water depth in relation to marsh surface. The Suitability Index graph for open water depth in the saline marsh is similar to that for brackish marsh, where optimum conditions are assumed to occur when 70 to 80 percent of the open water area is less than or equal to 1.5 feet deep. However, at 100 percent shallow water, the saline graph yields an SI= 0.5 rather than 0.6 for the brackish model. That change reflects the increased abundance of tidal channels and generally deeper water conditions prevailing in a saline marsh due to increased tidal influences, and the importance of those tidal channels to estuarine organisms.

Variable V_5- Average annual salinity. The Suitability Index graph is constructed to represent optimum salinity conditions at between 9 ppt and 21 ppt. The Group acknowledges that average annual salinites between 9 and 12 ppt will effectively define a marsh as brackish, not saline. However, the suitability index graph makes allowances for lower salinities (i.e., < 12 ppt) to account for occasions when there is a trend of decreasing salinities through time toward a more brackish condition. Implicit in keeping the graph at optimum for salinites less than 12 ppt is the assumption that lower salinites (9-12 ppt) are not detrimental to a saline marsh. Average annual salinites greater than 21 ppt are assumed to be slightly stressful to saline marsh vegetation, as illustrated in the downward sloping right leg of the suitability index graph.

Variable V_6- Aquatic organism access. The Suitability Index graph for aquatic organism access in the saline marsh model is the same as that in the brackish marsh model.

4. Cypress-Tupelo Swamp Model

Variable V_1- Water regime. Four water regime categories are described for the cypress-tupelo swamp model. The optimum water regime for a cypress-tupelo swamp is assumed to be seasonal flooding (SI=1.0); seasonal flooding with periodic drying cycles is assumed to contribute to increased nutrient cycling (primarily through oxidation and decomposition of accumulated detritus), increased vertical structure complexity (due to growth of other plants on the swamp floor), and increased recruitment of dominant overstory trees. Semipermanent flooding is also assumed to be desirable, as reflected in the SI=0.8 for that water regime category. Permanent flooding is assumed to be the least desirable (SI=0.2).

Variable V_2- Water flow/exchange. This variable attempts to take into consideration the amounts and types of water inputs into a cypress-tupelo swamp. The Suitability Index graph is constructed under the assumption that abundant and consistent riverine input and water flow-through is optimum (SI=1.0), because under that regime the full functions and values of a cypress-tupelo swamp in providing fish and wildlife habitat are assumed to be maximized. Habitat suitability is assumed to decrease as water exchange between the swamp and adjacent systems is reduced. A swamp system with no water exchange (e.g., an impounded swamp where the only water input is through rainfall and the only water loss is through evapotranspiration and ground seepage) is assumed to be least desirable, and is assigned an SI= 0.2.

Variable V_3- Average high salinity. Average high salinity is defined as the average of the upper 33 percent of salinity measurements taken during a specified period of record. Because baldcypress is salinity-sensitive, optimum conditions for baldcypress survival are assumed to occur at average high salinities less than 1 ppt. Habitat suitability is assumed to decrease rapidly at average high salinities in excess of 1 ppt.

VI. HABITAT SUITABILITY INDEX FORMULA

The final step in WVA model development was to construct a mathematical formula that combines all Suitability Indices for each wetland type into a single Habitat Suitability Index (HSI) value. Because the Suitability Indices range in value from 0.0 to 1.0, the HSI also ranges in from 0.0 to 1.0, and is a numerical representation of the overall or "composite" habitat quality of the particular wetland study area being evaluated. The HSI formula defines the aggregation of Suitability Indices in a manner unique to each wetland type depending on how the formula is constructed.

Within an HSI formula, any Suitability Index can be weighted by various means to increase the power or "importance" of that variable relative to the other variables in determining the HSI. Additionally, two or more variables can be grouped together into subgroups to further isolate variables for weighting.

In constructing HSI formulas for the marsh models, the Group recognized that the primary focus of the CWPPRA is on vegetated wetlands, and that some marsh protection strategies could have adverse impacts to estuarine organism access. Therefore, the Group made an *a priori* decision to emphasize variables V_1, V_2, and V_6 by grouping and weighting them together. Weighting was facilitated by treating the grouped variables as a geometric mean. Variables V_3, V_4, and V_5 were grouped to isolate their influence relative to V_1, V_2, and V_6.

For all marsh models, V_1 receives the strongest weighting. The relative weights of V_2 and V_6 differ by marsh model to reflect differing levels of importance for those variables between the marsh types. For example, the amount of aquatic vegetation was deemed more important in the context of a fresh/intermediate marsh than in a saline marsh, due to the relative contributions of aquatic vegetation between the two marsh types in terms of providing food and cover. Therefore, V_2 receives more weight in the fresh/intermediate HSI formula than in the saline HSI formula. Similarly, the degree of estuarine organism access was considered more important in a saline marsh than a fresh/intermediate marsh, and V_6 receives more weight in the saline HSI formula than in the fresh/intermediate formula.

As with the Suitability Index graphs, the Habitat Suitability Index formulas were developed by consensus among the Group members.

VI. BENEFIT ASSESSMENT

The net benefits of a proposed project are estimated by predicting future habitat conditions under two scenarios: with the proposed project in place and without the proposed project. Specifically, predictions are made as to how the model variables will change through time under the two scenarios. Through that process, HSI's are established for baseline (pre-project) conditions and for future-with- and future-without-project scenarios for selected "target years" throughout the expected life of the project. Those HSI's are then multiplied by the acreage of wetland type known or expected to be present in the target years to arrive at Habitat Units.

Habitat Units (HU's) represent a numerical combination of quality (HSI) and quantity (acres) existing at any given point in time. The "benefit" of a project can be quantified by comparing HU's between the future-with and future-without-project scenarios. The difference in HU's between the two scenarios represents the net benefit attributable to the project in terms of habitat quantity <u>and</u> quality.

The HU's resulting from the future-with- and future-without-project scenarios are annualized, averaged out over the project life, and compared to determine the net gain in average annual HU's (AAHU's) attributable to the project. Net gain in AAHU's is then combined with annualized cost data to arrive at a cost per AAHU for the evaluated project. That figure is compared to the same figure from other projects in order to rank all proposed projects in order of cost per AAHU.

LITERATURE CITED

U. S. Fish and Wildlife Service. 1980. Habitat evaluation procedures (HEP). Div. Ecol. Serv. ESM 102, U. S. Fish and Wildl. Serv., Washington, DC. 141pp.

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WETLAND VALUE ASSESSMENT COMMUNITY MODEL

Fresh/Intermediate Marsh

Vegetation:

Variable V_1 Percent of wetland area covered by emergent vegetation (≥ 10% canopy cover).

Variable V_2 Percent of open water area dominated (> 50% canopy cover) by aquatic vegetation.

Interspersion:

Variable V_3 Marsh edge and interspersion.

Water Depth:

Variable V_4 Percent of open water area ≤ 1.5 feet deep, in relation to marsh surface.

Water Quality:

Variable V_5 Mean high salinity during the growing season (March through November).

Aquatic Organism Access:

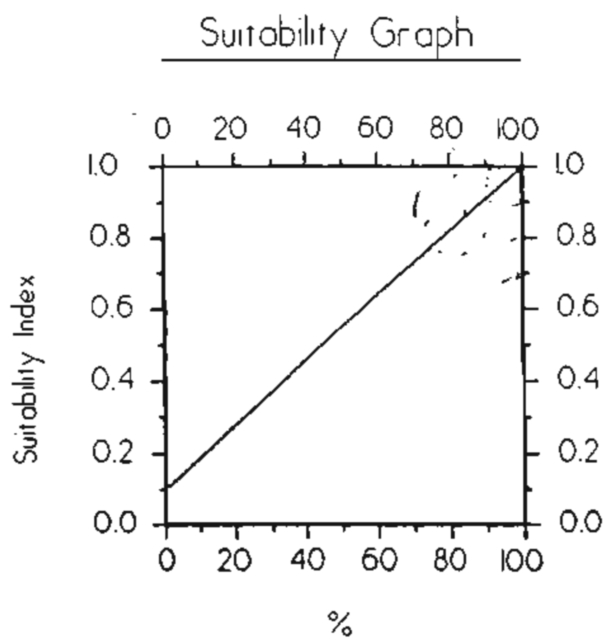
Variable V_6 Aquatic organism access.

HSI Calculation:

$$HSI = \frac{\left[3.5 \times (SIV_1^{3} \times SIV_2^{1.2} \times SIV_6^{0.5})^{(1/4.7)}\right] + \left[\frac{(SIV_3 + SIV_4 + SIV_5)}{3}\right]}{4.5}$$

FRESH/INTERMEDIATE MARSH

Variable V_1 Percent of wetland area covered by emergent vegetation (≥ 10% canopy cover).

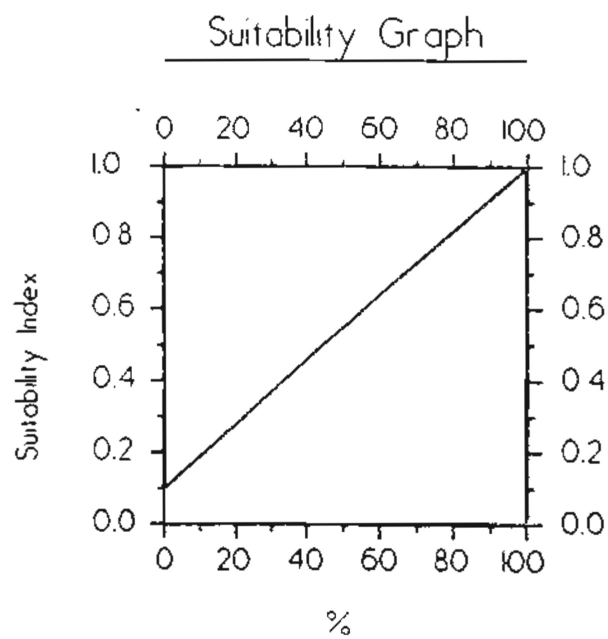


Line Formulas

SI = (0.009 * %) + 0.1

FRESH/INTERMEDIATE MARSH

Variable V_2 Percent of open water area dominated (> 50% canopy cover) by aquatic vegetation.



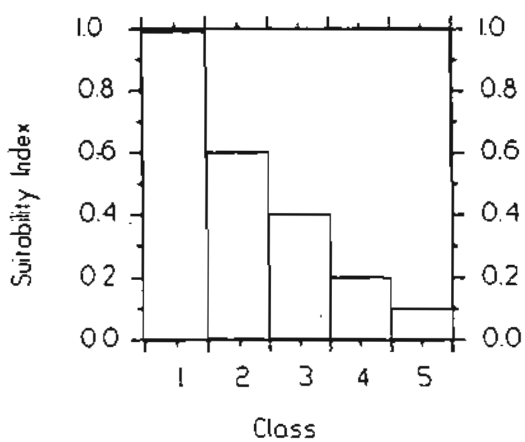
Line Formulas

SI = (0.009 * %) + 0.1

FRESH/INTERMEDIATE MARSH

Variable V_3 Marsh edge and interspersion.

Suitability Graph



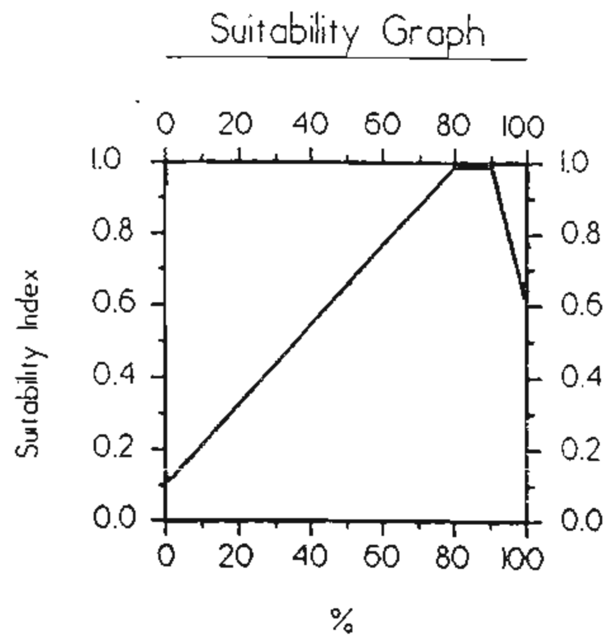
Instructions for Calculating SI for Variable 3:

1. Refer to Attachment 5 for examples of the different interspersion classes (=types).

2. Estimate percent of project area in each class and compute a weighted average to arrive at SIV_3. If the entire project area is solid marsh, assign an interspersion class #1 (SI=1.0). Conversely, if the entire project area is open water, assign an interspersion class #5 (SI=0.1).

FRESH/INTERMEDIATE MARSH

Variable V_4 Percent of open water area ≤ 1.5 feet deep, in relation to marsh surface.



Line Formulas

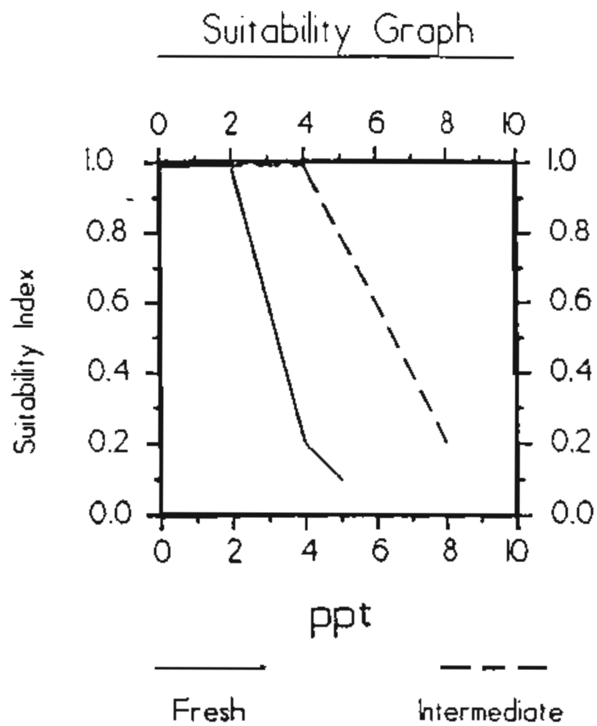
If $0 \leq \% < 80$, then $SI = (0.01125 * \%) + 0.1$

If $80 \leq \% < 90$, then $SI = 1.0$

If $\% \geq 90$, then $SI = (-0.04 * \%) + 4.6$

FRESH/INTERMEDIATE MARSH

Variable V_5 Mean high salinity during the growing season (March through November).



Line Formulas

Fresh Marsh:

If 0 ≤ ppt < 2, then SI = 1.0
If 2 ≤ ppt < 4, then SI = (-0.4 * ppt) + 1.8
If 4 ≤ ppt ≤ 5 then SI = (-0.1 * ppt) + 0.6

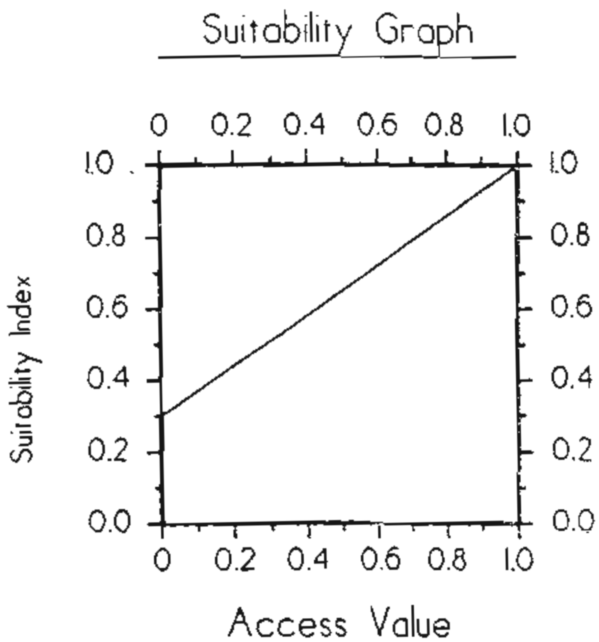
Intermediate Marsh:

If 0 ≤ ppt < 4, then SI = 1.0
If 4 ≤ ppt ≤ 8, then SI = (-0.2 * ppt) + 1.8

NOTE: Mean high salinity is defined as the average of the upper 33 percent of salinity readings taken during the period of record.

FRESH/INTERMEDIATE MARSH

Variable V_6 Aquatic organism access.



<u>Line Formula</u>

SI = (0.7 * Access Value) + 0.3

<u>NOTE</u>: Access Value = P * R, where "P" = percentage of wetland area considered accessible by estuarine organisms during normal tidal fluctuations, and "R" = Structure Rating.

Refer to Attachment 6 "Procedure For Calculating Access Value" for complete information on calculating "P" and "R" values.

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WETLAND VALUE ASSESSMENT COMMUNITY MODEL

Brackish Marsh

Vegetation:

Variable V_1 Percent of wetland area covered by emergent vegetation ($\geq$ 10% canopy cover).

Variable V_2 Percent of open water area dominated (> 50% canopy cover) by aquatic vegetation.

Interspersion:

Variable V_3 Marsh edge and interspersion.

Water Depth:

Variable V_4 Percent of open water area $\leq$ 1.5 feet deep, in relation to marsh surface.

Water Quality:

Variable V_5 Average annual salinity.

Aquatic Organism Access:

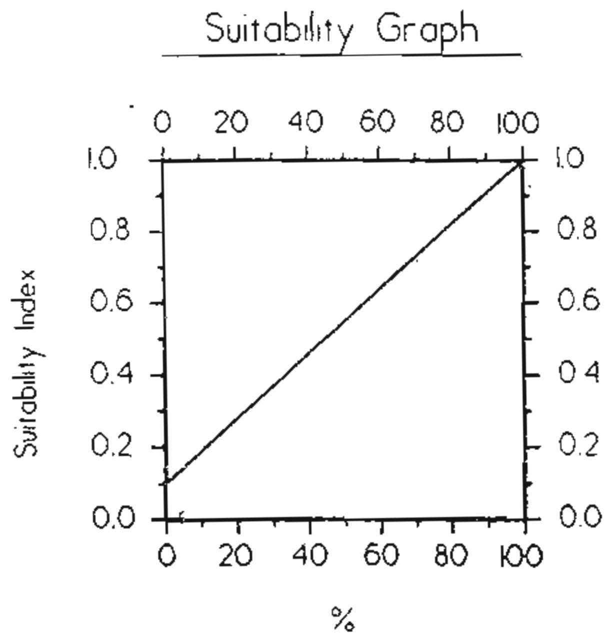
Variable V_6 Aquatic organism access.

HSI Calculation:

$$HSI = \frac{\left[3.5 \times (SIV_1^{\,3} \times SIV_2 \times SIV_6)^{(1/5)}\right] + \left[\frac{(SIV_3 + SIV_4 + SIV_5)}{3}\right]}{4.5}$$

BRACKISH MARSH

Variable V_1 Percent of wetland area covered by emergent vegetation (≥ 10% canopy cover).

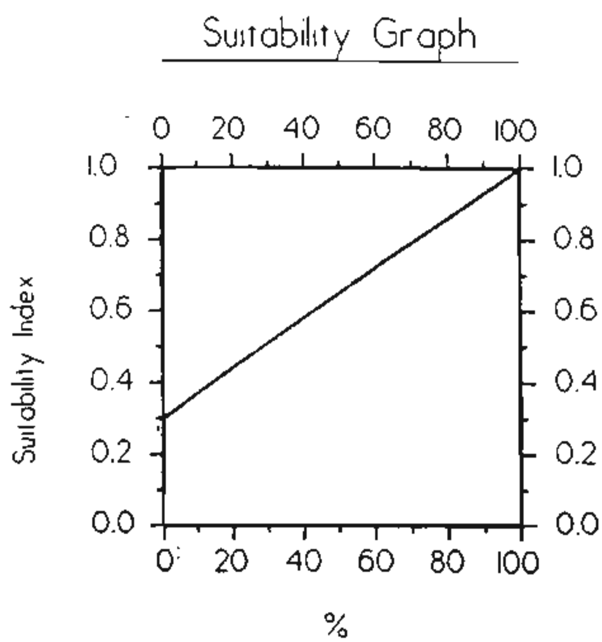


Line Formulas

SI = (0.009 * %) + 0.1

BRACKISH MARSH

Variable V_2 Percent of open water area dominated (> 50% canopy cover) by aquatic vegetation.

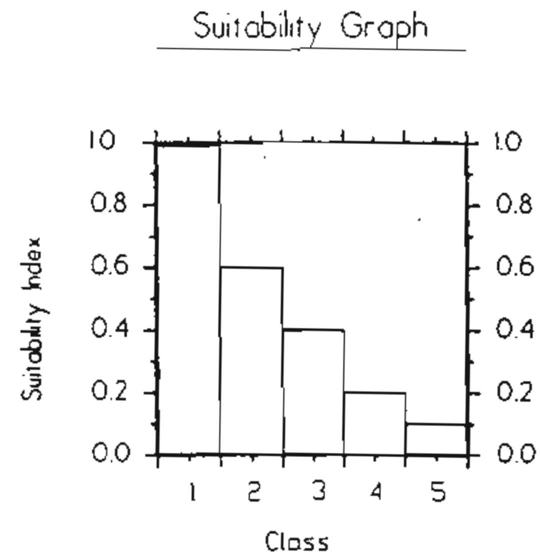


Line Formulas

SI = (0.007 * %) + 0.3

BRACKISH MARSH

Variable V_3 - Marsh edge and interspersion.



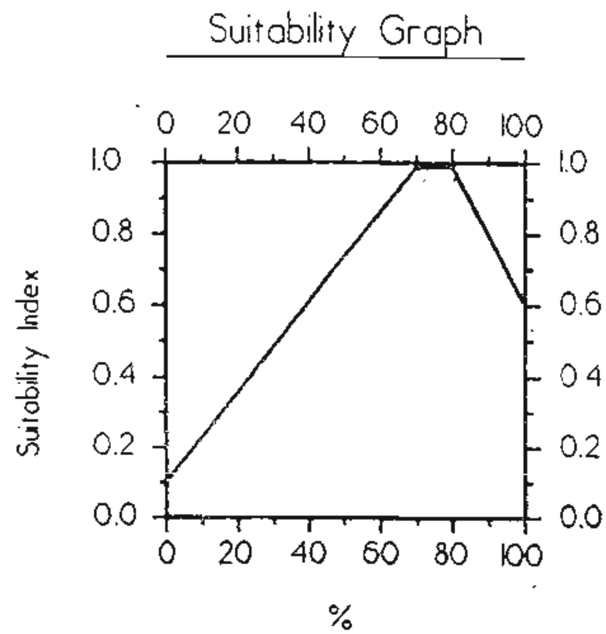
Instructions for Calculating SI for Variable 3:

1. Refer to Attachment 5 for examples of the different interspersion classes (=types).

2. Estimate percent of project area in each class and compute a weighted average to arrive at SIV_3. If the <u>entire</u> project area is solid marsh, assign an interspersion class #1 (SI=1.0). Conversely, if the <u>entire</u> project area is open water, assign an interspersion class #5 (SI=0.1).

BRACKISH MARSH

Variable V_4 Percent of open water area ≤ 1.5 feet deep, in relation to marsh surface.



Line Formulas

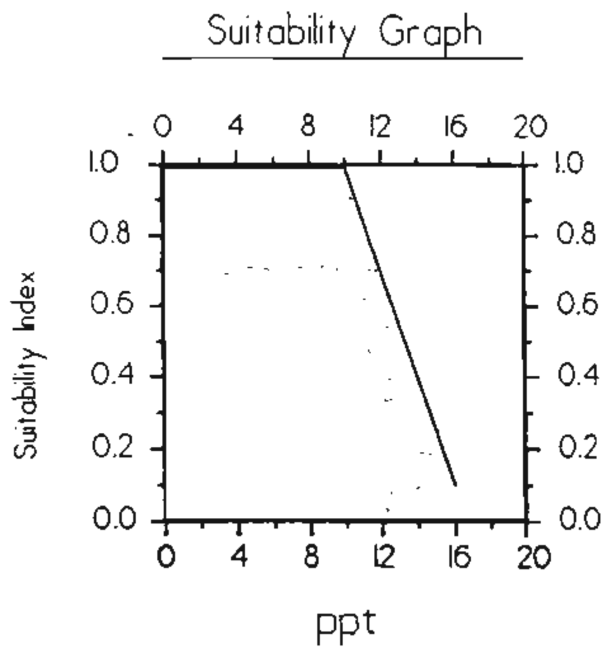
If 0 ≤ % < 70, then SI = (0.01286 * %) + 0.1

If 70 ≤ % < 80, then SI = 1.0

If % ≥ 80, then SI = (-0.02 * %) + 2.6

BRACKISH MARSH

Variable V_5 Average annual salinity.



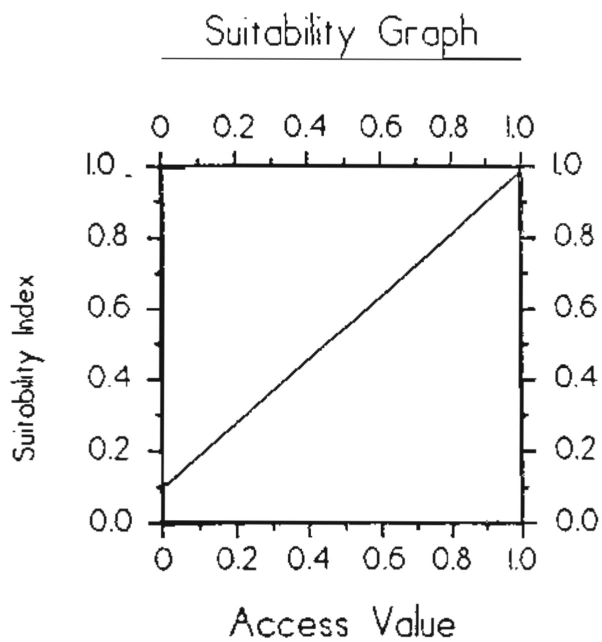
Line Formulas

If $0 \le ppt < 10$, then SI = 1.0

If $ppt \ge 10$, then SI = $(-0.15 * ppt) + 2.5$

BRACKISH MARSH

Variable V_6 Aquatic organism access.



Line Formula

SI = (0.9 * Access Value) + 0.1

Note: Access Value = P * R, where "P" = percentage of wetland area considered accessible by estuarine organisms during normal tidal fluctuations, and "R" = Structure Rating.

Refer to Attachment 6 "Procedure For Calculating Access Value" for complete information on calculating "P" and "R" values.

Revised May 2, 1994

WETLAND VALUE ASSESSMENT COMMUNITY MODEL

Saline Marsh

Vegetation:

Variable V_1 Percent of wetland area covered by emergent vegetation (≥ 10% canopy cover).

Variable V_2 Percent of open water area dominated (> 50% canopy cover) by aquatic vegetation.

Interspersion:

Variable V_3 Marsh edge and interspersion.

Water Depth:

Variable V_4 Percent of open water area ≤ 1.5 feet deep, in relation to marsh surface.

Water Quality:

Variable V_5 Average annual salinity.

Aquatic Organism Access:

Variable V_6 Aquatic organism access.

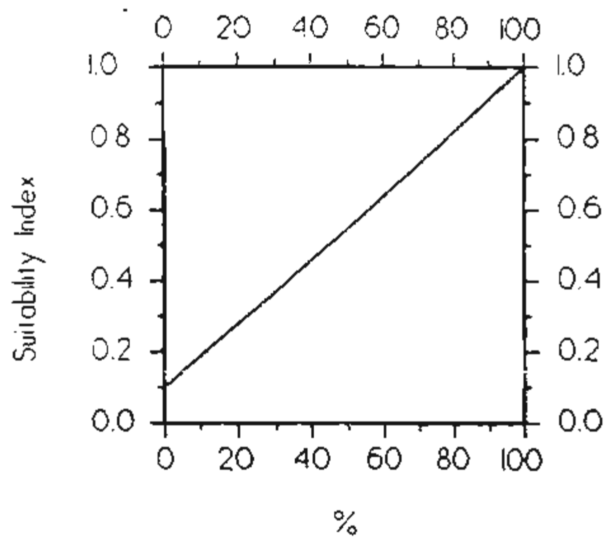
HSI Calculation:

$$HSI = \frac{\left[3.5 \times (SIV_1^{3} \times SIV_2^{0.5} \times SIV_6^{1.2})^{(1/4.7)}\right] + \left[\frac{(SIV_3 + SIV_4 + SIV_5)}{3}\right]}{4.5}$$

SALINE MARSH

Variable V_1 Percent of wetland area covered by emergent vegetation (≥ 10% canopy cover).

Suitability Graph

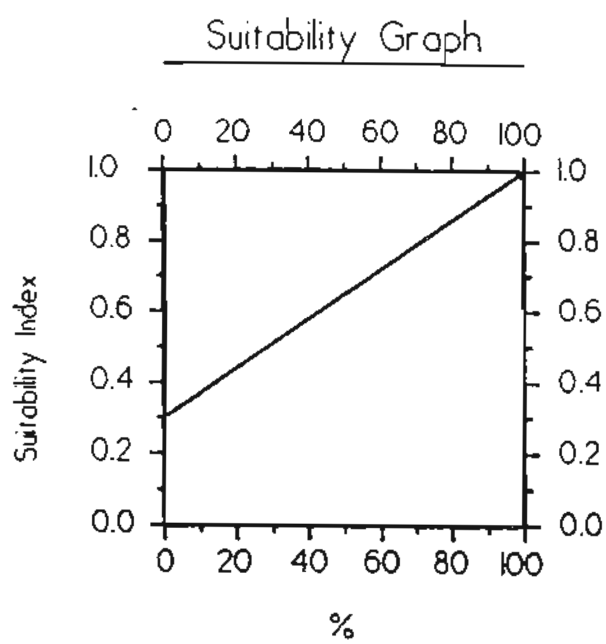


<u>**Line Formulas**</u>

SI = (0.009 * %) + 0.1

SALINE MARSH

Variable V_2 Percent of open water area dominated (> 50% canopy cover) by aquatic vegetation.



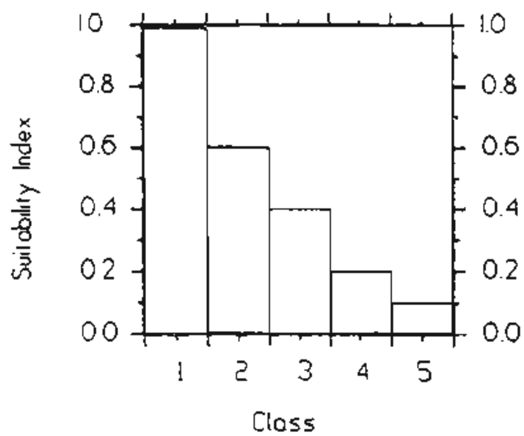
Line Formulas

SI = (0.007 * %) + 0.3

SALINE MARSH

Variable V_3 Marsh edge and interspersion.

Suitability Graph



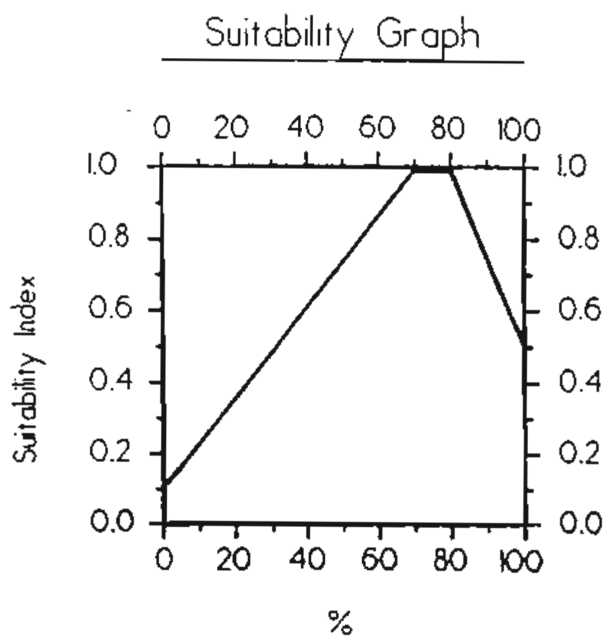
Instructions for Calculating SI for Variable 3:

1. Refer to Attachment 5 for examples of the different interspersion classes (=types).

2. Estimate percent of project area in each class and compute a weighted average to arrive at SIV_3. If the entire project area is solid marsh, assign an interspersion class #1 (SI=1.0). Conversely, if the entire project area is open water, assign an interspersion class #5 (SI=0.1).

SALINE MARSH

Variable V_4 Percent of open water area ≤ 1.5 feet deep, in relation to marsh surface.



<u>Line Formulas</u>

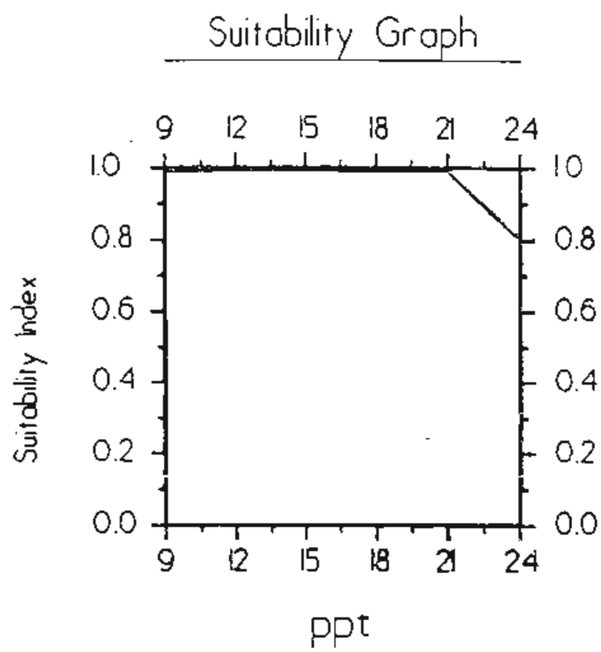
If 0 ≤ % < 70, then SI = (0.01286 * %) + 0.1

If 70 ≤ % < 80, then SI = 1.0

If % ≥ 80, then SI = (-0.025 * %) + 3.0

SALINE MARSH

Variable V_5 Average annual salinity.

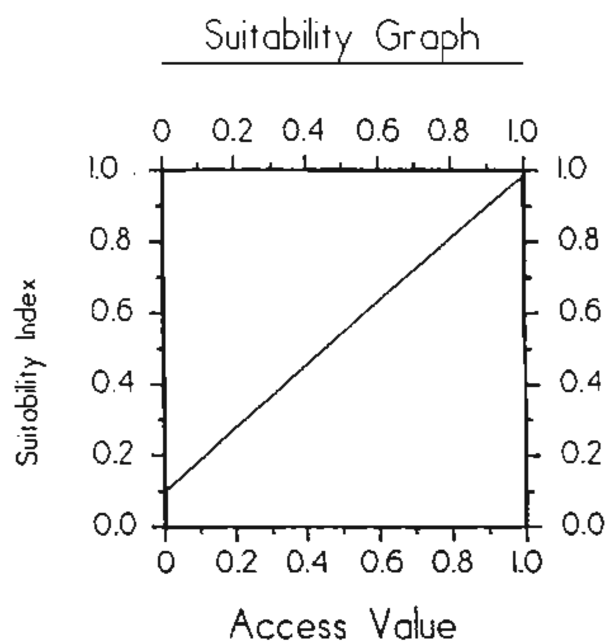


<u>Line Formulas</u>

If 9 ≤ ppt < 21, then SI = 1.0

If ppt ≥ 21, then SI = (-0.067 * ppt) + 2.4

Variable V_6 Aquatic organism access.



Line Formula

SI = (0.9 * Access Value) + 0.1

Note: Access Value = P * R, where "P" = percentage of wetland area considered accessible by estuarine organisms during normal tidal fluctuations, and "R" = Structure Rating.

Refer to Attachment 6 "Procedure For Calculating Access Value" for complete information on calculating "P" and "R" values.

Revised August 6, 1992

WETLAND VALUE ASSESSMENT COMMUNITY MODEL

Cypress-Tupelo Swamp

Water Depth and Duration:

Variable V_1 Water regime.

Water Quality:

Variable V_2 Water flow/exchange.

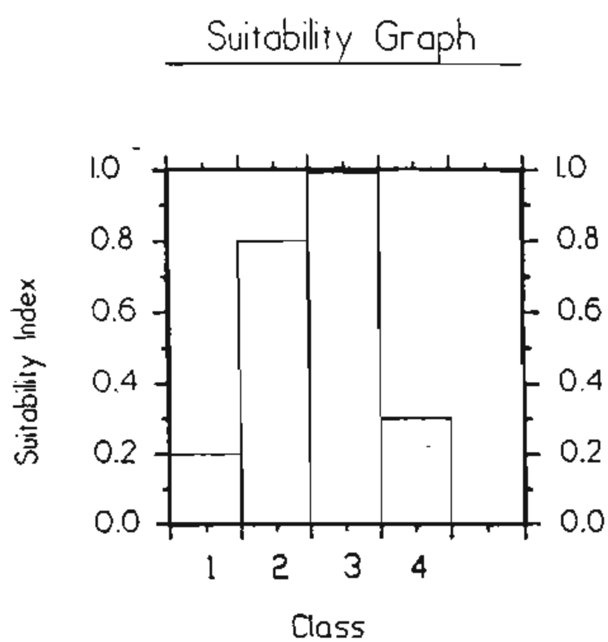
Variable V_3 Average high salinity.

HSI Calculation:

$$HSI = (SI_{V_1} \times SI_{V_2} \times SI_{V_3})^{1/3}$$

CYPRESS-TUPELO SWAMP

Variable V_1 Water regime.



1 - Permanently Flooded: water covers the substrate throughout the year in all years.

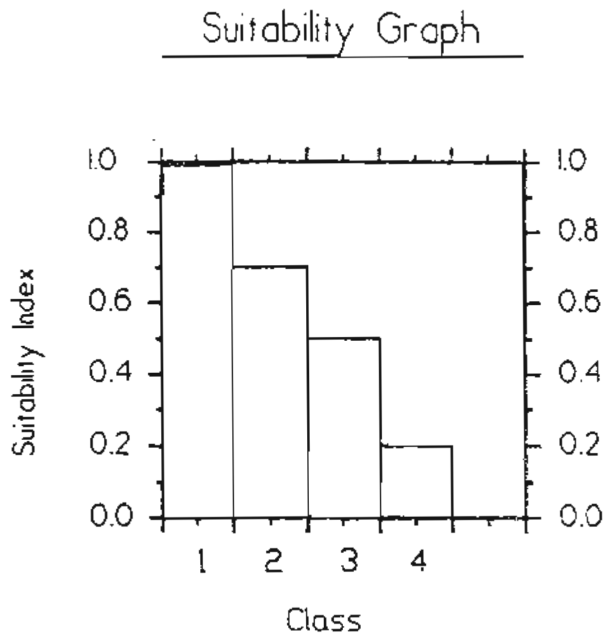
2 - Semipermanently Flooded: surface water is present throughout the growing season in most years.

3 - Seasonally Flooded: surface water is present for extended periods, especially in the growing season, but is absent by the end of the growing season in most years.

4 - Temporarily Flooded: surface water is present for brief periods during the growing season, but the water table usually lies well below the surface for most of the season.

CYPRESS-TUPELO SWAMP

Variable V_2 Water flow/exchange.



1 - Receives abundant and consistent riverine input and through-flow.

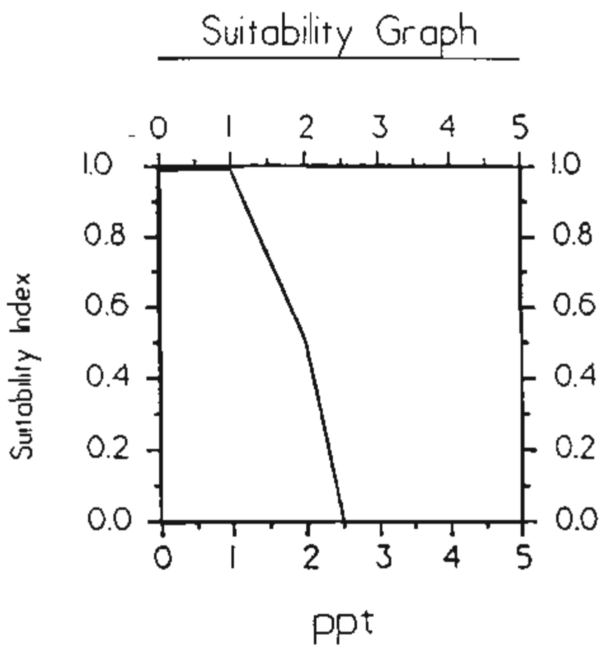
2 - Moderate water exchange, through riverine and/or tidal input.

3 - Limited water exchange, through riverine and/or tidal input.

4 - No water exchange (stagnant, impounded).

CYPRESS-TUPELO SWAMP

Variable V_3 Average high salinity.



Line Formulas

If $0 \le ppt < 1$, then SI = 1.0

If $1 \le ppt < 2$, then SI = $(-0.5 * ppt) + 1.5$

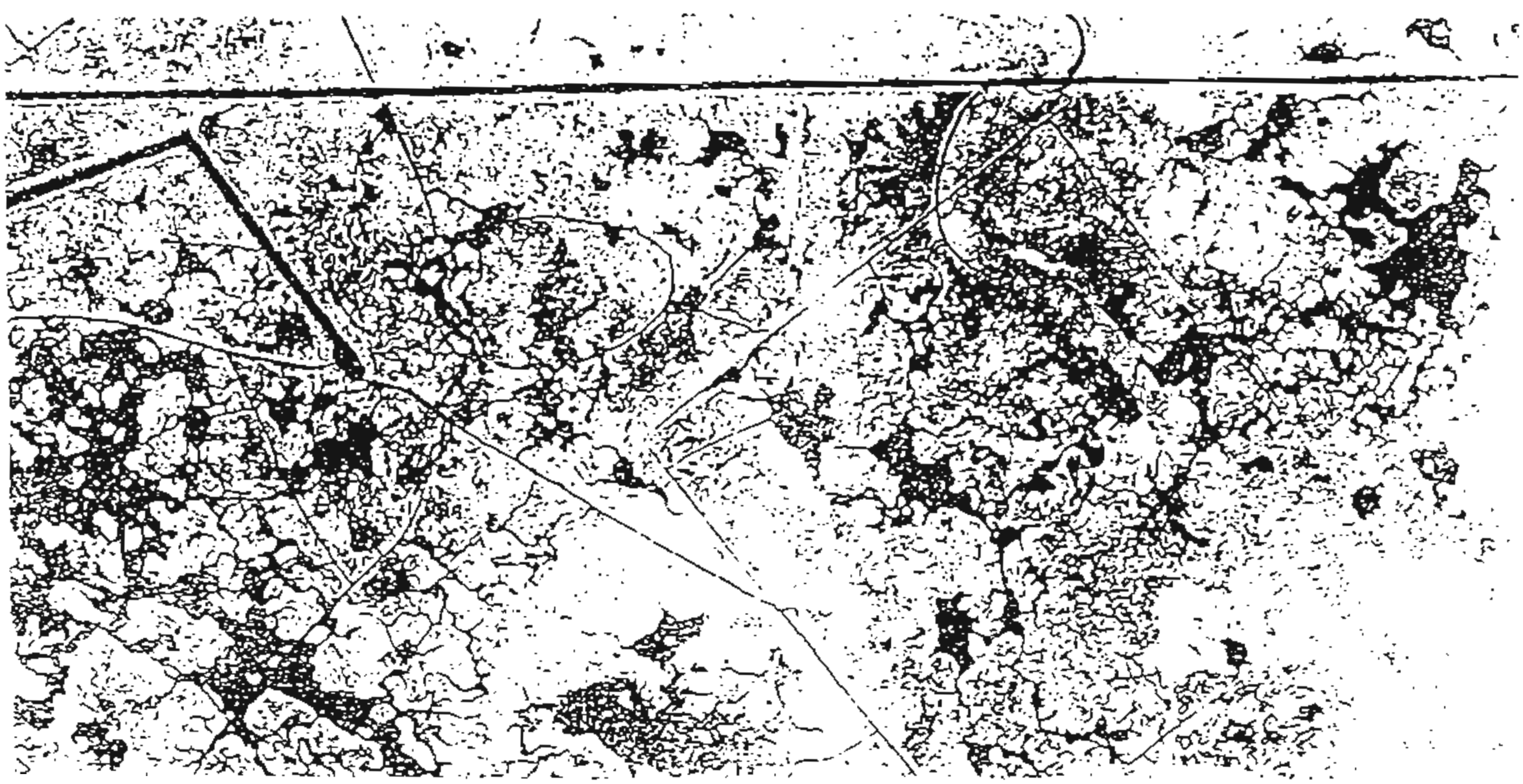
If $2 \le ppt < 2.5$, then SI = $(-1.0 * ppt) + 2.5$

If $ppt \ge 2.5$, then SI = 0

Average high salinity is defined as the average of the upper 33 percent of salinity readings taken during the period of record.

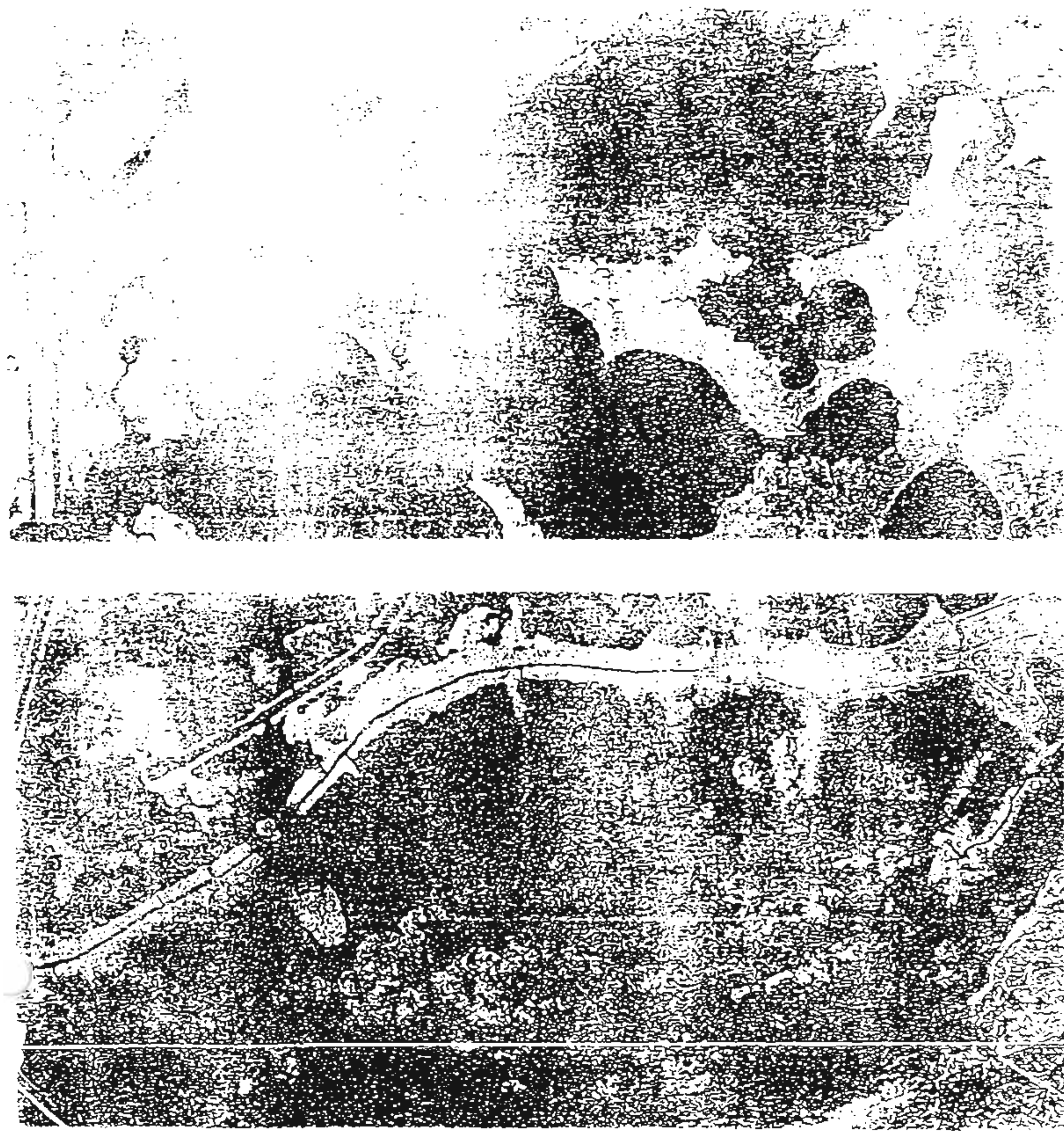
Variable 3-Marsh Interspersion Type 1
Scale 1" = 2000'

Variable 3 - Marsh Interspersion Type 2
Scale 1" = 2000'

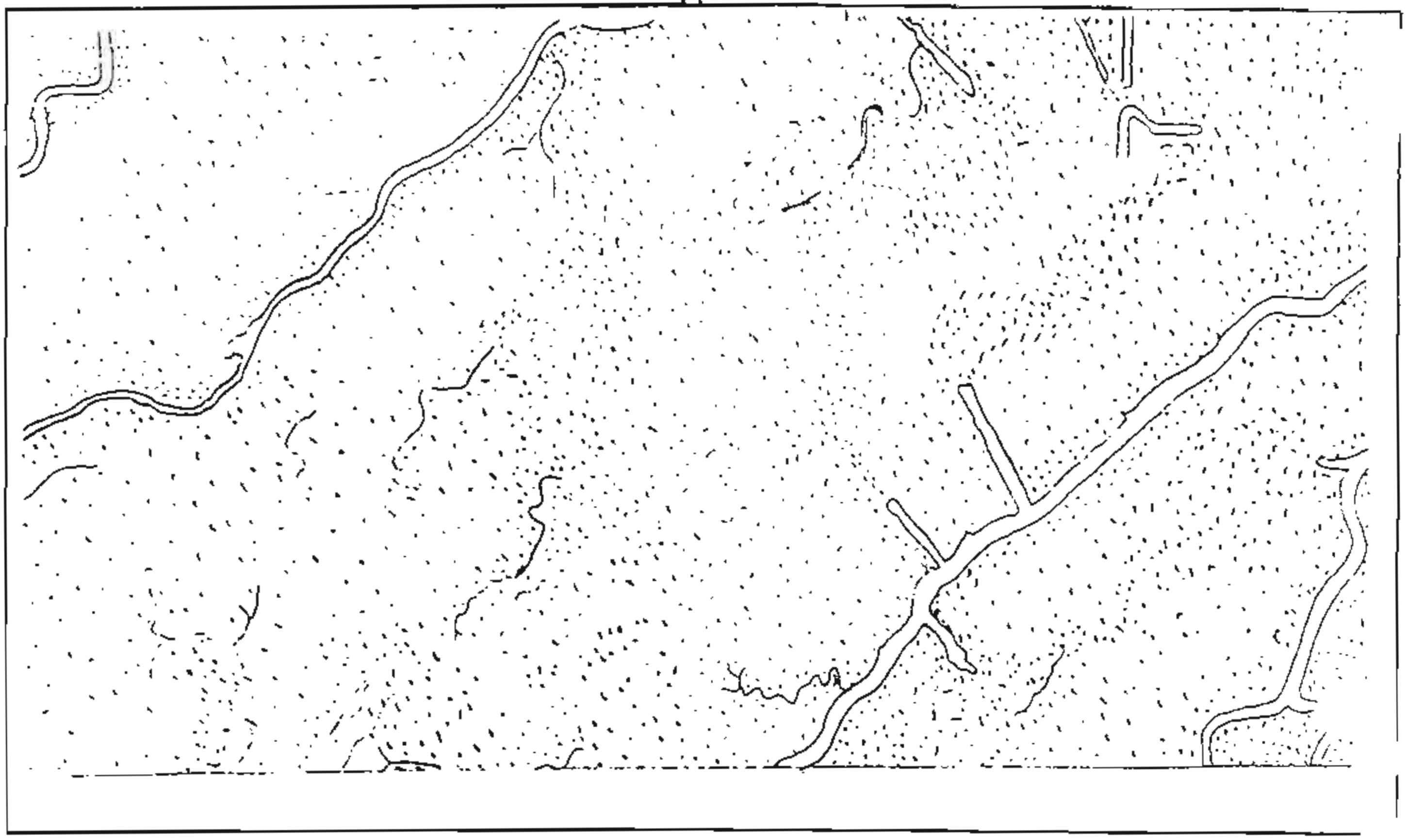


Variable 3 - Marsh Interspersion Type 3
Scale 1" = 2000'

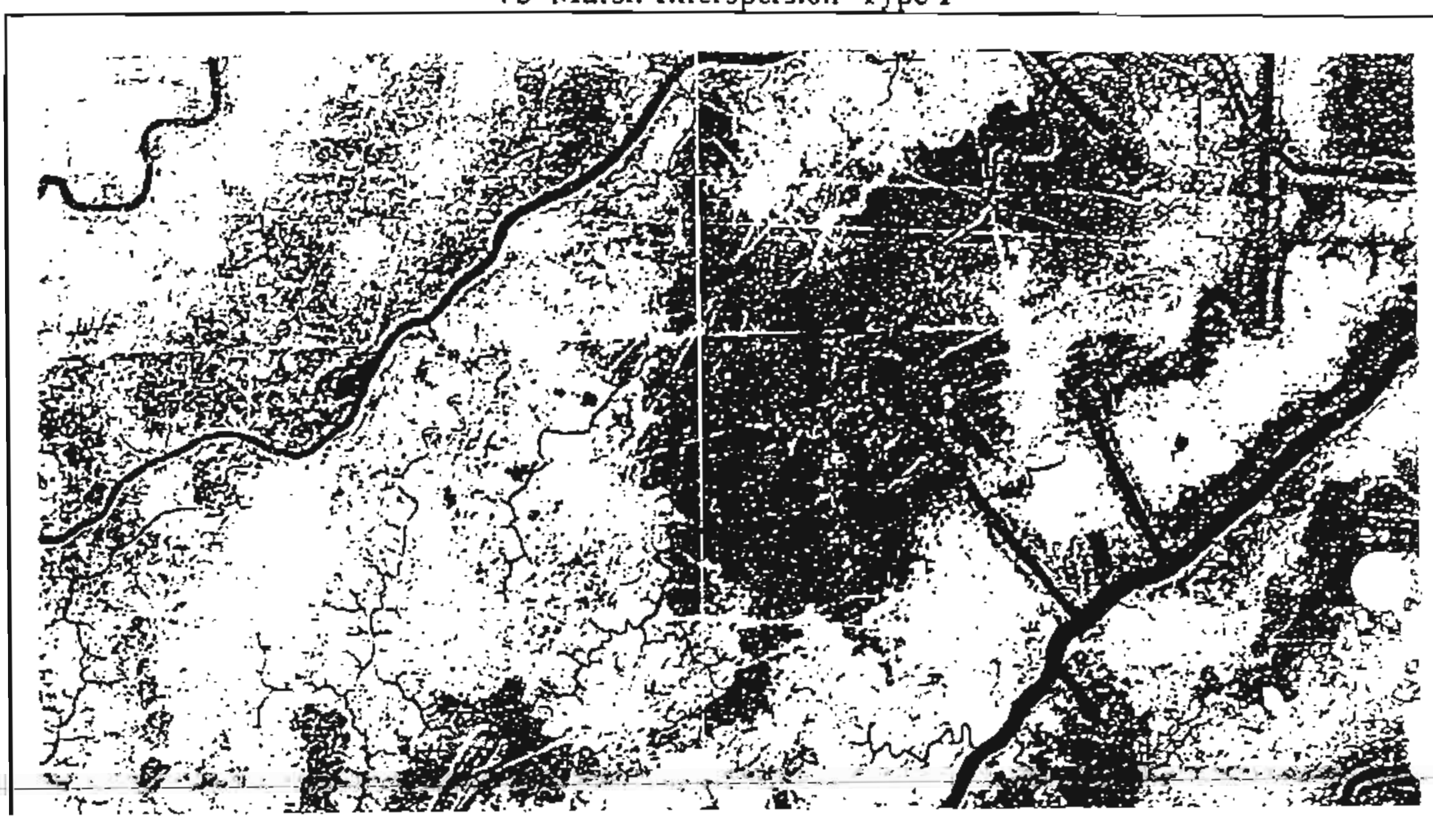
Variable 3 - Marsh Interspersion Type 4
Scale 1" = 2000'



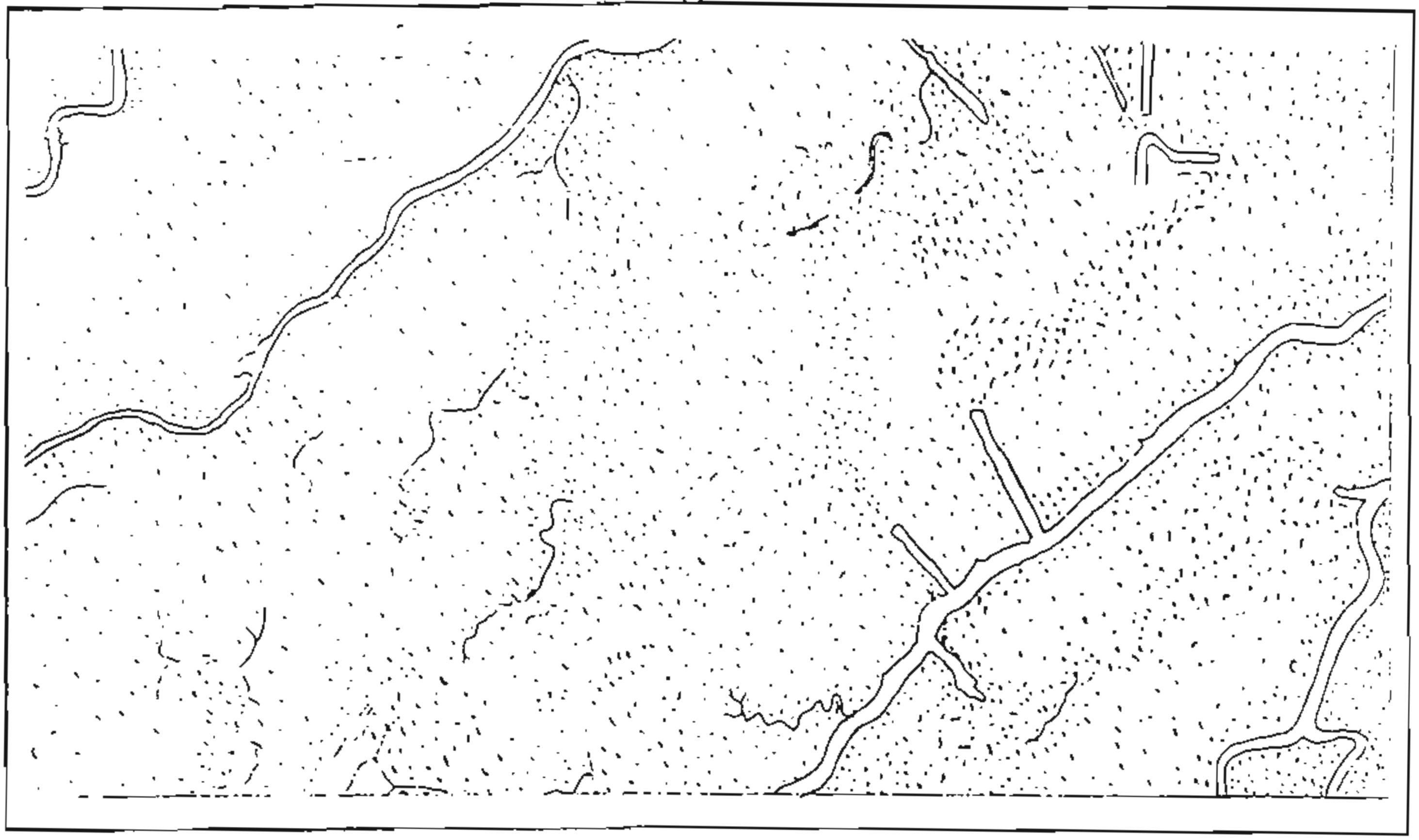
V3 Marsh Interspersion
Type 1



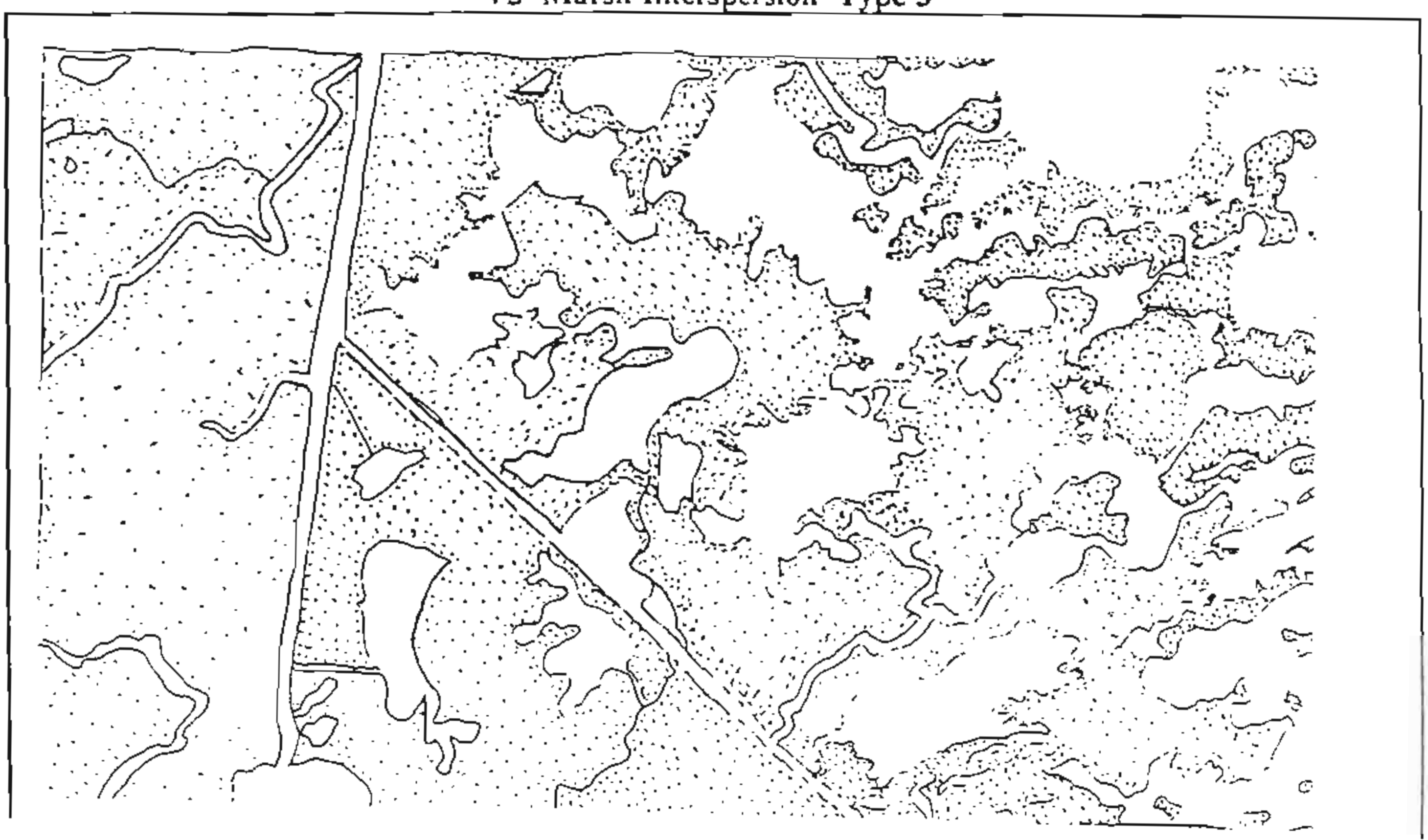
V3 Marsh Interspersion Type 1



V3 Marsh Interspersion
Type 1



V3 Marsh Interspersion Type 3



Revised June 2, 1993

PROCEDURE FOR CALCULATING ACCESS VALUE

1. Determine the percent of wetland area accessible by estuarine organisms during normal tidal fluctuations (P) for baseline (TY0) conditions. P may be determined by examination of aerial photography, knowledge of field conditions, or other appropriate methods.

2. Determine the Structure Rating (R) for each project structure as follows:

Structure Type	Rating
open system	1.0
rock weir set at 1ft BML[1], w/ boat bay	0.8
rock weir with boat bay	0.6
rock weir set at ≥ 1ft BML	0.6
slotted weir with boat bay	0.6
open culverts	0.5
weir with boat bay	0.5
weir set at ≥1ft BML	0.5
slotted weir	0.4
flapgated culvert with slotted weir	0.35
variable crest weir	0.3
flapgated variable crest weir	0.25
flapgated culvert	0.2
rock weir	0.15
fixed crest weir	0.1
solid plug	0.0001

For each structure type, the rating listed above pertains only to the standard structure configuration and assumes that the structure is operated according to common operating schedules consistent with the purpose for which that structure is designed. In the case of a "hybrid" structure or a unique application of one of the above-listed types (including unique or "non-standard" operational schemes), the WVA analyst(s) may assign an appropriate Structure Rating between 0.0001 and 1.0 that most closely approximates the relative degree to which the structure in question would allow ingress/egress of estuarine organisms. In those cases, the rational used in developing the new Structure Rating shall be documented.

3. Determine the Access Value. Where multiple openings equally affect a common "accessible unit", the Structure Rating (R) of

[1] Below Marsh Level

the structure proposed for the "major" access point for the unit will be used to calculate Access Value. The designation of "major" will be made by the Environmental Work Group. An "accessible unit" is a defined as a portion of the <u>total</u> accessible area that is served by one or more access routes (canals, bayous, etc.), yet is isolated in terms of estuarine organism access to or from other units of the project area. Isolation factors include physical barriers that prohibit further movement of estuarine organisms, such as natural levee ridges, and spoil banks; and dense marsh that lacks channels, trenasses, and similar small connections that would, if present, provide access and intertidal refugia for estuarine organisms.

Access Value should be calculated according to the following examples (<u>Note</u>: for all examples, P for TY0 = 90%. That designation is arbitrary and is used only for illustrative purposes; P could be any percentage from 0% to 100%):

a. One opening into area; no structure.

Access Value = P
= .90

b. One opening into area that provides access to the entire 90% of the project area deemed accessible. A flapgated culvert with slotted weir is placed across the opening.

Access Value = P * R
= .90 * .6
= .54

c. Two openings into area, <u>each capable by itself</u> of providing full access to the 90% of the project area deemed accessible in TY0. Opening #2 is determined to be the major access route relative to opening #1. A flapgated culvert with slotted weir is placed across opening #1. Opening #2 is left unaltered.

Access Value = P
= .90

<u>Note</u>: Structure #1 had no bearing on the Access Value calculation because its presence did not reduce access (opening #2 was determined to be the major access route, and access through that route was not altered).

d. Two openings into area. Opening #1 provides access to an accessible unit comprising 30% of the area. ening #2 provides access to an accessible unit comr ing the remaining 60% of the project area. A flapgated ert with slotted weir is placed across #1. Opening #2 i eft open.

Access Value = weighted avg. of Access Values the two accessible units

$$
\begin{aligned}
&= ([P_1 * R_1] + [P_2 * R_2])/(P_1+P_2) \\
&= ([.30*0.6] + [.60*1.0])/(.30+.6 \\
&= (.18 + .60)/.90 \\
&= .78/.90 \\
&= .87
\end{aligned}
$$

Note: $P_1 + P_2 = .90$, because only 90 percent the study area was determined to be accessible at TY0.

e. Three openings into area, each capable of pr ding full access to the entire area independent of others. Opening #3 is determined to be the major ess route relative to openings #1 and #2. Opening #1 is ocked with a solid plug. Opening #2 is fitted with a flap ed culvert with slotted weir, and opening #3 is left open

$$
\begin{aligned}
\text{Access Value} &= P \\
&= .90
\end{aligned}
$$

Note: Structures #1 and #2 had no bearing on the Access Value calculation because their presence did not reduce access (opening #3 was determined to be the major access route, and access through that route was not altered).

f. Three openings into area, each capable of providing full access to the entire area independent of the others. Opening #2 is determined to be the major access route relative to openings #1 and #3. Opening #1 is blocked with a solid plug. Opening #2 is fitted with a flapgated culvert with slotted weir, and opening #3 is fitted with a fixed crest weir.

$$
\begin{aligned}
\text{Access Value} &= P * R_2 \\
&= .90 * .6 \\
&= .54
\end{aligned}
$$

Note: Structures #1 and #3 had no bearing on the Access Value calculation because their presence did not reduce access. Opening #2 was determined beforehand to be the major access route; thus, it was the flapgated culvert with slotted weir across that opening that actually served to limit access.

g. Three openings into area. Opening #1 provides access to an accessible unit comprising 20% of the area. Openings #2 and #3 provide access to an accessible unit comprising the remaining 70% of the area, and within that area, each is capable by itself of providing full access. However, opening #3 is determined to be the major access route relative to opening #2. Opening #1 is fitted with an open culvert, #2 with a flapgated culvert with slotted weir, and #3 with a fixed crest weir.

$$\text{Access Value} = ([P_1*R_1] + [P_2*R_3])/(P_1+P_2)$$

$$= ([.20*.7]+[.70*.6])/(.20+.70)$$
$$= (.14 + .42)/.90$$
$$= .56/.90$$
$$= .62$$

h. Three openings into area. Opening #1 provides access to an accessible unit comprising 20% of the area. Opening #2 provides access to an accessible unit comprising 40% of the area, and opening #3 provides access to the remaining 30% of the area. Opening #1 is fitted with an open culvert, #2 a flapgated culvert with slotted weir, and #3 a fixed crest weir.

$$\textbf{Access Value} = ([P_1*R_1]+[P_2*R_2]+[P_3*R_3])/(P_1+P_2+P_3)$$

$$= ([.20*.7]+[.40*.6]+[.30*.1])/(.20+.40+.30)$$
$$= (.14+.24+.03)/.90$$
$$= .41/.90$$
$$= .46$$

Published Habitat Suitability Index (HSI) Models Consulted for Variables for Possible Use in the Wetland Value Assessment Models

tuarine Fish and Shellfish

nk shrimp
ite shrimp
own shrimp
otted seatrout
lf flounder
uthern flounder
lf menhaden
venile spot
venile Atlantic croaker
d drum

ptiles and Amphibians

erican alligator
ider turtle
llfrog

mmals

nk
skrat

Freshwater Fish

channel catfish
largemouth bass
red ear sunfish
bluegill

Birds

clapper rail
great egret
northern pintail
mottled duck
coot
marsh wren
great blue heron
laughing gull
snow goose
red-winged blackbird
roseate spoonbill
white-fronted goose

HABITAT ASSESSMENT MODELS FOR
FRESH SWAMP AND BOTTOMLAND HARDWOODS
WITHIN THE LOUISIANA COASTAL ZONE

LOUISIANA DEPARTMENT OF NATURAL RESOURCES

BATON ROUGE, LOUISIANA

JANUARY 10, 1994

HABITAT ASSESSMENT MODELS FOR FRESH SWAMP AND BOTTOMLAND HARDWOODS WITHIN THE LOUISIANA COASTAL ZONE

I. INTRODUCTION

The habitat assessment models presented in this document are a modification of the U.S. Fish and Wildlife Service's Habitat Evaluation Procedures (HEP) and utilize, for each habitat type, one assemblage of variables considered important for determining the suitability of an area to support a diversity of fish and wildlife species. These models are intended to complement the Wetland Value Assessment Methodology (WVAM) models for fresh, intermediate, brackish, and saline marsh and shall used to quantify net gains and losses of ecological value associated with permitted activities and compensatory mitigation proposals in the Louisiana Coastal Zone. (The WVAM models were developed by the Environmental Work Group for the Coastal Wetlands Planning, Protection, and Restoration Act to evaluate projects proposed to be constructed pursuant to that Act.)

The models presented in this document were developed concurrently with the proposed Mitigation Regulations for the Louisiana Coastal Zone. The models were distributed for review, in draft form, on March 15, 1993, and July 17, 1993, with additional modifications distributed October 22, 1993. Reviewers of the models included representatives of state and federal agencies, environmental groups, oil and gas industry, chemical industry, real estate interests, agricultural interests, landowners, and local governments. While the proposed mitigation regulations will not go into affect until at least July 1, 1994, these models are considered applicable immediately.

Questions or comments regarding this document should be directed to Quin Kinler, Louisiana Department of Natural Resources, Office of Coastal Restoration and Management, P.O. Box 44487, Baton Rouge, LA 70804-4487, 504-342-1375.

II. CONCEPT / METHODOLOGY

The concept and methodology for use of these models are almost identical to the WVAM:

> "The WVA operates under the assumption that optimal conditions for general fish and wildlife habitat within a given coastal wetland type can be characterized, and that existing or predicted conditions can be compared to that optimum to provide an index of habitat quality. Habitat quality is estimated or expressed through the use of a mathematical model developed specifically for each wetland type. Each model consists of 1) a list of variables that are considered important in characterizing fish and wildlife habitat, 2) a Suitability Index graph for each variable, which defines the assumed relationship between habitat quality (Suitability Index) and different

variable values, and 3) a mathematical formula that combines Suitability Index for each variable into a single value for wetland habitat quality; that single value is referred to as the Habitat Suitability Index, or HSI."

The WVAM models and the models for fresh swamp and bottomland hardwoods attempt to assess the suitability of each habitat type for providing resting, foraging, breeding, and nursery habitat to a diverse assemblage of fish and wildlife species. While the models do not specifically assess other wetland functions and values such as storm-surge protection, floodwater storage, water quality improvement, nutrient import/export, and aesthetics, it can be generally assumed that these functions and values are positively correlated with fish and wildlife habitat quality.

III. VARIABLE SELECTION

The selection of variables was based on review of 1) Habitat Suitability Index models, published by the U.S. Fish and Wildlife Service, for wood duck, barred owl, swamp rabbit, mink, downy woodpecker, and gray squirrel, 2) a community model for forest birds, published by the U.S. Fish and Wildlife Service, 3) "A Habitat Evaluation System for Water Resources Planning", published by the U.S. Army Corps of Engineers, and 4) a draft version of "A Community Habitat Evaluation Model for Bottomland Hardwood Forests in the Southeastern United States", coauthored by the U.S. Army Corps of Engineers and the U.S. Fish and Wildlife Service.

Several habitat variables appeared repeatedly in the various models reviewed. In general, it was concluded that those habitat variables which occurred most frequently in the various models were the most important for assessing habitat quality. The species-specific models concentrate on assessment of site-specific habitat quality features such as tree species composition, forest stand structure (understory, midstory, overstory conditions), stand maturity, and hydrology. The other models rely heavily on how a site fits into the overall "landscape". Both approaches are important and warrant consideration. The models presented in this document attempt to incorporate both approaches.

IV. SUITABILITY INDEX GRAPHS

The concept of suitability index graphs for the subject models is identical to that for the WVAM models:

"A Suitability Index (SI) graph is a graphical representation of how fish and wildlife habitat quality or 'suitability' of a given wetland type is predicted to change as values of the given variable change, and allows the model user to describe, through a Suitability Index, the habitat quality of a wetland area for any variable value."

In theory, each Suitability Index should range from 0.0 to 1.0, with 1.0 representing the optimal condition for the variable in question. However, because the mathematical formula that combines Suitability Indices into a single HSI involves multiplication of all Suitability Indices, a 0.0 for any Suitability Index would produce 0.0 for the HSI in the models. Therefore, in practice the lowest possible Suitability Index for these draft models is 0.01.

The suitability index graphs are presented in Appendices A (fresh swamp) and B (bottomland hardwoods).

V. SUITABILITY INDEX GRAPH ASSUMPTIONS

A. Fresh Swamp Model

Fresh swamp is defined as an area supporting or capable of supporting a canopy of woody vegetation which covers at least 33 percent of the area's surface, <u>and</u> with at least 60 percent of that canopy consisting of any combination of baldcypress, tupelogum, red maple, buttonbush, and/or planertree. (See Appendix C for scientific names.) If woody vegetation is present but the canopy covers less than 33 percent of the area, the fresh marsh WVAM model should be applied. If greater than 40 percent of the woody vegetation canopy consists of other tree species such as oaks, hickories, American elm, cedar elm, green ash, sweetgum, sugarberry, boxelder, common persimmon, honeylocust, red mulberry, eastern cottonwood, black willow, American sycamore, etc., the bottomland hardwood model should be applied.

Variable V1 - Stand Structure

Fresh swamp tree species do not produce hard mast; consequently, wildlife foods predominantly consist of soft mast, other edible seeds, invertebrates, and vegetation. Because most swamp tree species produce some soft mast or other edible seeds, the actual tree species composition is not usually a limiting factor. More limiting is the presence of stand structure to provide resting, foraging, breeding, nesting, and nursery habitat and the medium for invertebrate production. This medium can exist as herbaceous vegetation, shrub-scrub/midstory cover, or overstory canopy and preferably as a combination of all three. This variable assigns the lowest suitability to sites with a limited amount of all three stand structure components, the highest suitability to sites with a significant amount of all three stand structure components, and mid-range suitability to various combinations when one or two stand structure components are present.

Variable V2 - Stand Maturity

Because of man's historical conversion of fresh swamp, the loss of fresh swamp to saltwater intrusion, historical and ongoing timber harvesting within fresh swamp, and slow tree growth rate in the subsiding Coastal Zone, fresh swamps with mature sizeable trees are a unique but ecologically important feature. These older (mature) trees provide important wildlife requisites such as tree snags and nesting cavities and the medium for invertebrate (wildlife food) production. Additionally, as the stronger trees establish themselves in the canopy, weaker trees are out-competed and eventually die, forming additional snags and downed treetops that would not be present in younger stands. The suitability graph for this variable assumes that snags, cavities, downed treetops, and invertebrate production are present in suitable amounts beginning at about age 50. Therefore, stands with a canopy of trees with an average age of 50 years or greater are considered optimal for this variable (SI = 1.0). Below age 50, it is assumed that the above-mentioned wildlife requisites become more available with increasing age. When the average age of canopy-dominant and canopy-codominant trees is unknown, average tree diameter at breast height (dbh) can be used to determine the Suitability Index for this variable.

Variable V3 - Hydrology

The primary assumption for this variable is that a natural water regime producing temporarily flooded, seasonally flooded, or semi-permanently flooded conditions is optimal. Such a water regime in fresh swamp produces ground vegetation (food, cover, detritus), crawfish, and other invertebrates; provides fish spawning and nursery habitat; and maintains water quality for fish and wildlife (SI = 1.0).

Permanently flooded fresh swamp with consistent riverine input or other water exchange provides optimal fish spawning and nursery habitat but moderate value wildlife habitat; considering both fish and wildlife components, a composite SI of 0.8 was selected for this situation.

Permanently flooded fresh swamp with little water exchange can produce poor quality water during warm weather, periodically reducing fish use and crawfish production; however, that same water can weaken certain trees producing snags, downed treetops, and invertebrates; with all factors considered, permanent flooded swamp with little water exchange is assumed to have moderate (SI = 0.4) habitat value.

Also assumed to have moderate value is a fresh swamp which is part of drainage system that allows water to remain on the site for irregular periods of time; in this situation the vegetative component of the swamp would be optimal, providing excellent habitat for many wildlife species; however, species which are heavily dependent on water would have only temporary access and fish are would generally be excluded.

In an efficient forced drainage system, the vegetative component provides some habitat value, but wildlife species which are dependent on water and fish would essentially be excluded year round (SI = 0.1).

Variable V4 - Size of Contiguous Forested Area

Although edge and diversity, which are dominant features of small forested tracts, are important for certain wildlife species, it is important to understand four concepts: 1) species which thrive in edge habitat are highly mobile and presently occur in substantial numbers, 2) because of forest fragmentation and ongoing timber harvesting by man, edge and diversity are quite available, 3) most species found in "edge" habitat are "generalists" in habitat use and are quite capable of existing in larger tracts, and 4) those species in greatest need of conservation are "specialists" in habitat use and require large forested tracts. Therefore, the basic assumption for this variable is that larger forested tracts are less common and offer higher quality habitat than smaller tracts. For this model, tracts greater than 500 acres in size are considered large enough to warrant being considered optimal.

Variable V5 - Suitability and Traversability of Surrounding Land Uses

Many wildlife species commonly associated with fresh swamp will often use adjacent areas as temporary escape or resting cover and seasonal or diurnal food sources. Surrounding land uses which meet specific needs can render a given area of swamp more valuable to a cadre of wildlife species. Additionally, the type of surrounding land use may encourage, allow, or discourage wildlife movement between two or more desirable habitats. Land uses which allow such movement essentially increase the amount of habitat available to wildlife populations. The weighting factor assigned to various land uses reflects their estimated potential to meet specific needs and allow movement between more desirable habitats.

Variable V6 - Disturbance

Human-induced disturbance can displace individuals, modify home ranges, interfere with reproduction, cause stress, and force animals to use important energy reserves. The effect of disturbance is a factor of the distance to disturbance and the type of disturbance. A separate Suitability Graph was developed for each of those factors and the results are combined to yield a single Suitability Index for Disturbance. If the source of disturbance is located beyond 500 feet from the perimeter of the site or if the type of disturbance is "insignificant", the effects of disturbance are assumed to be negligible and SI = 1.0. If the source of disturbance is located within 50 feet of the perimeter of the site and the disturbance is "Constant or Major", the effects of disturbance are assumed to be maximum and SI = 0.01. Other combinations of distance to, and type of, disturbance yield moderate SI's of 0.26, 0.41, 0.5, and 0.65.

B. Bottomland Hardwoods Model.

Bottomland hardwoods are defined as an area supporting or capable of supporting a canopy of woody vegetation of which greater than 40 percent consists of tree species such as oaks, hickories, American elm, cedar elm, green ash, sweetgum, sugarberry, boxelder, common persimmon, honeylocust, red mulberry, eastern cottonwood, black willow, American sycamore, etc. (If 60 percent of the woody canopy consists of any combination of baldcypress, tupelogum, red maple, buttonbush, and/or planertree, the fresh swamp model should be applied).

Variable V1 - Tree Species Composition

Wildlife which utilize bottomland hardwoods depend heavily on mast, other edible seeds, and tree buds as primary sources of food. The basic assumptions for this variable are: 1) more production of mast (hard and/or soft) and other edible seeds is better than less production, and 2) because of its availability during late fall and winter and its high energy content, hard mast is more critical than soft mast, other edible seeds, and buds.

Variable V2 - Stand Maturity

Prior to about Age 10, bottomland hardwood tree species provide only a very limited amount of wildlife food, in the form of buds and leaves. Accordingly, the SI for those early years shows a very small increase from 0.0 for a site with no trees to 0.1 for a site with 10-year-old trees. The production of soft mast and other edible seeds is expected to begin at about Age 10, increase with age, and reach maximum potential by approximately Age 50 (SI = 1.0). In general, hard mast production is expected to begin at about Age 20 (SI = 0.3), increase substantially by age 30 (SI = 0.6), and reach maximum potential by approximately Age 50.

In addition to increased production of hard mast, soft mast, other edible seeds, and buds, or in stands without mast producing trees, older stands provide important wildlife requisites such as tree snags, nesting cavities, and the medium for invertebrate (wildlife food) production. Also, as the stronger trees establish themselves in the canopy, weaker trees are out-competed and eventually die, forming additional snags and downed treetops that would not be present in younger stands. Another factor to be considered is the rarity (and associated ecological importance) of mature stands, due to man's historical conversion of bottomland hardwoods and historical and ongoing timber harvesting. When the average age of canopy-dominant and canopy-codominant trees is unknown, average tree diameter at breast height (dbh) can be used to determine the Suitability Index for this variable.

Variable V3 - Understory / Midstory

The understory and midstory components of bottomland hardwoods provide resting, foraging, breeding, nesting, and nursery habitat. The understory and midstory provide soft mast, other edible seeds, and vegetation as sources of food. The understory and midstory also provide the medium for invertebrate production, an additional food source. The amount of understory coverage and the amount of midstory coverage are considered equally important and are given equal weight in determining the Suitability Index for this variable.

Variable V4 - Hydrology

Bottomland hardwood stands in the Louisiana Coastal Zone generally occur in one of four basic hydrology classes or water regimes: 1) efficient forced drainage system, 2) irregular periods of inundation due to an artificially lowered water table, 3) extended inundation or impoundment because of artificially raised water table, and 4) essentially unaltered. The optimum bottomland hardwood hydrology (SI = 1.0) is one that is essentially unaltered, allowing natural wetting and drying cycles which are beneficial to vegetation and associated fish and wildlife species. When a bottomland hardwood stand is part of an efficient forced drainage system, the vegetative component provides some habitat value, but wildlife species which are dependent on water would essentially be excluded year round, and the area would not in any way serve to promote fish production (SI = 0.1). With a moderately lowered water table, the vegetative component of the site could provide excellent habitat for many wildlife species and temporary habitat for wildlife species which are dependent on water, but fish would generally be excluded (SI = 0.5). With a raised water table, fish habitat and habitat for water-dependent wildlife could be equivalent to an unaltered system; however, other wildlife species could be adversely affected because of water-related impacts to the vegetative components of the stand (SI = 0.5).

Variable V5 - Size of Contiguous Forested Area

Although edge and diversity, which are dominant features of small forested tracts, are important for certain wildlife species, it is important to understand four concepts: 1) species which thrive in edge habitat are highly mobile and presently occur in substantial numbers, 2) because of forest fragmentation and ongoing timber harvesting by man, edge and diversity are quite available, 3) most species found in "edge" habitat are "generalists" in habitat use and are quite capable of existing in larger tracts, and 4) those species in greatest need of conservation are "specialists" in habitat use and require large forested tracts. Therefore, the basic assumption for this variable is that larger forested tracts are less common and offer higher quality habitat than smaller tracts. For this model, tracts greater than 500 acres in size are considered large enough to warrant being considered optimal.

Variable V6 - Suitability and Traversability of Surrounding Land Uses

Many wildlife species commonly associated with bottomland hardwoods will often use adjacent areas as temporary escape or resting cover and seasonal or diurnal food sources. Surrounding land uses which meet specific needs can render a given area of bottomland hardwoods more valuable to a cadre of wildlife species. Additionally, the type of surrounding land use may encourage, allow, or discourage wildlife movement between two or more desirable habitats. Land uses which allow such movement essentially increase the amount of habitat available to wildlife populations. The weighting factor assigned to various land uses reflects their estimated potential to meet specific needs and allow movement between more desirable habitats.

Variable V7 - Disturbance

Human-induced disturbance can displace individuals, modify home ranges, interfere with reproduction, cause stress, and force animals to use important energy reserves. The effect of disturbance is a factor of the distance to disturbance and the type of disturbance. A separate Suitability Graph was developed for each of those factors and the results are combined to yield a single Suitability Index for Disturbance. If the source of disturbance is located beyond 500 feet from the perimeter of the site or if the type of disturbance is "insignificant", the effects of disturbance are assumed to be negligible and SI = 1.0. If the source of disturbance is located within 50 feet of the perimeter of the site and the disturbance is "Constant or Major", the effects of disturbance are assumed to be maximum and SI = 0.01. Other combinations of distance to, and type of, disturbance yield moderate SI's of 0.26, 0.41, 0.5, and 0.65.

VI. HABITAT SUITABILITY INDEX FORMULAS

As with the WVAM, the final step in developing the subject models was "to construct a mathematical formula that combines all Suitability Indices for each wetland type into a single Habitat Suitability Index (HSI) value. Because the Suitability Indices range in value from 0.01 to 1.0, the HSI also ranges from 0.01 to 1.0, and is a numerical representation of overall or 'composite' habitat quality of the particular wetland study area being evaluated."

Any variable's Suitability Index can be weighted, by raising its exponent, to increase the importance of that variable relative to the other variables in the HSI formula. A larger exponent will increase the influence of that variable on the resultant HSI. As discussed above, the draft models attempt to incorporate site-specific habitat quality features (tree species composition, forest stand structure, stand maturity, and hydrology) and "landscape" parameters (forest size, surrounding habitat, and disturbance).

Because the primary application of these models is to quantify the loss of ecological values due to small and site-specific activities, the site specific variables (V1, V2, and V3 for fresh swamp and V1, V2, V3, and V4 for bottomland hardwoods) are considered more important and have been "given more weight" than the "landscape" variables.

For fresh swamp, the site specific variables V1 (Stand Structure) and V2 (Stand Maturity) are considered to be of greatest importance; they are weighted to the power of four. Variable V3 (Hydrology) is weighted to the power of two. The "landscape" variables (V4, V5, and V6) are not weighted.

For bottomland hardwoods, the site specific variables V1 (Tree Species Composition) and V2 (Stand Maturity) are considered to be of greatest importance; they are weighted to the power of four. Variables V3 (Understory / Midstory) and V4 (Hydrology) are weighted to the power of two. The "landscape" variables (V5, V6, and V7) are not weighted. In some cases, data for Variable V3 (Understory / Midstory) may not be readily available; in those instances that variable can be deleted from the HSI formula as indicated below.

For both fresh swamp and bottomland hardwoods, stands less than 7 years of age generally do not 1) exhibit distinguishable understory, midstory, and overstory components, 2) produce substantial mast, or 3) function as part of a forested landscape; hence, the variables Stand Structure, Tree Species Composition, Size of Contiguous Forest, and Understory / Midstory are not incorporated into the HSI formulas until the stand reaches 7 years of age.

The HSI formulas **fresh swamp** are:

1. If Age < 7 (or if cypress dbh < 5 and tupelogum et al. dbh < 4), then:

$$HSI = (SI_{V2}^4 \times SI_{V3}^2 \times SI_{V5} \times SI_{V6})^{1/8}, \text{ or}$$

2. If Age > 7 (or if cypress dbh > 5 or tupelogum et al. dbh > 4), then:

$$HSI = (SI_{V1}^4 \times SI_{V2}^4 \times SI_{V3}^2 \times SI_{V4} \times SI_{V5} \times SI_{V6})^{1/13}.$$

The HSI formulas bottomland hardwoods are:

1. If Age < 7 (or dbh < 5), then:

$$HSI = (SI_{V2}^{4} \times SI_{V4}^{2} \times SI_{V6} \times SI_{V7})^{1/8}, \text{ or}$$

2. If Age > 7 (or dbh > 5) **and** V3 (Understory / Midstory) data is available, then:

$$HSI = (SI_{V1}^{4} \times SI_{V2}^{4} \times SI_{V3}^{2}\ SI_{V4}^{2} \times SI_{V5} \times SI_{V6} \times SI_{V7})^{1/15}, \text{ or}$$

3. If Age > 7 (or dbh > 5) and V3 (Understory / Midstory) data is **not** available, then:

$$HSI = (SI_{V1}^{4} \times SI_{V2}^{4} \times SI_{V4}^{2} \times SI_{V5} \times SI_{V6} \times SI_{V7})^{1/13}.$$

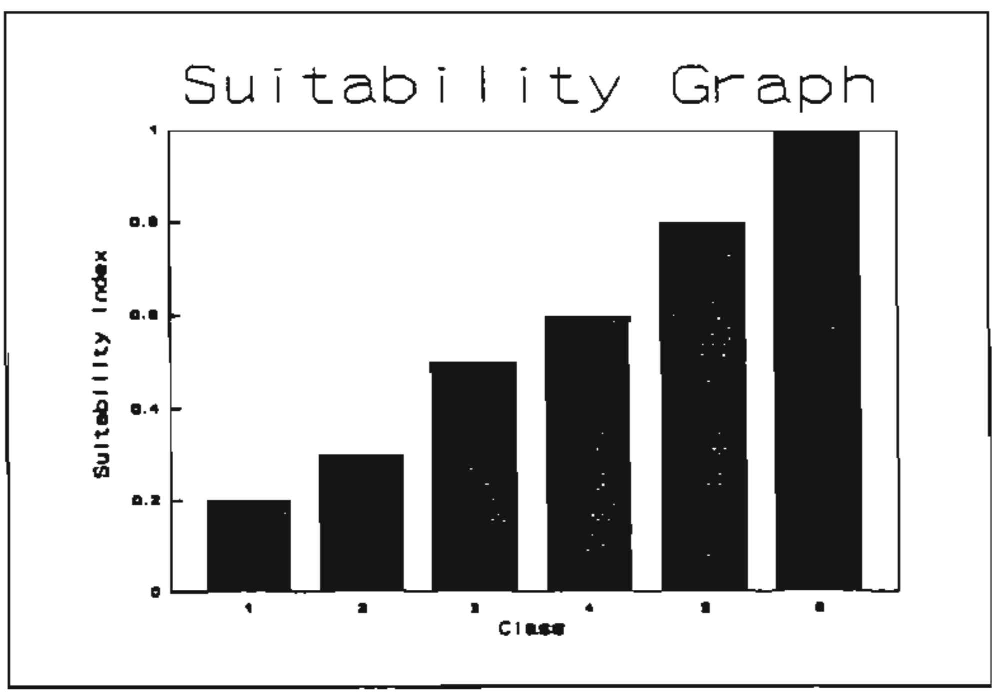
APPENDIX A

FRESH SWAMP

VARIABLE V1 - Stand Structure

Each component of stand structure should viewed independently to determine the percent closure or coverage.

	Overstory Closure		Herbaceous Cover		Scrub-shrub/ Midstory Cover
Class 1.	33% < 50%	and	< 33%	and	< 33%
Class 2.	> 50%	and	< 33%	and	< 33%
Class 3.	33% < 50%	and	> 33%	or	> 33%
Class 4.	> 50%	and	> 33%	or	> 33%
Class 5.	33% < 50%	and	> 33%	and	> 33%
Class 6.	> 50%	and	> 33%	and	> 33%



FRESH SWAMP

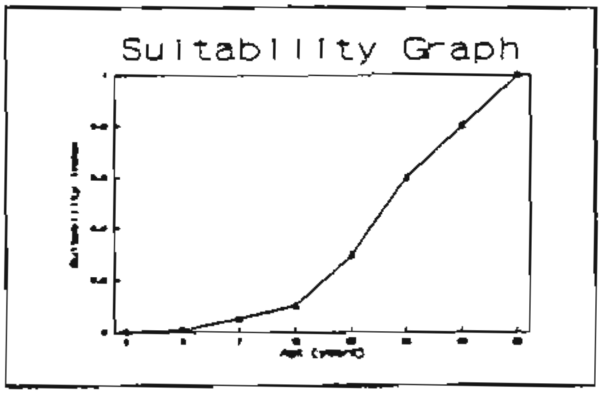
VARIABLE V2 - Stand Maturity (i.e., average age of canopy-dominant and canopy-codominant trees)

Notes:

1. When the average age of canopy-dominant and canopy-codominant trees is unknown, average tree diameter at breast height (dbh) can be used to determine the Suitability Index for this variable).

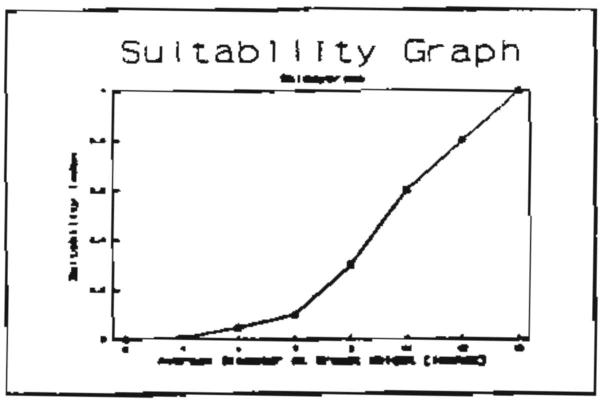
2. Canopy-dominant and canopy co-dominant trees are those trees whose crown rises above or is an integral part of the stand's overstory. When both baldcypress and tupelogum (and other species) are present in the overstory, the average age should be weighted according to the percent canopy coverage for each species group.

3. For trees with buttress swell, dbh is the diameter measured at 12" above the swell. In baldcypress and tupelogum, this can sometimes be as high as 10 - 12 feet above the ground.



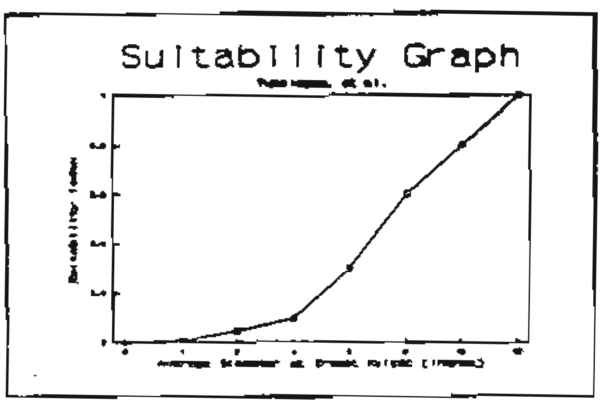
Suitability Index Line Formulas, when age is known:

If age = 0 then SI = 0.
If 0 < age ≤ 3 then SI = .0033 * age
If 3 < age ≤ 7 then SI = (.01 * age) - .02
If 7 < age ≤ 10 then SI = (.017 * age) - .07
If 10 < age ≤ 20 then SI = (.02 * age) - .
If 20 < age ≤ 30 then SI = (.03 * age) -
If 30 < age ≤ 50 then SI = .02 * age
If age > 50 then SI = 1.0.



Suitability Index Line Formulas for baldcypress, when age is unknown:

If dbh = 0 then SI = 0
If 0 < dbh ≤ 1 then SI = .01 * dbh
If 1 < dbh ≤ 4 then SI = (.013 * dbh) - .002
If 4 < dbh ≤ 7 then SI = (.017 * dbh) - .019
If 7 < dbh ≤ 9 then SI = (.1 * dbh) - .6
If 9 < dbh ≤ 11 then SI = (.15 * dbh) - 1.05
If 11 < dbh ≤ 13 then SI = (.1 * dbh) - .5
If 13 < dbh ≤ 16 then SI= (.067 * dbh) - .071
If dbh > 16 then SI = 1.0.



Suitability Index Line Formulas for tupelogum et al., when age is unknown:

If dbh = 0 then SI = 0
If 0 < dbh ≤ 1 then SI = .01 * dbh
If 1 < dbh ≤ 2 then SI = (.04 * dbh) - .
If 2 < dbh ≤ 4 then SI = .025 * dbh
If 4 < dbh ≤ 6 then SI = (.1 * dbh) - .3
If 6 < dbh ≤ 8 then SI = (.15 * dbh) - .6
If 8 < dbh ≤ 12 then SI = (.1 * dbh) - .2
If dbh > 12 then SI = 1.0.

BOTTOMLAND HARDWOOD

DBH	AGE IN YEARS
1"	3
2"	4
3"	5
4"	6
5"	7
6"	8
7"	9
8"	10
9"	13
10"	16
11"	20
12"	23
13"	27
14"	30
15"	33
16"	36
17"	40
18"	43
19"	46
≥20"	50

CYPRESS

DBH	AGE IN YEARS
1"	3
2"	4
3"	5
4"	7
5"	8
6"	9
7"	10
8"	15
9"	20
10"	25
11"	30
12"	35
13"	40
14"	43
15"	46
≥16"	50

TUPELO

DBH	AGE IN YEARS
1"	3
2"	7
3"	8
4"	10
5"	15
6"	20
7"	25
8"	30
9"	35
10"	40
11"	45
≥12"	50

CYPRESS

DBH	AGE IN YEARS
1"	3
2"	4
3"	5
4"	7
5"	8
6"	9
7"	10
8"	15
9"	20
10"	25
11"	30
12"	35
13"	40
14"	43
15"	46
≥16"	50

TUPELO

DBH	AGE IN YEARS
1"	3
2"	7
3"	8
4"	10
5"	15
6"	20
7"	25
8"	30
9"	35
10"	40
11"	45
≥12"	50

CYPRESS

DBH	SI
1"	0.01
2"	0.024
3"	0.037
4"	0.05
5"	0.066
6"	0.083
7"	0.1
8"	0.2
9"	0.3
10"	0.45
11"	0.6
12"	0.7
13"	0.8
14"	0.867
15"	0.934
≥16"	1.0

TUPELO

DBH	SI
1"	0.01
2"	0.05
3"	0.75
4"	0.1
5"	0.2
6"	0.3
7"	0.45
8"	0.6
9"	0.7
10"	0.8
11"	0.9
≥12"	1.0

CYPRESS/TUPELO

AGE IN YEARS	SI
1	0.003
2	0.007
3	0 0099
4	0.02
5	0.03
6	0.04
7	0.05
8	0.066
9	0.083
10	0.1
11	0.12
12	0.14
13	0.16
14	0.18
15	0.2
16	0.22
17	0.24
18	0.26
19	0.28
20	0.3
21	0.33
22	0.36
23	0.39
24	0.42
25	0.45
26	0.48
27	0.51
28	0.54
29	0.57
30	0.6
31	0.62
32	0.64
33	0.66
34	0.68
35	0.7
36	0.72
37	0.74
38	0.76
39	0.78
40	0.8
41	0.82
42	0.84
43	0.86
44	0.88
45	0.9
46	0.92
47	0.94
48	0.96
49	0.98
≥50	1.00

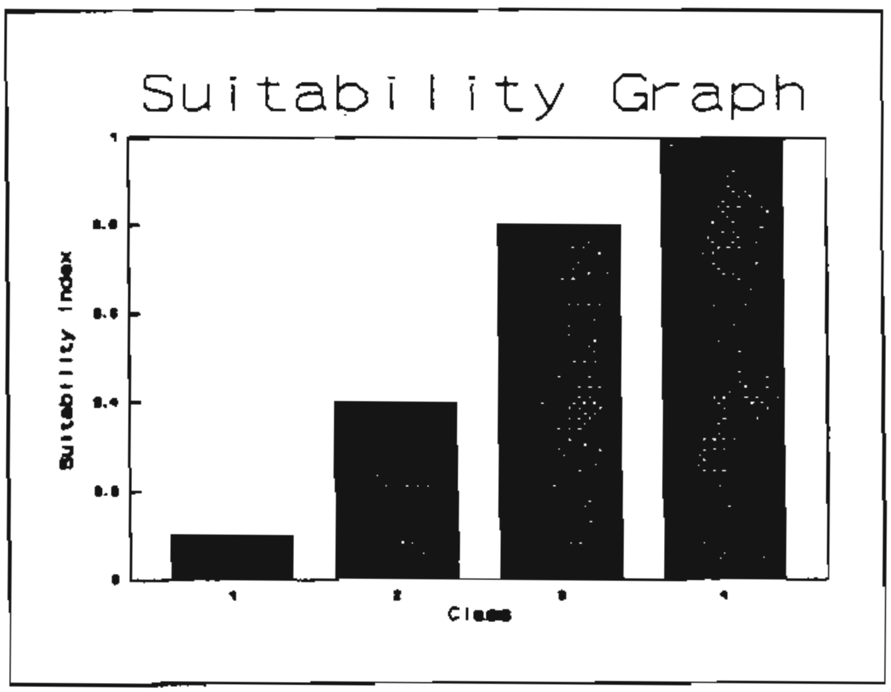
VARIABLE V3 - Hydrology

Class 1. Forced drainage system which efficiently removes water from the surface year round.

Class 2. Permanently flooded with little or no water exchange (stagnant, impounded); OR part of forced drainage or gravity drainage system which, because of subsidence or based on current operation, allows water to remain on-site for irregular but not extended periods of time.

Class 3. Permanently flooded, but receives consistent riverine input and/or other water exchange.

Class 4. Hydrology essentially unaltered and the natural water regime produces temporarily flooded, seasonally flooded, or semi-permanently flooded conditions. (The area could contain small levees and/or canals, provided that the water regime has not been significantly altered).



VARIABLE V4 - Size of Contiguous Forested Area

Note: Corridors less than 75 feet wide do not constitute a break in the forested area contiguity.

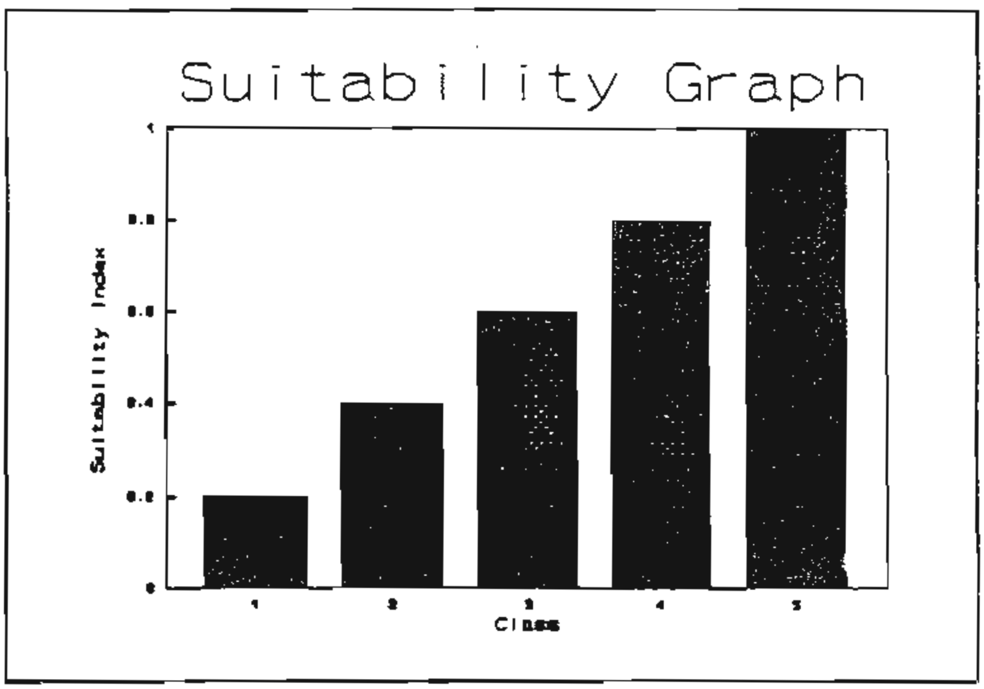
Class 1. 0 to 5 acres.

Class 2. 5.1 to 20 acres.

Class 3. 20.1 to 100 acres.

Class 4. 100.1 to 500 acres.

Class 5. > 500 acres.



FRESH SWAMP

VARIABLE V5 - Suitability and Traversability of Surrounding Land Uses

Within a 0.5 mile of the perimeter of the site, determine the percent of the surrounding area that is occupied by each of the following land uses (must account for 100 percent of the area). Multiply the percentage of each land use by the suitability weighting factor shown below, add the adjusted percentages and divide by 100 for a suitability index for this variable, except that **if 100% of the Surrounding Habitat is considered nonhabitat, SI equals 0.01.**

LAND USE	Weighting factor		% of 0.5 mi. circle		Weighted Percent
Bottomland hardwood, other forested areas, marsh habitat, etc.	1.0	X	____	=	____
Abandoned agriculture, overgrown fields, dense cover, etc.	0.6	X	____	=	____
Pasture, hayfields, etc.	0.4	X	____	=	____
Active agriculture.	0.2	X	____	=	____
Nonhabitat: linear, residential, commercial, industrial development, etc.	0.0	X	____	=	____

____/100 = SI

VARIABLE V6 - Disturbance

The effect of disturbance is a factor of the distance to, and the type of, disturbance, hence both are incorporated in the SI formula.

Note: Linear and/or large project sites may be exposed to various types of disturbances at various distances. The SI for this variable should be weighted to account for those variances; see the example calculation of a weighted SI for Disturbance on Page A-7.

Distance Classes

Class 1. 0 to 50 ft.

Class 2. 50.1 to 500 ft.

Class 3. > 500 ft.

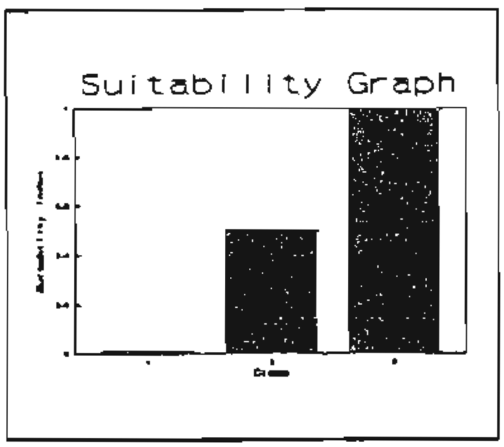
Type Classes

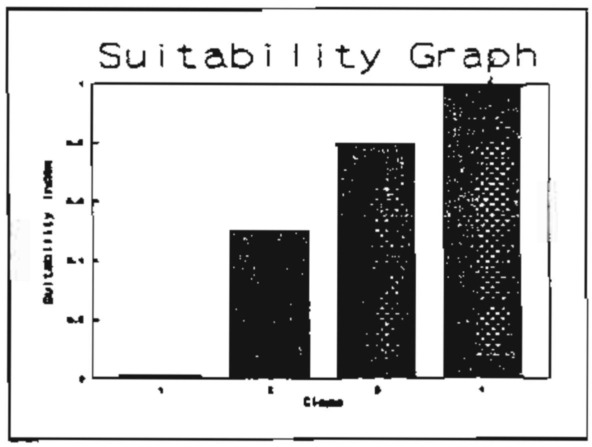
Class 1. Constant / Major (Major highways, industrial, commercial, major navigation.)

Class 2. Frequent / Moderate. (Residential development, moderately used roads, waterways commonly used by small to mid-sized boats.)

Class 3. Seasonal / Intermittent. (Agriculture, aquaculture.)

Class 4. Insignificant. (Lightly Used roads and waterways, individual homes, levees, rights of way.)





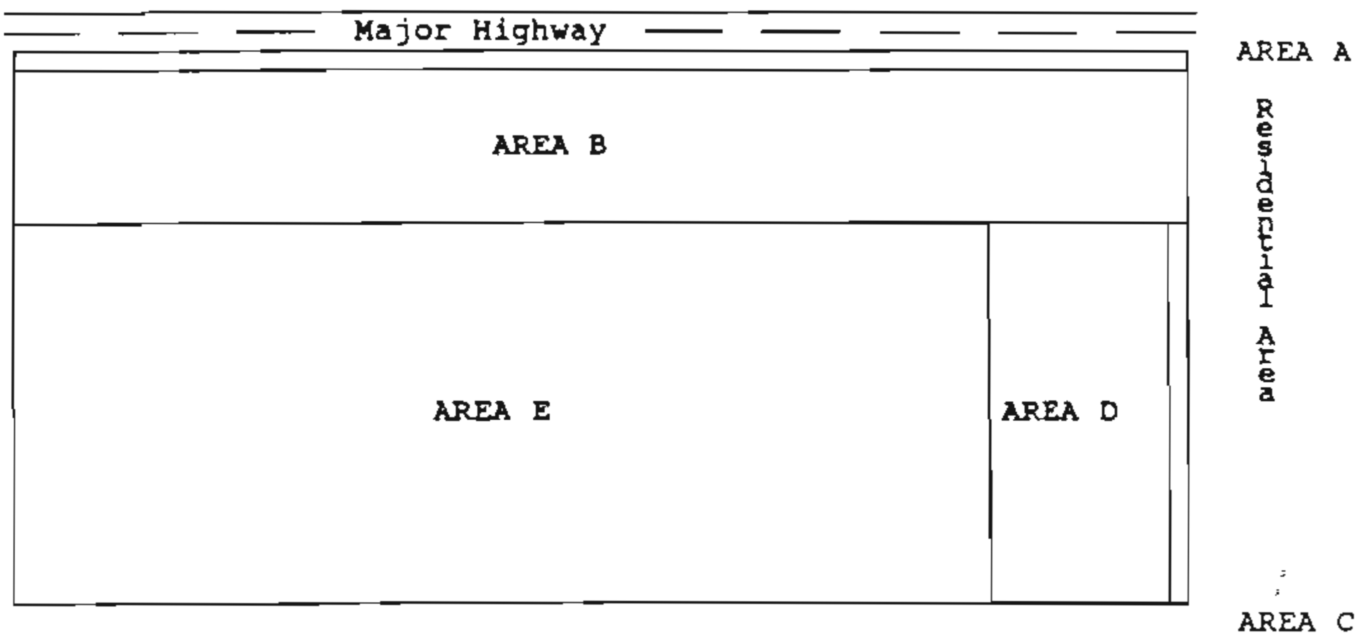
SI Formula: (Distance SI + Type SI) / 2, except that if Distance > 500 feet (Class 3) or Type is Insignificant (Class 4), HSI = 1.0.

Type Class

		1	2	3	4
	1	.01	.26	.41	1
Distance	2	.26	.50	.65	1
Class	3	1	1	1	1

Example Calculation of Weighted SI for Disturbance

The example project area is 1,500 feet by 3,000 feet or 103.3 acres. To calculate the weighted SI, the area is segregated to determine the percent of the project area that would be exposed to various types of disturbance at various distances. When a given portion of the project area is exposed to various type or distance classes, the type/distance combination which yields the lowest SI is utilized.



AREA	DIST-ANCE CLASS	TYPE CLASS	SI*	AREA DIMENSIONS	ACRES	% OF TOTAL AREA	WEIGHTING FACTOR (WF)
A	1	1	.01	50' x 3000'	3.4	3.3	.033
B	2	1	.26	450' x 3000'	31.0	30.0	.30
C	1	2	.26	50' x 1000'	1.1	1.2	.012
D	2	2	.50	450' x 1000'	10.3	10.0	.10
E	3	4	1.0	1000' x 2500'	57.4	55.5	.555

* See Table on Page A-6.

Weighted SI = $(SI_A \text{ X } WF_A) + (SI_B \text{ X } WF_B) + (SI_C \text{ X } WF_C) + (SI_D \text{ X } WF_D) + (SI_E \text{ X } WF_E)$

$(.01 \text{ X } .033) + (.26 \text{ X } .3) + (.26 \text{ X } .012) + (.50 \text{ X } .1) + (1.0 \text{ x } .555)$

.69

BOTTOMLAND HARDWOODS

VARIABLE V1 - Tree Species Association (see Appendix C for scientific names)

Non-mast / inedible seed producers: eastern cottonwood, black willow, American sycamore.

Hard mast producers: oaks, sweet pecan, other hickories.

Soft mast and other edible seed producers: red maple, sugarberry, green ash, boxelder, common persimmon, sweetgum, honeylocust, red mulberry, baldcypress, tupelogum, American elm, cedar elm, etc.

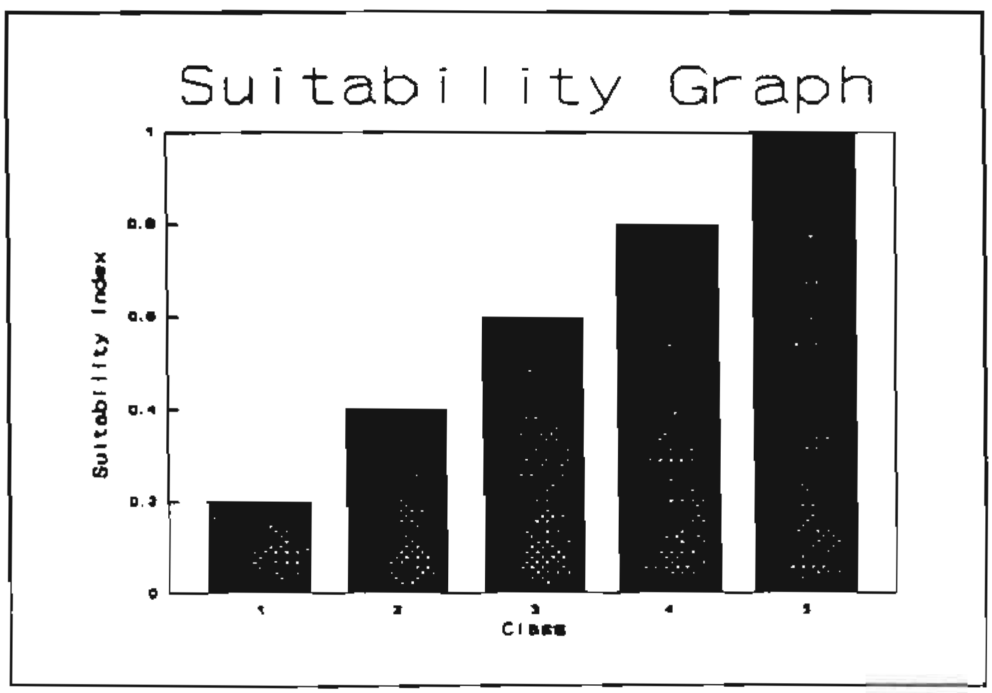
Class 1: Less than 25% of overstory canopy consists of mast or other edible-seed producing trees.

Class 2: 25% to 50% of overstory canopy consists of mast or other edible-seed producing trees, but hard mast producers constitute less than 10 % of the canopy.

Class 3: 25% to 50% of overstory canopy consists of mast or other edible-seed producing trees, and hard mast producers constitute more than 10 % of the canopy.

Class 4: Greater than 50% of overstory canopy consists of mast or other edible-seed producing trees, but hard mast producers constitute less than 20 % of the canopy.

Class 5: Greater than 50% of overstory canopy consists of mast or other edible-seed producing trees, and hard mast producers constitute more than 20 % of the canopy.



BOTTOMLAND HARDWOODS

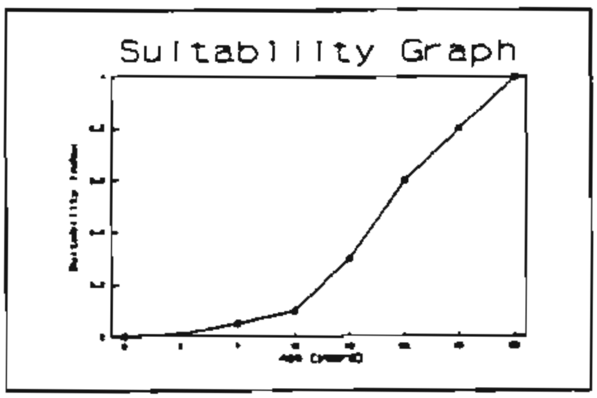
VARIABLE V2 - **Stand Maturity** [i.e., average age of canopy-dominant and canopy-codominant trees]

Notes:

1. When the average age of canopy-dominant and canopy-codominant trees is unknown, average tree diameter at breast height (dbh) can be used to determine the Suitability Index for this variable.

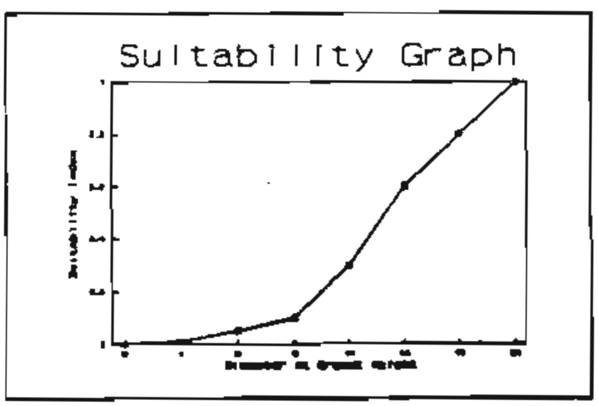
2. Canopy-dominant and canopy co-dominant trees are those trees whose crown rises above or is an integral part of the stand's overstory.

3. For trees with buttress swell, dbh is the diameter measured at 12" above the swell.



Suitability Index Line Formulas, when age is known:

If age = 0 then SI = 0.
If 0 < age ≤ 3 then SI = .0033 * age
If 3 < age ≤ 7 then SI = (.01 * age) - .02
If 7 < age ≤ 10 then SI = (.017 * age) - .(
If 10 < age ≤ 20 then SI = (.02 * age) - .1
If 20 < age ≤ 30 then SI = (.03 * age) - .3
If 30 < age ≤ 50 then SI = .02 * age
If age > 50 then SI = 1.0.



Suitability Index Line Formulas for bottomland hardwoods, when age is unknown:

If dbh = 0 then SI = 0
If 0 < dbh ≤ 5 then SI = .01 * dbh
If 5 < dbh ≤ 8 then SI = (.017 * dbh) - .035
If 8 < dbh ≤ 11 then SI = (.067 * dbh) - .436
If 11 < dbh ≤ 14 then SI = (.1 * dbh) - .8
If 14 < dbh ≤ 20 then SI= (.067 * dbh) - .338
If dbh > 20 then SI = 1.0.

BOTTOMLAND HARDWOOD

DBH	AGE IN YEARS
1"	3
2"	4
3"	5
4"	6
5"	7
6"	8
7"	9
8"	10
9"	13
10"	16
11"	20
12"	23
13"	27
14"	30
15"	33
16"	36
17"	40
18"	43
19"	46
≥20"	50

BOTTOMLAND HARDWOOD

DBH	SI
1"	0.010
2"	0.020
3"	0.030
4"	0.040
5"	0.050
6"	0.067
7"	0.084
8"	0.101
9"	0.167
10"	0.234
11"	0.301
12"	0.400
13"	0.500
14"	0.600
15"	0.667
16"	0.734
17"	0.801
18"	0.868
19"	0.935
≥20"	1.00

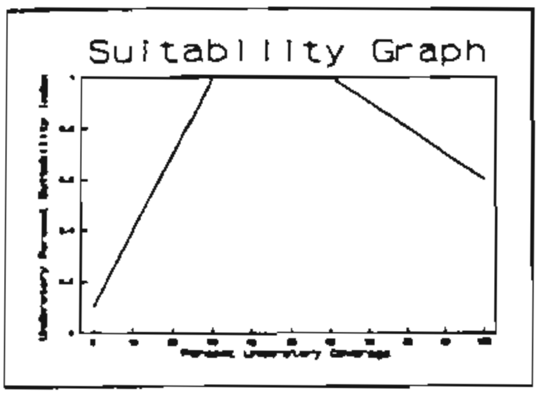
BOTTOMLAND HARDWOOD

AGE IN YEARS	SI
1	0.0033
2	0.0066
3	0.0099
4	0.02
5	0.03
6	0.04
7	0.05
8	0.066
9	0.083
10	0.1
11	0.12
12	0.14
13	0.16
14	0.18
15	0.20
16	0.22
17	0.24
18	0.26
19	0.28
20	0.30
21	0.33
22	0.36
23	0.39
24	0.42
25	0.45
26	0.48
27	0.51
28	0.54
29	0.57
30	0.60
31	0.62
32	0.64
33	0.66
34	0.68
35	0.70
36	0.72
37	0.74
38	0.76
39	0.78
40	0.80
41	0.82
42	0.84
43	0.86
44	0.88
45	0.90
46	0.92
47	0.94
48	0.96
49	0.98
≥50	1.0

BOTTOMLAND HARDWOODS

VARIABLE V3 - Understory / Midstory

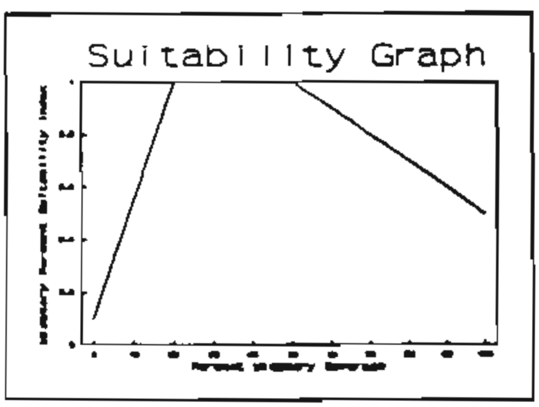
Understory



SI Line Formulas for Understory Coverage:

If understory % = 0 then SI = .1
If 0 < un. % ≤ 30 then SI = 0.03 * un. % + .1
If 30 < un % ≤ 60 then SI = 1.0
If un. % > 60 then SI = (-.01 * un %) + 1.6

Midstory



SI Line Formulas for Midstory Coverage:

If midstory % = 0, then SI = 0.1
If 0 < mid. % ≤ 20 then SI = .045 * mid. % + .1
If 20 < mid. % ≤ 50 then SI = 1.0
If mid. % > 50 then SI = (-.01 * mid. %) + 1.5

Understory / Midstory SI = Understory SI + Midstory SI / 2.

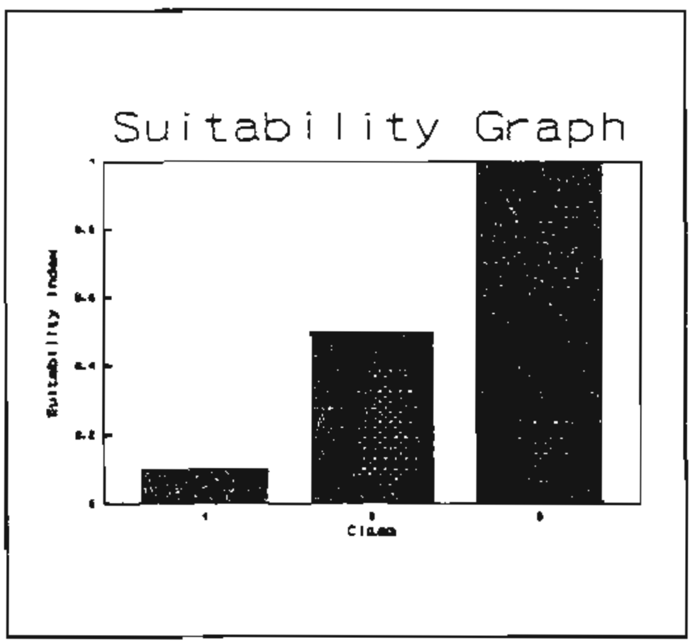
BOTTOMLAND HARDWOODS

VARIABLE V4 - Hydrology

Class 1. Forced drainage system which efficiently removes water from the surface year round.

Class 2. Water table lowered relative to ground level so as to significantly reduce periods of inundation or water table raised so as to cause extended inundation or impoundment.

Class 3. Hydrology essentially unaltered (area could contain small levees and/or ditches, provided that water regime has not been significantly altered).



BOTTOMLAND HARDWOODS

VARIABLE V5 - Size of Contiguous Forested Area

Note: Corridors less than 75 feet wide do not constitute a break in the forested area contiguity.

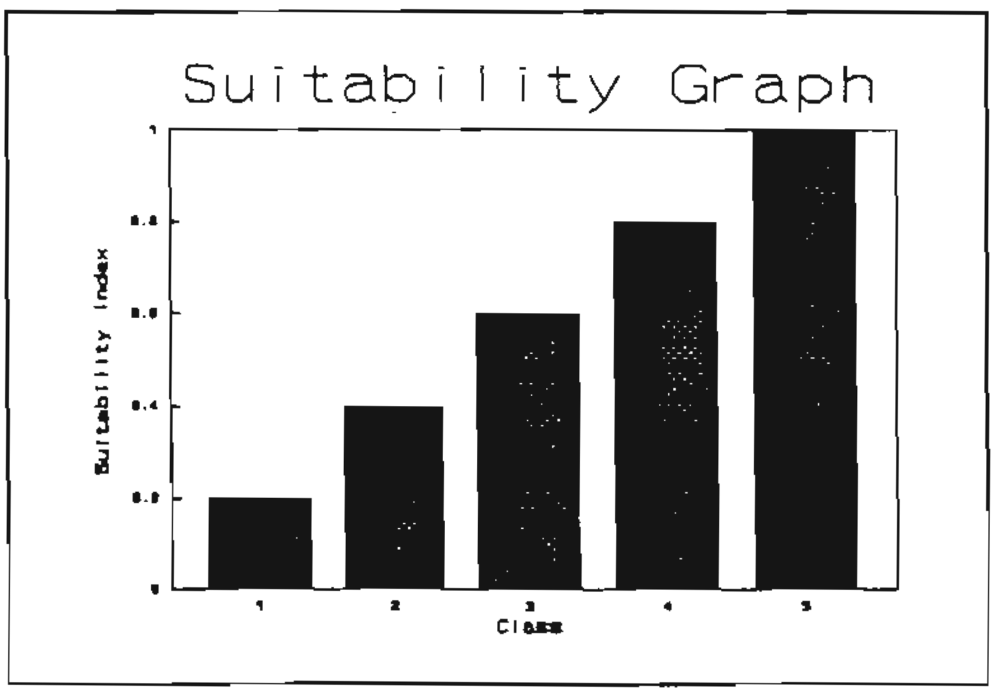
Class 1. 0 to 5 acres.

Class 2. 5.1 to 20 acres.

Class 3. 20.1 to 100 acres.

Class 4. 100.1 to 500 acres.

Class 5. > 500 acres.



BOTTOMLAND HARDWOODS

VARIABLE V6 - Suitability and Traversability of Surrounding Land Uses

Within a 0.5 mile of the perimeter of the site, determine the percent of the area that is occupied by each of the following land uses (must account for 100 percent of the area). Multiply the percentage of each land use by the suitability weighting factor shown below, add the adjusted percentages and divide by 100 for a suitability index for this variable, except that if 100% of the Surrounding Habitat is considered nonhabitat, SI equals 0.01.

LAND USE	Weighting factor		% of 0.5 mi. circle		Weighted Percent
Bottomland hardwood, other forested areas, marsh habitat, etc.	1.0	X	____	=	____
Abandoned agriculture, overgrown fields, dense cover, etc.	0.6	X	____	=	____
Pasture, hayfields, etc.	0.4	X	____	=	____
Active agriculture.	0.2	X	____	=	____
Nonhabitat: linear, residential, commercial, industrial development, etc.	0.0	X	____	=	____

____/100 = SI

VARIABLE V7 - Disturbance

The effect of disturbance is a factor of the distance to, and the type of, disturbance, hence both are incorporated in the SI formula.

Note: Linear and/or large project sites may be exposed to various types of disturbances at various distances. The SI for this variable should be weighted to account for those variances; see the example calculation of a weighted SI for Disturbance on Page A-7.

Distance Classes

Class 1. 0 to 50 ft.

Class 2. 50.1 to 500 ft.

Class 3. > 500 ft.

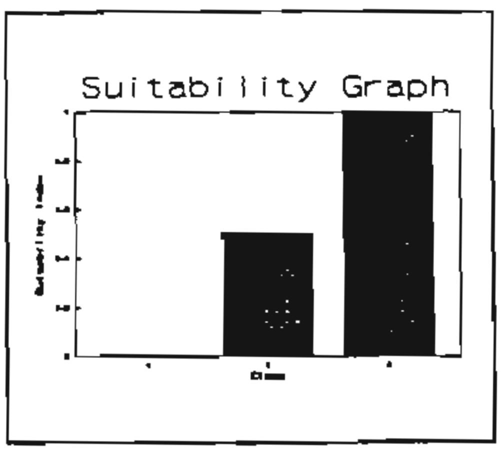
Type Classes

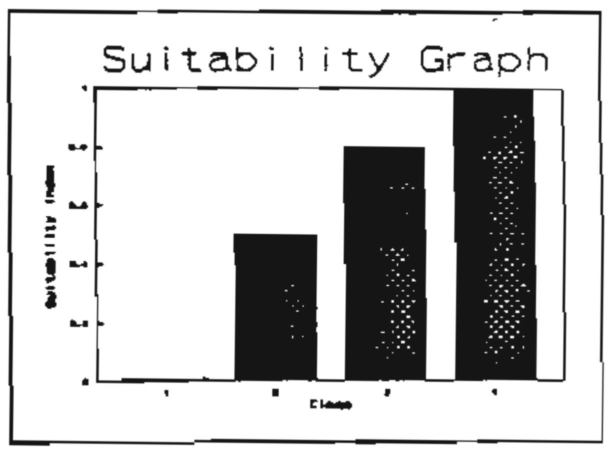
Class 1. Constant / Major (Major highways, industrial, commercial, major navigation.)

Class 2. Frequent / Moderate. (Residential development, moderately used roads, waterways commonly used by small to mid-sized boats.)

Class 3. Seasonal / Intermittent. (Agriculture, aquaculture.)

Class 4. Insignificant. (Lightly Used roads and waterways, individual homes, levees, rights of way.)





SI Formula: (Distance SI + Type SI) / 2, except that if Distance > 500 feet (Class 3) or Type is Insignificant (Class 4), HSI = 1.0.

Type Class

		1	2	3	4
	1	.01	.26	.41	1
Distance	2	.26	.50	.65	1
Class	3	1	1	1	1

APPENDIX C

Common Names	Scientific Names
American elm	Ulmus americana
American sycamore	Platanus occidentalis
Baldcypress	Taxodium distichum
Black willow	Salix nigra
Boxelder	Acer negundo
Buttonbush	Cephalanthus occidentalis
Cedar elm	Ulmus crassifolia
Common persimmon	Diospyros virginiana
Eastern cottonwood	Populus deltoides
Green ash	Fraxinus pennsylvanica
Hickories	Carya spp.
Honeylocust	Gleditsia triacanthos
Oaks	Quercus spp.
Planertree	Planera aquatica
Red maple	Acer rubrum
Red mulberry	Morus rubra
Sugarberry	Celtis laevigata
Sweet pecan	Carya illinoensis
Sweetgum	Liquidambar styraciflua
Tupelogum	Nyssa aquatica

MARSH PARAMETERS FOR MITIGATION CALCULATIONS

__________Percent of wetland area covered by emergent vegetation

__________Percent of open water area dominated by aquatic vegetation

__________Percent of open water area less than or equal to 1.5' deep in relation to marsh surface

__________Mean high salinity during growing season (if known)

Aquatic organism access sites (show on plats)

Location of weirs (slots?), plugs, culverts (flap gates?), etc. in the near vicinity of the project that affect the project wetlands (show on plat).

SWAMP PARAMETERS FOR MITIGATION CALCULATIONS

__________Percent scrub-shrub/midstory cover

__________Percent overstory closure

__________Percent herbaceous cover

Diameter at breast height (dbh) of dominant and co-dominant canopy trees (for trees with buttress swell, dbh is measured 12" above the swell)

Species	dbh
Baldcypress	__________
Tupelogum	__________
Other(name)	__________

Is this area part of a forced drainage system?

Is the area permanently flooded with little or no water exchange (stagnant or impounded)?

Is the area permanently flooded but receives consistent riverine input and/or other water exchange?

Is the area under the natural hydrology that produces temporarily flooded, seasonally flooded, or semi-permanent flooded conditions?

BOTTOMLAND HARDWOOD PARAMETERS FOR MITIGATION CALCULATION

__________Percent of overstory canopy consisting of mast or other edible seed producing trees*.

__________Percentage of the above that are hard mast producing trees

*Hard mast producers: oaks, sweet pecan, other hickories
Soft mast or other edible seed producers: red maple, sugarberry, green ash, boxelder, common persimmon, sweetgum, honeylocust, red mulberry, baldcypress, tupelogum, American elm, cedar elm, etc.

Species and dbh of dominant and co-dominant canopy trees

Species	dbh
__________	__________
__________	__________
__________	__________
__________	__________
__________	__________
__________	__________
__________	__________

__________Percent understory coverage

__________Percent midstory coverage

Is the area part of a forced drainage system?

What is the relative position of the water table (near surface, deep)?

Is the natural hydrology essentially unaltered allowing for natural wetting and drying cycles?

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