Appendix E
Certified BLH and Swamp Models

E-1.
U.S. Army Corps of Engineers
Planning Models Improvement Program

Wetland Value Assessment Bottomland Hardwoods Community Model for Civil Works (Version 1.2)

Revised from the Bottomland Hardwoods Community Model developed by the Environmental Working Group of the Coastal Wetlands Planning, Protection and Restoration Act

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WETLAND VALUE ASSESSMENT METHODOLOGY
Bottomland Hardwoods Community Model

Introduction

This document describes revisions to the Wetland Value Assessment (WVA) Coastal Bottomland Hardwoods (BLH) Community Model for recertification as a planning tool under the Planning Models Improvement Plan (PMIP) (EC 1105-2-412) and for the specific use on US Army Corps of Engineers (USACE) civil works (CW) projects.

The Wetland Value Assessment (WVA) methodology is a quantitative habitat-based assessment methodology developed for use in determining wetland benefits of project proposals submitted for funding under the Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA). The WVA was developed by the CWPPRA Environmental Work Group (EnvWG) after the passage of CWPPRA in 1990. The EnvWG includes members from U.S. Fish and Wildlife Service, Louisiana Coastal Protection and Restoration Authority, Natural Resources Conservation Service, National Oceanic and Atmospheric Administration, Environmental Protection Agency, and USACE. Various other subject matter experts, such as professors and scientists, also helped develop the original WVAs. The WVA quantifies changes in fish and wildlife habitat quality and quantity that are expected to result from a proposed wetland restoration project. The WVA operates under the assumption that optimal conditions for fish and wildlife habitat within a given coastal wetland habitat 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 community models developed specifically for each habitat type. The results of the WVA, measured in Average Annual Habitat Units (AAHUs), can be combined with cost data to provide a measure of the effectiveness of a restoration project in terms of annualized cost per AAHU gained. In addition, the WVA methodology could provide an estimate of the number of AAHUs negatively impacted by a CW project.

The WVA community models have been designed to function at a community level and therefore attempt to define an optimum combination of habitat conditions for all fish and wildlife species utilizing a given habitat type. Each model consists of 1) a list of variables that are considered important in characterizing fish and wildlife habitat, 2) a Suitability Index (SI) 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 the Suitability Index for each variable into a single value for habitat quality; that single value is referred to as the Habitat Suitability Index, or HSI. 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.

This model was developed to determine the suitability of bottomland hardwoods habitat in providing resting, foraging, and nesting habitat for a diverse assemblage of wildlife species. The model has been generally applied to areas with at least 40 percent of the woody vegetation canopy consisting of species such as oaks, hickories, American elm, green ash, sweetgum, sugarberry, boxelder, persimmon, honeylocust, red mulberry, eastern cottonwood, and American sycamore. If greater than 40 percent of the canopy consists of any combination of baldcypress, tupelogum, red maple, buttonbush, and/or water elm, then the swamp community model should be applied.

USACE Planning Models Improvement Program

The PMIP was established in 2003 to assess the state of USACE planning models and to assure that high quality methods and tools are available to provide informed decisions on investments in the Nation's water resources infrastructure and natural environment. The main objective of the PMIP is to carry out "a process to review, improve and validate analytical tools and models for USACE Civil Works business programs" (USACE EC 1105-2-407, May 2005). In accordance with the Planning Models Improvement Program: Model Certification (EC 1105-2-407, May 2005), certification is required for all planning models developed and/or used by USACE.

On June 13, 2018, USACE, Mississippi Valley Division, New Orleans District (CEMVN) initiated coordination requesting feedback from WVA experts from the US Fish and Wildlife Service (David Walther, Cathy Breaux, and Kevin Roy), the National Marine Fisheries Service (Patrick Williams and later Dawn Davis on August 7, 2018), US Geological Survey (Michelle Fischer), the US Environmental Protection Agency (Raul Gutierrez), and Louisiana Department of Wildlife and Fisheries (Dave Butler and Kyle Balkum). The Natural Resource Conservation Service (Ron Boustany) was later included in the WVA reapproval coordination on August 20, 2018. On September 25, CEMVN also reached out to Daniel Allen from Fort Worth District (CESWF). In addition, Sharon McCarthy from Louisiana Department of Natural Resources, Office of Coastal Management provided LDNR WVA models for addressing mitigation potentials on September 28, 2018.

Geographic Scope

The maximum area that the bottomland hardwood models should be applied is the coastal forested wetlands in the southeastern United States. These wetlands share similar community structure and function (Gosselink et al. 1990, Mitsch and Gosselink 2007, Mitsch et al. 2009). Coastal forests from South Carolina to east Texas share a similar climate and respond both positively and negatively to the same environmental conditions.

The WVA model examined herein was designed to capture habitat suitability of the flora and associated fauna that inhabit bottomland hardwood forests of coastal Louisiana. While these community assemblages are similar across the above mentioned geographical area, they vary widely in special case species such as Rafinesque's big-eared bat (*Corynorhinus rafinesquii rafinesquii*), the bald eagle (*Haliaeetus leucocephalus*), the Louisiana black bear (*Ursus americanus lutelous*), and a variety of neotropical migratory songbirds.

Geographic Range of Applicability

Figure 1 indicates the geographical range of applicability for the Wetland Value Assessment Bottomland Hardwoods Community Model. This model was developed for bottomland hardwoods habitats of coastal Louisiana, which share common functions, values, and habitats with the rest of the southern United States (Wharton et al. 1982). Four coastal level III ecoregions, 34, 73, 75, and 76, were initially used to focus on potential coastal habitats in the Southern U.S (Daigle et al., 2006; Griffith et al., 2007). Level IV ecoregions within these were screened for applicability based on their likelihood to contain bottomland hardwoods habitats. After screening, 26 level IV ecoregions remain as the geographic range of applicability (Table 1). Potential users outside of the geographical range of applicability presented here are encouraged to coordinate with ECO-PCX prior to applying this WVA community model for their project.

Table 1. Level IV ecoregions being considered for geographical range of applicability for the Wetland Value Assessment Bottomland Hardwoods Community Model for Civil Works (Version 1.2).

Northern Humid Gulf Coastal Prairies	Gulf Coast Flatwoods
Southern Subhumid Gulf Coastal Prairies	Southwestern Florida Flatwoods
Floodplains and Low Terraces	Eastern Florida Flatwoods
Coastal Sand Plain	Okefenokee Plains
Lower Rio Grande Valley	Sea Island Flatwoods
Lower Rio Grande Alluvial Floodplain	Okefenokee Swamp
Texas-Louisiana Coastal Marshes	Bacon Terraces
Lafayette Loess Plains	Floodplains and Low Terraces
Southern Holocene Meander Belts	Sea Islands/Coastal Marsh
Southern Pleistocene Valley Trains	Big Bend Coastal Marsh
Southern Backswamps	Everglades
Inland Swamps	Big Cypress
Deltaic Coastal Marshes and Barrier Islands	Miami Ride/Atlantic Coastal Strip

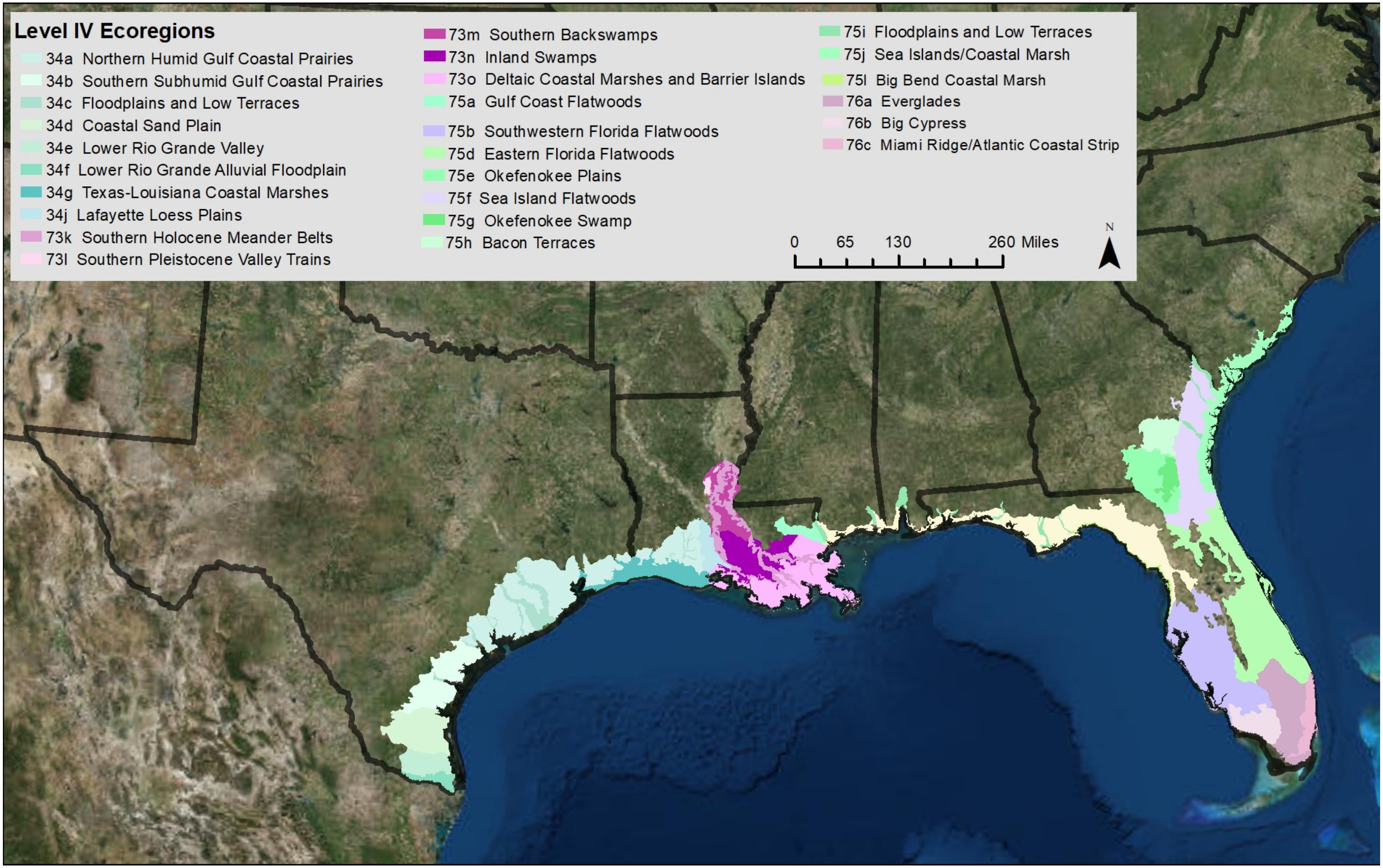


Figure 1. Geographic Range of Applicability for the WVA Bottomland Hardwoods Community Models.

Minimum Area of Application

The minimum area of application should be limited to an area that is large enough to be recognized as a bottomland hardwood site and provides some of the functions and values of the variables used to assess the site's condition. Various authors have concluded that even very small pieces of wooded habitat can be attractive to migrants (Skagen et al. 1998; Somershoe and Chanler 2004; Packett & Dunning 2009). Migrants were found in greater densities in smaller wooded hammocks in coastal South Carolina in a sample that ranged down to 7.9 acres, or 0.32 hectares (ha). Somershoe and Chandler 2004, and Skagen et al. (1998) concluded that riparian habitat patches were important to migrants in the southwestern USA no matter how small. Packett and Dunning (2009) found that migrant densities actually increased as woodlot size decreased, in wooded fragments in an agricultural landscape in Indiana. All their woodlots were less than 25 acres (10 ha) in size.

The value of tiny woodlots to migrant birds stems from the fact that migrants in an inhospitable landscape will gravitate to whatever forested habitat is available. It is quite possible that many of these small fragments are lower in quality than habitats in larger forested areas, but this is not a variable that can be reliably addressed by this model as data on food resources and predation threat are likely to be unavailable for most sites. Thus, this model can probably be profitably applied to even very small woodlot fragments less than 2.5 acres (1 ha) in size.

Field Investigations

The first step in evaluating candidate projects is to conduct a field investigation of the project area. This field investigation has several purposes: 1) familiarize the Interagency Review Team (IRT) with the project area, 2) visit the locations of project features, 3) determine habitat conditions in the project area, 4) compile a list of vegetative species and discuss habitat classification, and 5) collect data for the WVA (e.g., cover of submerged aquatics, water depths, salinities, etc.).

The primary purpose of the field investigation is to allow members of the IRT to familiarize themselves with the project area and project features in order to make informed decisions in the evaluation of the WVA. The interagency field investigation should not be treated as the only opportunity to conduct surveys or take measurements to develop designs and/or cost estimates for the project. That information could be obtained during previous field trips or should plan a follow-up field trip. In cases where the project area is very large, it may be necessary to divide the group into small work parties to collect WVA information across the project area or to allow some areas to be investigated by at least a subset of the entire group. However, an effort should be made to keep the group together to facilitate discussion about wetland conditions in the project area, the causes of habitat loss, the project features, and the effectiveness of the project features.

Project Boundary Determination

The project boundary is the area where a measurable biological impact, in regard to the WVA variables, is expected to occur with project implementation. The area must be divided into subareas based on habitat type so that the correct model can be applied. The most recent Vegetative Type Maps (Sasser et al. 2014) are typically used to delineate marsh areas from adjacent areas of forested wetlands. United States Geological Survey (USGS) Gap Analysis Project (GAP) data (USGS, 2011) is also utilized, particularly when forested wetlands are included. However, recent field investigations or other data (e.g., National Wetlands Inventory, www.fws.gov/wetlands) may be utilized to delineate habitat types within the project area. Reclassifying habitat should not be viewed as a means of reducing the number of subareas to simplify the project evaluation. Incorrect habitat classification can result in an inaccurate measure of project impacts. Reasons for habitat classification and/or reclassification should be documented.

In some instances, small areas of a particular habitat type may be combined with the more prevalent type within the project area. For example, a 100-acre area of bottomland hardwoods may be combined with an adjacent 5,000-acre tract of swamp. Determining the benefits for each individual small area could unnecessarily complicate the evaluation, be time-consuming, and may not significantly affect the overall project benefits. Any decision to combine a small area of one habitat type with a larger area of a different habitat type must be approved by the IRT.

Note: Remote sensing could also be determined through the use of aerial/satellite photographs, light imaging detection and ranging (LIDAR) information, USGS habitat and quadrangle maps and site visits. The boundary and revisions to the boundary are made by interagency group consensus. For non-restoration projects, boundaries are usually provided as areas designated for construction or clearing (typically to provide temporary or permanent rights-of-way) or areas that will experience changes in hydrology.

Selection of Target Years

In general, USACE Civil Works (CW) project WVAs are conducted for a period of 50 years which corresponds to the typical period of analysis of a CW Study (Table 2). Each project evaluation must include target years (TY) 0, 1, and 50 (or last year of the period of analysis). Target year 0 (TY0) represents baseline or existing conditions in the project area and TY50 (or last year of the period of analysis) represents the projected conditions at the end of the project life. A linear fit (over the project life) is used to make the projection unless there are expected changes that may occur in the intervening years. Examples of these changes include (but are not limited to):

1. Storm events: Storm frequencies for the Louisiana coast vary depending on the period of record analyzed but generally have been 8 to 10 years. For sites located along the shoreline, it may be necessary to select a target year which

corresponds to a storm event which is likely to occur within the project life in order to capture the effects of the storm. In forested wetlands, damaging winds from storms could cause tree mortality and reduce canopy cover by knocking trees down. Selection of a storm impact target year should be based on the storm return frequency that would result in substantial impact for the project vicinity. Climate change impacts to storm frequency and intensity varies spatially (Bender et al., 2010). It is not clear precisely how climate change will impact storm frequency and intensity, but many modelling results agree that we could expect decreased frequency and increased intensity (Walsh et al., 2015). However, an increase in frequency of tropical cyclonic storms was observed in the northern Atlantic in the recent past (1970-2005), which could, in part, have been due to a warming climate (Webster et al, 2005). Storm impact and return frequency by barrier system, should be used as justification when selecting target years (Stone et al. 1997). If the Future Without Project condition (FWOP) loss rates are based on data which include the effects of storm events then care must be taken to ensure that effects of storm events are not double counted.

2. Changes in frequency and duration of flooding: As relative sea level (RSL) rise continues, flooding frequency and duration may increase which could result in habitat loss and/or conversion. Project features could also decrease flooding frequency and duration or increase flooding duration if drainage is retarded by structures.

3. Salinity changes: Salinity may increase resulting in reduced tree growth or eventual mortality and subsequent conversion of habitat.

4. Project implementation: Additional CW (or non-CW) projects may be built which could influence the conditions in the current project area.

5. Maintenance events: These would include items such as phased vegetative plantings, replacement of hydrologic restoration structures, etc.

6. Increase or decrease in vegetative cover: These could be associated with project features (initial or phased) or environmental changes (see numbers 1 – 5).

Table 2. Summary of Target Years used for USACE Civil Works projects.

Project/Habitat Type	**Target Year**						
	0	**1**	**3**	**5**	**10, 20, 30, 40**	**50**	**>50**
Bottomland Hardwoods	Measured baseline		100% credit for marsh/dune plantings	100% credit for woody plantings	Storm Events (?)		Storm Event (?)

Use of the Community Habitat Models

Each community model contains a set of variables which is important in characterizing the habitat quality of several coastal wetland habitat types relative to the fish and wildlife communities dependent on those environments. Baseline (TY0) values are determined for each of those variables to describe existing conditions in the project area. Future values for those variables are projected to describe conditions in the area without the project and with the project. Projecting future values is the most complicated, and sometimes controversial, part of this process. It requires project sponsors to substantiate their claims with monitoring data, research findings, scientific literature, or examples of project success in other areas. Not all future projections can be substantiated by the results of monitoring or research, and, as with all wetland assessment methodologies, some projections are based on best professional judgment and can be subjective. It should be noted that future projections are not the sole responsibility of the project planner. It is the responsibility of the IRT (i.e., agency representatives, academics, and others) to use the best information available in developing those projections. Many times, the collective knowledge of the IRT is the only tool available to predict project impacts. Teams should be comprised of many individuals with diverse backgrounds and all project scenarios are discussed by the group and a final outcome is usually reached by consensus. The various workgroups are comprised of many individuals with diverse backgrounds and all project scenarios are discussed by the group and a final outcome is usually reached by consensus. Key assumptions made during the evaluation process, e.g., regarding the effects of climate change or storms, should be recorded on the Project Information Sheet (See Appendix III).

Model Application

Bottomland hardwoods are defined as an area supporting or capable of supporting a canopy of woody vegetation of which greater than 40% 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% of the woody canopy consists of any combination of baldcypress, tupelogum, red maple, buttonbush, and/or water elm, the swamp community model should be applied).

Baseline Habitat Classification and Land/Water Data

Typically, the most recent habitat data provided by USGS are used to determine the areal extent of BLH within the project area. However, other datasets, e.g., Digital Orthophoto Quadrangles (DOQs; https://lta.cr.usgs.gov/DOQs), may be more appropriate for some applications. Upland and/or non-BLH habitats (e.g., open water, developed areas, cropland) should not be included within the project area. However, small areas of swamp, fresh marsh, or other habitats may be included within the project area. The insignificance of those areas will vary with the size of the project area. Any decision to combine a small area of one habitat type with a larger area of a different habitat type must be approved by the IRT.

Once all BLH subareas have been identified, USGS habitat data, National Oceanic and Atmospheric Administration (NOAA) land classification data, and aerial/satellite photographs should be used to further locate possible different BLH cover types in the area. Parish soil surveys may also provide useful information. Site visits for data gathering should be made to each cover type, if practicable. If sufficient variation exists in variable attributes or if significantly different responses to impacts are anticipated, separate analyses of different cover types may be warranted. Otherwise, combining cover types and sampling selected patches of each cover type is acceptable (Wakeley and O'Neil, 1988). Use of systematic sampling design (i.e., stratified random) rather than random to ensure each cover type is sampled may be necessary. Samples within each cover type (i.e., stratum) should be random and strata are classified on the basis of how well they represent the cover type and the variations within that cover type. These determinations are made by consensus. Once all data has been gathered, further combining of habitat types can be done as the values of individual variables and overall HSI are determined, but such combining must be coordinated with the interagency team.

In some areas, wetland loss is the conversion of emergent habitat to open water. However, in many areas, the historic loss of BLH has not resulted in a conversion to open water but conversion to marsh or swamp. Because much of the historic loss of BLH has not resulted in a conversion to open water, USGS habitat and land/water data generally do not allow the calculation of a "loss" rate for BLH habitat. However, habitat classification data and aerial/satellite photographs could be utilized to determine a "conversion" rate of BLH to other wetland types and that rate should be utilized in the WVA. These rates can be used in land loss spreadsheets to predict future conversion rates. In those instances, areas of BLH converting to other wetland types should be removed from the project area acreage. For areas undergoing land-use conversion (i.e., development) the same methodology should be used.

Whichever scenario exists for the project area, whether it is loss of habitat or conversion, the project planner should investigate the situation carefully and provide as much supporting documentation as possible to justify assumptions. Baseline habitat acreages must be adjusted from the habitat data being used to the current year.

Sampling Technique

The location and configuration of the area to be assessed direct the manner in which data are gathered. The plot size used by wetland forest ecologists of the southeastern United States is generally about 25 m x 25 m, or 625 m^2 (Conner et al. cites herein, Shaffer et al. 2003, 2009, Keim and King 2006). This plot size can be approximated by a circle constructed with a 41-foot (12.5 m) string which serves as the circle's radius. Perimeter trees can be flagged with survey tape to mark the plot while sampling. It is important to note that ecosystem function of forest interiors often is not reflected by forest edges (Gosselink et al. 1990, Llewellyn et al. 1996, Shaffer et al. 2009). Therefore, for larger forests data must be gathered at a distance (as much as 328 feet, 100 meters) from the edge that will minimize the edge's influence on the variables. Once the habitat of interest is reached, it may be necessary to sample several representative areas within it. Representative areas are generally reached by consensus and the process is operationally random. The center of each plot should be marked and the edge can be marked with string or flagging. Use of biodegradable string in hip chains to measure plot widths can be left in place during sampling; it provides a visible cue for the plot size and allows circular plots to be divided into quarters that aid in data gathering.

For mature even-aged forests with relatively few midstory trees, a factor 10 wedge prism may be utilized to gather data; however, data gathered for a project should utilize only one method. Because using a wedge prism can decrease the amount of time at a sample site, more sample sites can be measured. Proper techniques for using a wedge prism can be found in both the following US Forest Service and Corps publications: https://erdc-library.erdc.dren.mil/xmlui/bitstream/handle/11681/7195/TR%20EL-95-24.pdf?sequence=1&isAllowed=y and http://fia.fs.fed.us/library/field-guides-methods-proc/docs/core_ver_4-0_10_2007_p2.pdf.

There may be some situations (e.g., scientific research projects) when a more robust sampling scheme is necessary. In those situations, replicates of each forested habitat type (e.g., degraded, relict, throughput; Shaffer et al. 2009) should be located at least 1,640 feet (500 m) apart, yielding a theoretical equilateral triangle measuring 13.4 acres (5.4 ha) as the minimum area appropriate for data collection. The plot size used by wetland forest ecologists of the southeastern United States is generally about 25 m x 25 m, or 625 m^2 (Conner et al. cites herein, Shaffer et al. 2003, 2009, Keim and King 2006). This plot size can be approximated by a circle constructed with a 41-foot (12.5 m) string which serves as the circle's radius. Perimeter trees can be flagged with survey tape to mark the plot while sampling.

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 (USFWS), for wood duck, barred owl, swamp rabbit, mink, downy woodpecker, and gray squirrel, 2) a community model for forest birds, published by USFWS, 3) "A Habitat Evaluation System for Water Resources Planning," published by USACE, and 4) a draft version of "A Community Habitat Evaluation Model for Bottomland Hardwood Forests in the Southeastern United States," coauthored by USACE and USFWS.

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, and 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 model presented in this document attempt to incorporate both approaches.

Subsidence and Sea Level Change

At the time of publication, current guidance for incorporating the direct and indirect physical effects of projected future sea level change across the period of analysis cycle in managing, planning, engineering, designing, constructing, operating, and maintaining USACE projects and systems of projects can be found in Engineering Regulation 1100-2-8162 (Incorporating Sea level change in civil works programs). This Regulation discusses sea level change and subsidence. Please use current regulation concerning subsidence sea level change located in the Planning Community Toolbox (https://planning.erdc.dren.mil/toolbox/guidance.cfm?Option).

Suitability Index Graph Development

Each of the WVA community models developed for USACE CW projects includes SI graphs for each variable. Suitability Index graphs are unique to each variable and define the relationship between that variable and habitat quality. Suitability Index (SI) graph development for this model was very similar to the process used for other community models such as the coastal marsh community models. A variety of resources was utilized to construct each SI graph, including the HSI models from which the final list of variables was partially derived, consultation with other professionals, published and unpublished data and studies, and personal knowledge of those involved in model development. A review of contemporary, peer-reviewed scientific literature was also conducted for each of the variables, providing ecological support for the form of the SI graph for each of the variables (Appendix I).

The Suitability Index graphs were developed according to the following assumptions:

Variable V1 – Tree Species Composition

Wildlife species 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.

The baseline (TY0) value for this variable is usually determined during field investigations of the project area following the sampling technique previously discussed. Estimation of the canopy cover of each mast type is typically accomplished utilizing the "plant cramming" technique as presented by Hays, et al. 1981. Other methods can be utilized but the same technique must be used for all sample sites for that project.

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, 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 outcompeted 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 to agriculture and historical and ongoing timber harvesting. Because the average age of canopy-dominant and canopy-codominant trees is usually unknown, average tree diameter at breast height (dbh) can be used to determine the Suitability Index for this variable.

The baseline (TY0) value for this variable is usually determined during field investigations of the project area following the sampling technique previously discussed. All trees within the plot should have their dbh measured using Biltmore sticks or diameter tapes. For proper technique using Biltmore sticks refer to Hays, et al. 1981. Use of tapes is also addressed in that publication, however, more detailed techniques that are utilized are found in the U.S. Forest Services and Corps publications (see https://erdc-library.erdc.dren.mil/xmlui/bitstream/handle/11681/7195/TR%20EL-95-24.pdf?sequence=1&isAllowed=y and http://fia.fs.fed.us/library/field-guides-methods-proc/docs/core_ver_4-0_10_2007_p2.pdf)

Future projections should be supported by monitoring data, scientific literature, examples of project success in other areas, previous WVAs, or personal knowledge of the project area. A tree growth spreadsheet for coastal Louisiana was developed by FWS and USACE biologists. This can be used to assist with tree growth projections in coastal Louisiana. Other similar tree growth spreadsheets could be used or developed for other regions. Another reference to assist with tree growth projections is the U.S. Department of Agriculture's Silvics of North America (https://www.srs.fs.usda.gov/pubs/misc/ag_654/table_of_contents.htm).

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. The "plant cramming" technique is also used in determining this variable for 1/5 acre plots. For plots measured with the wedge prism, the trees most distant from the plot center should be used to determine the edge of the plot.

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).

This variable considers the duration and amount/degree of water flow/exchange. Four flow/exchange and four flooding duration categories are described to characterize the water regime. The optimal water regime is assumed to be temporary flooding with abundant and consistent riverine input and water flow-through (SI = 1.0). Temporary flooding 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 forest floor), and increased recruitment of dominant overstory trees. In addition, consistent input and water flow-through is optimal, because under that regime the full functions and values of a BLH in providing fish and wildlife habitat are assumed to be maximized. Seasonal flooding is also assumed to be desirable. Habitat suitability is assumed to decrease as water exchange between the forest and adjacent systems is reduced. The combination of permanently flooded conditions or no water exchange (e.g., an impounded bottomland where the only water input is through rainfall and the only water loss is through evapotranspiration and ground seepage) is assumed to be equivalent to areas that may be placed under a forced drainage system; either scenario is least desirable.

Water level gauges in combination with elevation data from USGS quadrangle maps or LIDAR data can be used to determine flood duration and frequency. Aerial/satellite photographs can also be used to determine duration, frequency and areal extent if the data of the photograph can be obtained and compared to gauge data. If gauge data are not available, aerial/satellite photographs, soil conditions, vegetative indicators and high water marks can be used to estimate flooding conditions. Also, high water marks can be measured from the ground surface and compared to gauge data.

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.

Use of geographic information system (GIS) and satellite photographs is the primary method of determining the contiguous forested area. DOQs provide the best resolution for this variable; more than one year can be utilized to verify any breaks in contiguity.

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.

The most recent aerial/satellite photographs and habitat/land classification databases should be used for this variable. A 0.5 mile buffer should be delineated around the project area (use of a buffer tool in GIS simplifies this step) and within that buffer, the land cover types designated in V6 should be identified and acreage determined. Land loss rates and/or habitat conversion rates should be applied to these areas provided that the land cover type percentages will change enough to change this variable's value.

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 effects of disturbance are 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 = 0.1. Other combinations of distance to, and type of, disturbance yield moderate SI's of 0.26, 0.41, 0.5, and 0.65.

Use of GIS and satellite photographs is the primary method of determining the type of possible disturbance such as highways, industrial areas, waterways, agriculture, homes, etc. Because this variable does not need as fine a resolution as V5, the use of aerial/satellite photographs other than DOQs may be sufficient.

Habitat Suitability Index Formulas

Within the 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. 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. The model attempts to incorporate site-specific habitat quality features (tree species composition, forest stand structure, stand maturity, and hydrology) and landscape variables (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 (V_1, V_2, V_3, and V_4) are considered more important and have been given more weight than the landscape variables.

The site specific variables V_1 (Tree Species Composition) and V_2 (Standard Maturity) are considered to be of greatest importance; they are weighted to the power of four. Variables V_3 (Understory/Midstory) and V_4 (Hydrology) are weighted to the power of two. The "landscape" variables (V_5, V_6, and V_7) are not weighted. In some cases, data for Variable V_3 (Understory/Midstory) may not be readily available; in those instances that variable can be deleted from the HSI formula as indicated below.

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 bottomland hardwoods are:

1. If Age < 7 (or dbh < 5 in), then:
$HSI = (SI_{v2}^4 \times SI_{v4}^2 \times SI_{v6} \times SI_{v7})^{1/8}$, or

2. If Age > 7 (or dbh > 5 in) and V3 (Understory/Midstory) data is available, then:
$HSI = (SI_{v1}^4 \times SI_{v2}^4 \times SI_{v3}^2 \times SI_{v4}^2 \times SI_{v5} \times SI_{v6} \times SI_{v7})^{1/15}$, or

For project areas where surrounding land use (V_6) will not change over the project life or the site is (or will) not be adversely impacted by changing land uses or where disturbances associated with human activities (V_7) are determined to be insignificant to the value of the habitat the following formulas may be used:

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

$$HSI = (SI_{v2}^4 \times SI_{v4}^2)^{1/6}, \text{ or}$$

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

$$HSI = (SI_{v1}^4 \times SI_{v2}^4 \times SI_{v3}^2 \times SI_{v4}^2 \times SI_{v5})^{1/13}$$

BOTTOMLAND HARDWOODS

Variable V_1 Tree Species Association (see following section 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, American elm, cedar elm

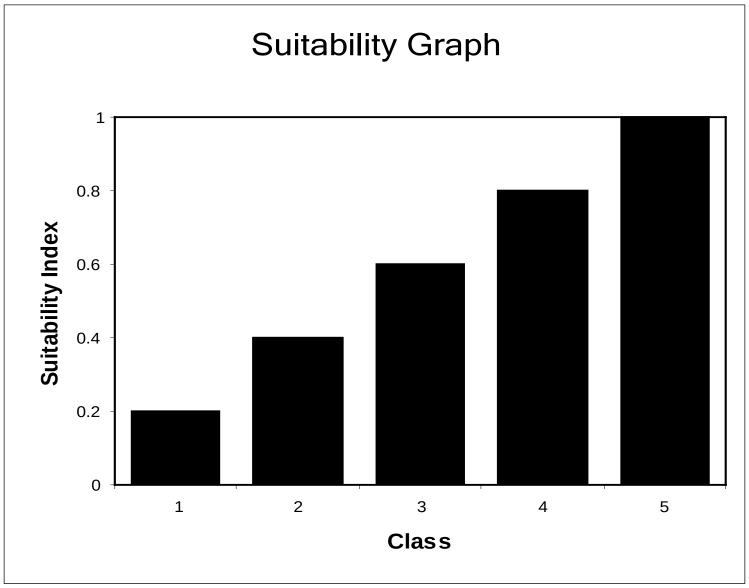
Class 1: Less than 25% of overstory canopy consists of mast or other edible-seed producing trees or more than 50% of soft mast present but no hard mast.

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 V_2 Stand Maturity

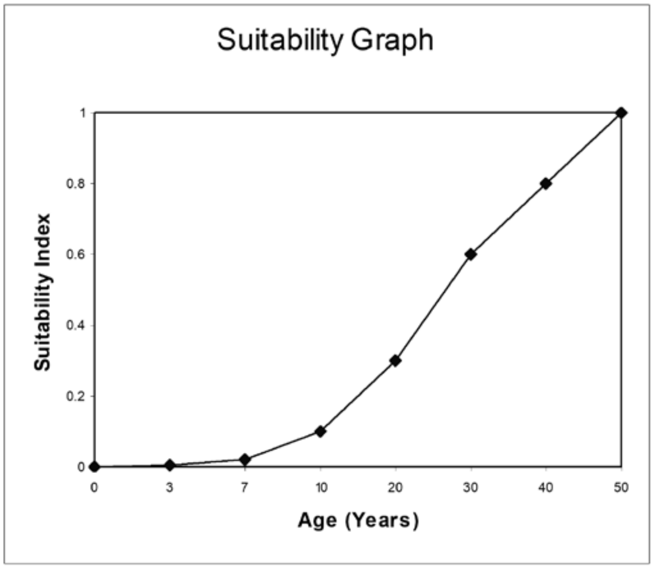
[i.e., average age of canopy-dominant and canopy-codominant trees].

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.

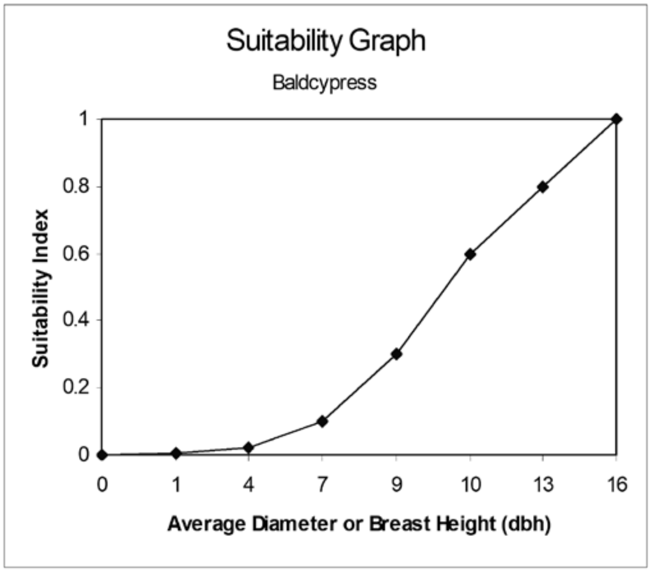
Line Formulas, when age is known:

If age = 0 then SI = 0
If 0 < age $\leq$ 3 then SI = .0033 * age
If 3 < age $\leq$ 7 then SI = (.01 * age) - .02
If 7 < age $\leq$ 10 then SI = (.017 * age) - .07
If 10 < age $\leq$ 20 then SI = (.02 * age) - .1
If 20 < age $\leq$ 30 then SI = (.03 * age) - .3
If 30 < age $\leq$ 50 then SI = .02 * age
If age 50 > then SI = 1.0



Line Formulas for bottomland hardwoods, when age is unknown:

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

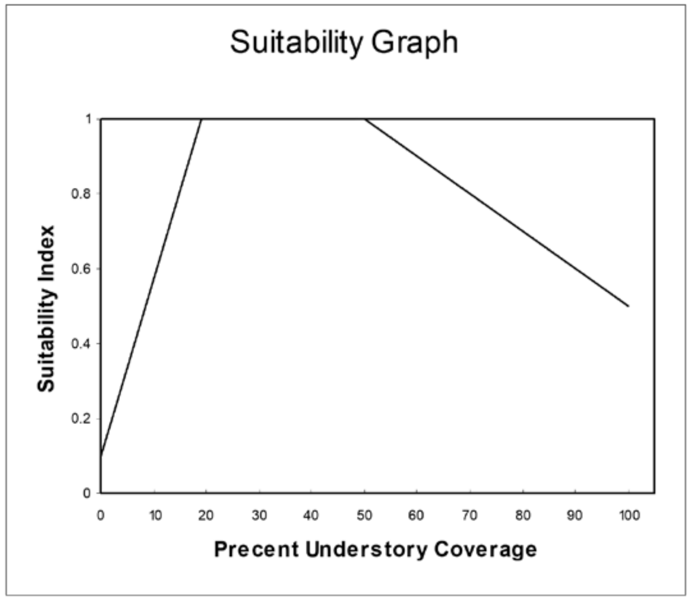


BOTTOMLAND HARDWOODS

Variable V_3 Understory / Midstory

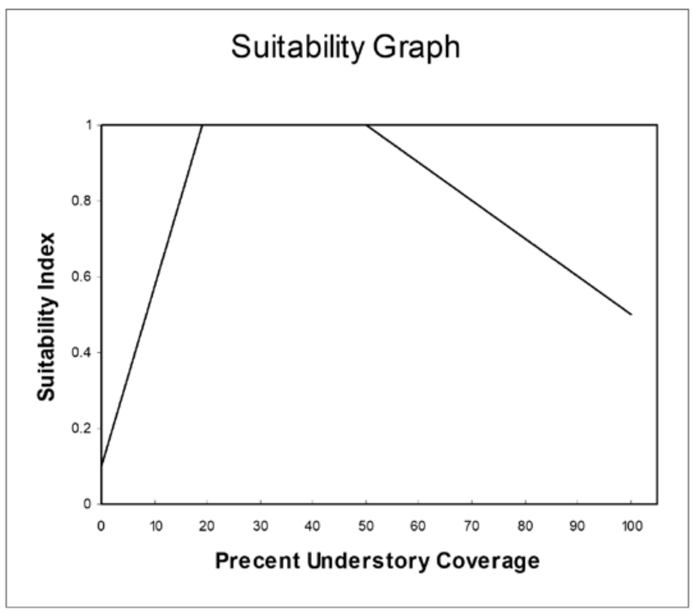
Line Formulas for Understory Coverage:

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



Line Formulas for Midstory Coverage:

If midstory % = 0 then SI = 0.1
If 0 < mid % ≤ 20 then SI = 0.45 * 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 V_4 Hydrology

		Flow/Exchange			
		High	Moderate	Low	None
Flooding Duration	Temporary	1.00	0.85	0.70	0.50
	Seasonal	0.85	0.75	0.65	0.40
	Semi-Permanent	0.75	0.65	0.45	0.25
	Permanent/Dewatered	0.65	0.45	0.30	0.10

Flooding Duration

1. Permanently Flooded/Dewatered: Water covers the substrate throughout the year in all years or no longer covers the substrate except in major flood events.
2. Semipermanently Flooded: Surface water is present throughout the growing season and may extend beyond 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 below the surface for most of the season.

Flow/Exchange

1. High: Receives abundant and consistent riverine input and through-flow.
2. Moderate: Moderate water exchange, through riverine and/or tidal input.
3. Low: Limited water exchange through riverine and/or tidal input, or just rainfall on an area that is not efficiently drained. This can include pumps that are maintaining some exchange or through flow.
4. None: No water exchange (stagnant, impounded), or no natural water exchange (i.e., forced drainage or pumping as only drainage mechanism). This would include forced drainage and/or pumping without any through flow.

Variable V_5 Size of Contiguous Forested Area.

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

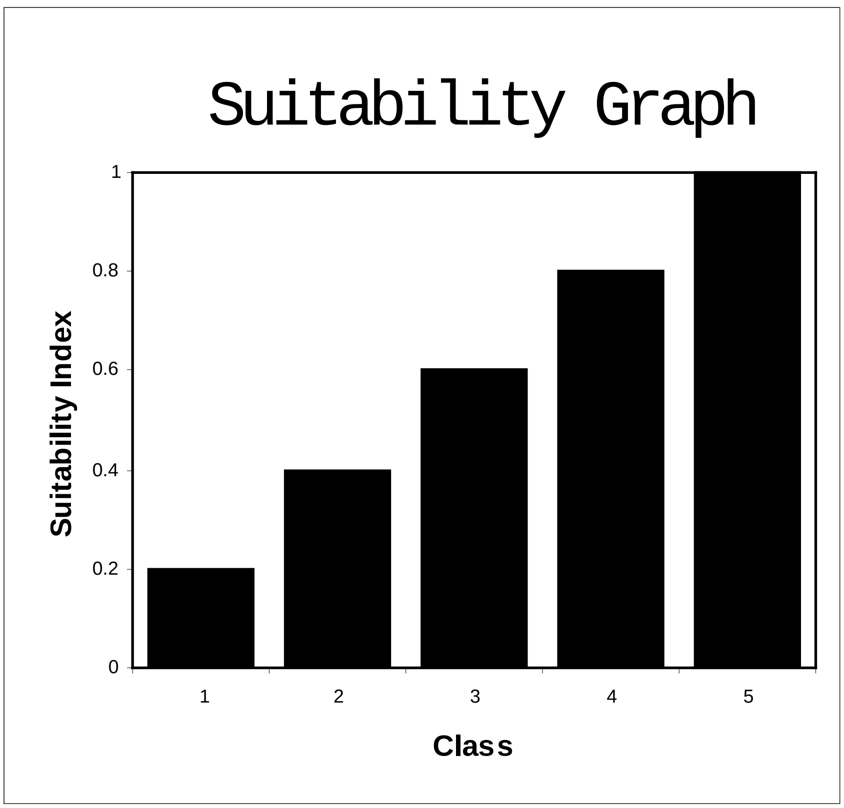
Class 1. 0 to 5 acres

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 V_6 – 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.

Land Use	**Weighting Factor**		**% of 0.5 mile 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, open water	0.2	X		=	
Nonhabitat: linear, residential, commercial, industrial development, etc.	0.01	X		=	
					___ /100 = SI

BOTTOMLAND HARDWOODS

Variable V_7 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.

Distance Classes	**Type Classes**
Class 1. 0 to 50 ft.	**Class 1.** Constant/Major. (Major highways, industrial, commercial, major navigation.)
Class 2. 50.1 to 500 ft.	**Class 2.** Frequent/Moderate. (Residential development, moderately used roads, waterways commonly used by small to mid-sized boats).
Class 3. > 500 ft.	**Class 3.** Seasonal/Intermittent. (Agriculture, aquaculture.)
	Class 4. Insignificant. (Lightly Used roads and waterways, individual homes, levees, rights of way).

Suitability Indices for Distance/Type Class

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

Common Names/Scientific Names

Common Names	Scientific Names
American elm	*Ulmus americana*
American sycamore	*Plantanus 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.*
Water elm	*Planera aquatica*
Red maple	*Acer rubrum*
Red mulberry	*Morus rubra*
Sugarberry	*Celtis laevigata*
Sweet pecan	*Carya illinoensis*
Sweetgum	*Liquidambar styraciflua*
Tupelogum	*Nyssa aquatica*

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Appendix I
Description of Model WVA Variables from Scientific Literature

A description of the relative role of the model variables in providing habitat to the modeled community based on available, contemporary peer-reviewed scientific literature is provided below.

Variable V1 – Tree Species Composition

Unlike Louisiana coastal swamps, bottomlands contain species (mostly oaks and hickories) that produce substantial quantities of hard mast. Unlike most soft mast, hard mast is available to wildlife during the winter and the seeds are large and contain abundant amounts of highly nutritious endosperm (Allen 1997, King and Keeland 1999). In general, it is assumed that light-seeded species will establish naturally through wind or water dispersal (Allen and Kennedy 1989, Allen 1990). Clear relationships exist between the quantity and quality of hard and soft mast and the fauna that rely on these resources (Gosselink et al. 1990a, Chambers et al. 2005).

The diverse vegetation composition, vertical and horizontal heterogeneity, and seasonal pulses of resources create many different niches and foods for animals (Fredrickson 1979, Junk et al. 1989, Harris and Gosselink 1990). Bottomland trees produce large crops of hard and soft mast (acorns, drupes, and samaras) with production being highly seasonal and can vary among years in relation to climate, flooding, and nutrient availability (Heitmeyer et al. 2005). The distribution and abundance of forest vegetation within bottomland hardwood forests also influence the distribution and abundance of organisms. Fredrickson (1979) and Wharton et al. (1982) have described the distribution of various organisms in relationship to forest zones in bottomland sites. Shrub-scrub habitats, for example, provide seeds, browse, and insects for feeding wildlife as well as dense cover for nesting, roosting sites, and thermal refugia (Fredrickson and Heitmeyer 1988). Overcup and pin oak forests are important for wintering waterfowl because of acorns and invertebrates (Heitmeyer 1985). Red oaks (pin, Nuttall, cherrybark, and willow) are of special interest because they produce acorns suitable for consumption by waterfowl and other wildlife (Barras et al. 1996) and also provide important invertebrate foods (Bateman 1987, Wehrle et al. 1995).

Variable V2 – Stand Maturity

The healthiest bottomland hardwood forests in coastal Louisiana are those characterized by high basal area and large trees (Conner and Day 1976, Nessel 1982; 1984 Conner et al. 1981, Muzika et al. 1987, Megonigal et al. 1997, Shaffer et al. 2009). Certain species of special interest, such as the Louisiana black bear and the Rafinesque big-eared bat frequently use hollows of large trees for nesting (Taylor 1971, Weaver et al. 1990, Cochran 1999, Hoffman 1999, Hightower et al. 2002, Gooding and Langford 2004). Large hollow hardwoods characteristic of older bottomlands appear particularly important to the Rafinesque big-eared bat (Cochran 1999, Lance et al. 2001, Gooding and Langford 2004).

Variable V3 – Understory/Midstory

In general, healthy bottomland hardwood forests in coastal Louisiana are dominated by overstory canopy consisting of oaks (*Quercus sp.*) and other hardwoods. Dominant midstory species include red maple (*Acer rubrum*), ash (*Fraxinus sp*.), and many other species. Herbaceous ground cover is highly variable and can be nearly absent in a mature BLH because of light limitation, or seasonal during periods of overstory dormancy. As bottomland hardwood forests degrade, generally due to altered hydrologic conditions, localized droughts, or major storms (Chambers et al. 2005) the canopy begins to open and groundcover often increases. This can lead directly to the formation of an immature swamp habitat creating a mixed community of more flood tolerant BLH species, herbaceous cover and emergent swamp species. Therefore, it is the combination of overstory, midstory, and ground cover that best indicate BLH stand structure. These stand structure components are sensitive to Future With Project condition (FWP) vs. FWOP conditions.

From a community perspective, a bottomland containing overstory and midstory trees, as well as herbaceous ground cover, in roughly even amounts, offers the highest degree of food and shelter for a diverse assemblage of wildlife (Brokaw and Lent 1999, Haila 1999, Bodie and Semlitsch 2000, Chambers et al. 2005). Healthy mature BLH will likely have low cover of herbaceous vegetation, due to light limitation (Chambers et al. 2005). Conversely, as bottomlands degrade, generally due to altered hydrologic conditions, the canopy begins to open allowing midstory, shrub-scrub and groundcover vegetation to increase (Allen 1958; Allen 1962, Conner et al. 1981, White 1983, Barras et al. 1994, Allen et al. 1996, Aust et al. 1998, Thomson et al. 2002, Conner and Inabinette 2003, Shaffer et al. 2009).

Variable V4 – Hydrology

Floodplain hydrology controls vegetation composition and productivity in bottomland hardwood forests. Flooding results in seasonal pulses of nutrient flow and food resources, and it is these pulses that have been a key factor influencing organismal adaptations and strategies for colonizing and exploiting bottomland resources (Heitmeyer et al. 2005). Even modest changes in the timing of flood events can be devastating to birds and mammals. Extended spring flooding can destroy annual production of most ground-nesting species or plant food supplies for herbivores. Delayed flooding in late fall or early winter can delay and decrease invertebrate populations that are critical for important functions of many species: prebasic molt of mallards, egg-laying in night herons and hooded mergansers, embryo development in raccoons, and storage of nutrient reserves by hibernating black bear (Heitmeyer et al. 2005). Waters flood bottomland hardwood forests from a variety of sources including rainfall, head- and backwater flooding from rivers and streams, and groundwater flows (Heitmeyer et al. 2005). The seasonal and long-term dynamics of this surface flooding help determine the structure, function, and value of the system. Almost all bottomland hardwood forests are flooded for some portion of the year with the timing, extent, depth, duration, and source of floodwaters varying among locations. The relative flooding patterns are what determine habitat types in bottomland hardwood forests. Heitmeyer et al. (1989) have broken these forests into sites of low elevation (dominated by overcup oak), intermediate elevation (significant amounts of Nuttall, willow, or pin oaks, sweetgum, and green ash), high elevation (cherrybark oak, water oak, sugarberry, and hickory), or scrub/shrub-cypress/tupelo elevation.

Because of their location and connection to rivers, bottomland hardwood forests introduce organic material as well as nutrients of terrestrial origin into aquatic dimensions of the ecosystem (Junk et al. 1989, Sparks 1995). Once river waters overtop the main channel banks, invertebrates and fishes colonize inundated areas to take advantage of resources (Jackson 2005). This aquatic/terrestrial interface is particularly important because this ephemeral environment promotes faunal interactions biotically as well as abiotically, and rapid nutrient exchanges (Goulding 1980, Bayley 1989). Fishes exploit the spatially complex floodplain for spawning and nursery habitat as well as for refuge and feeding (Risotto and Turner 1985, Bayley 1989, Ward and Stanford 1989). Because flooded bottomland areas are shallower than the main river channel, water in flooded backwater locations tends to be warmer earlier in the year which promotes biological activity of invertebrates and fishes in these systems (Rutherford et al. 1995). The presence of aquatic invertebrates encourages spawning of fishes, and the earlier the spawning occurs, the longer the fish can remain on the floodplain, leading to higher recruitment potentials for the river's fish stocks (Ye 1996).

Variable V5 - Size of Contiguous Forest

Whereas single blocks of BLH used to cover hundreds of thousands of hectares in the Mississippi Alluvial Plain, there now remain only isolated fragments, most less than 250 acres (100 ha) in size and most of these are surrounded by agricultural fields (Gosselink et al. 1990b). Certain species of neotropical migratory birds require a minimum of 6,900 acres (2,800 ha) of forest interior to sustain viable populations (Robbins et al. 1989, Twedt and Loesch 1999). In their plan to restore large tracks of BLH, The Nature Conservancy focuses on three migratory-bird guilds, namely Bachman's warbler which requires 9,880 acres (4,000 ha) of forest interior for successful breeding habitat, the Cerulean warbler requiring 19,770 acres (8,000 ha) of forest interior, and the swallowtail kite requiring 98,840 acres (40,000 ha) of interior forest (Shaffer et al. 2005, Weitzell et al. 2003). Gosselink and Lee (1989) estimate that 494,200 acres (200,000 ha) of forested habitat is required to sustain a viable population of the Louisiana black bear. In general, ecosystem function of forest interiors often is not reflected by forest edges (Gosselink et al. 1990a,b, Llewellyn et al. 1996, Saunders et al. 1991, Shaffer et al. 1992, 2009). To date, the bottomland hardwood forest of coastal Louisiana have been reduced by over 80% (Llewellyn et al. 1996, Shaffer et al. 2005, Weitzell et al. 2003), rendering large patches of contiguous BLH extremely valuable for floral and faunal species diversity (Gosselink et al. 1990). The decrease in BLH area has been correlated with a decrease in the species richness of migratory birds (Burdick et al. 1989). Furthermore, there exists a significant relationship between decreases in BLH area and decreases in forest bird abundance and densities (Burdick et al. 1989).

Variable V6 - Suitability and Traversability of Surrounding Habitat

The quality of a bottomland hardwood forest patch is clearly associated with the type of habitat that surrounds it (Gosselink and Lee 1989, Rudis 1995). Certain species of birds and mammals will not traverse other types of habitats, especially those developed by humans, to move from one patch of BLH to another (Gosselink and Lee 1989, Gosselink et al. 1990b). Clearly habitat types such as abandoned agricultural fields or pastures are of higher habitat value than cultivated fields, residential areas, or busy streets.

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. Clearly, the effect of a disturbance is a function of the type of disturbance and the distance of the disturbance to the habitat in question (Rudis 1995). Many species of birds and mammals are highly sensitive to disturbance (Twedt et al. 1999, Wigley and Roberts 1997). As described above, animals have different habitat requirements from 6,900 acres (2,800 ha) for certain neotropical migrants to 494,200 acres (200,000) ha for the Louisiana black bear. In general, ecosystem function of forest interiors often is not reflected by forest edges prone to disturbance (Gosselink et al. 1990a, b, Llewellyn et al. 1996, Shaffer et al. 1992, 2009a). Furthermore, as patch size increases, the effects of outside disturbances have been shown to decrease (Rudis 1993, 1995).

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Appendix II
Document Revisions

Version 1.0 – April 2010 document developed via the Corps' WVA certification process

Version 1.1 – April 2012

1) Pertinent sections from the Procedural Manual incorporated

Version 1.2 – November 2018

1) Manual updated, including additional language for V4.

Appendix III

Project Information Sheet Format

Project Name:

Sponsoring Agency: List Environmental and Engineering Work Group Contacts

Project Location and Description: Describe project location (Coast 2050 region, basin, parish, nearby cities, important bodies of water, total acres, wetland type, etc.). Include a project map.

Problem: Discuss the major causes (historical and current) of habitat loss/degradation in the project area.

Objectives: How will the project address the major causes of habitat loss/degradation in the project area? What are the specific objectives of the project?

Project Features: List all project features including their locations, dimensions, etc. The project map should include the locations of all project features.

Monitoring and Modeling Results for Similar Projects: Relevant monitoring reports and modeling studies should be discussed.

Miscellaneous: As necessary, discuss the following subjects as they relate to the project.
Climate change
Off site disturbances – these are generally the same FWOP and FWP.
Any project risks or uncertainties

V1 – Tree Species Association

1) Discuss the historical and current vegetative community and any trends noted for the area.

2) Discuss the methods used to determine the percentage of hard mast, soft mast, and non-mast producing species in the overstory.

TY 0 – Existing class of Tree Species Association (percentages of hard mast, soft mast, and non-mast producing species).

FWOP – Provide percentages and class value for each target year (TY) and include all assumptions. Use as many TYs as necessary and justify each.
TY 1 –
TY X –
TY Y –

TY 50 –

FWP – Provide percentages and class value for each target year (TY) and include all assumptions. Use as many TYs as necessary and justify each.
TY 1 –
TY X –
TY Y –
TY 50 –

V2 – Stand Maturity

1) Discuss the methods used to collect dbh values or determine the age of canopy-dominant and canopy-codominant trees for the baseline condition.

TY 0 – Average dbh or age for canopy-dominant and canopy-codominant trees.

FWOP – Provide average dbh or age for canopy-dominant and canopy-codominant trees for each target year (TY) and include all assumptions. Use as many TYs as necessary and justify each.
TY 1 –
TY X –
TY Y –
TY 50 –

FWP – Provide average dbh or age for canopy-dominant and canopy-codominant trees for each target year (TY) and include all assumptions. Use as many TYs as necessary and justify each.
TY 1 –
TY X –
TY Y –
TY 50 –

V3 – Understory / Midstory Coverage

1) Discuss the methods used to determine the understory and midstory cover values for the baseline condition.

TY 0 – Understory and midstory cover values.

FWOP – Provide cover values for each target year (TY) and include all assumptions. Use as many TYs as necessary and justify each.
TY 1 –
TY X –
TY Y –
TY 50 –

FWP – Provide cover values for each target year (TY) and include all assumptions. Use as many TYs as necessary and justify each.
TY 1 –
TY X –
TY Y –
TY 50 –

V4 – Hydrology

1) Discuss the methods used to determine the flooding duration and degree of flow/exchange for the baseline condition.

TY 0 – Flooding duration and degree of water flow/exchange.

FWOP – Determine flooding duration and degree of exchange for each target year (TY) and include all assumptions. Use as many TYs as necessary and justify each.
TY 1 –
TY X –
TY Y –
TY 50 –

FWP – Determine flooding duration and degree of exchange for each target year (TY) and include all assumptions. Use as many TYs as necessary and justify each.
TY 1 –
TY X –
TY Y –
TY 50 –

V5 – Size of Contiguous Forested Area

1) Discuss the methods used to determine the size of the contiguous forested area for the baseline condition.

TY 0 – Class value for the size of the contiguous forested area.

FWOP – Determine the class value for each target year (TY) and include all assumptions. Use as many TYs as necessary and justify each.
TY 1 –
TY X –
TY Y –
TY 50 –

FWP – Determine the class value for each target year (TY) and include all assumptions. Use as many TYs as necessary and justify each.
TY 1 –

TY X –
TY Y –
TY 50 –

V6 – Suitability and Traversability of Surrounding Land Uses

1) Discuss the methods used to determine the surrounding land uses for the baseline condition.

TY 0 – Percentage values for each surrounding land use.

FWOP – Determine the percentage values for each surrounding land use for each target year (TY) and include all assumptions. Use as many TYs as necessary and justify each.
TY 1 –
TY X –
TY Y –
TY 50 –

FWP – Determine the percentage values for each surrounding land use for each target year (TY) and include all assumptions. Use as many TYs as necessary and justify each.
TY 1 –
TY X –
TY Y –
TY 50 –

V7 – Disturbance

1) Discuss the methods used to determine the distance class and the type class for disturbances surrounding the project area for the baseline condition.

TY 0 – Distance class and type class for disturbances around the project area.

FWOP – Determine the distance class and type class for disturbances surrounding the project area for each target year (TY) and include all assumptions. Use as many TYs as necessary and justify each.
TY 1 –
TY X –
TY Y –
TY 50 –

FWP – Determine the distance class and type class for disturbances surrounding the project area for each target year (TY) and include all assumptions. Use as many TYs as necessary and justify each.
TY 1 –

TY X –
TY Y –
TY 50 –

Literature Cited

Other Supporting Information

WETLAND VALUE ASSESSMENT COMMUNITY MODEL
Bottomland Hardwoods 1.2

Project: Acres:

Condition: Future Without Project

Variable		TY	0	TY		TY	
		Class/Value	SI	Class/Value	SI	Class/Value	SI
V1	Tree Species Composition	Class		Class		Class	
V2	Maturity (input age or dbh, not both)	Age		Age		Age	
		dbh		dbh		dbh	
V3	Understory / Midstory	Understory %		Understory %		Understory %	
		Midstory %		Midstory %		Midstory %	
V4	Hydrology	Flow/Exchange		Flow/Exchange		Flow/Exchange	
		Flooding Duration		Flooding Duration		Flooding Duration	
V5	Forest Size	Class		Class		Class	
V6	Surrounding Land Use	Values %		Values %		Values %	
	Forest / marsh						
	Abandoned Ag						
	Pasture / Hay						
	Active Ag						
	Development						
V7	Disturbance Type	Class		Class		Class	
	Distance	Class		Class		Class	
		HSI =		HSI =		HSI =	

Project: Acres:

FWOP

Variable		TY		TY		TY	
		Class/Value	SI	Class/Value	SI	Class/Value	SI
V1	Tree Species Composition	Class		Class		Class	
V2	Maturity (input age or dbh, not both)	Age		Age		Age	
		dbh		dbh		dbh	
V3	Understory / Midstory	Understory %		Understory %		Understory %	
		Midstory %		Midstory %		Midstory %	
V4	Hydrology	Flow/Exchange		Flow/Exchange		Flow/Exchange	
		Flooding Duration		Flooding Duration		Flooding Duration	
V5	Forest Size	Class		Class		Class	
V6	Surrounding Land Use	Values %		Values %		Values %	
	Forest / marsh						
	Abandoned Ag						
	Pasture / Hay						
	Active Ag						
	Development						
V7	Disturbance Type	Class		Class		Class	

	Distance	Class		Class		Class	
		HSI =		HSI =		HSI =	

Project: Acres:

FWOP

Variable		TY		TY		TY	
		Class/Value	SI	Class/Value	SI	Class/Value	SI
V1	Tree Species Composition	Class		Class		Class	
V2	Maturity (input age or dbh, not both)	Age		Age		Age	
		dbh		dbh		dbh	
V3	Understory / Midstory	Understory %		Understory %		Understory %	
		Midstory %		Midstory %		Midstory %	
V4	Hydrology	Flow/Exchange		Flow/Exchange		Flow/Exchange	
		Flooding Duration		Flooding Duration		Flooding Duration	
V5	Forest Size	Class		Class		Class	
V6	Surrounding Land Use	Values %		Values %		Values %	
	Forest / marsh Abandoned Ag Pasture / Hay Active Ag Development						
V7	Disturbance Type	Class		Class		Class	
	Distance	Class		Class		Class	
		HSI =		HSI =		HSI =	

WETLAND VALUE ASSESSMENT COMMU

Bottomland Hardwoods 1.2

Project: Acres:

Condition: Future With Project

Variable		TY	0	TY		TY	
		Class/Value	SI	Class/Value	SI	Class/Value	SI
V1	Tree Species Composition	Class		Class		Class	
V2	Maturity (input age or dbh, not both)	Age		Age		Age	
		dbh		dbh		dbh	
V3	Understory / Midstory	Understory %		Understory %		Understory %	
		Midstory %		Midstory %		Midstory %	
V4	Hydrology	Flow/Exchange		Flow/Exchange		Flow/Exchange	
		Flooding Duration		Flooding Duration		Flooding Duration	
V5	Forest Size	Class		Class		Class	
V6	Surrounding Land Use	Values %		Values %		Values %	
	Forest / marsh Abandoned Ag Pasture / Hay						

	Active Ag Development						
V7	Disturbance Type	Class		Class		Class	
	Distance	Class		Class		Class	
		HSI =		HSI =		HSI =	

Project: Acres:

FWP

Variable		TY		TY		TY	
		Class/Value	SI	Class/Value	SI	Class/Value	SI
V1	Tree Species Composition	Class		Class		Class	
V2	Maturity (input age or dbh, not both)	Age		Age		Age	
		dbh		dbh		dbh	
V3	Understory / Midstory	Understory %		Understory %		Understory %	
		Midstory %		Midstory %		Midstory %	
V4	Hydrology	Flow/Exchange		Flow/Exchange		Flow/Exchange	
		Flooding Duration		Flooding Duration		Flooding Duration	
V5	Forest Size	Class		Class		Class	
V6	Surrounding Land Use	Values %		Values %		Values %	
	Forest / marsh Abandoned Ag Pasture / Hay Active Ag Development						
V7	Disturbance Type	Class		Class		Class	
	Distance	Class		Class		Class	
		HSI =		HSI =		HSI =	

Project: Acres:

FWP

Variable		TY		TY		TY	
		Class/Value	SI	Class/Value	SI	Class/Value	SI
V1	Tree Species Composition	Class		Class		Class	
V2	Maturity (input age or dbh, not both)	Age		Age		Age	
		dbh		dbh		dbh	
V3	Understory / Midstory	Understory %		Understory %		Understory %	
		Midstory %		Midstory %		Midstory %	
V4	Hydrology	Flow/Exchange		Flow/Exchange		Flow/Exchange	
		Flooding Duration		Flooding Duration		Flooding Duration	
V5	Forest Size	Class		Class		Class	
V6	Surrounding Land Use	Values %		Values %		Values %	
	Forest / marsh Abandoned Ag Pasture / Hay Active Ag Development						

V7	Disturbance Type	Class		Class		Class	
	Distance	Class		Class		Class	
		HSI =		HSI =		HSI =	

AAHU CALCULATION

Project:

Future Without Project			Total	Cummulative
TY	**Acres**	**x HSI**	**HUs**	**HUs**
0			0.00	
Max TY=	0		Total AAHUs =	
			AAHUs =	

Future With Project			Total	Cummulative
TY	**Acres**	**x HSI**	**HUs**	**HUs**
0			0.00	
Max TY=	0		Total	

E-2.
U.S. Army Corps of Engineers
Planning Models Improvement Program

Wetland Value Assessment Swamp Community Model for Civil Works (Version 2.0)

Revised from the Swamp Community Model developed by the Environmental Working Group of the Coastal Wetlands Planning, Protection and Restoration Act

November 2018

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US Army Corps of Engineers®
New Orleans District

WETLAND VALUE ASSESSMENT METHODOLOGY
Swamp Community Model

Introduction

This document describes revisions to the Wetland Value Assessment (WVA) Swamp Community Model for recertification as a planning tool under the Planning Models Improvement Plan (PMIP) (EC 1105-2-412) and for the specific use on US Army Corps of Engineers (USACE) civil works (CW) projects.

The Wetland Value Assessment (WVA) methodology is a quantitative habitat-based assessment methodology developed for use in determining wetland benefits of project proposals submitted for funding under the Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA). The WVA was developed by the CWPPRA Environmental Work Group (EnvWG) after the passage of CWPPRA in 1990. The EnvWG includes members from U.S. Fish and Wildlife Service, Louisiana Coastal Protection and Restoration Authority, Natural Resources Conservation Service, National Oceanic and Atmospheric Administration, Environmental Protection Agency, and USACE. Various other subject matter experts, such as professors and scientists, also helped develop the original WVAs. The WVA quantifies changes in fish and wildlife habitat quality and quantity that are expected to result from a proposed wetland restoration project. The WVA operates under the assumption that optimal conditions for fish and wildlife habitat within a given coastal wetland habitat 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 community models developed specifically for each habitat type. The results of the WVA, measured in Average Annual Habitat Units (AAHUs), can be combined with cost data to provide a measure of the effectiveness of a restoration project in terms of annualized cost per AAHU gained. In addition, the WVA methodology could provide an estimate of the number of acres AAHUs negatively impacted by a CW project.

The WVA community models have been designed to function at a community level and therefore attempt to define an optimum combination of habitat conditions for all fish and wildlife species utilizing a given habitat type. Each model consists of 1) a list of variables that are considered important in characterizing fish and wildlife habitat, 2) a Suitability Index (SI) 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 the Suitability Index for each variable into a single value for habitat quality; that single value is referred to as the Habitat Suitability Index, or HSI. 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.

USACE approved the CWPPRA WVA Swamp Community Model in 2011 that was initially developed by the Louisiana Department of Natural Resources (LDNR) and later revised by CWPPRA. The LDNR model was developed to quantify the impacts of permitted activities and compensatory mitigation proposals in the Louisiana coastal zone and contained a more complete list of variables to characterize habitat quality of swamp in the coastal zone. Because that model was developed for regulatory purposes, it contained some variables which were not being impacted by candidate CWPPRA restoration projects. Therefore, in 2001, the CWPPRA Environmental Work Group (EnvWG) decided to modify that model by removing landscape variables (i.e. size of contiguous forested areas, surrounding land uses, and disturbance) and updated other variables to better reflect the impacts of proposed restoration projects. The 2001 CWPPRA model was approved for use for CW projects as the WVA Swamp Community Model for Civil Works (Version 1.0) in November 2011. The WVA Swamp Community Model for Civil Works (Version 2.0) is a revised version that adds the three landscape variables included in the original LDNR model to the model approved for use in November 2011.

The WVA Swamp Community Model was developed to determine the suitability of swamp habitat in providing resting, foraging, and nesting habitat for a diverse assemblage of wildlife species. The model is generally applied to areas supporting or capable of supporting a canopy of woody vegetation which covers at least 33% of the area's surface, and with at least 60% of that canopy consisting of any combination of baldcypress (*Taxodium distichum*), tupelo gum (*Nyssa sylvatica*), red maple (*Acer rubrum*), buttonbush (*Cephalanthus occidentalis*), and/or water elm (*Planera aquatic*). The Interagency Review Team (IRT) has agreed that 33% canopy cover criterion should be treated as a general “rule of thumb” for model application, with some exceptions (to be documented in the Project Information Sheet). Areas with canopy cover less than 33% are then considered using the fresh marsh model. If greater than 40% of the woody vegetation canopy consists of species such as oaks (*Quercus* spp.), hickories (*Carya* spp.), American elm (*Ulmus americana*), green ash (*Fraxinus pennsylvanica*), American sweetgum (*Liquidambar styraciflua*), sugarberry (*Celtis laevigata*), boxelder (*Acer negundo*), persimmon (*Diospyros virginiana*), honey locust (*Gleditsia tracanthos*), red mulberry (*Morus rubra*), eastern cottonwood (*Populus deltoids*), American sycamore (*Platanus occidentalis*), etc., then a bottomland hardwood model should be applied.

USACE Planning Models Improvement Program (PMIP)

The PMIP was established in 2003 to assess the state of USACE planning models and to assure that high quality methods and tools are available to provide informed decisions on investments in the Nation’s water resources infrastructure and natural environment. The main objective of the PMIP is to carry out “a process to review, improve and validate analytical tools and models for USACE CW business programs” (USACE EC 1105-2-407, May 2005). In accordance with the Planning Models Improvement Program: Model Certification (EC 1105-2-407, May 2005), certification is required for all planning models developed and/or used by USACE.

On June 13, 2018, USACE, Mississippi Valley Division, New Orleans District (CEMVN) initiated coordination requesting feedback from WVA experts from the US Fish and Wildlife Service (David Walther, Cathy Breaux, and Kevin Roy), the National Marine

Fisheries Service (Patrick Williams and later Dawn Davis on August 7, 2018), US Geological Survey (Michelle Fischer), the US Environmental Protection Agency (Raul Gutierrez), and Louisiana Department of Wildlife and Fisheries (Dave Butler and Kyle Balkum). The Natural Resource Conservation Service (Ron Boustany) was later included in the WVA reapproval coordination on August 20, 2018. On September 25, CEMVN also reached out to Daniel Allen from Fort Worth District (CESWF). In addition, Sharon McCarthy from Louisiana Department of Natural Resources, Office of Coastal Management provided LDNR WVA models for addressing mitigation potentials on September 28, 2018.

Geographic Scope

The maximum area that the swamp model should be applied to is the coastal forested wetlands of the southeastern United States. These wetlands have similar community structure and function (Gosselink et al. 1990, Mitsch and Gosselink 2007, Mitsch et al. 2009). Coastal swamps from South Carolina to east Texas share a similar climate and respond both positively and negatively to the same environmental conditions.

The WVA models examined herein were designed to capture habitat suitability of the flora and associated fauna that inhabit swamps of coastal Louisiana. While these community assemblages are similar across the above mentioned geographical area, they vary widely in special case species such as Rafinesque's big-eared bat (*Corynorhinus rafinesquii rafinesquii*), bald eagle (*Haliaeetus leucocephalus*), Louisiana black bear (*Ursus americanus lutelous*), and a variety of Neotropical migratory songbirds.

Geographic Range of Applicability

Figure 1 indicates the geographical range of applicability for the Wetland Value Assessment Swamp Community Model. This model was developed for swamp habitats of coastal Louisiana, which share common functions, values, and habitats with the rest of the southern United States (Wharton et al. 1982). Four coastal level III ecoregions, 34, 73, 75, and 76, were initially used to focus on potential coastal habitats in the Southern U.S (Daigle et al., 2006; Griffith et al., 2007). Level IV ecoregions within these were screened for applicability based on their likelihood to contain swamp habitats. After screening, 26 level IV ecoregions remain as the geographic range of applicability (Table 1). Potential users outside of the geographical range of applicability presented here are encouraged to coordinate with ECO-PCX prior to applying this WVA community model for their project.

Table 1. Level IV ecoregions being considered for geographical range of applicability for the Wetland Value Assessment Swamp Community Model for Civil Works (Version 2.0).

Northern Humid Gulf Coastal Prairies	Gulf Coast Flatwoods
Southern Subhumid Gulf Coastal Prairies	Southwestern Florida Flatwoods
Floodplains and Low Terraces	Eastern Florida Flatwoods
Coastal Sand Plain	Okefenokee Plains
Lower Rio Grande Valley	Sea Island Flatwoods
Lower Rio Grande Alluvial Floodplain	Okefenokee Swamp
Texas-Louisiana Coastal Marshes	Bacon Terraces
Lafayette Loess Plains	Floodplains and Low Terraces
Southern Holocene Meander Belts	Sea Islands/Coastal Marsh
Southern Pleistocene Valley Trains	Big Bend Coastal Marsh
Southern Backswamps	Everglades
Inland Swamps	Big Cypress
Deltaic Coastal Marshes and Barrier Islands	Miami Ride/Atlantic Coastal Strip

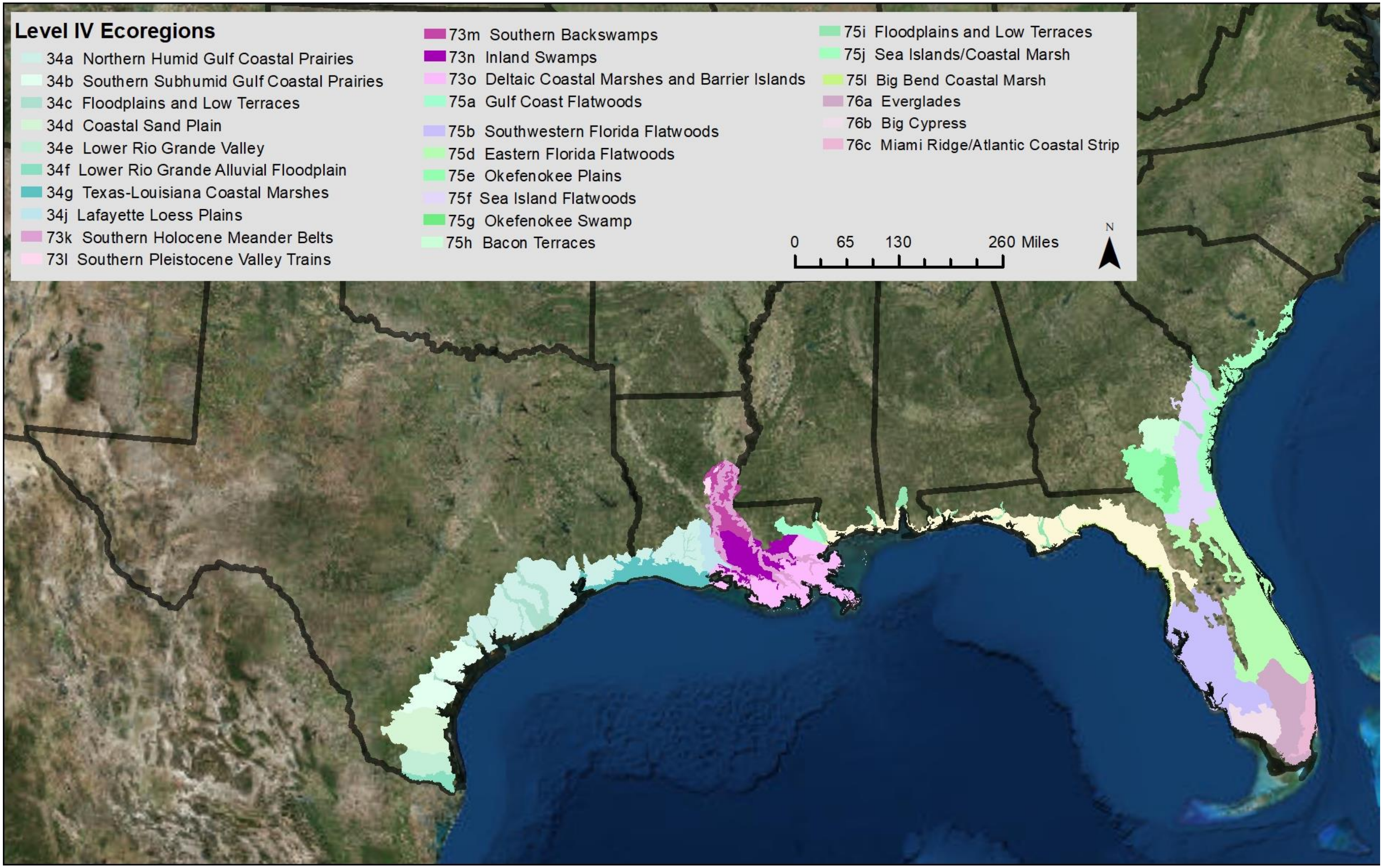


Figure 1. Geographic Range of Applicability for the WVA Swamp Community Model.

Minimum Area of Application

The minimum area of application of the swamp model is defined by the sample size required to collect three true replicates within each habitat type (see the instructions in the Sampling Technique section). The reason for this is that small patches of each habitat type may be critical for survival during extreme climatic events. For example, a small patch of Bottomland Hardwood Forest (BLH) within a swamp may enable survival of many species during high-water events caused by tropical storms. In contrast, small patches of swamp within a BLH could prove critical during periods of drought when water is at a premium. Practical constraints also mandate that the WVA models be applied to relatively small areas. For example, a large swamp restoration project may call for the gapping of spoil banks that impound it. Those gaps will destroy small areas of bottomland hardwood forest and the WVA bottomland hardwood model must be applied to these.

The size required to obtain at least three true replicates of each habitat type is considerably smaller, approximately 13.5 acres, or 5.4 hectares (ha), than the viable population size of one or more critical species. For example, certain species of Neotropical migratory birds require a minimum of 6,920 acres (2,800 ha) of forest interior to sustain viable populations (Robbins et al. 1989). Gosselink and Lee (1989) estimate that 494,200 acres (200,000 ha) of forested habitat is required to sustain a viable population of the Louisiana black bear (*Ursus americanus luteolus*). In cases where the model is applied to areas less than 13.5 acres, users must determine scale using best professional judgment.

Field Investigations

The first step in evaluating candidate projects is to conduct a field investigation of the project area. This field investigation has several purposes: 1) familiarize the IRT with the project area, 2) visit the locations of project features, 3) determine habitat conditions in the project area, 4) compile a list of vegetative species and discuss habitat classification, and 5) collect data for the WVA (e.g., cover of submerged aquatics, water depths, salinities, etc.).

The primary purpose of the field investigation is to allow members of the IRT to familiarize themselves with the project area and project features in order to make informed decisions in the evaluation of the WVA. The interagency field investigation should not be treated as the only opportunity to conduct surveys or take measurements to develop designs and/or cost estimates for the project. That information could be obtained during previous field trips or should plan a follow-up field trip. In cases where the project area is very large, it may be necessary to divide the group into small work parties to collect WVA information across the project area or to allow some areas to be investigated by at least a subset of the entire group. However, an effort should be made to keep the group together to facilitate discussion about wetland conditions in the project area, the causes of habitat loss, the project features, and the effectiveness of the project features.

<u>Project Boundary Determination</u>

The project boundary is the area where a measurable biological impact, in regard to the WVA variables, is expected to occur with project implementation. The area must be divided into subareas based on habitat type so that the correct model can be applied. The most recent Vegetative Type Maps (Sasser et al. 2014) are typically used to delineate marsh areas from adjacent areas of swamp. United States Geological Survey (USGS) Gap Analysis Project (GAP) data (USGS, 2011) is also utilized, particularly when forested wetlands are included. However, recent field investigations or other data (e.g., National Wetlands Inventory, www.fws.gov/wetlands) may be utilized to delineate habitat types within the project area. Reclassifying habitat should not be viewed as a means of reducing the number of subareas to simplify the project evaluation. Incorrect habitat classification can result in an inaccurate measure of project benefits, depending on project impacts. Reasons for habitat classification and/or reclassification should be documented.

In some instances, small areas of a particular habitat type may be combined with the more prevalent type within the project area. For example, a 100-acre area of bottomland hardwoods may be combined with an adjacent 5,000-acre tract of swamp. Determining the benefits for each individual small area could unnecessarily complicate the evaluation, be time-consuming, and may not significantly affect the overall project benefits. Any decision to combine a small area of one habitat type with a larger area of a different habitat type must be approved by the IRT.

Note: Remote sensing could also be determined through the use of aerial/satellite photographs, light imaging detection and ranging (LIDAR) information, USGS habitat and quadrangle maps and site visits. The boundary and revisions to the boundary are made by interagency group consensus. For non-restoration projects, boundaries are usually provided as areas designated for construction or clearing (typically to provide temporary or permanent rights-of-way) or areas that will experience changes in hydrology.

Selection of Target Years

In general, USACE Civil Works (CW) project WVAs are conducted for a period of 50 years which corresponds to the typical period of analysis of a CW study (Table 2). Each project evaluation must include target years (TY) 0, 1, and 50 (or last year of the period of analysis). Target year 0 (TY0) represents baseline or existing conditions in the project area and TY50 (or last year of the period of analysis) represents the projected conditions at the end of the project life. A linear fit (over the project life) is used to make the projection unless there are expected changes that may occur in the intervening years. Examples of these changes include (but are not limited to):

1. Storm events: Storm frequencies for the Louisiana coast vary depending on the period of record analyzed but generally have occurred every 8 to 10 years. For sites located along the gulf shoreline, it may be necessary to select a target year which corresponds to a storm event which is likely to occur within the project life in order to capture the effects of the storm. In forested wetlands, damaging winds from storms could cause tree mortality and reduce canopy cover by knocking trees down. Selection of a storm impact target year should be based on the storm return frequency that would result in substantial impact for the project vicinity. Climate change impacts to storm frequency and intensity varies spatially (Bender et al., 2010). It is not clear precisely how climate change will impact storm frequency and intensity, but many modelling results agree that we could expect decreased frequency and increased intensity (Walsh et al., 2016). However, an increase in frequency of tropical cyclonic storms was observed in the northern Atlantic in the recent past (1970-2005), which could, in part, be due to a warming climate (Webster et al, 2005). Storm impact and return frequency by barrier system, should be used as justification when selecting target years (Stone et al. 1997). If the Future Without Project condition (FWOP) loss rates are based on data which include the effects of storm events then care must be taken to ensure that effects of storm events are not double counted.

2. Changes in frequency and duration of flooding: As relative sea level (RSL) rise continues, flooding frequency and duration may increase which could result in habitat loss and/or conversion. Project features could also decrease flooding frequency and duration or increase flooding duration if drainage is retarded by structures.

3. Salinity changes: Salinity may increase resulting in reduced tree growth or eventual mortality and subsequent conversion of habitat.

4. Project implementation: Additional CW (or non-CW) projects may be built which could influence the conditions in the current project area.

5. Maintenance events: These would include items such as phased vegetative plantings, replacement of hydrologic restoration structures, etc.

6. Increase or decrease in vegetative cover: These could be associated with project features (initial or phased) or environmental changes (see numbers 2, 3, and 5).

Table 2. Summary of Target Years used for USACE Civil Works projects.

Project/Habitat Type	Target Year						
	0	**1**	**3**	**5**	**10, 20, 30, 40**	**50**	**>50**
Swamp Civil Works	Measured baseline		100% credit for marsh/dune plantings	100% credit for woody plantings	Storm Events (?)		Storm Event (?)

Use of the Community Habitat Model

Each community model contains a set of variables which is important in characterizing the habitat quality of several coastal wetland habitat types relative to the fish and wildlife communities dependent on those environments. Baseline (TY0) values are determined for each of those variables to describe existing conditions in the project area. Future values for those variables are projected to describe conditions in the area without the project and with the project. Projecting future values is the most complicated, and sometimes controversial part of this process. It requires the substantiation of with monitoring data, research findings, scientific literature, or examples of project success in other areas. Not all future projections can be substantiated by the results of monitoring or research, and, as with all wetland assessment methodologies, some projections are based on best professional judgment and can be subjective. It should be noted that future projections are the responsibility of the IRT (i.e., agency representatives, academics, and others) to use the best information available in developing those projections. Many times, the collective knowledge of the IRT is the only tool available to predict project impacts (positive or negative). Teams should be comprised of many individuals with diverse backgrounds and all project scenarios are discussed by the group and a final outcome is usually reached by consensus. Key assumptions made during the evaluation process, e.g., regarding the effects of climate change or storms, should be recorded on the Project Information Sheet (See Appendix III). There are occasionally off-site conditions and human disturbances adjacent to a project area. These have an effect on the animals in the project area, however these disturbances are considered to be the same under FWOP and Future With Project (FWP) conditions.

Model Application

The swamp community model should be applied to areas supporting or capable of supporting a canopy of woody vegetation which covers at least 33% of the area and with at least 60% of that canopy consisting of any combination of baldcypress, tupelo gum, red maple, buttonbush, and/or water elm. The model also states that if woody canopy cover is less than 33%, the fresh marsh model should be applied. Some areas with less than 33% canopy cover may provide functions and values more closely associated with a swamp than a fresh marsh. Therefore, the 33% canopy cover criterion should be treated as a general rule of thumb for model application and that some exceptions may exist. If greater than 40% of the canopy consists of species such as oaks, hickories, American elm, green ash, sweetgum, sugarberry, box elder, persimmon, honey locust, red mulberry, eastern cottonwood, American sycamore, etc., a bottomland hardwood community model should be applied.

Baseline Habitat Classification and Land/Water Data

Typically, the most recent habitat data for the project boundary are provided by USGS. However, other datasets, e.g., Digital Orthophoto Quadrangles (DOQs; https://lta.cr.usgs.gov/DOQs), may be more appropriate for some applications. Upland and/or non-wetland habitats (e.g., spoil banks, developed areas, cropland) are usually removed from the project area. Acreages for those habitat types should not be included within the project area acreage.

Wetland loss is the conversion of emergent habitat to open water. However, in many areas along the coast, the historic loss of swamp habitat has not resulted in a conversion to open water but conversion to marsh. Because much of the historic loss of swamp has not resulted in a conversion to open water, USGS habitat and land/water data generally do not allow the calculation of a “loss” rate for swamp habitat. However, habitat classification data could be utilized to determine a “conversion” rate of swamp to marsh and that rate could be utilized in the WVA. In those instances, areas of swamp converting to fresh marsh should be evaluated as open water habitat using the fresh marsh model. Allowing those areas to be evaluated as marsh habitat would underestimate project benefits as conversion to marsh, under FWOP, would not result in a net loss of wetland habitat. If an area of swamp was determined to completely convert to marsh over the project life, then the converted habitat is treated as open water and evaluated using the fresh marsh model. However, other conventions may be proposed and considered.

In other instances, where swamp has converted to open water, a loss rate could be calculated for the WVA. In addition, the Coast 2050 reports provide estimated loss rates for swamp by mapping units (Louisiana Coastal Wetlands Conservation and Restoration Task Force and the Wetlands Conservation and Restoration Authority 1998). That information should also be investigated and provided to the IRT for discussion during the WVA. However, it is important to note that due to the tree canopy, aerial imagery often poorly quantifies degradation of forested wetland habitat. Whichever scenario exists for the project area, whether it is loss of habitat to open water or conversion to marsh, the team should investigate the situation carefully and provide as much supporting documentation as possible.

As previously discussed for the marsh models, baseline habitat acreages must be adjusted to the current year.

Sampling Technique

The location and configuration of the area to be assessed direct the manner in which data are gathered. The plot size used by wetland forest ecologists of the southeastern United States is generally about 25 m x 25 m, or 625 m^2 (Conner et al. cites herein, Shaffer et al. 2003, 2009, Keim and King 2006). This plot size can be approximated by a circle constructed with a 41-foot (12.5 m) string which serves as the circle's radius. Perimeter trees can be flagged with survey tape to mark the plot while sampling. It is important to note that ecosystem function of forest interiors often is not reflected by forest edges (Gosselink et al. 1990, Llewellyn et al. 1996, Shaffer et al. 2009). Therefore, for larger forests data must be gathered at a distance (as much as 328 feet, 100 meters) from the edge that will minimize the edge's influence on the variables. Once the habitat of interest is reached, it may be necessary to sample several representative areas within it. Representative areas are generally reached by consensus and the process is operationally random. The center of each plot should be marked and the edge can be marked with string or flagging. Use of biodegradable string in hip chains to measure plot widths can be left in place during sampling; it provides a visible cue for the plot size and allows circular plots to be divided into quarters that aid in data gathering.

For mature even-aged forests with relatively few midstory trees, a factor 10 wedge prism may be utilized to gather data; however, data gathered for a project should utilize only one method. Because using a wedge prism can decrease the amount of time at a sample site, more sample sites can be measured. Proper techniques for using a wedge prism can be found in both the following US Forest Service and Corps publications: https://erdc-library.erdc.dren.mil/xmlui/bitstream/handle/11681/7195/TR%20EL-95-24.pdf?sequence=1&isAllowed=y and http://fia.fs.fed.us/library/field-guides-methods-proc/docs/core_ver_4-0_10_2007_p2.pdf.

There may be some situations (e.g., scientific research projects) when a more robust sampling scheme is necessary. In those situations, replicates of each forested habitat type (e.g., degraded, relict, throughput; Shaffer et al. 2009) should be located at least 1,640 feet (500 m) apart, yielding a theoretical equilateral triangle measuring 13.4 acres (5.4 ha) as the minimum area appropriate for data collection. The plot size used by wetland forest ecologists of the southeastern United States is generally about 25 m x 25 m, or 625 m^2 (Conner et al. cites herein, Shaffer et al. 2003, 2009, Keim and King 2006). This plot size can be approximated by a circle constructed with a 41-foot (12.5 m) string which serves as the circle's radius. Perimeter trees can be flagged with survey tape to mark the plot while sampling.

Variable Selection

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

Several habitat variables appeared repeatedly in the various models. In general, it was concluded that those variables which occurred most frequently in the various models were the most important for assessing habitat quality. The species-specific (i.e., HSI) models concentrated on assessment of site-specific habitat quality features such as tree species composition, forest stand structure (understory, midstory, overstory conditions), stand maturity, and hydrology. Other models reviewed concentrated on how a site fits into the overall "landscape." The final variables selected were reviewed by representatives of the LDNR, the USFWS, USACE, the U.S. Environmental Protection Agency, and the Louisiana Department of Wildlife and Fisheries. The final list of variables includes 1) stand structure, 2) stand maturity, 3) hydrology, and 4) mean high salinity during the growing season, 5) size of contiguous forested area, 6) suitability and traversability of surrounding land use, and 7) disturbance.

After using the LDNR model for several years, CWPPRA recognized that for restoration projects several of the model variables were not being impacted, thus model sensitivity and project benefits were being compromised. Values for the non-impacted variables (i.e., size of the contiguous forested area, suitability and traversability of surrounding land uses, and disturbance) were the same under future without-project and future with-project conditions for CWPPRA swamp restoration projects. In an effort to improve model sensitivity, those variables were omitted. In addition, the stand structure, stand maturity, and hydrology variables were revised and a salinity variable was included in the model. A salinity variable was included in the original swamp model developed by the CWPPRA EnvWG and was recognized as an important variable in characterizing the habitat quality of swamp ecosystems. This CWPPRA revised model is equivalent to the CW Swamp WVA Community Model 1.1.

The CW Swamp WVA Community Model 2.0 includes the three landscape variables that were a part of the original LDNR swamp model. Therefore, the final list of variables includes; 1) stand structure, 2) stand maturity, 3) water regime, 4) mean high salinity during the growing season, 5) size of contiguous forested area, 6) suitability and traversability of surrounding land use, and 7) disturbance.

Subsidence and Sea Level Change

At the time of publication, current guidance for incorporating the direct and indirect physical effects of projected future sea level change across the period of analysis cycle in managing, planning, engineering, designing, constructing, operating, and maintaining USACE projects and systems of projects can be found in Engineering Regulation 1100-2-8162 (Incorporating Sea level change in civil works programs). This Regulation discusses sea level change and subsidence. Please use current regulation concerning subsidence sea level change located in the Planning Community Toolbox (https://planning.erdc.dren.mil/toolbox/guidance.cfm?Option).

Suitability Index Graph Development

Each of the WVA community models approved for USACE CW projects includes SI graphs for each variable. Suitability Index graphs are unique to each variable and define the relationship between that variable and habitat quality. Suitability Index (SI) graph development for this model was very similar to the process used for other community models such as the coastal marsh community models. A variety of resources was utilized to construct each SI graph, including the HSI models from which the final list of variables was partially derived, consultation with other professionals, published and unpublished data and studies, and personal knowledge of those involved in model development. A review of contemporary, peer-reviewed scientific literature was also conducted for each of the variables, providing ecological support for the form of the SI graph for each of the variables (Appendix I).

The Suitability Index graphs were developed according to the following assumptions:

Variable V1 - Stand structure

Most 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, scrub-shrub/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. A mature stand dominated by overstory trees also receives the highest suitability rating (SI = 1.0).

Variable V2 - Stand maturity

Because of man's historical conversion of swamp, the loss of swamp to saltwater intrusion, historical and ongoing timber harvesting, and a reduced tree growth rate in the subsiding coastal zone, swamps with mature sizeable trees are a unique but ecologically important feature. Older trees provide important wildlife requisites such as snags and nesting cavities and the medium for invertebrate production. Additionally, as the stronger trees establish themselves in the canopy, weaker trees are outcompeted and eventually die, forming additional snags and downed treetops that would not be present in younger stands.

The SI for this variable is based upon the average diameter-at-breast height (dbh) for canopy-dominant and canopy co-dominant trees within the plot/sample. The suitability graph assumes that snags, cavities, downed treetops, and invertebrate production are present in suitable amounts when the average dbh of canopy-dominant and canopy-codominant trees is above 16 inches for baldcypress and above 12 inches for tupelo gum and other species. Therefore, stands with those characteristics are considered optimal for this variable (SI = 1.0). This variable utilizes two SI graphs, one for baldcypress and one for tupelo gum and other species, and a weighted SI value is calculated. The weighted SI is calculated using the basal area for baldcypress and the basal area for tupelo gum and other species.

Another important consideration for this variable is stand density, measured in terms of basal area (ft^2). A scenario sometimes encountered in mature swamp ecosystems is an overstory consisting of a very few, widely-scattered, mature baldcypress. If stand density was not considered, and average dbh only, then those stands would receive a high SI for this variable without providing many of the important habitat components of a mature swamp ecosystem, specifically a suitable number of trees for nesting, foraging, and other habitat functions. Therefore, the SI for this variable is dependent on average dbh and total basal area which is used as a measure of stand density. The weighted SI is multiplied by a basal area factor which takes into account stand density (i.e., total basal area).

Variable V3 - Water regime

This variable considers the duration and amount of water flow/exchange. Four flow/exchange and four flooding duration categories are described to characterize the water regime. The optimal water regime is assumed to be seasonal flooding with abundant and consistent riverine/tidal input and water flow-through (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. In addition, abundant and consistent input and water flow-through is optimal, because under that regime the full functions and values of a swamp in providing fish and wildlife habitat are assumed to be maximized. Temporary flooding is also assumed to be desirable. Habitat suitability is assumed to decrease as water exchange between the swamp and adjacent systems is reduced. The combination of permanently flooded conditions and 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 the least desirable (SI=0.1). Those conditions can produce poor water quality during warm weather, reducing fish use and invertebrate production.

Variable V4 - Mean high salinity during the growing season

Mean high salinity during the growing season (i.e. March 1 to October 31) is defined as the average of the upper 33% of salinity measurements taken during the specified period of record. Similar to V_2 (Stand Maturity), this variable also utilizes two SI graphs, one for baldcypress and one for tupelo gum and other species, and a weighted SI value is calculated. The weighted SI is calculated using the basal area for baldcypress and the basal area for tupelo gum and other species utilized for V_2.

Baldcypress is able to tolerate higher salinities than other swamp species. Thus, optimal conditions for baldcypress are assumed to occur at mean high salinities of less than 1.5 parts per thousand (ppt). Optimal salinities for other species such as tupelo gum and many herbaceous species are assumed to occur at mean high salinities less than 0.5 ppt. Habitat suitability is assumed to decrease rapidly at mean high salinities in excess of 1.5 ppt for baldcypress and in excess of 0.5 ppt for other swamp species.

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 timber harvesting, edge and diversity are quite available, 3) most species found in "edge" habitats 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.

Use of geographic information system (GIS) and satellite photographs is the primary method of determining the contiguous forested area. DOQs provide the best resolution for this variable; more than one year can be utilized to verify any breaks in contiguity.

Variable V6 – Suitability and Traversability of Surrounding Land Uses

Many wildlife species commonly associated with 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.

The most recent aerial/satellite photographs and habitat/land classification databases should be used for this variable. A 0.5 mile buffer should be delineated around the project area (use of a buffer tool in GIS simplifies this step) and within that buffer, the land cover types designated in V5 should be identified and acreage determined. Land loss rates and/or habitat conversion rates should be applied to these areas provided that the land cover type percentages will change enough to change this variable's value.

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 = 0.1. Other combinations of distance to, and type of, disturbance yield moderate SI's of 0.26, 0.41, 0.5, and 0.65.

Use of GIS and satellite photographs is the primary method of determining the type of possible disturbance such as highways, industrial areas, waterways, agriculture, homes, etc. Because this variable does not need as fine a resolution as V5, the use of aerial/satellite photographs other than DOQs may be sufficient.

Habitat Suitability Formulas

During development, Variables V_1 and V_3, stand structure and water regime, were considered the most important variables in characterizing the habitat quality of a swamp and were given greater influence. Variable V_2, stand maturity, was given slightly less weight than stand structure and water regime. Variable V_4, salinity, was deemed less important than V_1, V_2, and V_3. The landscape variables (V_5, V_6, and V_7) were deemed to be the least important and were all given equal and lowest influence. All variables are grouped to produce a geometric mean and variable influence is only controlled by the weight (i.e., exponent) assigned to each variable.

HSI Calculation: $HSI = (SIv_1^{3} \times SIv_2^{2.5} \times SIv_3^{3} \times SIv_4^{1.5} \times SI_{V5} \times SI_{V6} \times SI_{V7})^{1/13}$

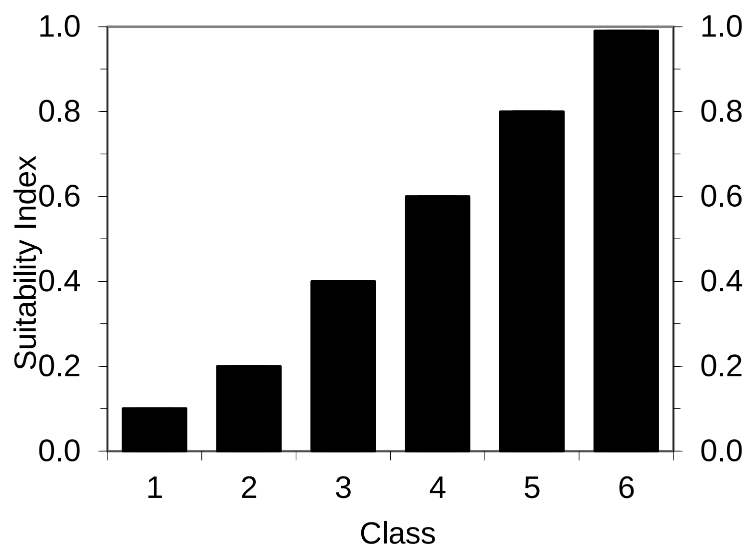
SWAMP

Variable V_1 Stand structure

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

	Overstory		**Scrub-shrub/ Midstory Cover**		**Herbaceous Cover**
Class 1.	<33%				
Class 2.	≥33%<50%	and	<33%	and	<33%
Class 3.	≥33%<50%	and	≥33%	or	≥33%
			OR		
	≥50%<75%	and	<33%	and	<33%
Class 4.	≥50%<75%	and	≥33%	or	≥33%
			OR		
	≥75%	and	<33%	and	<33%
Class 5.	≥33%<50%	and	≥33%	and	≥33%
Class 6.	≥50%	and	≥33%	and	≥33%
			OR		
	≥75%	and	≥33%	or	≥33%

Suitability Graph



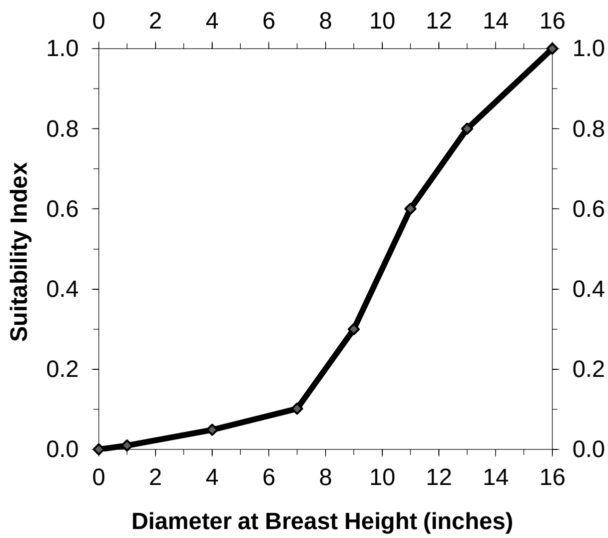
SWAMP

Variable V_2 Stand maturity

Average dbh of canopy-dominant and canopy-codominant trees.

Notes:
1. Canopy-dominant and codominant trees are those whose crown rises above or is an integral part of the overstory.
2. For trees with buttress swell, dbh is the diameter measured at 12" above the swell.
3. The basal area for baldcypress and the basal area for tupelo gum and other species must be calculated to determine a weighted SI.
4. The SI for this variable is multiplied by the factors in the table below depending on stand density.

Suitability Graph



Suitability Index Line Formulas for baldcypress:

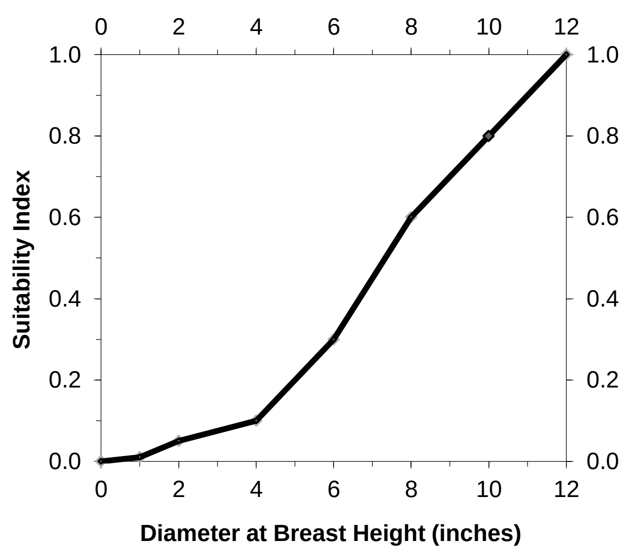
If dbh = 0 then SI = 0
If 0 < dbh ≤ 1 then SI = .01 * dbh
If 1 < dbh ≤ 4 then SI = (.013 * dbh) - .002
If 4 < dbh ≤ 7 then SI = (.017 * dbh) - .019
If 7 < dbh ≤ 9 then SI = (.1 * dbh) - .6
If 9 < dbh ≤ 11 then SI = (.15 * dbh) - 1.05
If 11 < dbh ≤ 13 then SI = (.1 * dbh) - .5
If 13 < dbh ≤ 16 then SI= (.067 * dbh) - .072
If dbh > 16 then SI = 1.0

Suitability Index Line Formulas for tupelogum et al.:

If dbh = 0 then SI = 0
If 0 < dbh ≤ 1 then SI = .01 * dbh
If 1 < dbh ≤ 2 then SI = (.04 * dbh) - .03
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

Density	Basal Area	Factor
Open	$<40ft^2$	0.2
Moderately Open	$40ft^2 \leq BA \leq 80ft^2$	0.4
Moderate	$81ft^2 \leq BA \leq 120ft^2$	0.6
Moderately Dense	$121ft^2 \leq BA \leq 160ft^2$	0.8
Dense	$>161ft^2$	1.0

Suitability Graph



SWAMP

Variable V_3 Water regime

		Flow/Exchange			
		High	Moderate	Low	None
Flooding Duration	Permanent	0.65	0.45	0.30	0.10
	Semi-Permanent	0.75	0.65	0.45	0.25
	Seasonal	1.00	0.85	0.70	0.50
	Temporary	0.9	0.75	0.65	0.40

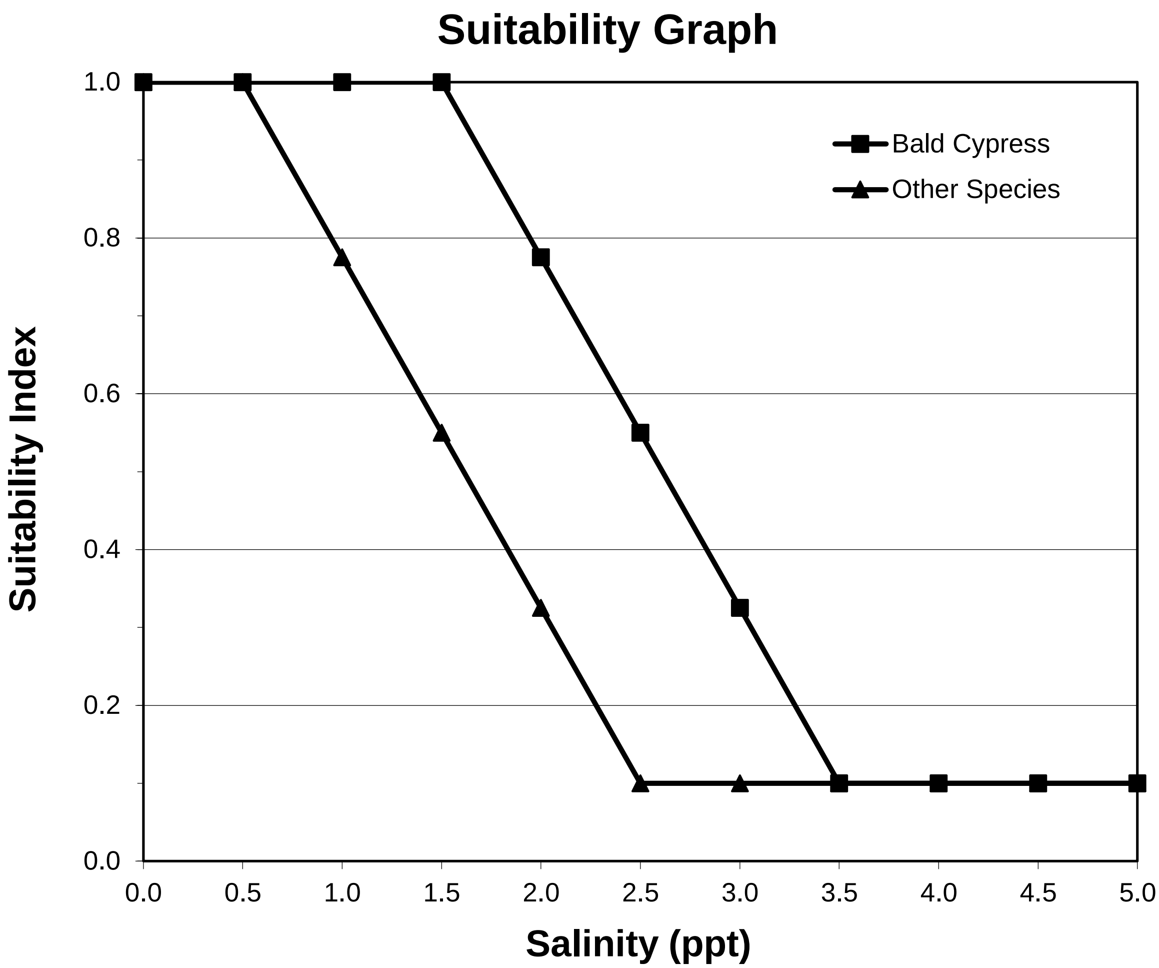
Flooding Duration

1. Permanently Flooded/Dewatered: Water covers the substrate throughout the year in all years except in extreme drought; or water no longer covers the substrate throughout the year in all years except in major flood events.
2. Semipermanently Flooded: Surface water is present throughout the growing season and may extend beyond 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 below the surface for most of the year.

Flow/Exchange

1. High: Receives abundant and consistent riverine input and through-flow.
2. Moderate: Moderate water exchange through riverine and/or tidal input.
3. Low: Limited water exchange through riverine and/or tidal input or just rainfall on an area that is not efficiently drained. Area may be under pump or forced drainage, but is managed for forest and/or ecological health.
4. None: No water exchange (stagnant, impounded) or under an efficient drainage system. Area may be under pump or forced drainage, but is not managed for forest and/or ecological health.

Variable V_4 Mean high salinity during the growing season (March to November)



Baldcypress Salinity Regression

If 0 < ppt <= 1.5, then SI = 1.0
If 1.5 > ppt < 3.5, then SI = (-0.45 * ppt) + 1.675
If ppt >= 3.5 then SI = 0.1

All Other Tree Species Salinity Regression

If 0 < ppt <= 0.5, then SI = 1.0
If 0.5 > ppt < 2.5, then SI = (-0.45 * ppt) + 1.225
If ppt >= 2.5 then SI = 0.1

Mean high salinity during the growing season is defined as the average of the highest 33 percent of consecutive salinity readings taken during the period of record (March 1 through October 31).

SWAMP

Variable V_5 Size of Contiguous Forested Area

Note: Corridors less than 75 feet wide do not constitute a break in the forested area contiguity.
Note: If dbh is < 5 then this variable is not used.

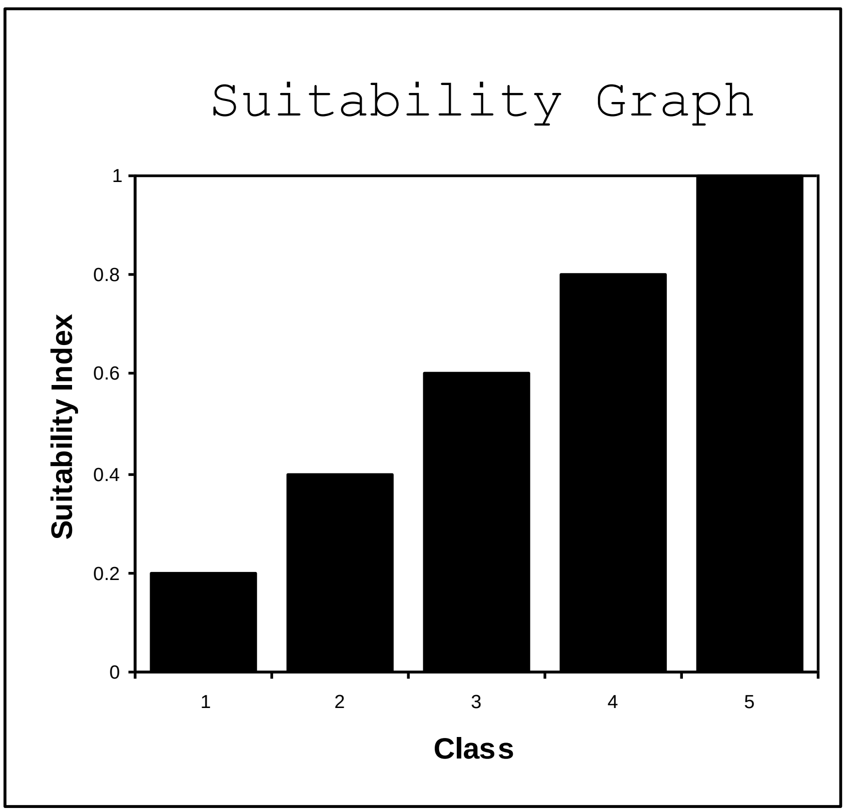
Class 1. 0 to 5 acres

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



Variable V_6 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% 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.

Land Use	Weighting Factor		% of 0.5 mile 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, open water	0.2	X		=	
Nonhabitat: linear, residential, commercial, industrial development, etc.	0.01	X		=	
					___ /100 = SI

SWAMP

Variable V_7 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.

Distance Classes	**Type Classes**
Class 1. 0 to 50 ft.	**Class 1.** Constant/Major. (Major highways, industrial, commercial, major navigation.)
Class 2. 50.1 to 500 ft.	**Class 2.** Frequent/Moderate. (Residential development, moderately used roads, waterways commonly used by small to mid-sized boats).
Class 3. > 500 ft.	**Class 3.** Seasonal/Intermittent. (Agriculture, aquaculture.)
	Class 4. Insignificant. (Lightly Used roads and waterways, individual homes, levees, rights of way).

Suitability Indices for Distance/Type Class

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

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<u>Appendix I</u>
Description of Model WVA Variables from Scientific Literature

A description of the relative role of the model variables in providing habitat to the modeled community based on available, contemporary peer-reviewed scientific literature is provided below.

<u>Variable V1 – Stand Structure</u>

From a community perspective, a swamp containing overstory and midstory trees, as well as herbaceous ground cover, in roughly even amounts, offers the highest degree of food and shelter for a diverse assemblage of wildlife (Brokaw and Lent 1999, Haila 1999, Bodie and Semlitsch 2000, Chambers et al. 2005). However, at present, a swamp in coastal Louisiana with less than 50% overstory cover is either on a trajectory of degradation (Keim and King 2006, Shaffer et al. 2009a) or is a young or recently cut over ecosystem on a trajectory towards maturity. Healthy mature swamp will likely have low cover of herbaceous vegetation, due to light limitation and prevalent flooding (Chambers et al. 2005). Conversely, as swamps degrade, generally due to altered hydrologic conditions, saltwater intrusion, or both, the canopy begins to open allowing midstory, shrub-scrub and groundcover vegetation to increase (Allen 1958; Allen 1962, Conner et al. 1981, White 1983, Barras et al. 1994, llen et al. 1996, Aust et al. 1998, Thomson et al. 2002, Conner and Inabinette 2003, Shaffer et al. 2009a). Therefore, swamp with 50% overstory coverage receives an SI of 1.0.

With respect to Neotropical migratory birds, it has been shown that swamps with intact overstory canopies are more species diverse than degraded swamps (Zoller 2004). The reduction in species diversity was believed to be a result of a reduction of the vertical structure of the forest. Virtually all of the eastern land bird species in the United States and numerous species from the western USA migrate through the coastal forests of Louisiana and utilize the forest canopy (Lowery 1974). Some bird species of special interest, such as the bald eagle and swallow-tailed kite, which nest in the wetland forests of coastal Louisiana, require very tall overstory trees for nesting.

A step function is necessary in the V_1 Suitability Index relationship, because most steps require categorical rules concerning ground, midstory, and overstory cover. In general, combinations of ground cover and midstory cover rank higher than either category alone. From a community perspective, the habitat value certainly increases as vertical and horizontal structure of the forest increases (Bormann and Likens 1979, Oliver and Larson 1990, Perry 1994, Kimmins 1996, Barnes et al. 1998, Chambers et al. 2005). Therefore the ‘and’ ‘or’ step increases are grounded in the literature. From a restoration perspective, a healthy, mature swamp must receive a Suitability Index of 1.0; this swamp will most likely be characterized by near complete overstory canopy closure with little light penetrating to the forest floor.

<u>Variable V2 – Stand Maturity</u>

The healthiest swamps in coastal Louisiana are those characterized by high basal area and large trees (Conner and Day 1976, Nessel and Bayley 1984, Nessel et al. 1982, Conner et al. 1981, Muzika et al. 1987, Megonigal et al. 1997, Hoeppner et al. 2008, Shaffer et al. 2009a). An inverse relationship exists between the density of large overstory trees and hurricane damage (Shaffer et al. 2009a, b), so mature stands better protect faunal community assemblages. Certain species of special interest, such as the Louisiana black bear and the Rafinesque big-eared bat frequently use hollows of large trees for nesting (Taylor 1971, Weaver et al. 1990, Cochran 1999, Hoffman 1999, Hightower et al. 2002, Gooding and Langford 2004). Large hollow water tupelo characteristic of older swamp forests appear particularly important to the Rafinesque big-eared bat (Cochran 1999, Lance et al. 2001, Gooding and Langford 2004).

In general, stand maturity is the most sensitive predictor of FWP vs. FWOP conditions, because it is a surrogate for net primary production, the single best integrator for ecosystem function (Conner and Day 1976, Costanza et al. 1989, Gosselink et al. 1990, Odum 1996, Costanza et al. 1997, Mitsch and Gosselink 2007). Addition of basal area to the 2001 version of the model was imperative (Carter et al. 1973, Brown 1981, Conner et al. 1981, Taylor 1985, Dicke and Toliver 1990, Wilhite and Toliver 1990, Mitsch et al. 1991, Conner and Day 1992), as without it a single large overstory and midstory tree could yield a Suitability Index of 1.0.

Variable V3 – Water Regime

The optimal hydrology for baldcypress – water tupelo swamps consists of several periods of flooding and drawdown, or a “pulsing” hydrology (Montz and Cherubini 1973, Conner and Day 1976, Mitsch et al. 1991, Day et al. 1995, Odum et al. 1995, Visser and Sasser, 1995, Day et al. 2009). A pulsing hydrology also will promote regeneration events as baldcypress and water tupelo seeds must have a bare, moist seedbed to germinate and will not germinate under water (Mattoon 1915, DuBarry 1963).

Wetland and aquatic invertebrates are a major link in food web dynamics of the coastal forests of Louisiana and elsewhere. Differences in invertebrate distribution, composition, and density among wetland habitats are driven by hydrologic regimes and vegetation structure (Murkin et al. 1992, Mitsch and Gosselink 2007). Wetland and aquatic invertebrate productivity is critical for the maintenance of fish and wildlife populations (Chambers et al. 2005). Impounded, stagnant water can reduce invertebrate production as well as diversity (Batzer et al. 1999) and therefore negatively affect the fish and wildlife that depend on them as a food source. Furthermore, impoundments have detrimental effects on mature trees through reduced net production, crown dieback, increased susceptibility to insects and pathogens, and increased mortality (Conner et al. 1981, King 1995, Keeland et al. 1997).

Variable V4 – Salinity

In terms of FWP vs. FWOP conditions, salinity is an important variable to include in the WVA swamp model (Penfound and Hathaway 1938, Pezeshki et al. 1989, Conner 1994, Allen et al. 1994, USACE 1999, Thomson et al. 2002, Conner and Inabinette 2003, van Heerden et al., 2007, FitzGerlad et al., 2008, Shaffer et al. 2009a,b). However, unlike Stand Maturity, two relationships are necessary to accurately differentiate between the saltwater tolerances of baldcypress vs. water tupelo, ash, and swamp red maple (Dickson and Broyer 1972, Pezeshki et al. 1989, Keeland and Sharitz 1995, Pezeshki et al. 1995, Conner et al. 1997, Souther-Effler 2004, Chambers et al. 2005, Shaffer et al. 2009a,b). We know, for example, that the average high salinity in the Manchac/Maurepas area was about 1.5 ppt for a period of approximately 50 years (Wiseman et al. 1990, Thomson et al. 2002). This salinity was sufficiently high to cause massive degradation and lethality to water tupelo, ash, and swamp red maple trees, but not baldcypress (Shaffer et al. 2009a). The drought of 1998 – 2000, however, caused salinity extremes (Thomson et al. 2002) sufficient to kill century-old baldcypress (Shaffer et al. 2009a). The slope for water tupelo, ash, and maple should range between 0.5 ppt and 2.5 ppt (Pezeshki et al. 1989, Conner and Askew 1993, Conner et al. 1997, McCarron et al. 1998, Chambers et al. 2005), whereas that for baldcypress should range between 1.5 and 3.5 ppt (USACE 1963, Conner and Askew 1993, Krauss et al. 1998, Krauss et al., 2000, Souther-Effler 2004, Chambers et al. 2005, Shaffer et al. 2009a, b).

With increased rate of relative sea-level rise (FitzGerald et al. 2008), saltwater intrusion into coastal swamps is expected to increase, which will reduce net primary production and increase mortality (Allen 1992, Krauss et al. 2000, Pezeshki et al. 1990, Souther-Effler 2004). Baldcypress may tolerate salinities as high as 7 ppt, but productivity and survivorship decline with salinities > 3 ppt (Pezeshki et al. 1990, Conner and Askew 1993, Conner 1994, Pezeshki et al. 1995, Allen et al. 1996, Shaffer et al. 2009b).

Variable V5 - Size of Contiguous Forest

Whereas single blocks of forested wetlands used to cover hundreds of thousands of hectares in the Mississippi Alluvial Plain, there now remain only isolated fragments, most less than 250 acres (100 ha) in size and most of these are surrounded by agricultural fields (Gosselink et al. 1990b). Certain species of Neotropical migratory birds require a minimum of 6,900 acres (2,800 ha) of forest interior to sustain viable populations (Robbins et al. 1989, Twedt and Loesch 1999). In their plan to restore large tracks of forested wetlands, The Nature Conservancy focuses on three migratory-bird guilds, namely Bachman's warbler which requires 9,880 acres (4,000 ha) of forest interior for successful breeding habitat, the Cerulean warbler requiring 19,770 acres (8,000 ha) of forest interior, and the swallow-tailed kite requiring 98,840 acres (40,000 ha) of interior forest (Shaffer et al. 2005, Weitzell et al. 2003). Gosselink and Lee (1989) estimate that 494,200 acres (200,000 ha) of forested habitat is required to sustain a viable population of the Louisiana black bear. Fragmented forested wetlands were found to reduced species richness and abundance of plants, macroinvertebrates, amphibians, and birds with greater numbers of exotic species (Faulkner, 2004). In general, ecosystem function of forest interiors often is not reflected by forest edges (Gosselink et al. 1990a,b, Llewellyn et al. 1996, Saunders et al. 1991, Shaffer et al. 1992, 2009). Habitat loss and fragmentation has been shown to significantly decrease bird populations (e.g., Sauer et al. 2017). To date, the forested wetlands of coastal Louisiana have been reduced by over 80% (Llewellyn et al. 1996, Shaffer et al. 2005, Weitzell et al. 2003, Shaffer et al., 2016), rendering large contiguous patches extremely valuable for floral and faunal species diversity (Gosselink et al. 1990). Large expanses of forested wetland dominated parts of coastal Louisiana (e.g., the Pontchartrain Basin was over 90% swamp; Saucier 1963, Shaffer et al., 2016). Much of this has transitioned from Cypress-Tupelo swamp to marsh (Shaffer et al., 2009).

Variable V6 - Suitability and Traversability of Surrounding Habitat

The quality of a bottomland hardwood forest patch is clearly associated with the type of habitat that surrounds it (Gosselink and Lee 1989, Rudis 1995). Certain species of birds and mammals will not traverse other types of habitats, especially those developed by humans, to move from one patch of forested wetland to another (Gosselink and Lee 1989, Gosselink et al. 1990b). Fragmented forested wetlands were found to reduced species richness and abundance of plants, macroinvertebrates, amphibians, and birds with greater numbers of exotic species (Faulkner, 2004). Clearly habitat types such as abandoned agricultural fields or pastures are of higher habitat value than cultivated fields, residential areas, or busy streets.

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 a disturbance is a function of the type of disturbance and the distance of the disturbance to the habitat in question (Rudis 1995). Many species of birds and mammals are highly sensitive to disturbance (Twedt et al. 1999, Wigley and Roberts 1997). As described above, animals have different habitat requirements from 6,900 acres (2,800 ha) for certain Neotropical migrants to 494,200 acres (200,000) ha for the Louisiana black bear. In general, ecosystem function of forest interiors often is not reflected by forest edges prone to disturbance (Gosselink et al. 1990a, b, Llewellyn et al. 1996, Shaffer et al. 1992, Shaffer et al., 2009, Shaffer et al., 2016). Furthermore, as patch size increases, the effects of outside disturbances have been shown to decrease (Rudis 1993, 1995). Fifty percent less Neotropical migratory birds were reported in disturbed forested wetlands than undisturbed forested wetlands (Croonquist and Brooks 1993). Similarly, lower frog and toad abundances were lower in urbanized habitats than forested wetlands (Knutson et al., 1999).

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Appendix II
Document Revisions

Version 1.0 – April 2010 document developed via the Corps' WVA certification process.

Version 1.1 – April 10, 2012
1) Pertinent sections from the Procedural Manual incorporated

Version 1.2 – April 26, 2012
1) Variable V4 SI graph and line formulas corrected. The previous version contained incorrect SI curves and incorrect line formulas which were not consistent with the discussion in Appendix A. The line formulas have also been corrected in the Excel spreadsheet.

Version 2.0 – November 2018 document revised via the USACE PMIP process; including the re-inclusion of three landscape variables V5, V6, V7 and update of V1 to include all possibilities.

Appendix III

Project Information Sheet Format

Project Name:

Sponsoring Agency: List Environmental and Engineering Work Group Contacts

Project Location and Description: Describe project location (Coast 2050 region, basin, parish, nearby cities, important bodies of water, total acres, wetland type, etc.). Include a project map.

Problem: Discuss the major causes (historical and current) of habitat loss/degradation in the project area.

Objectives: How will the project address the major causes of habitat loss/degradation in the project area? What are the specific objectives of the project?

Project Features: List all project features including their locations, dimensions, etc. The project map should include the locations of all project features.

Monitoring and Modeling Results for Similar Projects: Relevant monitoring reports and modeling studies should be discussed.

Miscellaneous: As necessary, discuss the following subjects as they relate to the project.

Climate change

Off site disturbances – these are generally the same FWOP and FWP.

Any project risks or uncertainties

V1 – Stand Structure

1) Discuss the historical and current vegetative community and any trends noted for the area.
2) Discuss the methods used to determine percent cover for each component of stand structure.

TY 0 – Existing cover values for overstory, midstory, and herbaceous cover.

FWOP – Provide cover values for each target year (TY) and include all assumptions. Use as many TYs as necessary and justify each.
TY 1 –
TY X –
TY Y –
TY 50 –

FWP – Provide cover values for each target year (TY) and include all assumptions. Use as many TYs as necessary and justify each.
TY 1 –
TY X –
TY Y –
TY 50 –

V2 – Stand Maturity

1) Discuss methods used to collect dbh values for the baseline condition. Provide calculations for basal area.

TY 0 – Average dbh and basal area for baldcypress. Average dbh and basal area for tupelogum and all other species.

FWOP – Provide dbh and basal area values for each target year (TY) and include all assumptions. Use as many TYs as necessary and justify each.
TY 1 –
TY X –
TY Y –
TY 50 –

FWP – Provide dbh values for each target year (TY) and include all assumptions. Use as many TYs as necessary and justify each.
TY 1 –
TY X –
TY Y –
TY 50 –

V3 – Water Regime

1) Discuss methods used to determine the flooding duration and degree of flow/exchange for the baseline condition.

TY 0 – Flooding duration and degree of water flow/exchange.

FWOP – Determine flooding duration and degree of exchange for each target year (TY) and include all assumptions. Use as many TYs as necessary and justify each.
TY 1 –
TY X –
TY Y –
TY 50 –

FWP – Determine flooding duration and degree of exchange for each target year (TY) and include all assumptions. Use as many TYs as necessary and justify each.
TY 1 –
TY X –
TY Y –
TY 50 –

V4 – Mean high salinity during the growing season

1) Discuss methods used to determine the mean high salinity during the growing season for the baseline condition. Provide a location map for gages/stations used in the analysis.

TY 0 – Mean high salinity during the growing season.
FWOP – Determine mean high salinity during the growing season for each target year (TY) and include all assumptions. Use as many TYs as necessary and justify each.
TY 1 –
TY X –
TY Y –
TY 50 –

FWP – Determine mean high salinity during the growing season for each target year (TY) and include all assumptions. Use as many TYs as necessary and justify each.
TY 1 –
TY X –
TY Y –
TY 50 –

Literature Cited

Other Supporting Information

WETLAND VALUE ASSESSMENT COMMUNITY MO

Swamp 2.0

Project: | Project Area:

Condition: Future Without Project

Variable		TY	0	TY		TY	
		Class/Value	**SI**	**Class/Value**	**SI**	**Class/Value**	**SI**
V1	Stand Structure	% Cover		% Cover		% Cover	
		Overstory		Overstory		Overstory	
		Scrub-shrub		Scrub-shrub		Scrub-shrub	
		Herbaceous		Herbaceous		Herbaceous	
		Class		Class		Class	
V2	Stand Maturity	Cypress dbh		Cypress dbh		Cypress dbh	
		Cypress Basal Area		Cypress Basal Area		Cypress Basal Area	
		Tupelo et al dbh		Tupelo et al dbh		Tupelo et al dbh	
		Tupelo et al. Basal Area		Tupelo et al. Basal Area		Tupelo et al. Basal Area	
V3	Water Regime	Flow/Exchange		Flow/Exchange		Flow/Exchange	
		Flooding Duration		Flooding Duration		Flooding Duration	
V4	Salinity	Salinity		Salinity		Salinity	
		Class		Class		Class	
V5	Forest Size						
V6	Surrounding Land Use	Values %		Values %		Values %	
	Forest / marsh						
	Abandoned Ag						
	Pasture / Hay						
	Active Ag						
	Development						
V7	Disturbance						
	Type	Class		Class		Class	
	Distance	Class		Class		Class	
		HSI =		**HSI =**		**HSI =**	

Project: | Project Area:

FWOP

Variable		TY		TY		TY	
		Class/Value	**SI**	**Class/Value**	**SI**	**Class/Value**	**SI**
V1	Stand Structure	% Cover		% Cover		% Cover	

		Overstory		Overstory		Overstory	
		Scrub-shrub		Scrub-shrub		Scrub-shrub	
		Herbaceous		Herbaceous		Herbaceous	
		Class		Class		Class	
V2	Stand Maturity	Cypress dbh		Cypress dbh		Cypress dbh	
		Cypress Basal Area		Cypress Basal Area		Cypress Basal Area	
		Tupelo et al dbh		Tupelo et al dbh		Tupelo et al dbh	
		Tupelo et al. Basal Area		Tupelo et al. Basal Area		Tupelo et al. Basal Area	
V3	Water Regime	Flow/Exchange		Flow/Exchange		Flow/Exchange	
		Flooding Duration		Flooding Duration		Flooding Duration	
V4	Salinity	Salinity		Salinity		Salinity	
V5	Forest Size	Class		Class		Class	
V6	Surrounding Land Use	Values %		Values %		Values %	
	Forest / marsh Abandoned Ag Pasture / Hay Active Ag Development						
V7	Disturbance						
	Type	Class		Class		Class	
	Distance	Class		Class		Class	
		HSI =		HSI =		HSI =	

Project:

Project Area:

FWOP

Variable		TY		TY		TY	
		Class/Value	SI	Class/Value	SI	Class/Value	SI
V1	Stand Structure	% Cover		% Cover		% Cover	
		Overstory		Overstory		Overstory	
		Scrub-shrub		Scrub-shrub		Scrub-shrub	
		Herbaceous		Herbaceous		Herbaceous	
		Class		Class		Class	
V2	Stand Maturity	Cypress dbh		Cypress dbh		Cypress dbh	
		Cypress Basal Area		Cypress Basal Area		Cypress Basal Area	

		Tupelo et al dbh		Tupelo et al dbh		Tupelo et al dbh	
		Tupelo et al. Basal Area		Tupelo et al. Basal Area		Tupelo et al. Basal Area	
V3	Water Regime	Flow/Exchange		Flow/Exchange		Flow/Exchange	
		Flooding Duration		Flooding Duration		Flooding Duration	
V4	Salinity	Salinity		Salinity		Salinity	
V5	Forest Size	Class		Class		Class	
V6	Surrounding Land Use Forest / marsh Abandoned Ag Pasture / Hay Active Ag Development	Values %		Values %		Values %	
V7	Disturbance Type	Class		Class		Class	
	Distance	Class		Class		Class	
		HSI =		**HSI =**		**HSI =**	

WETLAND VALUE ASSESSMENT COMMUNITY MODEL
Swamp 2.0

Project: Project Area:

Condition: Future With Project

		TY	0	TY		TY	
Variable		**Class/Value**	**SI**	**Class/Value**	**SI**	**Class/Value**	**SI**
V1	Stand Structure	% Cover		% Cover		% Cover	
		Overstory		Overstory		Overstory	
		Scrub-shrub		Scrub-shrub		Scrub-shrub	
		Herbaceous		Herbaceous		Herbaceous	
		Class		Class		Class	
V2	Stand Maturity	Cypress dbh		Cypress dbh		Cypress dbh	
		Cypress Basal Area		Cypress Basal Area		Cypress Basal Area	
		Tupelo et al dbh		Tupelo et al dbh		Tupelo et al dbh	
		Tupelo et al. Basal Area		Tupelo et al. Basal Area		Tupelo et al. Basal Area	
V3	Water Regime	Flow/Exchange		Flow/Exchange		Flow/Exchange	

		Flooding Duration		Flooding Duration		Flooding Duration	
V4	Salinity	Salinity		Salinity		Salinity	
V5	Forest Size	Class		Class		Class	
V6	Surrounding Land Use Forest / marsh Abandoned Ag Pasture / Hay Active Ag Development	Values %		Values %		Values %	
V7	Disturbance Type	Class		Class		Class	
	Distance	Class		Class		Class	
		HSI =		HSI =		HSI =	

Project: Project Area:

FWP

Variable		TY		TY		TY	
		Class/Value	SI	Class/Value	SI	Class/Value	SI
V1	Stand Structure	% Cover Overstory Scrub-shrub Herbaceous Class		% Cover Overstory Scrub-shrub Herbaceous Class		% Cover Overstory Scrub-shrub Herbaceous Class	
V2	Stand Maturity	Cypress dbh Cypress Basal Area Tupelo et al dbh Tupelo et al. Basal Area		Cypress dbh Cypress Basal Area Tupelo et al dbh Tupelo et al. Basal Area		Cypress dbh Cypress Basal Area Tupelo et al dbh Tupelo et al. Basal Area	
V3	Water Regime	Flow/Exchange Flooding Duration		Flow/Exchange Flooding Duration		Flow/Exchange Flooding Duration	
V4	Salinity	Salinity		Salinity		Salinity	
V5	Forest Size	Class		Class		Class	
V6	Surrounding Land Use Forest / marsh Abandoned Ag	Values %		Values %		Values %	

	Pasture / Hay Active Ag Development						
V7	Disturbance Type	Class		Class		Class	
	Distance	Class		Class		Class	
		HSI =		HSI =		HSI =	

Project: Project Area:

FWP

Variable		TY		TY		TY	
		Class/Value	SI	Class/Value	SI	Class/Value	SI
V1	Stand Structure	% Cover Overstory		% Cover Overstory		% Cover Overstory	
		Scrub-shrub		Scrub-shrub		Scrub-shrub	
		Herbaceous		Herbaceous		Herbaceous	
		Class		Class		Class	
V2	Stand Maturity	Cypress dbh		Cypress dbh		Cypress dbh	
		Cypress Basal Area		Cypress Basal Area		Cypress Basal Area	
		Tupelo et al dbh		Tupelo et al dbh		Tupelo et al dbh	
		Tupelo et al. Basal Area		Tupelo et al. Basal Area		Tupelo et al. Basal Area	
V3	Water Regime	Flow/Exchange		Flow/Exchange		Flow/Exchange	
		Flooding Duration		Flooding Duration		Flooding Duration	
V4	Salinity	Salinity		Salinity		Salinity	
V5	Forest Size	Class		Class		Class	
V6	Surrounding Land Use	Values %		Values %		Values %	
	Forest / marsh Abandoned Ag Pasture / Hay Active Ag Development						
V7	Disturbance Type	Class		Class		Class	
	Distance	Class		Class		Class	
		HSI =		HSI =		HSI =	

AAHU CALCULATION

Project:

Future Without Project			Total	Cummulative
TY	Acres	x HSI	HUs	HUs
0			#VALUE!	
Max TY=	0		Total CHUs =	
			AAHUs =	

Future With Project			Total	Cummulative
TY	Acres	x HSI	HUs	HUs
0			#VALUE!	