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HABITAT SUITABILITY INDEX MODEL: CYPRESS/TUPELO COMMUNITY IN SOUTHERN ILLINOIS

L. Jean O'Neil[1], Antisa C. Webb[1], and Beth Middleton[2]

[1]Environmental Laboratory, U.S. Army, Corps of Engineers, Engineer Research and Development Center, Environmental Laboratory, Vicksburg, MS 39180
[2]Department of Plant Biology, Southern Illinois University, Carbondale, IL 62901

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PREFACE

This work was authorized and funded by Headquarters, U.S. Army Corps of Engineers (HQUSACE), as part of the Wetlands Regulatory Assistance Program (WRAP). HQUSACE representatives at the time of this report were Mr. Charles Hess, Chief, Operations Division (CECW-O); Mr. John Studt, Chief, Regulatory Branch (CECW-OR); and Mr. Ted Rugiel, Regulatory Branch (CECW-OR). Dr. Russell Theriot, U.S. Army Engineer Research and Development Center (ERDC), Environmental Laboratory (EL), Vicksburg, MS, was the WRAP Program Manager.

This report was prepared under the general supervision of Dr. Michael Passmore, Chief, Ecological Analysis and Restoration Branch; Dr. Dave Tazik, Chief, Ecosystem Evaluation and Engineering Division; Dr. Richard A. Price, Acting Assistant Director, EL; and Dr. James R. Houston, Acting Director, EL.

The report was written by Dr. L. Jean O'Neil, Wildlife Ecologist in CEERD-EE-E; Ms. Antisa C. Webb, Biologist, Applied Research Associates, Inc., Vicksburg, MS; and Dr. Beth Middleton, Associate Professor, Department of Plant Biology, Southern Illinois University, Carbondale, IL.

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INTRODUCTION

The need to quantify intangible environmental features for water resource projects has been met to some degree by development of evaluation tools such as the Habitat Evaluation Procedures (U.S. Fish and Wildlife Service 1980) and its component Habitat Suitability Index (HSI) models. Using HEP and HSI models, a planner has the ability to quantify baseline conditions, predict changes from planned activities over time, make comparisons among project alternatives, and determine potential gains and losses to selected resources. Although less common, the same tools can be used to describe and monitor project results.

Original HSI models scored habitat quality for fish or wildlife species, or rarely, groups of species. In recent years, interest of users has broadened to a perspective of evaluating a biotic community for wildlife habitat quality (Schroeder 1986, 1997).

In addition to supplying food, cover, and other needs of fish and wildlife, a plant community serves other functions that humans value (e.g., stabilize soil, sequester carbon, improve water quality). The community itself may be a unique or specialized assemblage of species and processes, be considered a significant resource, and therefore merit its own evaluation. The HEP and HSI framework is sufficiently flexible to accommodate such an evaluation, e.g., model subjects now include wetland functions (Smith 1993).

This document contains natural history information and a model to evaluate a plant community in southern Illinois. The model was constructed in the style of an HSI model for a wildlife species, considering life requisites of the community as (1) maintenance of the existing population and (2) recruitment of new individuals.

APPLICABILITY

The primary application of this model is to the climax cypress/tupelo (*Taxodium distichum* and *Nyssa aquatica*) forests of Alexander and Pulaski Counties, Illinois (Figure 1). The St. Louis District conducted a habitat restoration study in the Cache River basin. River bed entrenchment, sediment deposition, and an altered hydrological regime threaten the integrity of two river wetland areas designated as National Natural Landmarks (USAE St. Louis District 1992). This model was constructed to evaluate the potential impacts of project features on the existing climax forest and on its productivity. The model is also applicable to ecoclinal cypress and/or cypress/tupelo forests at the northern part of their range (Figure 2).

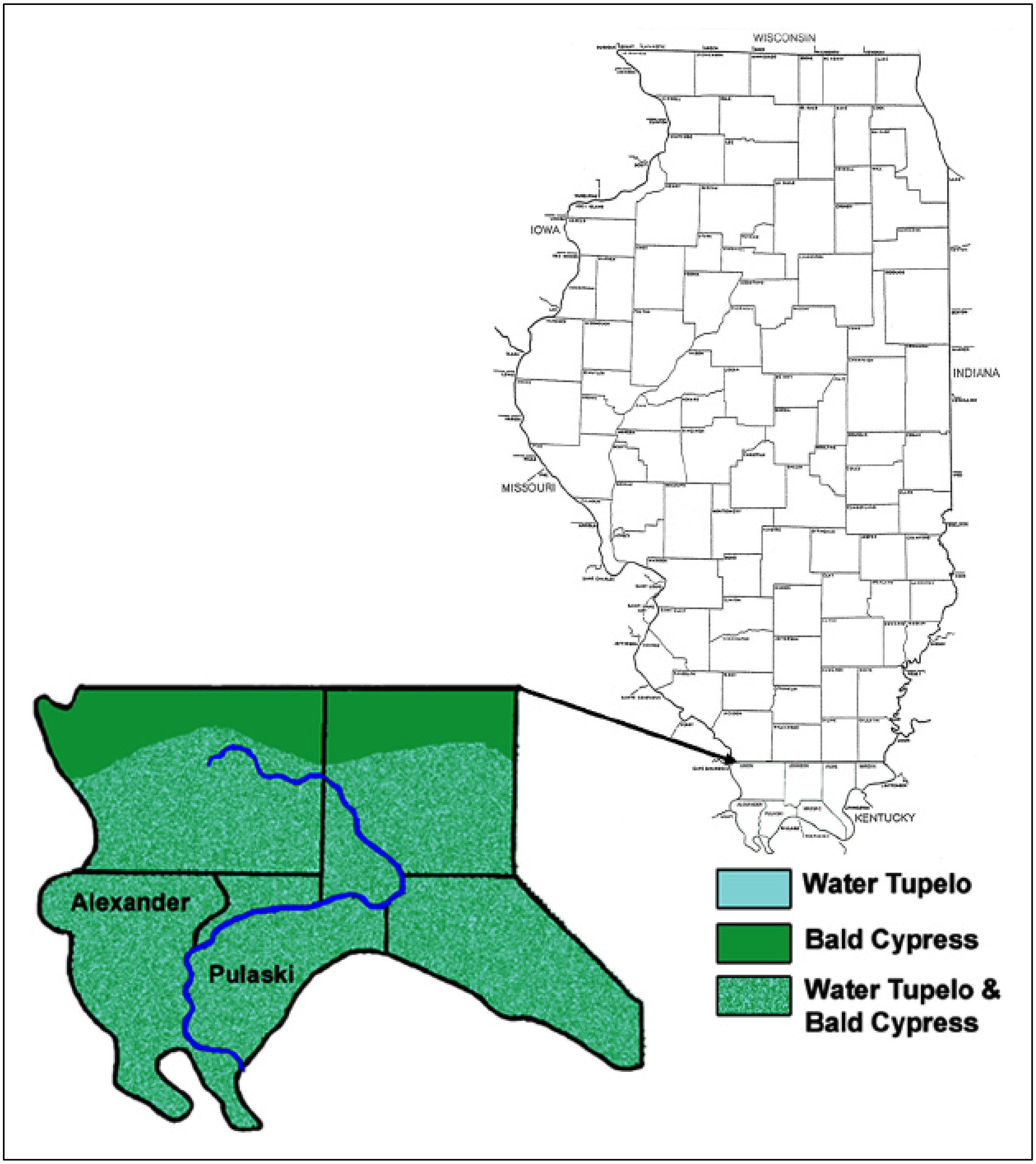


Figure 1. Project area in Lower Cache River watershed (Alexander and Pulaski counties, southern Illinois.

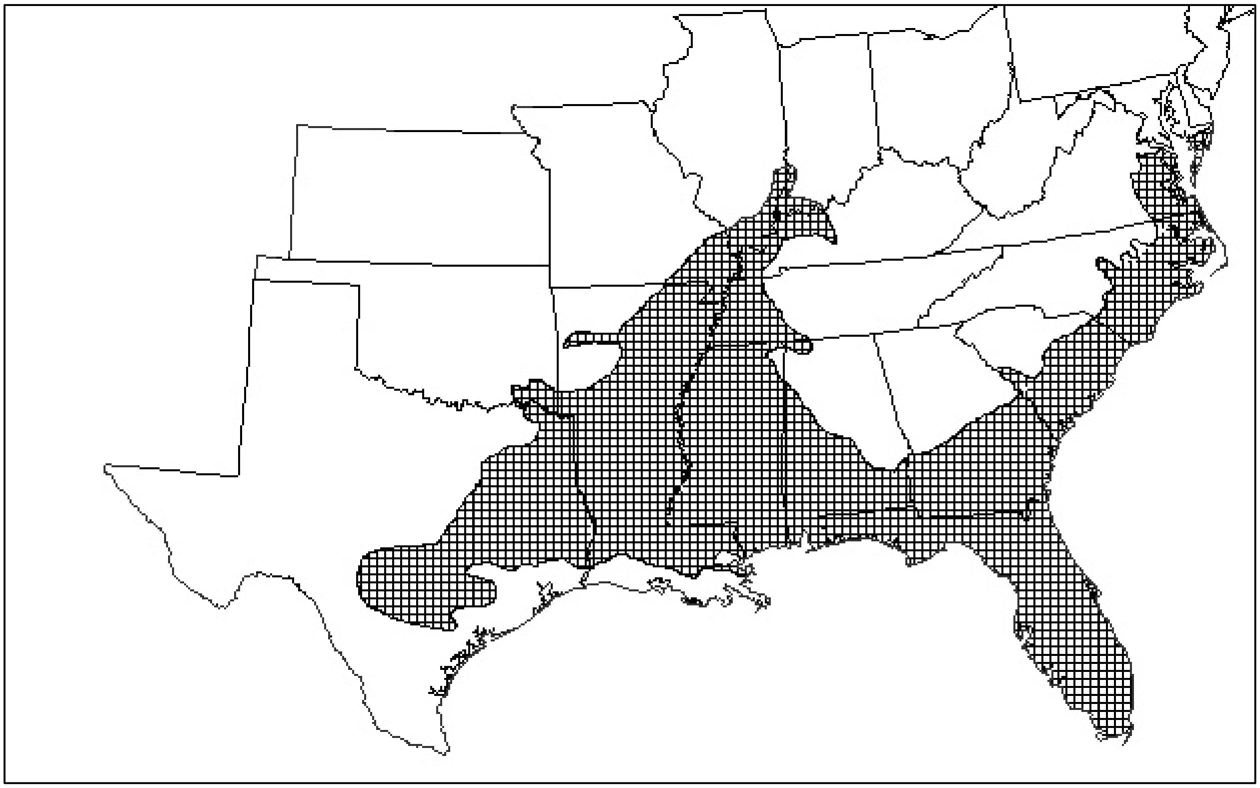


Figure 2. Distribution of bottomland hardwoods with bald cypress in the southeastern United States (adapted from Mitsch and Gosselink 1993, Figure 13-1).

OBJECTIVES

The St. Louis District project objectives pertaining to cypress/tupelo forests were to restore natural occurring cypress/tupelo habitat to provide adequate seed dispersal, seed germination, seedling survival, and tree growth by:

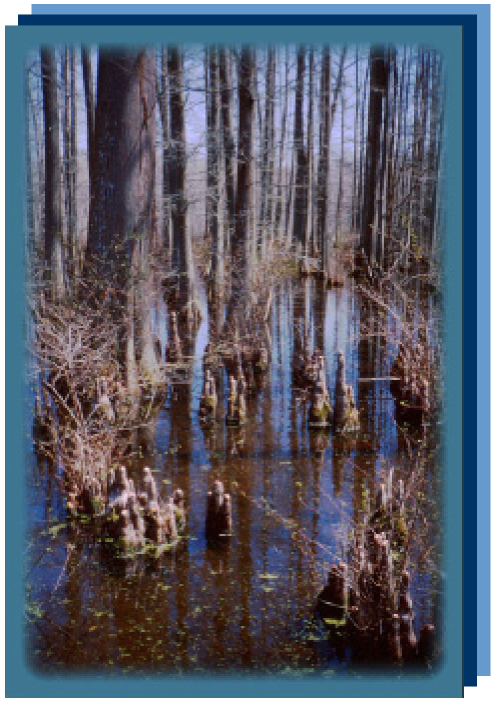
a) controlling water flows with the following potential measures:
   1) Big Creek flow control structure
   2) Cypress Creek diversion to the old channel
   3) Forest management plan
   4) Water control structure through Cache River levee near Karnak
b) controlling water levels with additional potential measures:
   1) Drop structure
   2) Lower Cache River water control structure
   3) Site water control management plan
   4) Rock weirs, and
c) controlling nutrient flows with measures listed in item (a) above.

The model objectives are to describe the cypress/tupelo communities in the project area using variables that reflect environmental factors important for maintaining current stands and recruiting new individuals. Recruitment includes natural growth and sapling plantings. We assume that if conditions accommodate cypress, then companion plant species will be present as well.

Model variables are written for the design of the project, i.e., formulating alternatives in a more specific way. Optimum and marginal or unacceptable thresholds could/should serve as standards and bounds for design.

NATURAL HISTORY

Description



The Association Summary from Nature Serve (2000) is as follows: "This type represents bald-cypress - water tupelo swamp forests found in the Mississippi River Alluvial Plain and adjacent areas of the Gulf Coastal Plain of the southern United States, apparently extending northeast to the Interior Low Plateau. Stands are characterized by the presence of shallow standing water all or most of the year. The vegetation contains mixed dominants of *Taxodium distichum* and *Nyssa aquatica*, with *Taxodium* most often emergent in the overstory above shorter individuals of *Nyssa aquatica*. In some instances *Carya aquatica* and (rarely) *Quercus lyrata* may also be present. Dominant trees exhibit tall, straight growth and swelled buttresses. The subcanopy is sparse, consisting primarily of *Forestiera acuminata*, *Cephalanthus occidentalis*, and *Planera aquatica*. Shrubs may include *Cephalanthus occidentalis* and *Itea virginica* with a variety of other species, such as *Acer rubrum var. drummondii*, *Acer negundo*, *Cornus amomum ssp. obliqua*, *Fraxinus pennsylvanica*, *Ilex decidua*, and *Liquidambar styraciflua*, mostly occurring around the slough margins. Woody vines are uncommon but may include *Ampelopsis arborea* and *Berchemia scandens*. The herbaceous layer is also very sparse, being restricted to rotting logs, buttresses of trees, and small mounds and ridges which remain dry most of the growing season."

Water levels during the year in southern Illinois swamps are highly varied (Voigt and Mohlenbrock 1964). The water regime in Heron Pond includes low water levels all year (less than one foot) with a distinct pulse of high water (more 3-6 feet) in February and March (Dorge et al. 1984, Mitsch et al. 1979).

An obvious feature of the bald cypress community is the presence of knees, which are woody extensions of the root system. Knees are thought to function in gas exchange, perhaps to aerate the stored carbohydrates.

Stand Composition

The two areas of greatest concern are the Lower Cache River Swamp and Heron Pond-Little Black Slough. For this model, they will serve as representatives of the cypress/tupelo communities in Alexander and Pulaski Counties. Site descriptions are largely taken from USAE St. Louis District (1992).

The Lower Cache River Swamp is a 2700-acre wetland consisting of a swampy flood plain forest and open swamp. It is dominated by cypress and tupelo trees with varying amounts of buttonbush (*Cephalanthus occidentalis*) shrub thickets. It contains unusually old and large trees. This tract of cypress/tupelo is at the northern edge of its range. In Buttonland Swamp of the Lower Cache River, the alluvial wetland consists of a braided stream channel (Cache River Drainage Commission 1905) which

serves as a floodwater storage reservoir. In cross-section, the basin varies widely from the channel to the edge of the basin, with shallow areas near the channel and riddled with point bars throughout (Taylor unpublished). The Lower Cache River Swamp provides habitat for 23 state endangered and/or threatened species.

The Heron Pond-Little Black Slough comprises 6700 acres. Heron Pond is a dense cypress forest east of the Mississippi River. Little Black Slough is primeval tupelo and cypress swamp with rich floodplain forests, upland woods, and small patches of limestone prairie glades. It is dominated by tupelo with scattered stands of cypress. In the open areas are Virginia willow (*Itea virginica*), swamp rose (*Rosa palustris*), and buttonbush shrubs. The swamp border and low floodplain includes Drummond's red maple (*Acer rubrum drummondii*), red elm (*Ulmus rubra*), pumpkin ash (*Fraxinus tomentosa*), overcup (*Quercus lyrata*), and pin (*Quercus palustris*) oaks. The hilly areas include tulip trees (*Liriodendron tulipifera*), sweetgum (*Liquidambar styraciflua*), spicebush (*Lindera benzoin*), and oaks. Poison ivy (*Rhus radicans*) is a common understory species. This area provides habitat for 14 state endangered and/or threatened species.

Water Regime

There is conflicting literature on the water regime charcteristics appropriate for cypress/tupelo communities. Refer to Table 1 for a summary of findings.

Duration of flooding and water depth affect cypress and other bottomland species, acting either independently or interactively. Depth and duration of flooding are correlated to signs of water stress in cypress (Bacchus 1992, Harms et al. 1980). Variation in duration and/or depth is included in forming this model because of stronger recognition in recent years of the importance of disturbance and pattern in sustaining ecological processes.

Table 1. Summary of literature on water duration, depth, variation, and quality	
DURATION	
Bacchus 1992	• Depth, duration and season of flooding all contribute to adverse impacts of cypress - resulting in growth reduction transpiration alterations, root death and even tree mortality. • Saplings are more tolerant to abnormal flooding than mature trees.
Broadfoot and Williston 1973	• Vigorous dominant hardwoods of many species benefit from flooding during the dormant season. • Species that leaf out late most likely will survive a spring flood even if water remains through July. • Many hardwood seedlings can survive extended flooding during dormant season and brief flooding in growing season. Most are killed back to ground if flooded more than 2 weeks after leafing out. If roots survive, they may resprout after floodwaters leave. • Even hardwoods native to the area may succumb to prolonged flooding in depressions where water remains throughout the growing season. • Length of time a tree can survive flooding varies greatly with local conditions.
Demaree (1932) in Klimas 1982	• Reproduction of cypress and tupelo require occasional drying of soil surface followed by a year without seedling submergence otherwise they cannot reproduce.
Gill 1970	• Duration of flooding is only critical when it occurs in the growing season. • Even the most flood-tolerant species generally need to be unflooded for at least 55-60% of the growing season. Year-round root inundation can be tolerated in isolated years.
Harms et al. 1980	• Prolonged flood impacts tupelo by causing high concentrations of carbon dioxide resulting in growth restrictions or death.
Hook 1984	• Deep flooding is tolerated, but mortality may increase after 15-25 years with sudden and sustained deep flooding.
Johnson 1973	• Low water for the balance of the first spring and summer is essential. Seedlings cannot tolerate more than 2-3 weeks of submergence, thus low water.
Klimas, Martin, and Teaford 1981	• Cypress/tupelo are classed as very tolerant to flooding and may tolerate deep, prolonged flooding for more than 1 year.
Pell 1982	• Cypress/tupelos are associated with very low, poorly drained flats, deep sloughs, and swamps; thus, they can withstand nearly permanent inundation.

(Continued)

Table 1 (Continued)

Young et al. 1995	• Growth surge of short duration followed by long-term depression in growth observed in bald cypress that was permanently flooded. • With permanent flooding, tree survival can be affected by tree size, soil fertility, water movement, and depth.
DEPTH	
Hook 1984	• In winter, trees can sustain more water than in summer months.
Mitsch et al. 1979	• Reported decline in growth following deep flooding for bald cypress in Illinois. • Data suggest higher water levels lead to significant decline in cypress growth in Heron Pond, southern Illinois.
Voigt and Mohlenbrock 1964	• In southern Illinois deep swamps, the water levels vary from several feet in the winter, to 10 in. or less in the summer.
Young et al. 1995	• Modification of natural hydrologic regimes can result in alterations of flood frequency, depth, and duration. • Mature bald cypress trees have tolerated flood depth of 3 yd or more however, they may become unable to regenerate in standing water and eventually die.
VARIATION	
Conner and Day 1992	• Drought conditions in 1981 allowed the sites to dry out for the first time in many years, thus improving growing conditions.
Johnson 1973	• Seedlings become established when water recedes to below ground level during germination periods. After first season, young trees can survive inundation during much of winter, provided they have not leafed out.
Shelford 1954	• Two-year drawdown period is necessary for cypress seedlings to establish.

(Continued)

Table 1 (Concluded)	
WATER QUALITY	
Conner and Day 1992	• Litterfall values are used as indicator of minimum levels of net primary productivity in forests. Continuous flooding by stagnant water may render some nutrients unavailable and thus lower productivity of forested wetlands. • Flooding with stagnant water decreases rate of height growth, needle expansion, and dry weight increments of needles of bald cypress. Dry weight of tupelo in stagnant water was 5 times less than seedling growing in moving water.
Harms 1973	• Growth and dry weight of swamp and water tupelos were poorest in regime with stagnant water, high carbon dioxide concentrations, and low oxygen concentrations.
Hook et al. 1970	• Growth in height and weight of water and swamp tupelos were correlated positively with high oxygen concentrations and negatively with high carbon dioxide concentrations. • The type of flooding is critical to growth. All of stagnant water treatments were more detrimental to growth than any of the moving water treatments. • Seedlings should deterioration of initial root system and lack of new root development in stagnant water versus abundant root system in moving water.
Mitsch et al. 1979	• Rivers overflow their banks and deposit sediments in the swamps. Sediments are high in phosphorous, a limiting nutrient, for cypress growth.

Duration

Cypress and tupelo are very tolerant to flooding and may tolerate deep prolonged flooding for more than one year (Klimas et al. 1981). According to Pell (1982), the established community can withstand nearly permanent inundation, but exposed, saturated soils are necessary for bald cypress seed germination and establishment. However, persistent flooding reduces diameter growth, alters transpiration, and may cause root death and tree mortality (Bacchus 1992, Young et al. 1995). Gill (1970) generalized that year-round root inundation can be tolerated only in isolated years and that even cypress and tupelo must be unflooded at least 55-60% of the growing season to survive indefinitely.

Variability appears to exist among cypress life stages relative to flooding. For example, cypress saplings are more tolerant to sudden abnormal flooding than mature trees (Bacchus 1992). Seedlings have been reported to die after two to three weeks of complete submergence (Demaree 1932 in Klimas 1982, Johnson 1973). Adults show increased mortality after 15-25 years of flooding (defined as soil saturation or inundation during the growing season) (Hook 1984).

Depth

The relative effects of water depth, flood duration, and tree size and maturity are difficult to determine. Young et al. (1995) attributed conflicting literature on tree response to long-term flooding to differing data collection and analysis techniques and study length. Data on flooding depth, especially, must be interpolated. Data on cypress mortality from Harms et al. (1980) in Florida, four years after impoundment, are given in Table 2. The data show no differences from controls in water depth classes less than 32 in, but increasing mortality with greater depth. Other species (ash, maples) showed increases in mortality in the 20-in class.

Table 2. Cypress mortality and water depth in Florida (Harms et al. 1980)

Average water depth (in)	Sample size	Mortality (%)
11*	220	4
9*	25	0
8	106	2
20	62	0
26	79	3
32	230	16
42	205	13
47	25	50
** Control sites*		

In deep swamps in southern Illinois, the water levels vary from several feet in the winter to an inch or less in the summer (Voigt and Mohlenbrock 1964). In the winter months, trees can sustain more water than in the summer months (Hook 1984). Species adapted to regular deep flooding tend to leaf out later than other species and thus are better able to survive an early growing season flood (Broadfoot and Williston 1973). Sudden (road construction in 1973) and prolonged deep flooding (increases of about

23 in) in South Carolina resulted in increased cypress growth for 3-5 years followed by a 16-year decrease (Young et al. 1995). There is growing literature that suggests that swamps downstream of dams do not benefit from growing season releases.

Productivity of most species in Buttonland Swamp declined from 1992-1998 (Middleton and McKee submitted). This was seen especially on the three transects that received the most flooding. The highest productivity levels for all species except bald cypress were at sites with a mean minimum water depth in summer of 0.8 in or less; cypress productivity was highest at a mean minimum depth of 2 in.

Seedlings are likely to be more sensitive to water depth than mature trees. There is an approximate 10-20-in growth rate of cypress seedlings during a growing season (Middleton, personal observation), requiring water depths less than that after establishment. In an experimental situation, total immersion killed seedlings in two weeks (Demaree 1932 *in* Klimas 1982).

Variation

Successful cypress and tupelo reproduction requires occasional drying of the soil or saturated but not flooded conditions during the germination period and the first growing season (March-October), after which the seedlings can survive winter flooding if they have yet to leaf out (Johnson 1973, Middleton 1999). Shelford (1954) suggested a 2-year drawdown period for cypress seedlings to establish (Middleton accepted). Increase in growth is related to periodic drying of the substrate (Conner and Day 1992).

Water Quality and Flow

Flowing water contains increased oxygen levels to sustain the trees. Hook et al. (1970) and Harms (1973) both reported that the growth of swamp and water tupelo seedlings was depressed by stagnant floodwater. Conner and Day (1992) reported that litterfall, an indicator of productivity, was often higher in flowing water than in stagnant. Alterations in flooding disrupt nutrient exchange between forested floodplain and adjacent ecosystems. Cypress growth may depend on phosphorus subsidies resulting from overflow flooding (Mitsch et al. 1979). Flowing water is also necessary for seed dispersal (Mitsch and Gosselink 2000).

Soil and Sediments

Cypress and tupelo are generally found in southern bottomland hardwood forests with intermittently exposed, saturated soils (Klimas 1982). Wet saturated but oxidated (aerobic) and non-acidic soils are considered optimal (Conner and Day 1992). Tree mortality is induced by raised water tables or increased flooding resulting in oxygen depletion in flooded soil within the root zone. Root zones for most bottomland hardwood species growing in heavy soils and occasionally flooded are restricted to the upper two feet of the soil. Lighter or better drained soils may have roots three to four feet deep (Klimas 1982). Root death and the inability to form new roots are the fundamental sources of plant injury from soil saturation (Klimas 1982). When the soil is saturated during the growing season, i.e., the water table reaches the root zone, trees are more likely to die. Cypress and tupelo trees should not be affected immediately by minor increases in flood depths or duration, but growth may be reduced or trees may die if large or abnormal flood depths or durations occur (Klimas 1982).

Roots undergo anaerobic respiration. They tolerate high concentrations of ethanol, carbon dioxide, methane, hydrogen sulfide, and other reduced compounds in reduced soils (Hook 1984). As soil temperature increases, oxygen becomes less soluble in warm water and microbial activity increases and lowers soil aeration (Hook 1984). Death of cypress seedlings was "hastened" by warm water (and assumed low oxygen levels) (Demaree 1932 in Klimas 1982). Increasingly reduced soils during prolonged flooding cause build-up of waste products resulting in decreased vigor, nutrient deficiencies, and sometimes adventitious roots (Bacchus 1992).

Broadfoot and Williston (1973) described cypress as able to withstand moderate siltation, although the depth of siltation was not reported. Seedlings are more susceptible to sedimentation than mature trees (Broadfoot and Williston 1973). Even low amounts of sedimentation (< 0.12 in) almost completely suppress seed germination (Reddy and Singh 1992, Fessel and Middleton unpublished). It is assumed, however, that "normal" sedimentation will not entirely negate seed germination because a sufficient amount of new seeds will fall on top of sediments or on surfaces not covered with sediment. In southern Illinois, the Cypress Creek channel banks are eroding and supplying sediments (Sengupta 1995, Flanagan and Sengupta 1999).

THE MODEL

Model variables are organized into two components. The first is maintenance of existing conditions, i.e., continued viability of trees. The second is recruitment of new individuals, described by seed production, seed viability and germination, and seedling establishment. Variables are introduced in this section and their logic explained. The form of the variables and accompanying numerical classes are found in Table 3 in the next section, “Variable Summary.”

An optimum model score will result when mature trees are viable and productive, and when some of the seeds they produce result in additions to the gene pool. For these conditions to occur, shallow flood waters must move through the site during part of the growing season but must not remain.

Selection of variables and assignment of their Suitability Index (SI) scores came from a literature review complemented by field experience. Conflicting results reported in the literature were resolved by best professional judgement. We will appreciate user feedback on the content and utility of the model.

Maintenance of Existing Conditions

Standing water that is too high for too long reduces productivity and ultimately kills trees because of a reduction in aeration. Water conditions for maintaining mature trees are described by three independently-written variables.

V1. Hydrologic regime

Hydrologic Regime refers to water coverage and duration during the growing season over years. Presence of water during the growing season is necessary to eliminate competition from other plant species and thus maintain species composition. Cypress/tupelo can tolerate permanently flooded conditions, but require periodic exposure for reproduction. Without reproduction, the area would eventually convert to open water habitat (Xiao et al. accepted). Therefore, intermittently exposed conditions are optimal and their SI is 1.0 as described in the Variable Summary. Definitions for regime classes are from Cowardin et al. (1979) with some modification from Klimas (1982). Growing season for Alexander and Pulaski Counties is defined as March through October.

V2. Hydrologic connections

Hydrologic connections determine the degree of stagnation of water. If water is flowing, trees can tolerate deeper water and maintain viability during a growing season. Optimal conditions are the natural unaltered hydrologic connections that maintain seasonal flooding, allow flushing, and maintain appropriate depth and duration of flooding which influences species composition. Alterations from spring or summer releases and beaver impoundments may alter depth and/or timing. Three categories are defined, but users can define and insert others if more intermediate conditions are present or anticipated (Variable Summary).

V3. Water depth in the growing season

Water depths greater than 20 in during the growing season are assumed to cause stress and ultimate mortality in trees. Water depths of 2 in are assumed optimum in southern Illinois. A lack of standing water allows competition from other species. Assuming that cypress knees play a role in aeration, three categories are defined (Variable Summary).

Calculation of the Maintenance Index (MI)

$$\text{MAINTENANCE INDEX (MI)} = (V1 + V2 + V3)/3 \qquad \textbf{(1)}$$

The arithmetic mean function is used because a high SI for one variable can partly compensate for a low SI score for another. Overall suitability is greater than zero as long as the SI for one of the variables is greater than zero.

Recruitment of New Individuals

Limits on recruitment may apply to seeds and/or seedlings. Seed production decreases as productivity of mature trees decreases; seeds remain viable a short time; and seeds cannot germinate, establish, or maintain themselves in water until they are >10-in tall. Water conditions for establishment of cypress are described by two variables, and a third variable on sedimentation may be applicable. If recruitment is occurring or the potential for recruitment exists, then all variables are necessary.

V4. Productivity of mature trees

Seed production is an expression of productivity which decreases as mature trees are exposed to suboptimal water conditions. The Maintenance Index derived from V1-V3 will serve as V4.

V5. Time or conditions without standing water

Cypress seeds cannot germinate or grow when covered by standing water. This variable describes two circumstances that may exist and thus provide a temporary absence of standing water. The user should select one of the two, depending on the site.

V5a. One circumstance is the absence of standing water, with preference given to drier conditions in the first part of the growing season to (1) catch the period of greater seed viability and (2) increase the chances of a seedling outgrowing the winter flood waters. Optimum conditions are two 9-month periods with no standing water for two growing seasons occurring at a frequency of 5 to 20 years. If water is absent for longer than 18 months or the frequency is <5 years, the SI decreases because competition from other species increases (Variable Summary).

V5b. A second circumstance is the amount of topographic variation. If sufficient variation exists, higher points in the landscape can partially compensate for continuous flooding by providing substrate that is wet but not covered with water. Adequate variation may come from the presence of point bars, channel banks, swales, old stumps, log mounds, and other such features. This condition is more subjective than the others and will require comparative observations at different sites, e.g., presence of cohorts from a previous period of recruitment. Four categories are described in the Variable Summary.

Calculation of the Recruitment Index (RI)

RECRUITMENT INDEX (RI) = the minimum of (V4) or (V5) **(2)**

Each variable is necessary for recruitment, and each can be a limiting factor that reduces recruitment. V6 below may also apply.

Sedimentation Adjustment Factor

Sedimentation refers to patterns of sediment additions to the cypress forest. Selected conditions of sedimentation may alter the RI. It is assumed that "normal" sedimentation will not completely negate seed germination because a sufficient amount of new seeds will fall on top of sediments or on surfaces not covered by sediments to replenish the seed bank that is covered. However, if sedimentation occurs at a faster rate or at times of year that are outside the normal pattern, then a negative effect may be seen. A lack of data on this aspect does not allow construction of a scaled variable. Instead, the users of the model will examine conditions in the watershed, e.g., amount of bank erosion in a channel that feeds a cypress forest, and determine if the recruitment index should be adjusted downward as described in the three situations below.

a. If sedimentation patterns are "normal" in amount and timing AND this pattern has allowed seedlings to germinate in previous years, then make no change in the RI.

b. If sedimentation patterns are "normal" in amount and timing AND seedlings have NOT germinated in previous years, then subtract 20% from the RI unless another reason for lack of germination is given.

c. If sedimentation rates have increased from previous years or if the pattern is expected to change, then subtract 25-50% from the RI, depending on the severity of the change.

HABITAT SUITABILITY INDEX (HSI) = the minimum of MI or RI **(3)**

Each factor, maintenance of adults and recruitment of individuals, is necessary for sustaining the cypress/tupelo community over a long time. Each can be a limiting factor in reaching that objective.

High, medium, and low conditions and the model scores that result are shown in Appendix A. A full simulation of the model has not been run. The model has been applied by personnel in the St Louis District.

VARIABLE SUMMARY

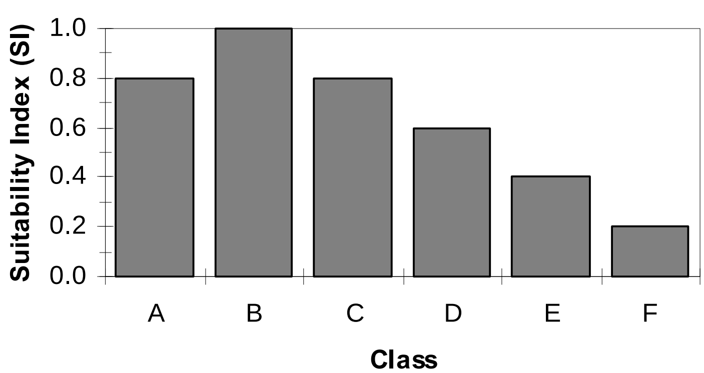
The variables are described in the text and summarized here. Each variable is presented in two forms. First is a table and second is a SI curve similar to HSI format.

Table 3. Variable summary

MAINTENANCE OF EXISTING CONDITIONS

V1. Hydrologic regime.

Class	Description	Suitability Index (0-1) (SI)
A = Permanently flooded	Water covers the land surface on a permanent basis throughout the year in all years.	0.8
B = Intermittently exposed	Surface water is present on a nearly permanent basis throughout the year except during extreme drought.	1.0
C = Semipermanently flooded	Surface water occurs with detectable intermittent periodicity throughout the growing season (exceeding 25% of the growing season). When surface water is absent, the water table is often near the land surface.	0.8
D = Seasonally flooded	Surface water occurs with detectable intermittent periodicity for 1-2 months during the growing season, but is absent by the end of the season in most years (12.5% - 25% of the growing season).	0.6
E = Temporarily flooded	Surface water occurs with detectable intermittent periodicity for short periods during the growing season ($\leq$ 1 month) (2% - 12.5% of the growing season).	0.4
F = Intermittently flooded	The substrate is usually exposed, but surface water is present for variable periods without detectable seasonal periodicity.	0.2

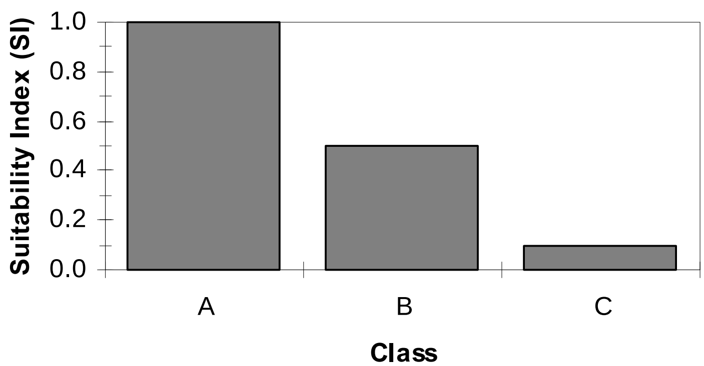


(Continued)

Table 3 (Continued)

V2. Hydrologic connections.

Class	Description	Suitability Index (0-1) (SI)
A = Unaltered	Existing unaltered conditions that are free-flowing; water levels on site respond in a timely fashion.	1.0
B = Altered timing	Water levels are still achieved as in class A, but the timing is altered, generally to longer periods of flooding.	0.5
C = Altered depth and timing	Water levels and timing are completely altered.	0.1

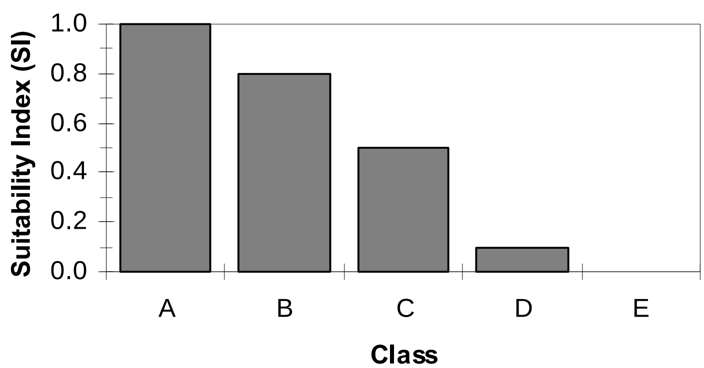


(Continued)

Table 3 (Continued)

V3. Water depth in the growing season.

Class	Description	Suitability Index (0-1) (SI)
A	Roots covered with water, with a mean minimum depth of 2 in knees exposed.	1.0
B	Roots covered with water with a mean minimum in depth of <2 in	0.8
C	Roots and knees covered but water 2 - 20 in deep.	0.5
D	Roots and knees covered and water > 20-in deep.	0.1
E	Saturated soil, but no standing water or completely dry.	0.0



(Continued)

Table 3 (Continued)

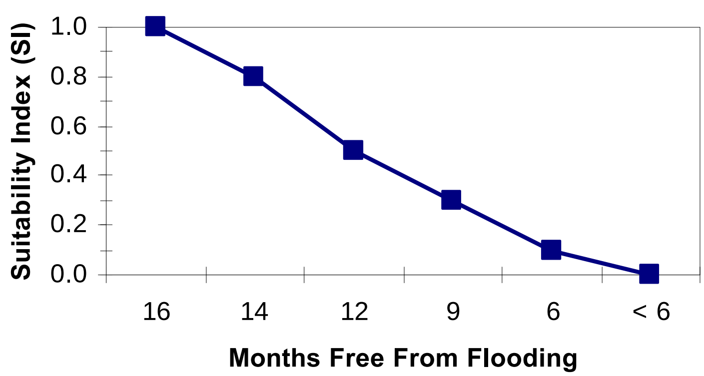
RECRUITMENT OF NEW INDIVIDUALS (RI)

V4. Productivity of mature trees. The Maintenance Index derived from V1-V3 will serve as V4.

V5. Time or conditions without standing water. The user should select one of two circumstances. Shown in V5a or V5b:

V5a. Number of months with drawdown during two successive growing seasons (March - October).

Class	Description	Suitability Index (0-1) (SI)
A	16 months over two growing seasons	1.0
B	14 months over two growing seasons	0.8
C	12 months over two growing seasons	0.5
D	9 months over two growing seasons	0.3
E	6 months over two growing seasons	0.1
F	< 6 months over two growing seasons	0.0

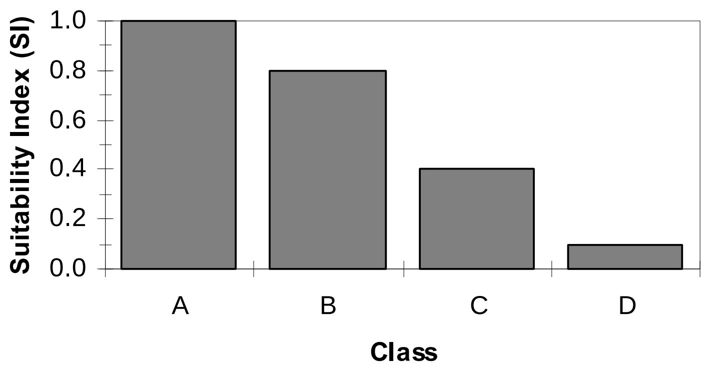


(Continued)

Table 3 (Concluded)

V5b. The amount of topographic variation.

Class	Description	Suitability Index (0-1) (SI)
A = Variation and recruitment present	Adequate topographic variation exists and recruitment occurred at least once in the last 5 years.	1.0
B = Variation only	Topographic variation exists, but there is no evidence of recent recruitment.	0.8
C = Minimal variation present	Topographic variation is present but not of sufficient height or degree to allow an absence of standing water most years.	0.4
D = Variation absent	Topographic variation is absent.	0.1



Sedimentation adjustment factor. (The below may also apply to modify the RI.)

a. If sedimentation patterns are "normal" in amount and timing AND this pattern has allowed seedlings to germinate in previous years, then make no change in the RI.

b. If sedimentation patterns are "normal" in amount and timing AND seedlings have NOT germinated in previous years, then reduce the RI by 20% unless another reason for lack of germination is given.

c. If sedimentation rates have increased from previous years or if the pattern is expected to change, then reduce the RI by 25-50%, depending on the severity of the change.

MAINTENANCE INDEX (MI) = (V1 + V2 + V3)/3 = V4 **(4)**

RECRUITMENT INDEX (RI) = the minimum of (V4) or (V5) **(5)**

HABITAT SUITABILITY INDEX (HSI) = The minimum of MI or RI **(6)**

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APPENDIX A

Example Runs of Model Scores

Case	MI = V1 + V2 + V3 / 3				Minimum of RI = V4 or V5				Minimum of MI or RI
	V1	V2	V3	MI	V4	V5	RI	No Sediment Adjustment to RI	HSI
Optimum	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Worst	0.20	0.10	0.00	0.10	0.10	0.00	0.00	0.00	0.00
High 1	0.80	1.00	1.00	0.93	0.93	0.80	0.80	0.80	0.80
High 2	0.80	1.00	0.50	0.77	0.77	0.80	0.77	0.77	0.77
Med 1	0.60	0.50	0.50	0.53	0.53	0.50	0.50	0.50	0.50
Med 2	0.40	0.50	0.50	0.47	0.47	0.40	0.40	0.40	0.40
Low 1	0.20	0.50	0.10	0.27	0.27	0.10	0.10	0.10	0.10
Low 2	0.40	0.10	0.10	0.20	0.20	0.05	0.05	0.05	0.05

Case	MI = V1 + V2 + V3 / 3				Minimum of RI = V4 or V5				Minimum of MI or RI
	V1	V2	V3	MI	V4	V5	RI	Sediment Adjustment to RI (- 20%)	HSI
Optimum	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.80	0.80
Worst	0.20	0.10	0.00	0.10	0.10	0.00	0.00	0.00	0.00
High 1	0.80	1.00	1.00	0.93	0.93	0.80	0.80	0.64	0.64
High 2	0.80	1.00	0.50	0.77	0.77	0.80	0.77	0.61	0.61
Med 1	0.60	0.50	0.50	0.53	0.53	0.50	0.50	0.40	0.40
Med 2	0.40	0.50	0.50	0.47	0.47	0.40	0.40	0.32	0.32
Low 1	0.20	0.50	0.10	0.27	0.27	0.10	0.10	0.08	0.08
Low 2	0.40	0.10	0.10	0.20	0.20	0.05	0.05	0.04	0.04

Case	MI = V1 + V2 + V3 / 3				Minimum of RI = V4 or V5				Minimum of MI or RI
	V1	V2	V3	MI	V4	V5	RI	Sediment Adjustment to RI (-50%)	HSI
Optimum	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.50	0.50
Worst	0.20	0.10	0.00	0.10	0.10	0.00	0.00	0.00	0.00
High 1	0.80	1.00	1.00	0.93	0.93	0.80	0.80	0.40	0.40
High 2	0.80	1.00	0.50	0.77	0.77	0.80	0.77	0.38	0.38
Med 1	0.60	0.50	0.50	0.53	0.53	0.50	0.50	0.25	0.25
Med 2	0.40	0.50	0.50	0.47	0.47	0.40	0.40	0.20	0.20
Low 1	0.20	0.50	0.10	0.27	0.27	0.10	0.10	0.05	0.05
Low 2	0.40	0.10	0.10	0.20	0.20	0.05	0.05	0.03	0.03

APPENDIX B

Template for Calculating Model Scores

	MI = V1 + V2 + V3 / 3				Minimum of RI = V4 or V5					Minimum of MI or RI
Site	V1	V2	V3	MI	V4	V5	RI	Sediment Adjustment		HSI
								Factor	Adjusted RI	
1				0.00	0.00		0.00		0.00	0.00
2				0.00	0.00		0.00		0.00	0.00
3				0.00	0.00		0.00		0.00	0.00
4				0.00	0.00		0.00		0.00	0.00
5				0.00	0.00		0.00		0.00	0.00
6				0.00	0.00		0.00		0.00	0.00
7				0.00	0.00		0.00		0.00	0.00
8				0.00	0.00		0.00		0.00	0.00
9				0.00	0.00		0.00		0.00	0.00
10				0.00	0.00		0.00		0.00	0.00