Appendix C

Final List of Evaluation Species

Including: Habitat Definitions and Modeling Criteria
Model Modifications, Descriptions, and Citations

DEFINITION OF HABITATS IDENTIFIED FOR USE IN THE UMR-IWWS NAVIGATION STUDY HEP

Backwater **-** An area of water beyond the banks of the main channel that is typically connected during normal or high flows.

Side Channel **-** Includes all departures from the main channel in which there is inflow and outflow during normal river stages.

Backwater Lake **-** A water body only connected to the main channel during flood stage. Depth at low water is generally > 2m at the deepest part of the basin.

Bottomland Forest **-** Floodplain forest regularly inundated with floodwater which results in a unique species composition. Depending on hydrology, species composition varies and may include mast producing trees.

Non-forested Wetland **-** A moist soil area periodically flooded for long periods, thus devoid of trees. Can be subject to drying. Characterized by annual grasses and can include emergent and submergent wetlands with water generally < 1m deep.

Main Channel **-** The portion of the river where commercial vessels operate and is defined by river regulating structures. Minimum depth is 9 feet and substrate varies from silt to coarse or rocky material.

Main Channel Border **-** The zone between the main channel and the river bank. Wing dikes would be found here and substrates are typically sand or silt.

Tailwater **-** The main channel, main channel border and area directly below the navigation dam. The boundary is one-half mile below the dam.

Cutbank **-** An eroded shoreline with vertical or nearly vertical face, possibly with overhanging vegetation or root wads.

Sandbar **-** A slightly-sloped area within the main or side channel with sand substrate. It can be along a shoreline or an island and either natural or created by dredge material placement.

Mudflat **-** A slightly-sloped area within the main or side channel with mud substrate. Along a shoreline or island.

References:

Rasmussen, J., ed. 1979. A compendium of fishery information on the Upper Mississippi River. UMRCC.

Cowardin, L.M., et. al. 1979. Classification of wetlands and deepwater habitats of the United States. U.S. Fish and Wildlife Service.

Wilcox, D.B. 1993. An aquatic habitat classification system for the Upper Mississippi River System. U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wis. Publ. EMTC 93-T003.

Final List of Evaluation Species

Recommendations and considerations taken into account during the final selection process are included.

BOTTOMLAND HARDWOOD FOREST

pileated woodpecker
hairy woodpecker
gray squirrel
prothonotary warbler
wood duck
wild turkey
Western chorus frog

Considerations:

Hairy woodpecker. The Missouri Department of Conservation (MDOC) suggested removing this species from the species list. The HAT decided to retain this species to pick up medium-sized trees and snags, those between the sizes identified in the Pileated woodpecker and Prothonotary warbler models.

Gray squirrel. The MDOC suggested adding this species to the species list. The addition of this species will provide more complete coverage of mast tree diversity, which is an important aspect of bottomland hardwood forests. The HAT decided to add this species to the list.

Eastern gray treefrog. The MDOC suggested adding this species to the species list. The Illinois Department of Natural Resources (ILDNR) stated that the chorus frog would be an appropriate species to model for bottomland hardwood forest. The HAT believes a potential gray treefrog model may focus on smaller trees (covered by the prothonotary warbler model), shrubs (covered by the wild turkey model) and permanence of water. The intent for adding a herp. to the species list is to pick up ephemeral pool habitat. Therefore, we decided that *Western chorus frog* is a more appropriate addition to the list because its water requirements are more seasonal than those of gray treefrog.

Great-crested flycatcher. The MDOC suggested adding this species to the species list. The HAT believes a potential great-crested flycatcher model may focus on tree canopy cover and the presence of snags. The flycatcher's canopy cover preference should be covered by the prothonotary warbler model and its cavity needs covered by the hairy woodpecker model. Therefore, we decided not to add this species to the list.

Great blue heron. The MDOC suggested removing this species from the bottomland hardwood forest species list. The HAT decided to model it if a rookery is present. This will be accomplished by listing a rookery habitat type with great blue heron as the evaluation species.

Red-shouldered hawk. The HAT believes that the variables which may be included in a potential red-shouldered hawk model will be covered by other species on the list. Nest trees will be covered by the pileated woodpecker model. Canopy cover preference is expected to be covered by the prothonotary warbler model. The wild turkey model covers components which would be characteristic of foraging areas, as well as the wood duck model covering wetland interspersion. The prothonotary warbler model covers presence of water. Therefore, we decided to remove this species from the list.

ROOKERY

great blue heron

Considerations:

Great blue heron. The MDOC suggested removing this species from the bottomland hardwood forest list. The HAT decided to account for its particular habitat type by modeling great blue heron if a rookery is present.

MAIN CHANNEL / MAIN CHANNEL BORDER

lake sturgeon
channel catfish
paddlefish
sauger
walleye
emerald shiner

Considerations:

Skipjack herring. The U.S. Fish & Wildlife Service (USFWS) suggested removing this species from the species list in anticipation of its migration requirements being addressed by other species on the list. The ILDNR and USFWS are skeptical that a model can be developed because of the paucity of information on the species. Another biologist expressed the same concern at the Quincy meeting. The HAT also believes that the lack of information will make the development of a reliable model very difficult. In contrast to the opinion expressed by the ILDNR, the HAT is hopeful that its migration requirements will be addressed to some extent by the other two migratory species on the list. For these reasons, the HAT decided to remove skipjack herring from the list.

NATIVE MUSSELS

Considerations:

Existing information on mussel beds and occurrences will form the basis of the site-specific impact evaluations for native mussels. At this point, evaluations will be qualitative and will not involve surveys or HEP modeling.

SANDBAR

Considerations:

Because of the homogeneous and dynamic nature of sandbar habitat, the HAT decided to calculate the area of sandbar habitat lost or gained, rather than using a species model to make this determination. By definition, sandbar habitat will be limited to the sandy area, and the fringe vegetation will be picked up in the evaluations of other habitats types.

NON-FORESTED WETLAND

mallard	**sora**	**Western chorus frog**
muskrat		

Considerations:

Sora. The MDOC suggested adding this species to the species list. The HAT believes that modeling sora will pick up sedge and grass-like emergent vegetation. We decided to add this species to the list.

Muskrat. The MDOC suggested adding this species to the non-forested wetland list. Modeling this species will pick up a variety of variables for the permanent wetlands in this category, such as presence of bulrushes and cattails, permanence of water and other vegetation and water characteristics. The HAT decided to add this species to the list.

Least bittern. The MDOC suggested adding this species to the species list. The HAT believes a potential least bittern model would contain habitat requirements very similar to those in a potential sora model. Therefore, we decided not to add this species to the list.

Great blue heron. The MDOC suggested adding this species to the species list for non-forested wetland. Great blue heron is listed for rookery habitat and will be modeled when appropriate. When it is modeled, non-forested wetlands within three kilometers of the rookery will be picked up as forage areas. The HAT decided not to add this species to the non-forested wetland list.

Bullfrog. The MDOC suggested modeling this species under certain circumstances, instead of Western chorus frog. The HAT decided to use Western chorus frog in all instances.

CUTBANK

flathead catfish

Considerations:

No changes were made to this category.

MUDFLAT

Considerations:

Because of the homogeneous nature of mudflat habitat, the HAT decided to calculate the area of mudflat habitat lost or gained, rather than using a species model to make this determination. By definition, mudflat habitat will be limited to the muddy area, and the fringe vegetation will be picked up in evaluations of other habitats.

BACKWATER / BACKWATER LAKE

paddlefish	**largemouth bass**	**black crappie**
lesser scaup	**sora**	**bullfrog**
red-eared slider	**muskrat**	

Considerations:

Great blue heron. The MDOC suggested adding this species to the species list. Great blue heron is listed for rookery habitat and will be modeled when appropriate. When it is modeled, backwaters and backwater lakes within three kilometers of the rookery will be picked up as forage areas. The HAT decided not to add this species to the list for backwater/ backwater lakes.

Sora. The MDOC suggested adding this species to the species list. The HAT believes that modeling sora will pick up sedge and grass-like emergent vegetation. We decided to add this species to the list.

Red-eared slider. The MDOC suggested adding this species to the species list. The USFWS suggested adding this species to the list and modifying its model to pick up woody debris and basking sites. The HAT decided to add this species to the list.

Eastern gray treefrog. The MDOC suggested adding this species to the species list for fishless areas. The HAT believes that the variables in a potential gray treefrog model will be covered by the models of other species, particularly by the bullfrog and muskrat models in non-forested areas and by the Western chorus frog, prothonotary warbler and wild turkey models in forested areas.

Marsh wren. The MDOC suggested removing this species from the species list. The HAT believes that its requirements will be covered by the sora and muskrat models. Therefore, we decided to remove it from the list.

Bluegill. There were originally three Centrarchids on the species list, and after closer scrutinization of the model variables for the three species the HAT decided to remove bluegill from the list. Over half its model variables were the same as those in the largemouth bass and/or black crappie models. The only discrepancies were in some of the temperature and velocity variables. The variation of the bluegill's variables were not deemed significant enough to warrant its retention on the species list.

Largemouth bass. Because of the removal of bluegill from the species list, it will be necessary to modify the largemouth bass model to include overwintering variables.

SIDE CHANNEL

channel catfish	**smallmouth buffalo**	**emerald shiner**
river otter	**beaver**	

Considerations:

Bullhead minnow. The USFWS advocated modeling emerald shiner, rather than bullhead minnow, as a representative minnow. Some biologists at the Quincy meeting stated that the emerald shiner inhabits side channels and would be a suitable minnow species for that habitat type. Therefore, the HAT decided to model emerald shiner.

False map turtle. The HAT believes that a potential map turtle model may focus on aquatic vegetation and water velocity. These requirements should be covered by the fish species in this category. We decided not to add this species to the list.

HSI MODELS

PILEATED WOODPECKER

Source of Model: Schroeder, R. L. 1982. Habitat suitability index models: Pileated woodpecker. U.S. Dept. Int. Fish Wildl. Serv. FWS/OBS-82/ 10.39. 15 pp.

Habitat Type: Bottomland Hardwood Forest

WILD TURKEY

Source of Model: Schroeder, R. L. 1985 Habitat suitability index models: Eastern wild turkey. U.S. Fish Wildl. Serv. Biol. Rep. 82(10.106). 33 pp.

Habitat Type: Bottomland Hardwood Forest

HAIRY WOODPECKER

Source of Model: Sousa, P. J. 1987. Habitat suitability index models: Hairy woodpecker. U.S. Fish Wildl. Serv. Biol. Rep. 82(10.146). 19 pp.

Habitat Type: Bottomland Hardwood Forest

WOOD DUCK

Source of Model: Sousa, P. J. and A. H. Farmer. 1983. Habitat suitability index models: Wood duck. U.S. Dept. Int., Fish Wildl. Serv. FWS/OBS-82/10.43. 27 pp.

Habitat Type: Bottomland Hardwood Forest

Modifications:

- **V1**: Based on information in the Illinois Department of Natural Resources' (ILDNR) publication of Wood Duck Investigations by Aaron Yetter, Stephen Havera and Christopher Hine (1995, Final Report W-118-R-1-2-3), Havera and Yetter (Illinois Natural History Survey; ILNHS) recommended changing the value for $P1_T$ from 0.18 to 0.303. This change was incorporated and 0.303 became the multiplier for V1.
- **V2**: Havera and Yetter stated that a value of 0.52 was rather high for $P2_T$, but agreed that as an optimum this value is suitable.
- **V3**: Havera and Yetter advocated a minimum value of 3, rather than 5, to receive a SI of 1.0. This change was adopted.
- **V5**: Havera and Yetter stated that the wood duck model is not applicable as a winter model. Therefore, this variable was eliminated from the model, and comments from other reviewers were not applicable.
- **V7**: Havera and Yetter questioned the minimum value of 20% for a SI of 1.0. They suggested adopting a value from 25-35% and it was decided to use 30%.

MALLARD

Source of Model: Allen, A. W. 1986. Habitat Suitability Index Models: Mallard (winter habitat, Lower Mississippi Valley). U.S. Fish Wildl. Serv. Biol. Rep. 82(10.132). 37 pp.

Habitat Type: Bottomland Hardwood Forest

Modifications:

- Dave Harper (ILDNR) recommended dropping mallard from the species list. In light of comments from other biologists on the desirability of using mallard as an evaluation species as well as specific recommendations on model modification, it was decided to retain the species for evaluation. However, the season of applicability was changed to 15 October - 31 December and 1 February - 1 April to coincide with comments made by Dale Humburg (Missouri Department of Conservation; MDOC), Harper, Havera and Yetter regarding the fact that mallards migrate through the study area but do not winter there. This change specifically affects **V3**, **V7** and **V11**.
- **V1** & **V3**: Havera and Yetter stated that mallards do not feed on rice or soybeans in the region and recommended removing those crops from the model. This recommendation was adopted.
- **V2**: Havera and Yetter recommended adjusting the suitability index of fall-tilled corn to a value of 0.35. During a phone conversation, Humburg altered his initial recommendation and suggested reconfiguring the histogram into five categories: flooded standing, flooded harvested, dry harvested, dry standing and tilled. However, we feel the flooding issue is adequately addressed in V3. To incorporate all comments from these individuals it was decided to have four categories in the histogram and SI's were assigned as follows: standing or harvested other (1.0), tilled corn (0.35), standing corn (0.2) and tilled other (0.15).
- **V3**: Havera and Yetter suggested eliminating this variable for corn fields because inundation of the crop is not necessary for feeding. Because the curve reaches an index of 1.0 with as little as six days of flooding it was decided to leave this variable as is.

- **Table 1**: Humburg suggested reevaluating the table's values. Havera and Yetter recommended changing the nonforested wetland percentage to ≥40. This recommendation was adopted and will result in several changes to Table 1 (p. 24 in the model) as well as the calculations outlined in Step 5 on page 27.

Cover Type	Recommended Minimum % Composition of Cover Type	Habitat Composition Index
cropland	≥ 10	0.12
palustrine forested wetlands	≥ 40	0.44
nonforested palustrine, lacustrine and riverine wetlands	≥ 40	0.44
Total	90	1.00

- In relation to tillage practices and available waste grain, Humburg cited Fredrick's monograph on snow geese in western Iowa. He also cited Petrie's M.S. Thesis from the University of Missouri regarding food availability in flooded agricultural fields.

PROTHONOTARY WARBLER

Source of Model: Stauffer, D. 1995. Unpublished Draft. Prothonotary warbler Habitat Suitability Index Model.

Habitat Type: Bottomland Hardwood Forest

Assumptions: Water surrounding nesting trees is helpful in limiting nest depredation.

Aggregation Formula: $HSI = V6 * [\text{min. of } ((V1*V2*V3)^{1/3}) \text{ or } (V4 + (0.8*V5))]$

LESSER SCAUP

Source of Model: Modified from a Wildlife Habitat Appraisal Guide Migrating diving duck model developed by U.S. Army Corps of Engineers (USACE).

Habitat Type: Backwater/Backwater Lake

Assumptions: Because no variables reach an SI value of zero, all wetlands are assumed to have at least some value.

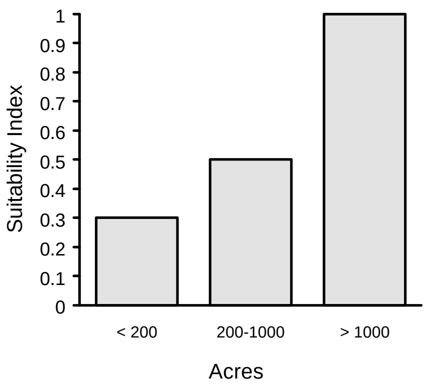
Aggregation Formula: HSI = (V1+V2+V3+V4+V5+V6+V7) / 7

Modifications:

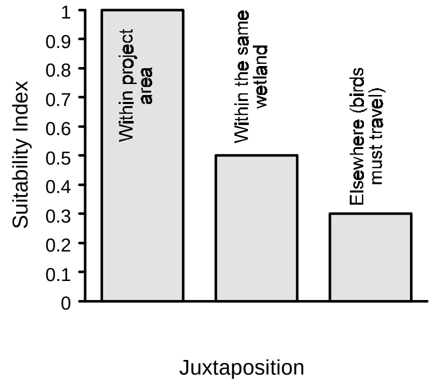
- **V3**: Steve Havera and Aaron Yetter (ILNHS) suggested that scaup feed primarily on invertebrates which makes this variable less important when determining habitat suitability. It was decided to deal with this in the variable aggregation, rather than redefining the variable.
- **V4**: Havera and Yetter stated that scaup feed in areas which are in excess of six feet in depth, and they recommended lowering the suitability index of the optimal category. After consultation with Havera it was decided to increase the depth to fifteen feet. It was decided to retain a suitability index of 1 for the optimal category because it is reasonable that there is indeed an optimal value which will be reached by increasing the amount of foraging habitat above a certain level (in this case, above 70%).
- **V4** and **V5**: Dale Humburg (MDOC) suggested emphasizing both migration periods for these variables. Thus, the variable definitions were changed to address the periods of 15 October to 31 December and 1 February to 1 April.
- **V5**: Humburg suggested changing the variable definition from disturbance to the percentage of the area which is inviolate refuge. Because many areas which are relatively undisturbed are not officially designated as refuges, it was decided not to change the variable.
- **V5**: Based on the literature and a conversation with Havera, we decided to define disturbance factors as boating activity (hunting, fishing, recreational), proximity to human habitation and other human shore activities, and tow traffic. There is some indication that these factors may have differential degrees of severity and seasonal variation which would be difficult to quantify. We also considered the proximity of the disturbance factor. We assumed equal effect among the factors and based our SI values upon proximity rather than rate. Therefore, any disturbance occurring within 400 meters will result in an SI of 0.4, and those disturbances at a distance of ≥ 400 meters will yield an SI of 1.0.
- **V4** and **V7**: Humburg stated that there is an apparent conflict between the dates used for these variables. However, we feel there is no conflict because the variables are independent of each other.
- Humburg recommended considering the model to only be applicable during migration periods. He asked that the non-numeric values for variables be defined, which we subsequently accomplished.
- **Abundance of aquatic invertebrates used as a food source**: We decided to drop this variable because of 1) the inability to define/measure it based on current data, and 2) the inherent variability of invertebrate populations.
- **Percentage of submergent vegetation desirable as a food source** and **Percent cover of emergent vegetation**: Based on information in Havera's in-press publication, *Waterfowl of Illinois: Status and Management*, pointing out that scaup feed primarily on invertebrates, Havera and Yetter suggested dropping these variables from the model. This recommendation was adopted.
- **Is the wetland/pool within a flyway corridor?**: We decided to drop this variable because the project areas will all be within the Mississippi flyway and that will not change. Also, any comparisons will be made to other areas within the flyway.

Lesser Scaup Model Variables

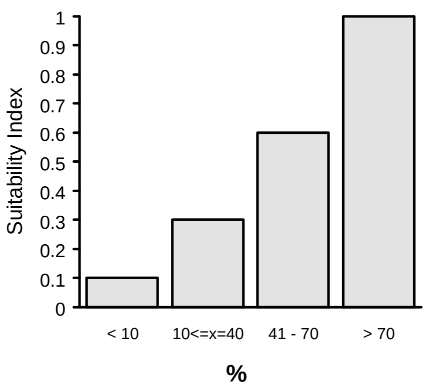
V1: Size of wetland or pool.



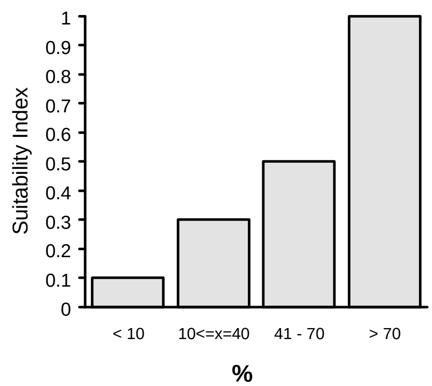
V2: Juxtaposition of critical habitat types (feeding, loafing/rafting, severe weather shelter).



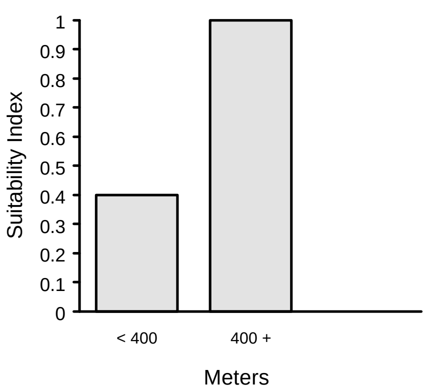
V3: Percentage of area covered with submergent vegetation.



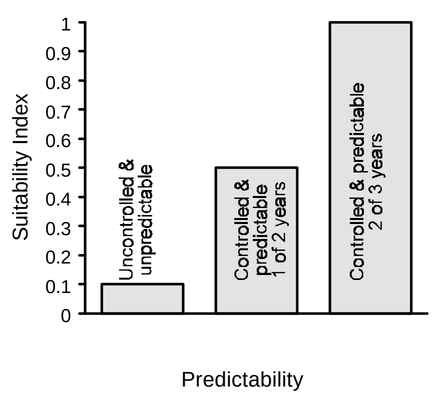
V4: Percentage of area with water depth of 18 in. - 15 ft. from 15 Oct. to 31 Dec and 1 Feb. to 1 Apr.



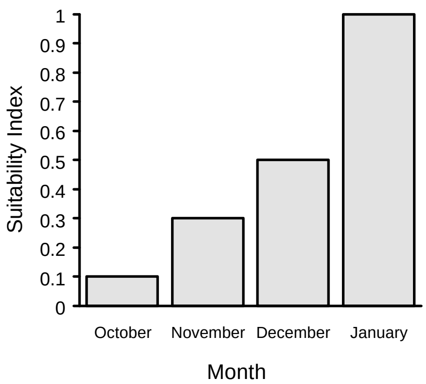
V5: Distance to disturbance during fall migration season (15 Oct. to 31 Dec.).



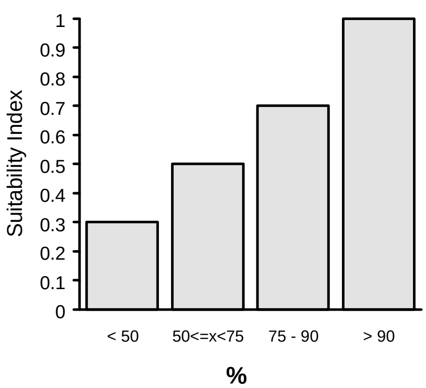
V6: Water level fluctuation predictability.



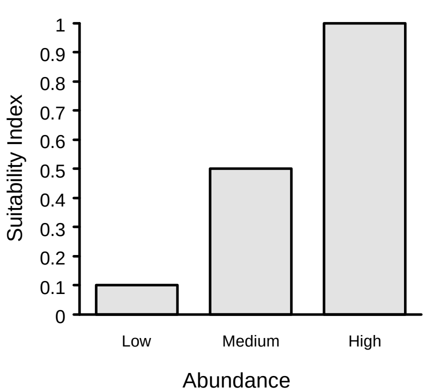
V7: Month in which ice-over first reduces available habitat by 50%.



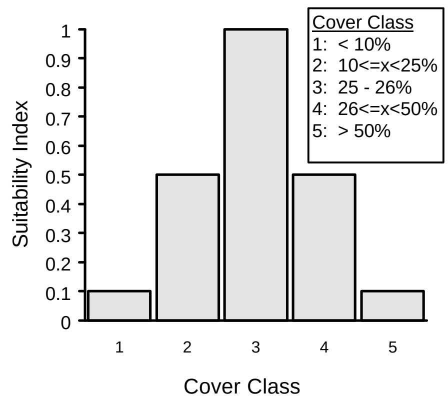
OMIT: Percentage of submergent vegetation desirable as a food source.



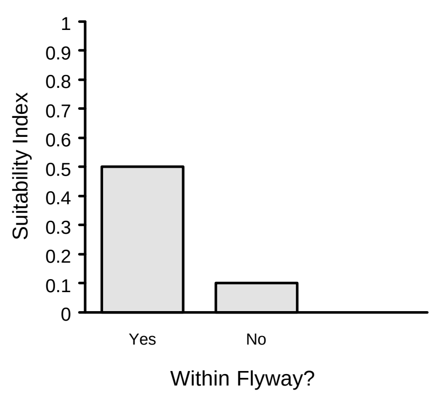
OMIT: Abundance of aquatic invertebrates used as a food source.



OMIT: Percent cover of emergent vegetation.



OMIT: Is the wetland/pool within a flyway corridor?



SORA

Source of Model: U.S. Army Corps of Engineers, Rock Island District, and U.S. Geological Survey, B.R.D.. 1996. Habitat Suitability Index Model: Sora rail. Unpublished Model.

Habitat Type: Backwater/Backwater Lake, Non-Forested Wetland

Assumptions:
- The major components of the model are identifiable in the habitat.
- Robust emergent vegetation with high interspersion is acceptable nesting habitat.
- Water depth from 5-20 cm must be maintained during the nesting season.
- Anthropogenic increases in water levels of greater than 3 cm result in nest failure.
- The amount of acceptable terrestrial cover has proportional importance.
- Suitable nesting habitat will be enhanced by optimal terrestrial cover around the wetland.
- Food availability (seed production) is proportional to plant community diversity.

Aggregation Formula: HSI = min. of $[((((V1*V2)^{1/2})*V4)*V3) + (V5*V6*V7*V8)]$ or 1

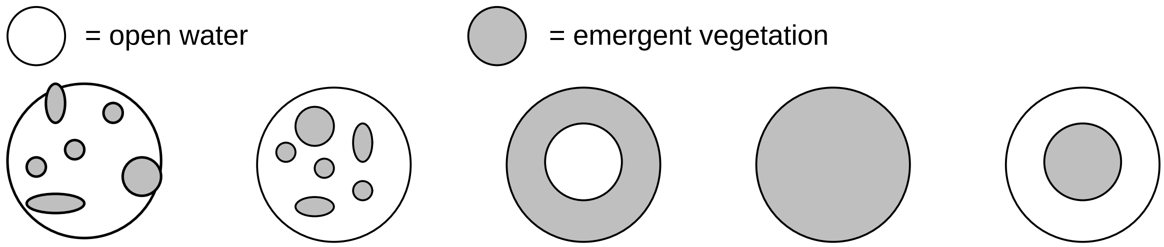
Modifications:
- **V2**: MDOC mentioned that an interspersion configuration may exist which is of greater value than #1 in the model. After further consultation, they suggested that an SI of 1 be given to an interspersion configuration where some patches of emergent vegetation are contiguous with the vegetation outside the perimeter of the open water area. We decided to adopt this recommendation and give an SI of 0.9 to the current configuration #1. The configurations are depicted below.
- **V3**: MDOC stated that water level increases may not be a critical issue as long as some of the habitat contains water in the 5-20 cm range. The possibility of nest destruction is what prompted the development of V3 and we feel that this is a legitimate concern. We decided to leave this variable as is.
- **V4**: MDOC suggested changing the water depth range to 0-20 cm because soras utilize areas with less than 5 cm of water, and saturated soil areas, for feeding. Though such areas are sometimes utilized, after further consultation the reviewer stated that utilization of areas in the 5-20 cm range is much more common. We decided not to alter the depth range for this variable.
- MDOC expressed a concern over the lack of consideration given to the seed production potential of the vegetation present. We feel that because the highest SI value for V1 is given to the most diverse plant community it is likely that seed production will be adequately addressed. This was added to the model's assumptions.

Sora Model Variables

V1: Quality of emergent vegetation (A=robust; B=moderate; C=weak-stemmed).

Menu Choice	Suitability Index
1 (A+B+C)	1.0
2 (A+C)	0.7
3 (B+C)	0.5
4 (A+B)	0.3
5 (A only)	0.2
6 (B only)	0.2
7 (C only)	0

V2: Interspersion configuration of emergent vegetation.

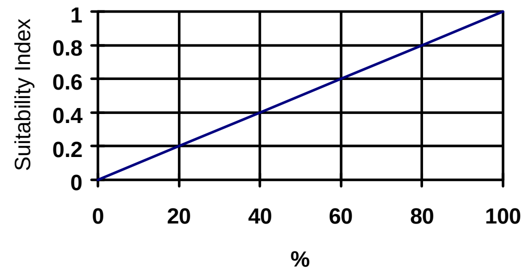


1 (SI=1) 2 (SI=0.9) 3 (SI=0.7) 4 (SI=0.3) 5 (SI=0)

V3: Is there an anthropogenic water level increase of ≥ 3 cm during April-June?

Menu Choice	Suitability Index
1 (yes)	0
2 (no)	1

5-20 cm water depth during April-June.



V4: Percent of emergent vegetation with

V5: Percent of wetland edge comprised of forest (multiply by 0).

V6: Percent of wetland edge comprised of crops or shrubs (multiply by 0.25).

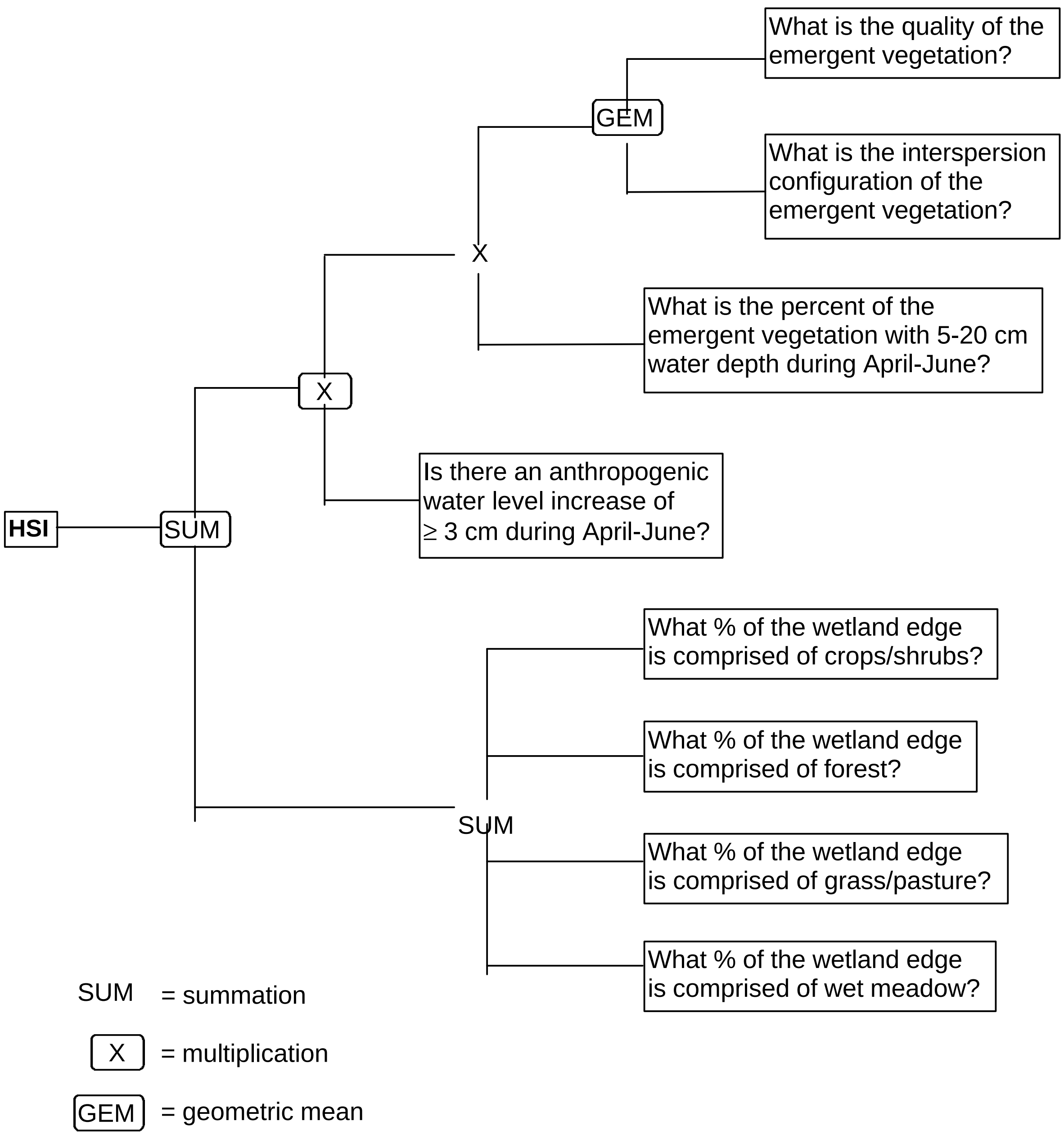
V7: Percent of wetland edge comprised of grass or pasture (multiply by 0.5).

V8: Percent of wetland edge comprised of wet meadow (multiply by 1.0).

Sora HSI Determination

The HSI is determined by asking the following questions:

- What is the quality of the emergent vegetation?
- What is the interspersion of the emergent vegetation?
- Is there an Anthropogenic water level increase during April-June?
- What percent of the emergent vegetation is in water 5-20 cm deep during April-June?
- What cover types surround the wetland?



GRAY SQUIRREL

Source of Model: Allen, A. W. 1987. Habitat suitability index models: Gray squirrel, revised. U.S. Fish Wildl. Serv. Biol. Rep. 82(10.135). 16 pp. [First printed as: FWS/OBS-82/10.19, July 1982.]

Habitat Type: Bottomland Hardwood Forest

MUSKRAT

Source of Model: Allen, A. W., and R. D. Hoffman. 1984. Habitat suitability index models: Muskrat. U.S. Fish Wildl. Serv. FWS/OBS-82/10.46. 27 pp.

Habitat Type: Non-Forested Wetland, Backwater/Backwater Lakes

Modifications:
- Dave Hamilton (MDOC) suggested adding a variable for denning substrate. Consultation with other State agency biologists revealed that bank denning is uncommon and that water level fluctuations in the Mississippi system tend to relegate muskrats to backwater areas where they prefer to use lodges. Therefore, it was decided that a denning substrate variable is unnecessary.
- Hamilton suggested that the effects on den sites should be assessed if project alternatives will affect water depth and fluctuations. Water regulation changes are not a part of the project and water levels are not expected to be influenced.
- **V8**: Hamilton asserted that muskrats tend to eat whatever vegetation is available, but he also forwarded information from a MDOC model which identified several specific plants which are important food sources. The blue book model listed three species as being of greatest importance and it was decided to use the variable as defined in the blue book. Although the MDOC model has a submergent vegetation variable, the authors of the blue book model did not feel that submergent vegetation warranted such treatment and we decided to follow the blue book pattern.

RIVER OTTER

Source of Model: U.S. Fish and Wildlife Service. 1984. Draft habitat suitability index model: River otter (*Lutra canadensis*). U.S. FWS, Division of Ecological Services, Sacramento, California.

Habitat Type: Side Channel

BEAVER

Source of Model: Allen, A. W. 1983. Habitat suitability index models: Beaver. U.S. Fish Wildl. Serv. FWS/OBS-82/10.30 Revised. 20 pp.

Habitat Type: Side Channel

Modifications:
- Personnel from the Rock Island Field Office (RIFO) of the FWS mentioned the blue book’s guidelines for determining the area to be evaluated. This will be taken into account when collecting the field data.

PADDLEFISH

Source of Model: Hubert, W. A., S. H. Anderson, P. D. Southall, and J. H. Crance. 1984. Habitat suitability index models and instream flow suitability curves: Paddlefish. U.S. Fish Wildl. Serv. FWS/OBS-82 10.80. 32 pp.

Habitat Type: Main Channel/Main Channel Border, Backwater/Backwater Lakes
Modifications:

- **V2**: Based on the results of Southall and Hubert (1984), Chuck Surprenant (FWS) recommended that spring access be defined as the condition of the dam gates being fully opened, and that the period under consideration be any two week period from 11 April to 25 May. Both recommendations were adopted. He further suggested that the better option would be if the fully opened condition existed at all dams within the study reach. However, based on information from Corps of Engineers Operations personnel, it is unlikely that such conditions would exist other than during a massive flood. Therefore, it was decided to consider fully opened conditions at each dam individually.
- **V8**: FWS, Fishery Resources Office, Onalaska recommended changing the minimum average channel depth from 1 m to 3 m. This recommendation was adopted.
- **V10**: FWS, Fishery Resources Office, Onalaska recommended changing channel depth from 1.5 m to ≥ 3 m. This recommendation was adopted.

CHANNEL CATFISH

Source of Model: McMahon, T. E., and J. W. Terrell. 1982. Habitat suitability index models: Channel catfish. U.S.D.I. Fish and Wildlife Service. FWS/OBS-82/10.2. 29 pp.

Habitat Type: Main Channel/Main Channel Border, Side Channel

Modifications:

- Richard Sparks and Marvin Hubbell (ILNHS) pointed out that certain information on the seasonal habitat preferences of channel catfish in the Illinois River can be found in the ILNHS report, *Barge Effects on Channel Catfish*. However, they offered no specific suggestions as to model modifications. One portion of their suggested readings which directly relates to the model is the information on velocity preferences. The model contains a variable for summertime velocity (V18) and gives a maximum SI value to velocities in the range of 0-0.41 ft/sec. The report indicates that average velocities in which fish were found was 0.39-0.43 ft/sec, with a range of 0-1.02 ft/sec. Therefore, the suitability curve in the model and the results in the report correlate adequately.
- Additional comments regarding habitat selectivity closely match the habitat types for which the species is being evaluated.
- Sparks and Hubbell expressed concern that some habitat may receive a poor rating if a selected species is on the margin of its natural range at the site under consideration. However, only the habitat characteristics are considered in the model, not the species' range or even its presence.

BLACK CRAPPIE

Source of Model: Edwards, E. A., D. A. Krieger, M. Bacteller, and O. E. Maughan. 1982. Habitat suitability index models: Black crappie. U.S.D.I. Fish and Wildlife Service. FWS/OBS-82/10.6. 25 pp.

Habitat Type: Backwater/Backwater lake

SMALLMOUTH BUFFALO

Source of Model: Edwards, E. A., and K. Twomey. 1982. Habitat suitability index models: Smallmouth buffalo. U.S. Dept. Int. Fish Wildl. Serv. FWS/OBS-82/10.13. 28 pp.

Habitat Type: Side Channel

LAKE STURGEON

Source of Model: Tarandus Associates Limited. 1996. Development of a Habitat Suitability Index Model for Lake Sturgeon (Acipenser fulvescens): DRAFT Final Report. Prepared for Ontario Hydro: Northern Development Department, Canada.

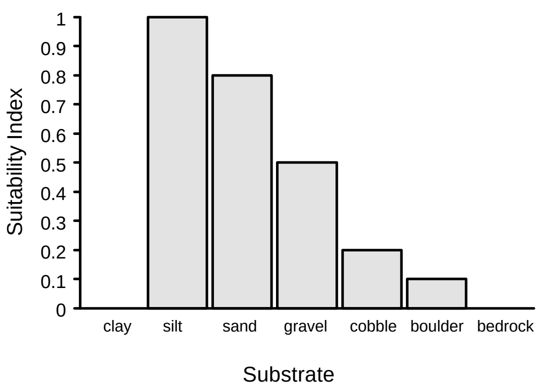
Habitat Type: Main Channel/Main Channel Border

Modifications:

- **V1**: MDOC recommended changing some of the SI values. The following SI changes were made.

Substrate	SI
sand	0.8
gravel	0.5
cobble	0.2
boulder	0.1

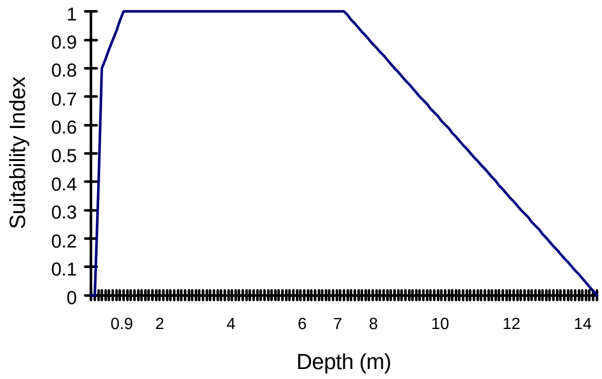
V1: Adult foraging substrate type.



- **V3**: MDOC recommended changing several of the SI values. After further consultation with the reviewer, the following changes were adopted.

Meters	SI
0.1	0
0.3	0.8
0.9	1.0
2.0	1.0

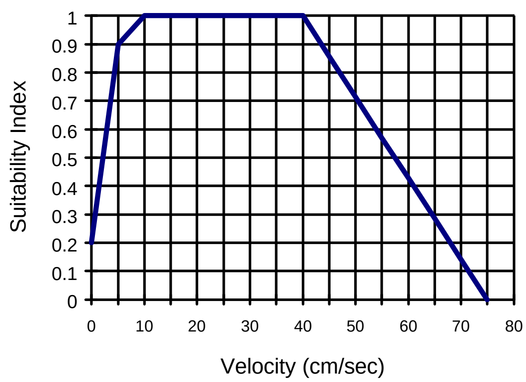
V3: Juvenile foraging depth.



X	Y
0.1	0
0.3	0.8
0.9	1
7	1
14	0

- **V4**: MDOC suggested that an SI value of 0.2 be given to a velocity of zero. This recommendation was adopted.

V4: Juvenile foraging water velocity.



EMERALD SHINER

Source of Model: Mathias, D., Hardy, T.B., Killgore, K.J., and Jordan, J.W. (1996). “Aquatic Habitat Appraisal Guide; User’s Manual,” Instruction Report EL-96-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS. (Emerald Shiner)

Habitat Type: Main Channel/Main Channel Border, Side Channel

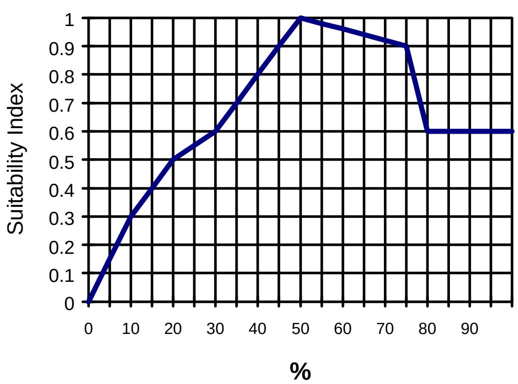
Assumptions:
- The model was developed for the Upper Mississippi River System.
- The abundance and distribution of species respond in a predictable and measurable fashion to changes in habitat quality.
- Habitat variables represent physical and water quality characteristics of the study area.

Modifications:

- **V1**: MDOC questioned the meaning of this variable, but after further consultation agreed that the variable is acceptable.
- **V4**: MDOC questioned whether there were data which demonstrated the importance of riprap. ILDNR stated that their data showed that emerald shiners were more abundant over riprapped areas than areas which had no riprap.
- **V7**: MDOC questioned the lack of clarity in the definitions of the variable and its categories. We determined that this variable should be considered during May-July because it will have its greatest effect on spawning activities. Therefore, we used the SI values for the spawning model. A conversation with Jack Kilgore, one of the developers of the model, revealed that rapid could be defined as occurring in a week or less and that slow would take more than a week.
- **V8**: MDOC suggested that the SI histogram should be reconfigured to indicate the fish's preference for lower velocities. A subsequent phone conversation led to the following changes to the SI values.

Velocity (cm/sec)	SI
0 - 30	1.0
30 - 50	0.8
50 - 75	0.45
75 - 100	0.15
> 100	0

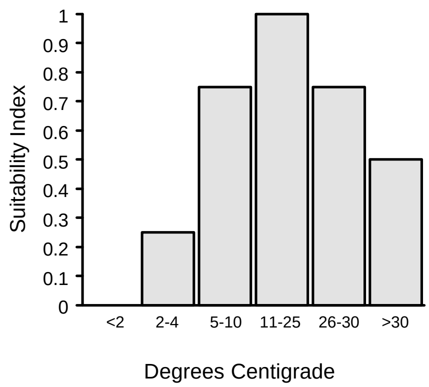
- **V9**: MDOC questioned the relevance of thalweg depth for emerald shiner. Further consultation with the reviewer resulted in a recommendation to drop this variable and add a variable for shallow water habitat. We decided to adopt this recommendation. This variable is now the *percentage of area £ 5 feet deep* and the SI curve is depicted below.



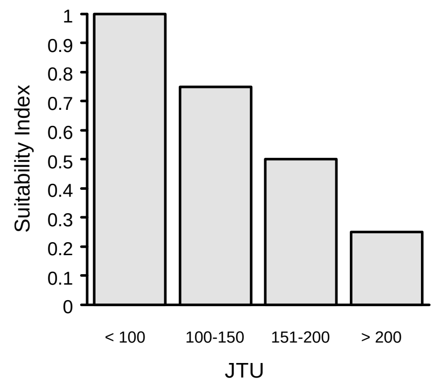
- **V10**: Our depiction of the SI values had an incorrect number in it, which prompted MDOC's comment. After explanation of the problem, they agreed that the SI's are acceptable.
- MDOC suggested that percent slope of bank and percent island/shoal/sand bar habitat should be considered because of the species' preference for shallow areas. We believe the revised V9 will address their concerns.
- MDOC suggested that depth at capture should be considered. The subject of depth preference was further discussed with the reviewer, which resulted in the revision of V9.

Emerald Shiner Model Variables

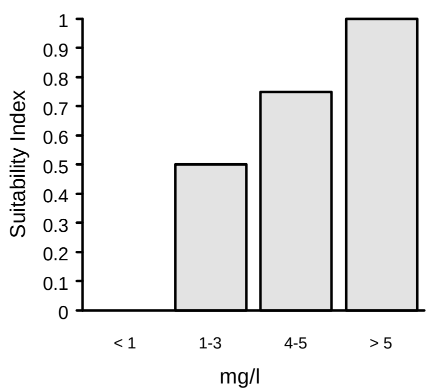
V1: Mean water temperature.



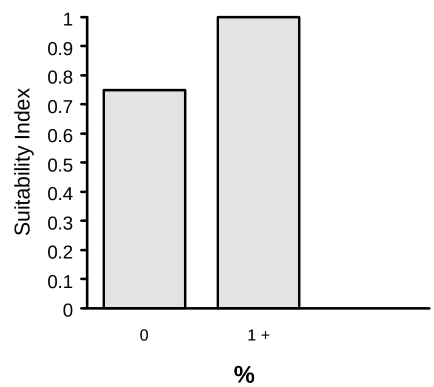
V2: Mean turbidity.



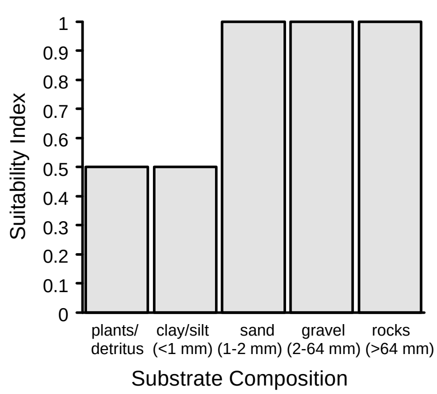
V3: Minimum daily dissolved oxygen.



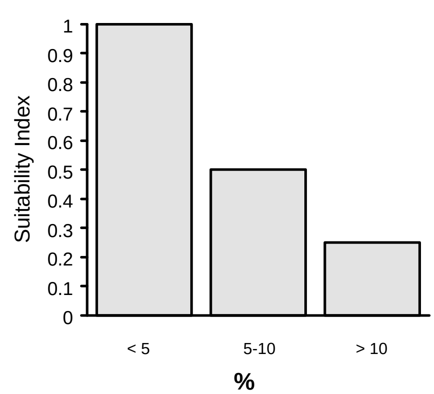
V4: Percent of shoreline riprapped.



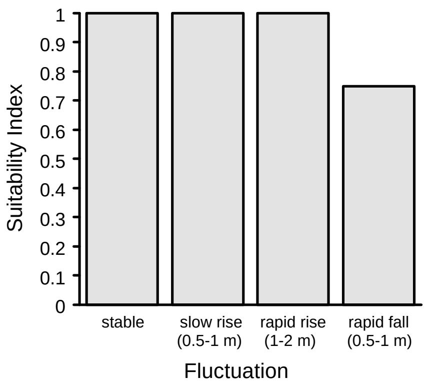
V5: Dominant substrate.



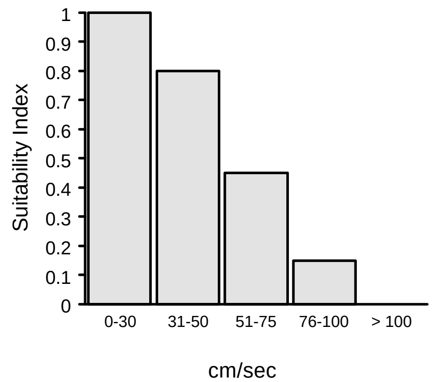
V6: Percent cover (logs, inundated timber, brush, undercut banks).



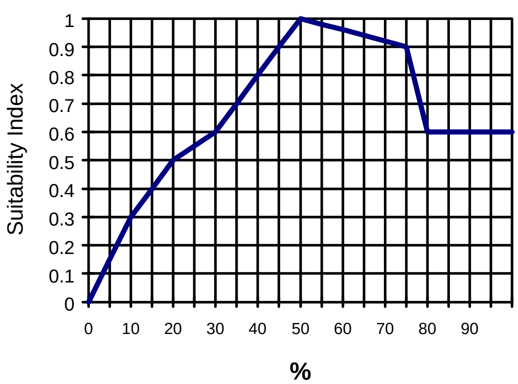
V7: Water level fluctuation (rapid = one week or less; slow = > one week).



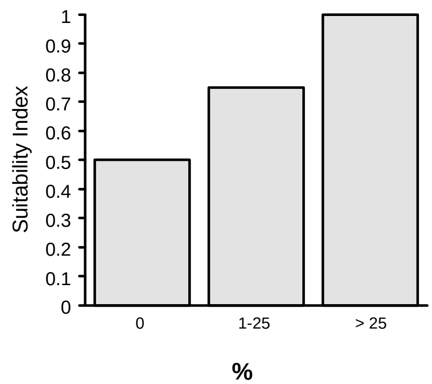
V8: Mean water velocity.



V9: Percentage of area ≤ 5 feet deep.



V10: Percent of backwater area suitable as overwintering habitat during Nov-Feb (no current, water temp. at least 1°C warmer than main channel, dissolved oxygen ≥ 3 mg/l, water depth ≥ 1.5 m, periodically contiguous with main channel).



SAUGER

Source of Model: Mathias, D., Hardy, T.B., Killgore, K.J., and Jordan, J.W. (1996). "Aquatic habitat appraisal guide; User's manual," Instruction Report EL-96-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS. (Sauger)

Habitat Type: Main Channel/Main Channel Border

Assumptions: The model is only applicable to large rivers.

Aggregation Formula:
(V1+V2+V3+V4+V5+V6+V7+V8+V9+V10) / 9

Modifications:

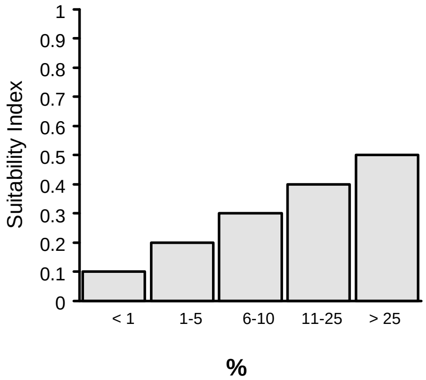
- **V2**: MDOC questioned the applicability of this variable. Because this variable has a maximum SI value of 0.5, the model developers determined that it was less important than most of the other variables but not completely without importance. We decided to retain this variable.
- **V4**: MDOC advocated increasing the SI value of the 25-50% category. We decided to increase the SI of the category to 0.7.
- **V5**: MDOC suggested decreasing the SI value of the > 50% category. To retain the maximum SI value of 1.0, we decided to assign that value to the 25-50% category. We reduced the SI value of the > 50% category to 0.5.
- **V8**: MDOC recommended giving an SI value of 1.0 to the 10-20-inch category and reducing the SI for the > 30 category. We gave an SI of 1.0 to the 10-20 and 20-30 categories, and changed the > 30 SI to 0.8.
- **V9**: MDOC questioned why the greater distances to gravel received higher scores. Based on the life history of the species and its requirement for spawning gravel, we agree that the numbers were somehow reversed when the model was put together. The correct values are listed below.

Distance (mi)	SI
< 0.5	1.0
0.5 - 1.0	0.7
1 - 2	0.4
> 2	0.1

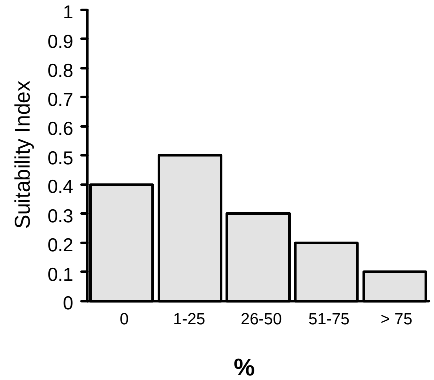
- **V10**: MDOC stated that this variable may artificially lower the HSI because of the absence of aquatic vegetation in the lower pools. We believe this variable was developed to address cover for young fish and it is an applicable variable.

Sauger Model Variables

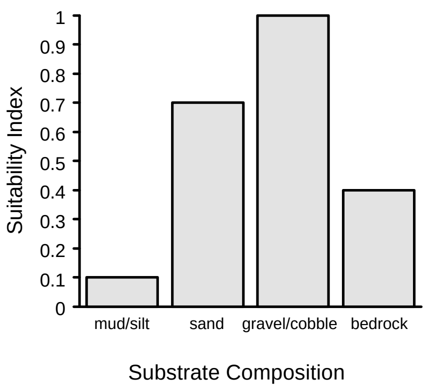
V1: % of 2 mile diameter circle which is water > 8 feet deep.



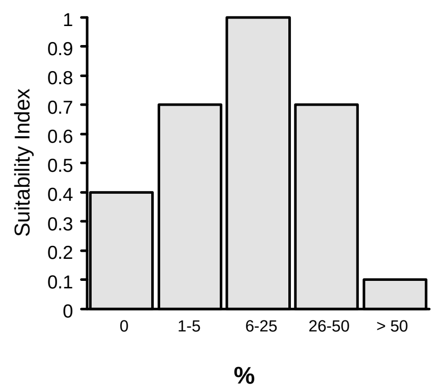
V2: % emergent, submergent, floating vegetation.



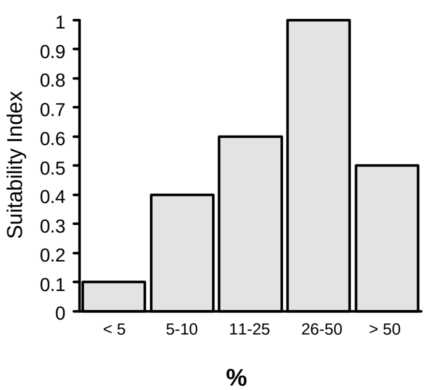
V3: Dominant substrate.



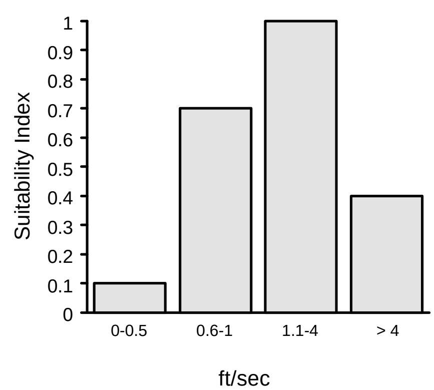
V4: % of submerged bank covered by riprap.



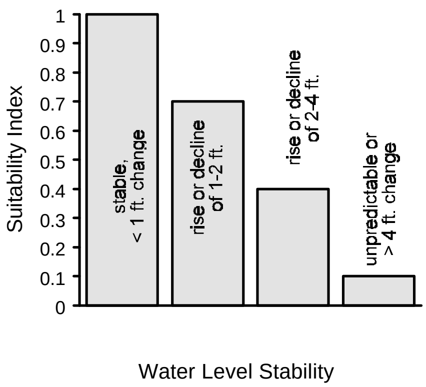
V5: % of channel < 8 feet deep.



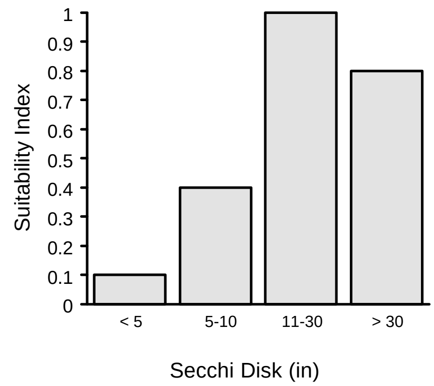
V6: Mean velocity at normal flows May through September.



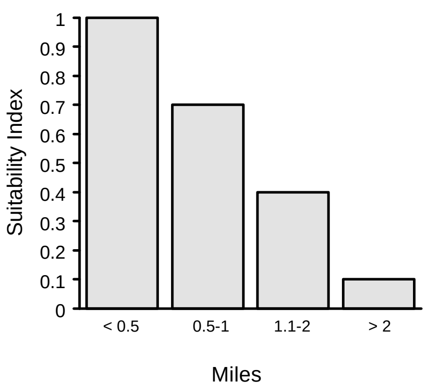
V7: Water level stability May through June.



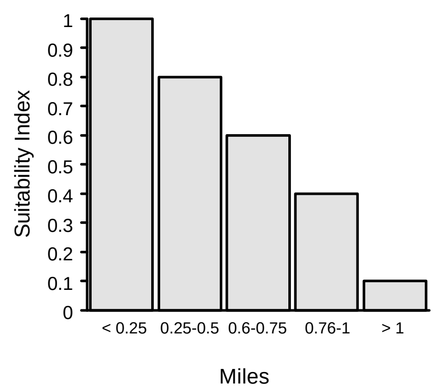
V8: Mean non-flood turbidity.



V9: Distance to gravel substrate or gravel shoreline.



V10: Distance to emergent vegetation in water 1-4 feet deep.



FLATHEAD CATFISH

Source of Model: Lee, L. A., and J. W. Terrell. 1987. Habitat and suitability index models: Flathead catfish. U.S. Fish Wildl. Serv. Biol. Rep. 82(10.152). 39 pp.

Habitat Type: Main Channel Border

Assumptions: The assumptions listed on page 14 of the blue book were accepted in order to apply the simplified version of the model.

Model Variables:
V1: m^2 of object cover
V2: m of undercut bank
V3: m^2 of deep pools without object cover

Aggregation Formula: HSI = min. of $\frac{[(V1/38) + (V2/12.6) + (V3/10{,}000)]}{\text{ha of aquatic habitat}} \times 0.17$ ha/fish or 1

LARGEMOUTH BASS

Source of Model: Tuber, R. J., G Gebhart, and O. E. Maughan. 1982. Habitat suitability index models: Largemouth bass. U.S. Fish Wildl. Serv. FWS/OBS-82/10.16. 32 pp.

Habitat Type: Backwater/Backwater Lake

Aggregation Formula: The model's riverine aggregation formulas are depicted on page 16 of the blue book, and V23 will be added to the cover component. This will result in the following formula.

$$C_C = \left[V1 \times \frac{(V3 + V4)}{2} \times \frac{(V16 + V18)}{2} \times V23 \right]^{1/4}$$

Modifications:

- **V23**: MDOC advocated adding a variable to the overwintering model for the distance between summer and winter habitat. John Pitlo (IADNR) also stated that such distances should be given consideration. We felt the SI for this variable would be artificially high if it was added to the overwintering model because much of the river can be considered summer habitat and would therefore be in close proximity to the area under evaluation. Therefore, we added this variable to the riverine blue book model. Acceptable winter habitat is defined as areas which are greater than five feet deep at normal pool elevation, have a minimum winter dissolved oxygen content of at least 3 mg/l, have a minimum winter water temperature of not less than 1° C, have a winter current velocity of less than 3 cm/sec and are contiguous with the main channel during winter. This definition is based upon publications by Sheehan et al.[1] and Gent et al.[2], as well as the overwintering variables we submitted to other agencies for their review. Additionally, Pitlo stated that winter habitat should be on the same side of the river as the summer habitat which it complements. This prompted us to modify the SI's recommended by MDOC. The variable is defined as the *distance (mi) to nearest acceptable winter habitat* (V23) and will be added to the model as a riverine variable.

The adopted SI's are in the table below.

Distance (mi)	Suitability Index	
	Same Side	Other Side
< 3	1.0	0.5
3 - 4	0.8	0.4
4 < x ≤ 5	0.5	0.2
5 < x ≤ 6	0.4	0.1
> 6	0.2	0

[1] Sheehan, R.J., W.M. Lewis, and L.R. Bodensteiner. Publ. date unk. Winter habitat requirements and overwintering of riverine fishes. Project F-79-R. Fisheries Research Lab., Southern Ill. Univ., Carbondale.

[2] Gent, R., J. Pitlo, Jr., and T. Boland. 1995. Largemouth bass response to habitat and water quality rehabilitation in a backwater of the Upper Mississippi River. N. Amer. J. Fish. Manage. 15:784-793.

LARGEMOUTH BASS (overwintering)

Source of Model: adapted from: Modification of the Habitat Suitability Index Model for the Bluegill (Lepomis macrochirus) for Winter Conditions for Upper Mississippi River Backwater Habitats by Gary Palesh and Dennis Anderson (1990, U.S. Army Corps of Engineers).

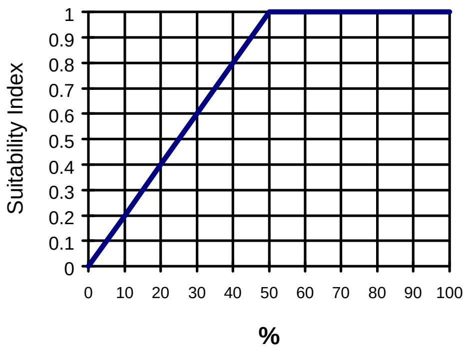
Habitat Type: Backwater/Backwater lake

Assumptions: The bluegill model was utilized because largemouth bass are expected to react to habitat conditions in a manner similar to bluegill.

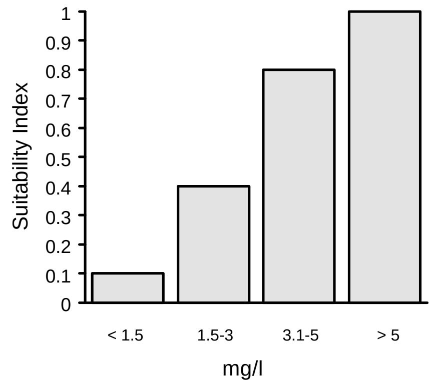
Modifications:
- **V1**: John Pitlo (IADNR) suggested changing the minimum depth to five feet to account for ice thickness. This recommendation was adopted.
- **V1**: MDOC recommended repositioning the SI curve so that 0% will receive an SI value of zero. This recommendation was adopted.
- **V2**: MDOC suggested giving the 3-5 mg/l category an SI value of 0.8. This recommendation was adopted.
- **V3**: MDOC recommended giving an SI value of 1 to the 2-3° range and lowering the SI value of 4° to 0.7. These recommendations were adopted.
- **V4**: MDOC suggested increasing the SI value for 0.5 cm/sec to 1.0. This recommendation was adopted.

Largemouth Bass Overwintering Variables

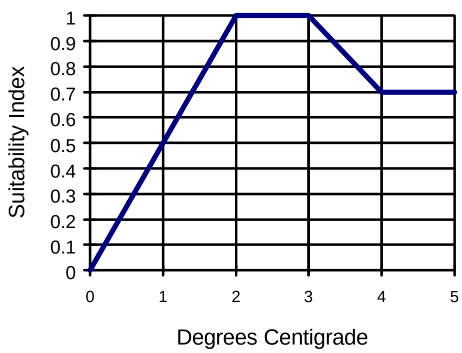
V1: Percent of backwater > 5 feet deep at normal pool elevation.



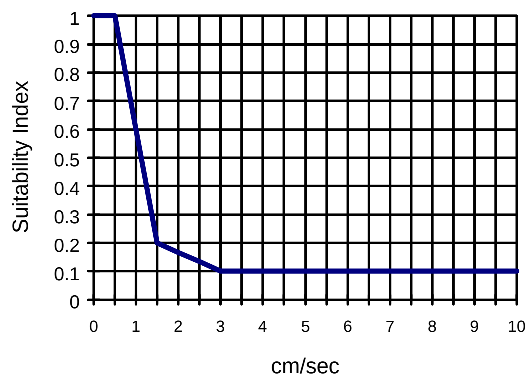
V2: Minimum winter dissolved oxygen.



V3: Winter water temperature.



V4: Current velocity.



Largemouth Bass HSI Determination

The information below is taken from *Modification of the Habitat Suitability Index Model for the Bluegill (Lepomis macrochirus) for Winter Conditions for Upper Mississippi River Backwater Habitats* by Gary Palesh and Dennis Anderson (1990, U.S. Army Corps of Engineers).

The summer HSI would be calculated using the methods described in the existing U.S. Fish and Wildlife Service habitat suitability index model. The winter HSI would be calculated as follows.

Winter HSI Determination
Winter Cover: $C_{W\text{-}C} = V1$

Winter Water Quality: $C_{W\text{-}WQ} = \frac{(2V2 + V3)}{3}$

If the SI for V2 or V3 is ≤ 0.4, then $C_{W\text{-}WQ}$ equals the lower of the two variables.

Winter Other: $C_{W\text{-}OT} = V4$

Winter HSI = $(C_{W\text{-}C} \times C_{W\text{-}WQ}^2 \times C_{W\text{-}OT})^{1/4}$
If $C_{W\text{-}WQ}$ is ≤ 0.4, then the winter HSI = $C_{W\text{-}WQ}$.

Overall HSI Determination
Two methods are suggested for determination of an overall HSI value for a particular Upper Mississippi River backwater habitat.

Scenario 1: The backwater habitat being evaluated is a relatively isolated area that must serve as both the summer and winter habitat for the resident largemouth bass population. The lowest quality habitat (summer or winter) will likely be the limiting factor on the largemouth population.

Overall HSI = the lower of the summer HSI or winter HSI

Scenario 2: The backwater habitat being evaluated is well connected to other suitable habitat for largemouth bass such that it does not have to provide both summer and winter habitat for survival of a particular largemouth population.

Overall HSI = $(\text{summer HSI} \times \text{winter HSI})^{1/2}$

Modifications:

- HSI Determination: RIFO recommended either using a weighting factor of 4 for the overwintering component, or considering winter habitat as the limiting factor in the HSI determination. Bill Bertrand (ILDNR) suggested assigning a weighting factor of 4. Pitlo stated that the proper weighting factor could go as high as 30. We agree that winter habitat is more scarce than summer habitat, and we feel that the weighting factor of 4 proposed by FWS and ILDNR adequately accounts for this disparity in availability. The aggregation formula is as follows:

  $HSI_O = (HSI_S \times HSI_W^4)^{1/5}$ where HSI_O = overall HSI, HSI_S = blue book HSI, HSI_W = overwintering HSI

WALLEYE

Source of Model: McMahon, T. E., J. W. Terrell, and P. C. Nelson. 1984. Habitat Suitability Information: Walleye. U.S. Fish Wildl. Serv. FWS/OBS-82/10.56. 43 pp.

Habitat Type: Main Channel/Main Channel Border

Modifications:

- Ken Brummett (MDOC) made several comments regarding the validity of the model. A subsequent phone conversation revealed that his primary concern was that the suitability index curves in the model agree with results from John Pitlo's 1992 paper on walleye. These evaluations will be made. For dissolved oxygen and pH, we will assess the availability of existing data. Specific efforts will be made to assess availability and applicability of existing prey abundance data, and if such data is unavailable a collection effort will be considered. He suggested adding overwintering variables to the model, which the HAT has accomplished.

WALLEYE (overwintering)

Source of Model: See Below.

Habitat Type: Main channel/main channel border

Assumptions: Overwintering variables and SI curves are based on the literature cited.

Aggregation Formulas:
C_W = min. of V1, V2 or V3, where C_W is the HSI of the overwintering component

overall HSI = min. of C_W, C_F, C_C, C_{WQ} or C_R, where:
C_F is the food component HSI from the blue book
C_C is the cover component HSI from the blue book
C_{WQ} is the water quality component HSI from the blue book
C_R is the reproduction component HSI from the blue book

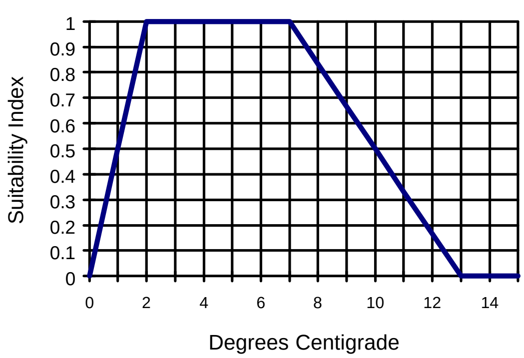
Modifications:
- **V3**: MDOC advocated giving an SI of 1.0 to velocities up to 0.2 m/sec. This correlates with velocity data supplied by ILDNR, so the recommendation was adopted.

Walleye Overwintering Variables

The following variables were developed in response to concerns that the present walleye HEP model did not adequately assess overwintering habitat for walleye in the Mississippi River. Three variables (water temperature, depth and velocity) represent the most important parameters impacting overwintering success. The existing HEP model bases the Habitat Suitability Index (HSI) on the lowest value of four habitat requisites: food, cover, water quality and reproduction. We recommend that a fifth requisite, overwintering, be added and that the HSI value be based on the lowest of all five requisites. To determine the value of the overwintering requisite, we suggest taking the lowest Suitability Index (SI) value of the following three variables. This methodology is consistent with the existing HEP model.

V1: Mean winter water temperature.

X	Y
0.0	0
1.7 (35°F)	1
7.2 (45°F)	1
12.8 (55°F)	0

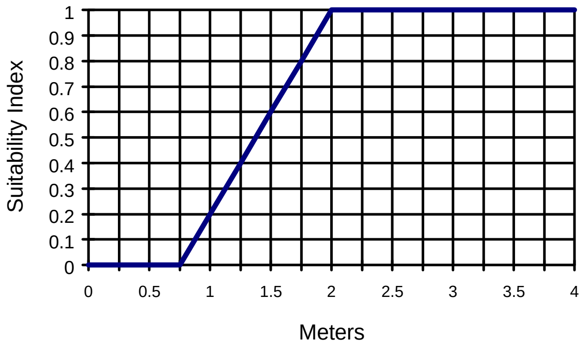


The SI curve for variable one came from the sauger curves developed from the Delphi method (Crance 1986). Biologically, these temperatures are also applicable to walleye. On the lower end, temperatures below freezing

(0°C) would not support walleye. On the upper end, Hokanson (1977) reported that proper maturation of gonads in female walleye required minimum winter water temperatures lower than 10°C. Miller (1967) found that walleyes failed to reproduce in a reservoir with minimum water temperatures between 10° and 25°C. Overwintering temperatures between 1.7° and 7.2°C should provide for optimal gonad development.

V2: Minimum winter water depth.

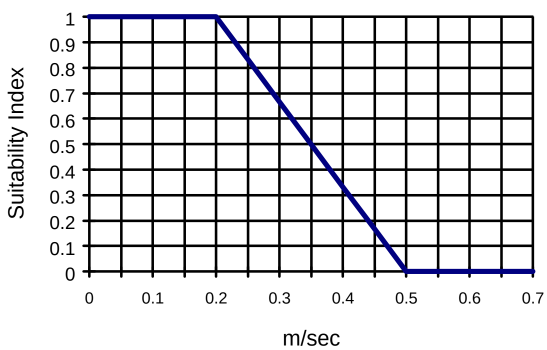
X	Y
0.0	0
0.75	0
2.0	1
> 2.0	1



Paragamian (1989) found that most walleye limited their movement during the winter and that fish appeared to select deep pool habitat during this time. Depths in these wintering pools ranged from 1.5 to 3 m (maximum depth of pools in the river was 3.7 m). He found that even in autumn fish were never found in water less than 0.6 m deep. Pitlo (1992) noted that walleye appeared to overwinter in areas with moderate depth, though no specific depths were given. We found no indication in the literature that depths like those seen in the Mississippi River (> 5 m) would adversely impact walleye overwintering success. Based on the information in Paragamian (1989) and Pitlo (1992), we estimated that depths less than 0.75 m would have no overwintering value to walleye and that depths greater than 2 m would be most suitable as overwintering habitat.

V3: Winter water velocity.

X	Y
0.0	1
0.2	1
0.5	0
> 0.5	0



We were not able to locate specific information on the overwintering water velocities required by walleye. Paragamian (1989) found that walleye selected deep pools with negligible current in the winter, but no specific velocities were given. Pitlo (1992) noted that walleye appeared to overwinter in areas with adequate flow, though no specifics were given. The draft Aquatic Habitat Appraisal Guide developed for the Corps of Engineers (1994) gave the following velocities and corresponding SI values for walleye:

m/sec	SI
< 0.1	1
0.1-0.25	0.75
0.25-0.5	0.5
> 0.5	0.25

The above values were not associated with a particular season. A review of the average main channel current velocities in Pool 26 during winter showed that velocities generally ranged between 0.15 and 0.5 m/sec. Based on information in Pitlo (1984), approximately 80% of all winter observations were in habitats (wingdam, main channel border, slough/side channel) where velocities would be expected to be lower than those found in the main channel. We have constructed an SI curve for Variable 3 which incorporates all of this information.

References

Crance, J.H. 1986. Sauger habitat suitability index curves developed by the Delphi method. U.S. Fish Wildl. Serv., Fort Collins. 34 pp.

Hokanson, K.E.F. 1977. Temperature requirements of some Percids and adaptations to the seasonal temperature cycle. J. Fish. Res. Board Can. 34(10):1524-1550.

McMahon, T.E., J.W. Terrell, and P.C. Nelson. 1984. Habitat suitability information: Walleye. U.S. Fish Wildl. Serv. FWS/OBS-82/10.56. 43 pp.

Miller, L.W. 1967. The introduction, growth, diet, and depth distribution of walleye, Stizostedion vitreum, in El Capitan Reservoir, San Diego County. Calif. Res. Agency, Dep. Fish Game, Inland Fish. Br., Admin. Rep. 67-10. 13 pp.

Paragamian, V.L. 1989. Seasonal habitat use by walleye in a warmwater river system, as determined by radiotelemetry. North Amer. J. Fish. Manag. 9:392-401.

Pitlo, J., Jr. 1984. Wing and closing dam investigations. Iowa Conservation Commission, Federal Aid in Fish Restoration, Completion Report F-96-R, Des Moines.

Pitlo, J., Jr. 1992. Walleye and sauger in the upper Mississippi River: early life history. Upper Mississippi River Conservation Committee, Rock Island, Ill. 39 pp.

U.S. Army Corps of Engineers. 1994. Aquatic habitat appraisal guide. Waterways Experiment Station, Vicksburg, Miss. Draft report. 60 pp.

BULLFROG

Source of Model: Graves, B. M., and S. H. Anderson. 1987. Habitat and Suitability Index Models: Bullfrog. U.S. Fish Wildl. Serv. Biol. Rep. 82(10.138). 22 pp.

Habitat Type: Backwater/Backwater Lake

Modifications:

- Tom Johnson (MDOC) recommended several changes to the text of the model. Those changes were noted but they do not affect the model's applicability.

RED-EARED SLIDER

Source of Model: Morreale, S. J., and J. W. Gibbons. 1986. Habitat suitability index models: Slider turtle. U.S. Fish Wildl. Serv. Biol. Rep. 82(10.125). 14 pp.

Habitat Type: Backwater/Backwater Lake

Modifications: RIFO recommended re-evaluating the applicability of the model to locks and dams 11-14 if it is to be used in those areas. This recommendation was adopted.

WESTERN CHORUS FROG

Source of Model: U.S. Army Corps of Engineers, Rock Island District, and U.S. Geological Survey, B.R.D.. 1996. Habitat Suitability Index Model: Chorus frog. Unpublished Model.

Habitat Type: Bottomland Hardwood Forest, Non-Forested Wetland

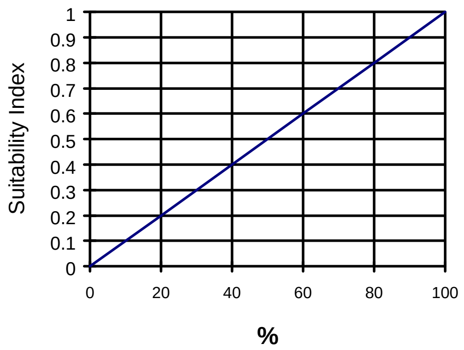
Assumptions:
- The major components of the model are identifiable in the habitat.
- All barriers to travel are impermeable to chorus frogs.
- All subjective distance factors are quantifiable.
- The amount of acceptable terrestrial cover has proportional importance.
- Suitable vegetative cover (for reproduction) consists of > 60 stems/m^2 of ≤ 1 cm diameter.
- Acceptable terrestrial cover consists of trees, brush, downed logs, stones and other debris.
- Most breeding activity takes place in water depths at the shallow end of the variable range.
- Because of its ability to breed in such ephemeral locations as rain pools and roadside ditches, it is not necessary to identify a minimum habitat area for this species.

Aggregation Formula: $HSI = [((V2*V3)^{1/2})*V1] * [(V4*V5)^{1/2}]$

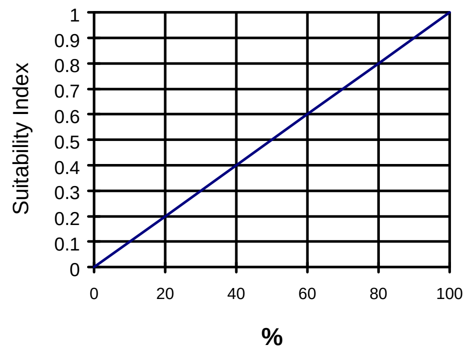
Modifications:
- RIFO requested that a minimum habitat area be established. At the workshop, *ideal* conditions were described as being a 5 acre pond plus 10 acres of undisturbed forest, but we do not believe there was any discussion of a minimum habitat area. Also, it was stated that the frogs are able to breed in such ephemeral locations as rain pools and roadside ditches. Therefore, we do not believe it is necessary to identify a minimum habitat area and this will be added to the model's assumptions.
- RIFO requested clarification of the assumption that predation by game fish is not an area of significant concern. MDOC stated that the only types of ponds which should be considered as suitable breeding sites are those which are small and fishless. The chorus frog model will be applied to bottomland hardwood forests and non-forested wetlands. Ponded areas within these cover types are assumed to be devoid of fish, except under temporary extraordinary circumstances, because they are typically not connected to the river. Therefore, we believe that predation does not warrant further consideration.
- **V4**: MDOC expressed the belief that grasses are important as terrestrial cover. A species expert involved in the modeling workshop stated that grass cover does not provide adequate moisture for survival of the frogs, so we decided to leave the definition of V4 and assumption 6 as they are. MDOC also stated that downed logs, rocks and other debris are seldom used for cover. However, the workshop species experts stated that such cover is utilized. Therefore, those cover types will remain in the model.
- **Assumption 7**: MDOC recommended changing this assumption to read that *most breeding activity takes place in water depths at the shallow end of the variable range*. This recommendation was adopted.

Chorus Frog Model Variables

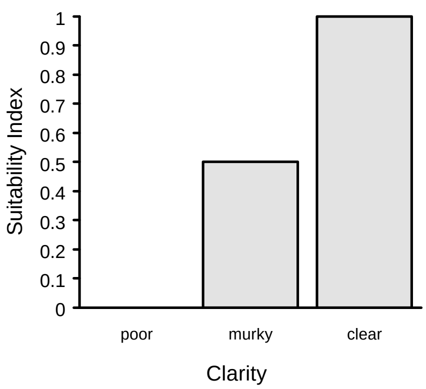
V1: Percent of pond with suitable water depth (10-45 cm).



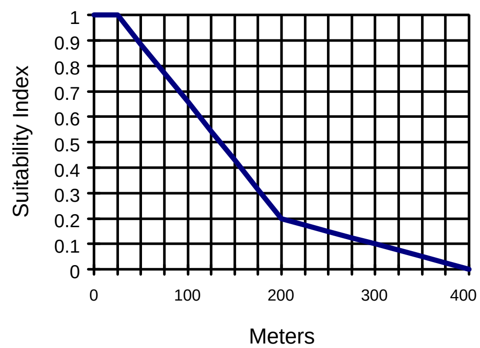
V2: Percent of suitable depth area with suitable vegetative cover (> 60 stems of ≤ 1 cm diameter per m^2).



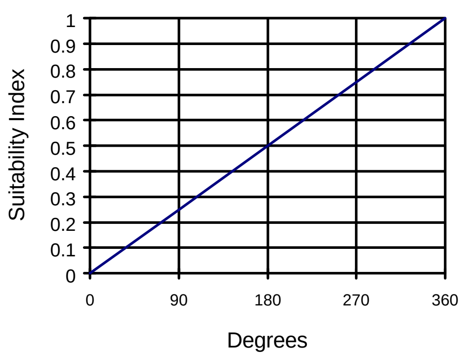
V3: Water clarity.



V4: Distance to acceptable terrestrial cover (trees, brush, downed logs, etc.).



V5: Pond perimeter with acceptable terrestrial cover.



Chorus Frog HSI Determination

The HSI is determined by asking the following questions:

- Is there suitable depth and vegetative cover?
- Does the pond have clear water?
- How far is it to acceptable terrestrial cover?
- How much of the pond perimeter contains acceptable terrestrial cover?