FWS/OBS-82/10.35
September 1983

HABITAT SUITABILITY INDEX MODELS: LONGNOSE SUCKER

by

Elizabeth A. Edwards
Habitat Evaluation Procedures Group
Western Energy and Land Use Team
U.S. Fish and Wildlife Service
Drake Creekside Building One
2627 Redwing Road
Fort Collins, CO 80526

Purchase Order Number 98300-6930-81

Project Officer

James W. Terrell
Western Energy and Land Use Team
U.S. Fish and Wildlife Service
Drake Creekside Building One
2627 Redwing Road
Fort Collins, CO 80526

Western Energy and Land Use Team
Division of Biological Services
Research and Development
Fish and Wildlife Service
U.S. Department of the Interior
Washington, DC 20240

This report should be cited as:

Edwards, E. A. 1983. Habitat suitability index models: Longnose sucker. U.S. Dept. Int., Fish Wildl. Serv. FWS/OBS-82/10.35. 21 pp.

PREFACE

The habitat use information and Habitat Suitability Index (HSI) models presented in this document are an aid for impact assessment and habitat management activities. Literature concerning a species' habitat requirements and preferences is reviewed and then synthesized into subjective HSI models, which are scaled to produce an index between 0 (unsuitable habitat) and 1 (optimal habitat). Assumptions used to transform habitat use information into these mathematical models are noted, and guidelines for model application are described. Any models found in the literature which may also be used to calculate an HSI are cited, and simplified HSI models, based on what the author believes to be the most important habitat characteristics for this species, are presented. Preference curves for use with the Instream Flow Incremental Methodology (IFIM) are excluded from this publication. A summary document describing curves for use with IFIM for this species and preceding species publications in this series (82/10) is planned for early 1984.

Use of the models presented in this publication for impact assessment requires the setting of clear study objectives and may require modification of the models to meet those objectives. Methods for modifying HSI models and recommended measurement techniques for model variables are presented in Terrell et al. (1982).[1] A discussion of HSI model building techniques is presented in U.S. Fish and Wildlife Service (1981).[2]

The HSI models presented herein are complex hypotheses of species-habitat relationships, not statements of proven cause and effect relationships. The models have not been tested against field data. For this reason, the U.S. Fish and Wildlife Service encourages model users to convey comments and suggestions that may help us increase the utility and effectiveness of this habitat-based approach to fish and wildlife planning. Please send comments to:

Habitat Evaluation Procedures Group
Western Energy and Land Use Team
U.S. Fish and Wildlife Service
2627 Redwing Road
Ft. Collins, CO 80526

---

[1]Terrell, J. W., T. E. McMahon, P. D. Inskip, R. F. Raleigh, and K. L. Williamson. 1982. Habitat suitability index models: Appendix A. Guidelines for riverine and lacustrine applications of fish HSI models with the Habitat Evaluation Procedures. U.S. Dept. Int., Fish Wildl. Serv. FWS/OBS-82/10.A. 54 pp.

[2]U.S. Fish and Wildlife Service. 1981. Standards for the development of habitat suitability index models. 103 ESM. U.S. Dept. Int., Fish Wildl. Serv., Div. Ecol. Serv. n.p.

CONTENTS

ACKNOWLEDGMENTS

I would like to thank B. Walton, B. F. Bidgood, and B. Barton for reviewing the manuscript. The life history information presented in the text is derived from a report written by M. C. Lindzey and R. V. Bulkley, Utah State Cooperative Fishery Research Unit, under the terms of contract number 14-16-0009-79-041. C. Short provided the editorial review, and word processing was provided by D. Ibarra and C. Gulzow. The cover illustration is from Freshwater Fishes of Canada 1973, Bulletin 184, Fisheries Research Board of Canada, by W. B. Scott and E. J. Crossman.

LONGNOSE SUCKER (Catostomus catostomus)

HABITAT USE INFORMATION

General

The longnose sucker (Catostomus catostomus) is the most widespread sucker in the North and is found in large numbers in most clear, cold waters (Lee et al. 1980). The species occurs throughout Canada and Alaska, and south to western Maryland, north to Minnesota, west and north through northern Colorado, and through Washington, in the U.S.A. (Scott and Crossman 1973). It occurs in arctic drainages of eastern Siberia (Bajkov 1927) and North America (McPhail and Lindsey 1970), but is not found in the arctic islands or in insular Newfoundland (Scott and Crossman 1973). Sporadic populations occur further south, where it appears as a glacial relict or semirelict population (Lee et al. 1980), but, in general, longnose suckers probably do not occur south of 40° north latitude, except in West Virginia (Jordan and Evermann 1902).

The longnose sucker has been reported to hybridize with the mountain sucker, C. platyrhynchus (Hubbs et al. 1943), and with the white sucker, C. commersoni (Middleton 1969; Nelson 1973). Dwarf forms of the longnose sucker, which are often late-spawning, have been considered separate subspecies (C. c. nannomyzon in the East, and C. c. pocatello in Idaho and Montana) (McPhail and Lindsey 1970).

Age, Growth, and Food

In the northern part of its range, the longnose sucker reaches maturity at ages IV-VII (Rawson and Elsey 1948; Brown and Graham 1953; Harris 1962; Barton 1980), usually IV-V for males and V-VI for females. In Colorado, maturity occurs at age III for males and age IV for females (Hayes 1957).

The largest longnose sucker on record was a 19-year old female that was 642 mm long and weighed 3.3 kg from Great Slave Lake (Harris 1962). Longnose suckers rarely attain a length greater than 450 mm and a weight greater than 1 kg (Simon 1946; Slastenenko 1958) and usually do not live more than 8-11 years (Barton 1980; Walton 1980). Individuals in the North are significantly smaller than those in the south (Rawson and Elsey 1948; Harris 1962). Females are larger than males and tend to live longer (Rawson and Elsey 1948; Brown and Graham 1953; Nikolskii 1954; Hayes 1957; Harris 1962).

Longnose sucker fry feed on zooplankton (Crawford 1923; Hubbs and Creaser 1924; Rawson and Elsey 1948) and diatoms (Nikolskii 1954), making a transition to larger organisms, such as benthic invertebrates (Ryan 1980), as they grow. Adults are generally omnivorous (Scott and Crossman 1973), consuming amphipods (Rawson and Elsey 1948; Hayes 1957), cladocerans (Barton 1980; Barton and Bidgood 1980), benthic insects (mainly Chironomidae), and other invertebrates (Nikolskii 1954; Barton and Bidgood 1980; Ryan 1980), depending on food availability. They also ingest plants, algae, and detritus (Hayes 1957; Ryan 1980), but have not been known to take vertebrates (Scott and Crossman 1973). Brown and Graham (1953) found that the species would primarily eat vegetation and insects in tributaries and crustaceans and dipterans in lakes. Longnose suckers tend to be more "pelagic" feeders than other suckers (Barton 1980).

Food supply is an important limit to growth for longnose suckers. In the southern part of the Great Slave Lake, Canada, which has been enriched with organic material, longnose sucker growth rate was greater than in the northern part of the lake, which is more oligotrophic (Harris 1962). Ryan (1980) found that growth of longnose suckers was lowest in the rapid waters below a waterfall and fastest in the slow moving waters downstream. In both cases, a greater supply of food is believed to have increased the growth rate.

Reproduction

Spawning usually occurs in tributary streams of large bodies of water (Brown and Graham 1953; Harris 1962; Walton 1980), but spawning will also take place in shallow areas of large lakes or reservoirs (Rawson and Elsey 1948; Smith 1979; Ryan 1980). Spawning migrations begin from mid-April to early July as ice breaks up in the spring, but the spawning peak is usually in June (Rawson and Elsey 1948; Brown and Graham 1953; Hayes 1957; Bassett 1958; Harris 1962; Barton 1980).

Spawning movements begin at 5-9° C (Geen et al. 1966; Walton 1980). Spawning itself occurs at about 10-15° C with all fish usually spent at 15° C (Rawson and Elsey 1948; Harris 1962; Walton 1980). Walton (1980) found that initial upstream movement is related to water temperature, while the rate of movement is influenced by fluctuations in discharge. Barton (1980) found that both water temperature and discharge play a role in the initiation of spawning migration, depending on which condition is limiting in the spring.

The longnose sucker does not prepare a nest. The adhesive eggs are broadcast over clean gravel and rocks (1-20 cm) in riffle areas, where there is a velocity of about 0.3-1.0 m/sec, or along wave-swept shorelines, at depths of about 15-30 cm (Geen et al. 1966; Walton 1980).

Specific Habitat Requirements

Longnose suckers in North America inhabit streams, lakes, and reservoirs. Longnose suckers from lake environments will enter rivers only to spawn or overwinter (Harris 1962; Walton 1980).

The species is most abundant in cold, oligotrophic lakes, 34-40 m deep (Rawson 1942; Hayes 1957; Walton 1980). These lakes are characterized as having very little littoral area, with the depth increasing rapidly. Total dissolved solids (TDS) levels of these lakes are generally < 10-20 mg/l (Johnson 1971), and Secchi disk readings range from 4-13 m (Rawson 1942; Johnson 1971).

Longnose suckers are less successful than other suckers, such as white suckers, in reservoirs with fluctuating water levels. They can do well initially in new impoundments of swift rivers due to increased production of benthos (Ryan 1980). Because they are well-adapted to high current velocities (Walton 1980), longnose suckers will also live in swift rivers with a stony bottom, moving into areas with strong currents to spawn (Nikolskii 1954).

Abundant populations of suckers were found in two Canadian lakes with pH ranges of 6.6-7.3 (Johnson 1971) and 7.8-8.2 (Rawson 1942). It is assumed that a pH within the range of 6.6-8.2 would be adequate for longnose suckers. Dissolved oxygen (DO) levels were high in these two lakes. In several studies of longnose suckers, the dissolved oxygen concentration levels have varied from 5.6-10.0 ppm (Rawson 1942; Rawson and Elsey 1948; Rawson 1959; Clemans et al. 1968). (The Committee on Water Quality Criteria (1972) indicates that DO concentrations should not fall below 6 ppm to maintain good freshwater fish populations.)

Longnose sucker habitat usually has very clear and clean water. Effects of turbidity on longnose suckers have not been determined. Harris (1962) observed the species spawning in a river with extreme turbidity but did not quantify the levels.

The longnose sucker is known to frequent brackish water (Nikolsii 1954) and can be abundant, at times, in brackish water around river mouths (McPhail and Lindsey 1970).

Adult. The preferred temperature range for adults is 10-15° C (Brown and Graham 1953), with the greatest numbers collected at 11.6° C (Cooper and Fuller 1945). Adults caught at 14.4° C all died at 28.3° C; for those fish acclimated at 11.5° C, the upper lethal temperature (50% mortality in 24 hours) was 27° C (Black 1953). In northern Saskatchewan, temperatures in a lake with longnose suckers ranged from 3° C in mid-June to 18.5° C in mid-August (Johnson 1971). Mean midsummer temperatures in a western Canadian alpine lake with abundant longnose suckers were 6.2-10.8° C (Rawson 1942), but exceeded 16° C in a southern Alberta reservoir also containing longnose suckers (Walton 1980).

Longnose sucker adults are most common at depths up to 30 m (Johnson 1971), but will move inshore at night to feed or to spawn (Hayes 1956). In Great Slave Lake, longnose suckers were uncommon below 17 m, but were occasionally found at great depths (McPhail and Lindsey 1970). The species has been found at depths up to 183 m in Lake Superior (Lee et al. 1980).

Overwintering areas are necessary primarily in northern areas with prolonged ice cover. These areas must have adequate oxygen as well as be of suitable depth.

Embryo. The eggs settle to the bottom in the gravel near the tail of the riffle (Walton 1980), where they receive an abundant supply of oxygen, which is necessary for embryo development. Incubation will take 8 days at about 15° C and 11 days at about 10° C (Geen et al. 1966). Walton (1980) observed embryos hatch after 14 days at a mean temperature of 12.2° C.

Fry. Fry (11-18 mm) remain in the gravel for 1-2 weeks (Geen et al. 1966; Scott and Crossman 1973). After emerging from the gravel, they drift downstream primarily at night (Balon 1975; Walton 1980). Drifting was greatest when stream velocity was very fast, but the rate of downstream movement was related to the age of the larvae and not to differences in temperature, discharge, or turbidity. Temperature can, however, influence embryological development (Walton 1980). Harris (1962) reports that fry spend the first summer in the river. Geen et al. (1966) reported that peak fry migration was about 1 month after spawning. Fry seek food and shelter in shallow, quiet water with vegetation (Brown and Graham 1953). Fry congregate in the top 150 mm of water and within 2 m of shore (Hayes 1956). Fry are assumed to tolerate temperature fluctuations common to shallower water. Reservoir drawdowns in June and July (before fry begin to move to deeper water) may cause fry mortality (Ryan 1980).

Juvenile. Juvenile longnose suckers (23 - 89 mm) live in lentic waters and frequent shallow, weedy areas. Juveniles remain in subsurface areas and have not been observed feeding on the bottom (Hayes 1956). Juveniles seek out areas with some current (Johnson 1971) and may enter the lower reaches of streams to live, yet they will only move into the upper reaches as adults to spawn (Walton 1980).

HABITAT SUITABILITY INDEX (HSI) MODELS

Model Applicability

Geographic area. The model is applicable throughout the native range of the longnose sucker in North America. The standard of comparison for each individual variable suitability index is the optimum value of the variable that occurs anywhere within the native region. Therefore, the model will never provide an HSI of 1.0 when applied to water bodies in the South where temperature related variables may not be optimum.

Season. The model provides a rating for a water body based on its ability to support a reproducing population of longnose suckers through all seasons of the year. The model will provide an HSI of 0.0 if any reproduction related variable indicates that the species is not able to reproduce in the habitat being evaluated.

Cover types. The model is applicable in riverine and lacustrine habitats as described by Cowardin et al. (1979).

Minimum habitat area. No attempt has been made to establish a minimum habitat size for longnose suckers.

Verification level. The acceptance goal of the longnose sucker model is to produce an HSI value between 0 and 1 that represents the overall habitat suitability, derived from specific abiotic variables, as combined by the author. The model has not been tested with actual population data.

Model Description - Lacustrine

Because longnose suckers that live in a lacustrine habitat enter a riverine habitat only to spawn or overwinter, the lacustrine model will include the riverine habitat used by lacustrine populations. Longnose sucker habitat quality analysis is based on life-stage components, including embryo, fry, juvenile, and adult requirements. Variables that have been shown to affect the survival, growth, and abundance of longnose suckers are placed in the appropriate components (Fig. 1).

In the limiting factor approach, an SI value of 0.7 is used. There is little direct evidence of compensation of a low SI value for one variable by a high value for another variable. It is assumed that compensation is more likely to occur at near optimum levels, and this assumption is quantified by selecting 0.7 as the SI value below which compensation does not occur. This value is a hypothesis, not a fact, and it is suggested that any data for habitats similar to those where the model will be used be examined to determine the extent of variable interaction.

Embryo component. The embryo component is the most important component because it defines the spawning habitat and hence the capability of the habitat to support reproducing populations of longnose suckers. Five variables are included in this component. Spawning location, including inlet streams, outlet streams, and shoreline areas, (V_1) is important because spawning would not occur without these areas. Riffle depth (V_2) is included because eggs are broadcast over the bottom at a certain depth so that they drift only far enough to lodge in the end of the riffle. Adequate current velocity (V_3) ensures that there will be abundant oxygen for successful development of the embryo. Water temperature during spawning (V_4) is very critical because spawning and incubation in longnose suckers occurs only within a narrow range. Percent riffles (V_5) is included because the species only spawns in riffle areas in riverine habitat, which are usually areas of high current velocity and high dissolved oxygen. Substrate type (V_6) is important because shoreline and stream spawning only occurs over a gravel and rock substrate.

Fry component. Fry live in both the lacustrine and riverine habitats. Little data were found on the fry life stage; however, two variables were considered important. Percent cover (V_7) is included because fry need some cover, usually in the form of vegetation, boulders, or rubble, during daylight hours in shallow areas. These areas also have abundant available food for developing young. Fluctuation in water level (V_8) is included because fry mortality can occur if there is a reservoir drawdown during summer.

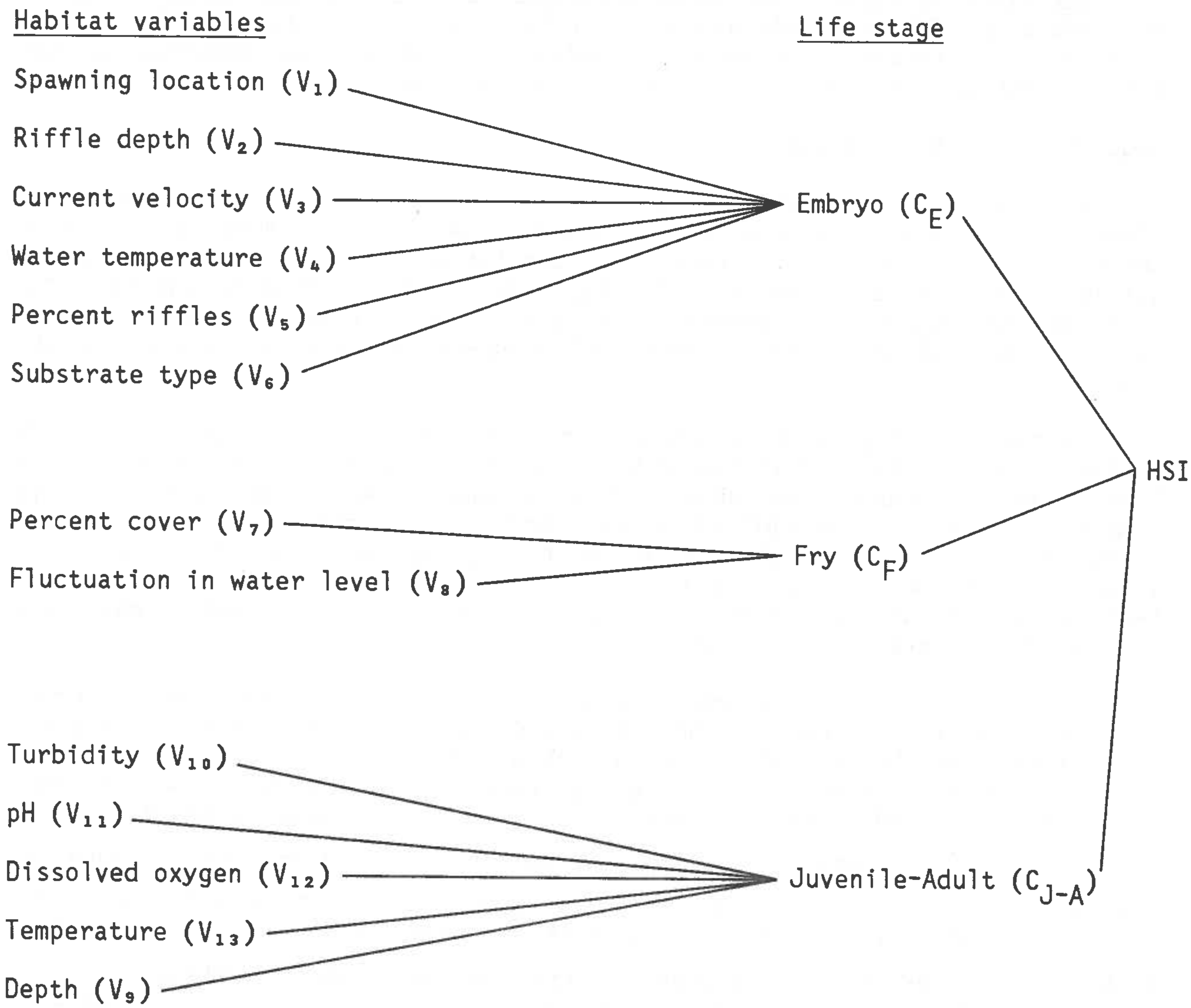


Figure 1. Tree diagram illustrating the relationship of habitat variables and life stages in the lacustrine model for the longnose sucker.

Temperature data for the fry life stage were not found in the literature. However, I assume that fry will tolerate slightly greater extremes than adults because they are adapted to the fluctuating temperature conditions of shallow water.

Juvenile-Adult (C_{J-A}). Juveniles and adults are combined into one component because the primary habitat for these life stages is lacustrine. Water quality variables, turbidity (V_{10}), pH (V_{11}), and dissolved oxygen (DO) (V_{12}), are included because these factors determine the abundance and survival of longnose suckers in lakes or reservoirs. Water temperature (V_{13}), which is a function of latitude, altitude, and water depth (V_9), is the most important limiting factor for longnose suckers.

Model Description - Riverine

Data on resident riverine populations of longnose suckers were not located in the literature. The riverine model consists of one component, Embryo (C_E), which describes the spawning habitat. It is assumed that the spawning habitat for riverine and lacustrine populations is the same. Riffle depth (V_2), current velocity (V_3), temperature (V_4), percent riffles (V_5), and substrate type (V_6) are included in the riverine embryo component (Fig. 2). See the Lacustrine model description for an explanation of why the variables are important.

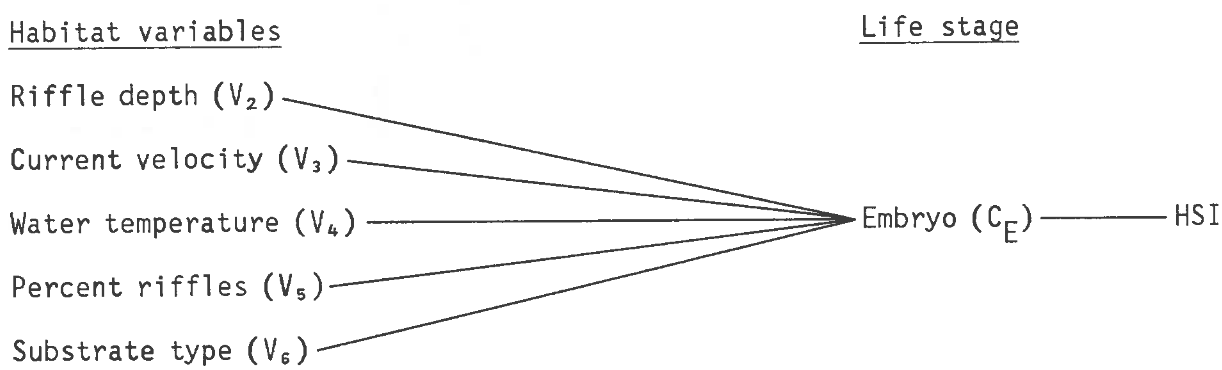
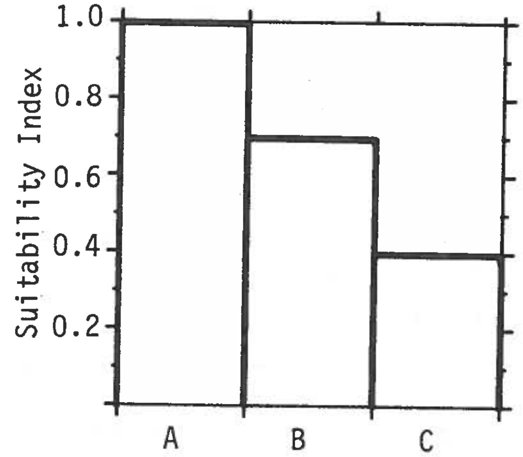
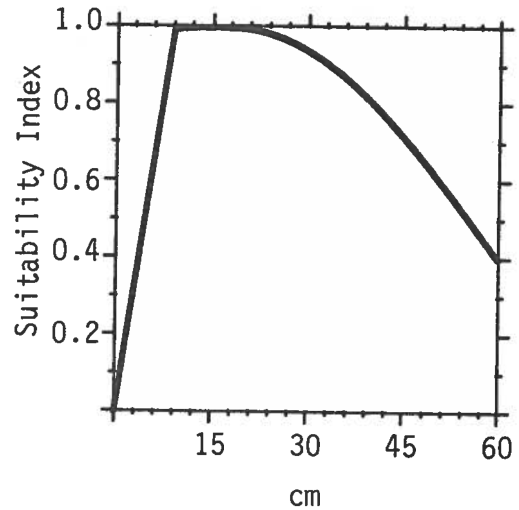
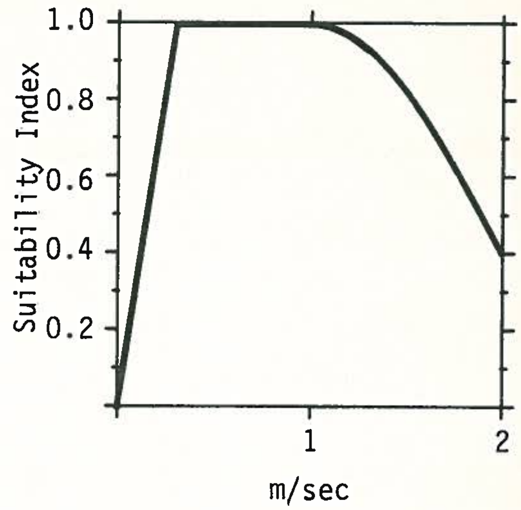
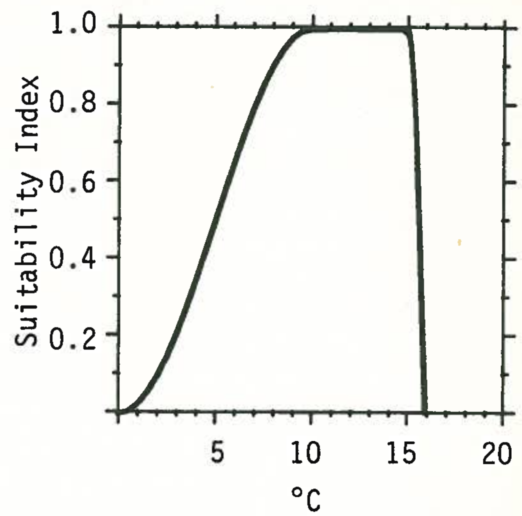
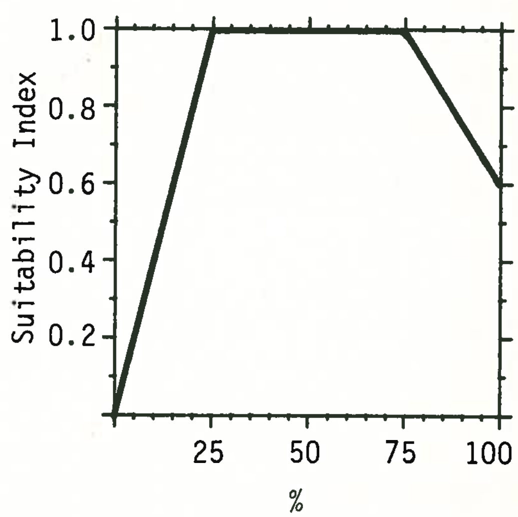


Figure 2. Tree diagram illustrating the relationship of habitat variables and life stage in the riverine model for the longnose sucker.

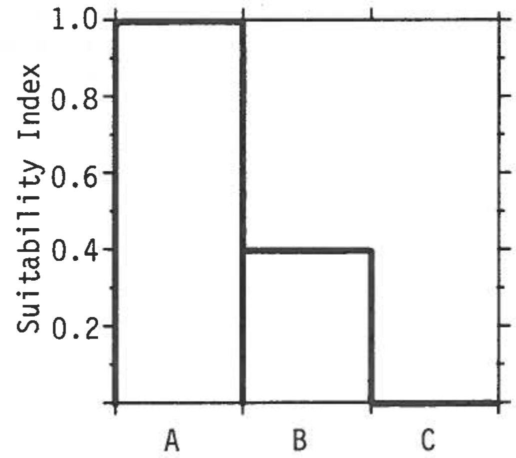
Suitability Index (SI) graphs for model variables. This section contains suitability index graphs for the 13 variables described above and equations for combining selected variable indices into a species HSI using the component approach. Variables may pertain to either a riverine (R) habitat, a lacustrine (L) habitat, or both.

Habitat	Variable		Suitability Graph
R,L	V_1	Spawning location A. Inlet streams. B. Outlet streams. C. Shoreline area.	
R,L	V_2	Depth of riffle or shoreline area for spawning.	

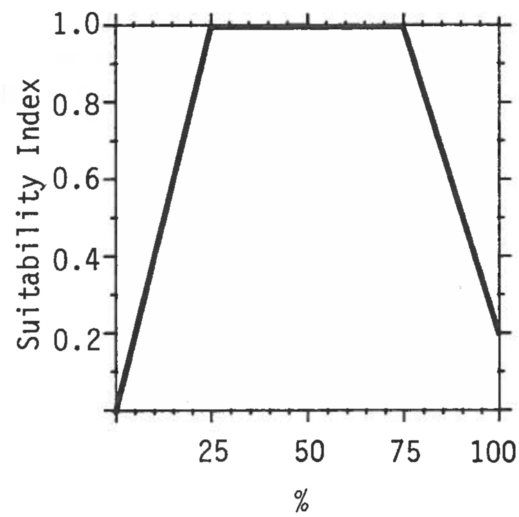
R,L	V_3	Current velocity within spawning habitat.	
R,L	V_4	Mean water temperature during spawning and incubation.	
A	V_5	Percent riffles in spawning stream.	

R V$_6$ Substrate type:

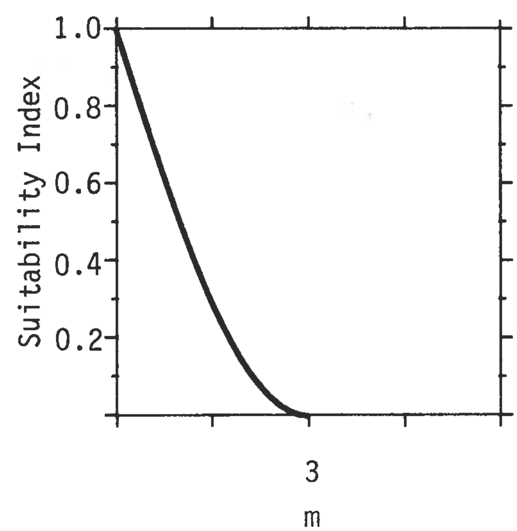
A. Gravel and rock 1-20 cm.
B. Mixture of gravel and sand and boulders.
C. Mud, silt, detritus, or bedrock.



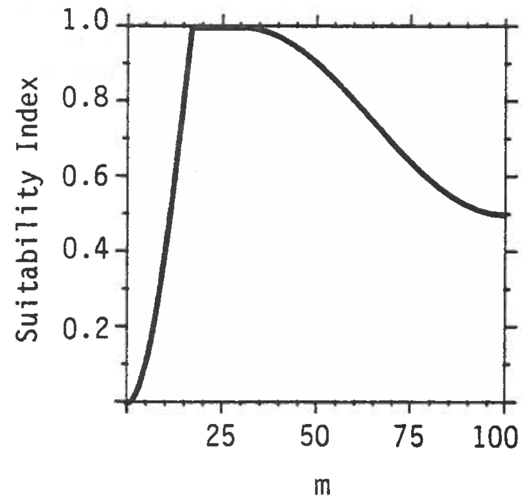
R,L V$_7$ Percent cover in the form of vegetation, boulders, or rubble in shallow edge or shoreline areas (May-July).



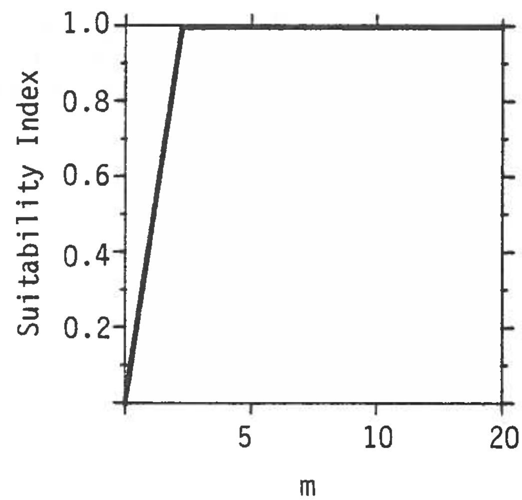
L V$_8$ Fluctuation in water level in mid-summer (reservoirs).



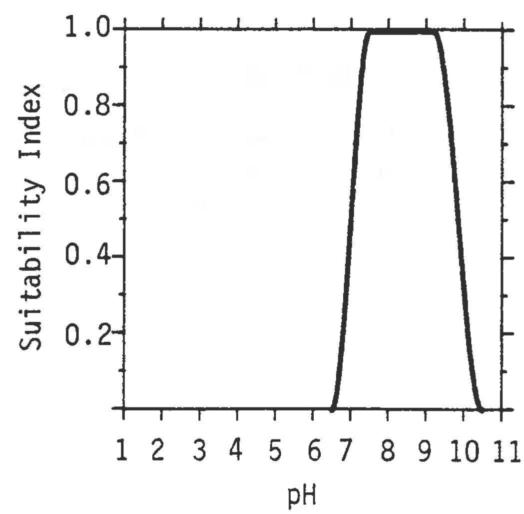
L V_9 Maximum depth.



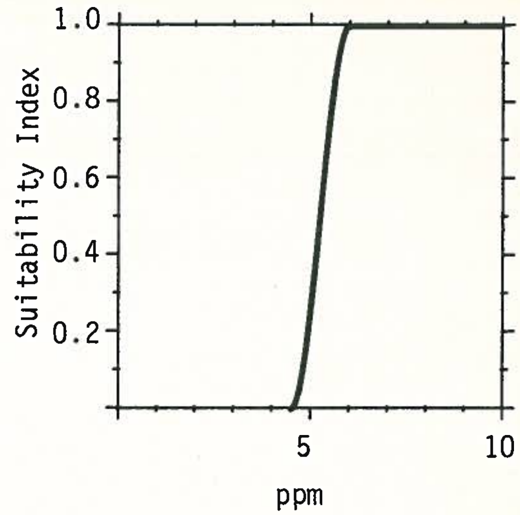
L V_{10} Average turbidity (Secchi disk) during the growing season.



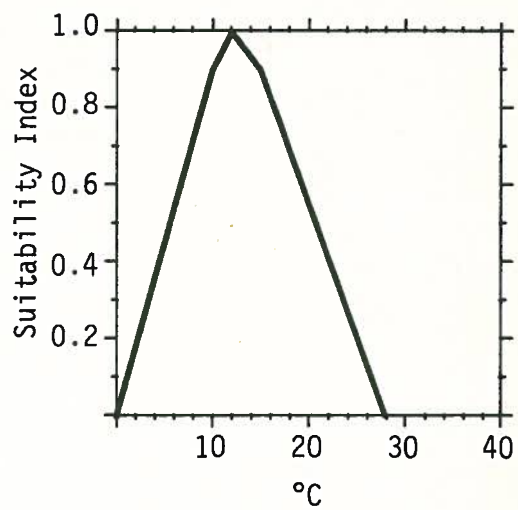
L V_{11} pH range during the summer.



L V_{12} DO (dissolved oxygen) during the summer.



L V_{13} Mean water temperature during the summer.



Lacustrine Model

This model utilizes the life-stage approach and consists of three components: embryo; fry; and juvenile-adult.

Embryo (C_E).

$$C_E = (V_1 \times V_2 \times V_3 \times V_4^2 \times V_5 \times V_6)^{1/7}$$

Except, if any variable is ≤ 0.7, C_E equals the lowest value of any variable in the above equation.

Fry (C_F).

$$C_F = \frac{V_7 + V_8}{2}$$

Juvenile-Adult (C_{J-A}).

$$C_{J-A} = \frac{V_9 + V_{10} + V_{11} + V_{12} + 2V_{13}}{6}$$

If V_{13} is ≤ 0.7, C_{WQ} equals the lowest of the following: V_{13} or the above equation.

HSI determination

$$HSI = (C_E^2 \times C_F \times C_{J-A})^{1/4}$$

If C_E is ≤ 0.7, the HSI equals the lowest of the following: C_E or the above equation.

Riverine Model

This model utilizes the life-stage approach and consists of one component: embryo.

Embryo (C_E).

$$C_E = (V_2 \times V_3 \times V_4^2 \times V_5 \times V_6)^{1/6}$$

Except, if any variable is ≤ 0.7, C_E equals the lowest value of any variable in the above equation.

HSI determination

$$HSI = C_E$$

Sources of data and assumptions made in developing the suitability indices are presented in Table 1.

Sample data sets from which HSI's have been generated using the riverine and lacustrine HSI equations are given in Tables 2 and 3. The data are not actual field measurements, but represent combinations that could occur in a riverine or lacustrine habitat. The HSI's calculated from the data appear to be reasonable indicators of what carrying capacity trends would be in riverine and lacustrine habitats with the listed characteristics. In its present state, the highest acceptance goal the model can meet is that it is reasonable to believe the HSI has a positive relationship to the carrying capacity of fry, juvenile, and adult longnose suckers and maximum survivability of the species.

Intrepreting Model Outputs

Longnose suckers may be present even when the HSI determined by one of the above models is 0; however, I believe it is unlikely that high population levels would occur in water bodies with a 0 rating. On the other hand, habitat with a high HSI may contain few fish because the standing crop does not totally depend on the ability of the habitat to meet all life requisite requirements of the species. If the model is a good representation of longnose sucker lacustrine or riverine habitat, it should be positively correlated with long term average population levels in areas where longnose sucker population levels are due primarily to habitat-related factors. However, this relationship has not been tested. The proper interpretation of the HSI is one of comparison. If two habitats have different HSI's, the one with the higher HSI should have the potential to support more longnose suckers than the one with the lower HSI, given that the model assumptions have not been violated.

Table 1. Data sources and assumptions for the suitability graphs for longnose suckers.

Variable and source		Assumption
V_1	Rawson and Elsey 1948 Brown and Graham 1953 Harris 1962 Smith 1979 Ryan 1980 Walton 1980	Adequate spawning habitat is essential for the reproduction of the species.
V_2	Geen et al. 1966 Walton 1980	Water depth that creates optimum spawning conditions is optimum.
V_3	Geen et al. 1966 Walton 1980	The current velocity that creates optimum spawning conditions is optimum.
V_4	Rawson and Elsey 1948 Harris 1962 Geen et al. 1966 Walton 1980	Temperatures that promote normal embryo development are optimum. Temperatures that lower survival are suboptimum. Lethal temperatures are unsuitable.
V_5	Geen et al. 1966 Walton 1980	The percent of riffles that ensures prime spawning habitat is optimum.
V_6	Geen et al. 1966 Walton 1980	The type of substrate that ensures maximum survivability is optimum.
V_7	Brown and Graham 1953	The amount of cover, in the form of vegetation, that harbors abundant numbers of fry is optimum.
V_8	Ryan 1980	Fluctuations in water level that cause mortality are unsuitable (reservoirs).
V_9	McPhail and Lindsey 1970 Johnson 1971 Lee et al. 1980	The maximum depth of water in a habitat that has abundant populations of longnose suckers is optimum.
V_{10}	Rawson 1942 Johnson 1971	Secchi disk readings in waters that have an abundance of longnose suckers are optimum.
V_{11}	Rawson 1942 Johnson 1971	pH levels in lakes with abundant populations of longnose suckers are optimum.

Table 1. (concluded).

Variable	and source	Assumption
V_{12}	Rawson 1942, 1959 Rawson and Elsey 1948 Clemens et al. 1968	DO levels in lakes with abundant populations of longnose suckers are optimum.
V_{13}	Rawson 1942 Cooper and Fuller 1945 Black 1953 Brown and Graham 1953 Johnson 1971	Optimum temperatures are those where the greatest numbers of suckers are found. Temperatures that caused death are unsuitable.

Table 2. Sample data sets using the lacustrine HSI modèl.

Variable		Data set 1 Data	SI	Data set 2 Data	SI	Data set 3 Data	SI
Spawning location	V_1	A	1.0	B	0.7	C	0.4
Depth for spawning (cm)	V_2	18	1.0	60	0.4	25	1.0
Current velocity (cm/sec)	V_3	0.5	1.0	0.1	0.4	1.9	0.5
Temperature (°C) (embryo)	V_4	12	1.0	7	0.8	10	1.0
Riffles (%)	V_5	30	1.0	30	1.0	10	0.4
Substrate type	V_6	A	1.0	A	1.0	C	0.0
Cover (%)	V_7	30	1.0	50	1.0	50	1.0
Water fluctuation (m)	V_8	0	1.0	0	1.0	1.5	0.4
Maximum depth (m)	V_9	20	1.0	10	0.4	12	0.6
Secchi disk (m)	V_{10}	10	1.0	8	1.0	1	0.4
pH	V_{11}	7.3	1.0	7.3	1.0	7.3	1.0
DO (mg/l)	V_{12}	10	1.0	6.0	1.0	8.0	1.0
Temperature (°C)	V_{13}	16	0.9	18	0.7	12	1.0
Component SI							
C_E =			1.00		0.40		0.00
C_F =			1.00		1.00		0.70
C_{J-A} =			0.97		0.80		0.83
HSI =			0.99		0.40		0.00

Table 3. Sample data sets using the riverine HSI model.

Variable		Data set 1		Data set 2		Data set 3	
		Data	SI	Data	SI	Data	SI
Depth for spawning (m)	V_2	18	1.0	22	1.0	24	1.0
Current velocity (cm/sec)	V_3	0.5	1.0	1.0	1.0	1.9	0.5
Spawning temperature (°C)	V_4	12	1.0	7	0.8	10	1.0
Riffles (%)	V_5	30	1.0	45	1.0	10	0.4
Substrate type	V_6	A	1.0	B	0.4	C	0.0
$HSI = C_E =$			1.0		0.40		0.00

ADDITIONAL HABITAT MODELS

Model 1

Optimum lacustrine habitat for longnose suckers is characterized by the following conditions: large, deep natural lakes; tributary streams (inlets) for spawning; cool midsummer temperatures (10-15° C); abundant oxygen (> 6 ppm); and adequate food supply.

$$HSI = \frac{\text{number of above criteria present}}{6}$$

Model 2

One approach that could be considered is to let the HSI value correspond to the lowest SI value determined for any one of the varibles in the model (Inskip 1982). This approach would avoid the use of equations. Many factors can affect the carrying capacity of a given habitat including the variables presently in the HSI model and others not included (predation, competition, fishing mortality, barriers to migration, ice scour, or other catastrophic events). If species population levels are not due primarily to habitat-related factors, it may be inappropriate to use a HSI value as an index of carrying capacity of an area for the species and other model approaches should be considered.

REFERENCES

Bajkov, A. 1927. Reports of the Jasper Park Lakes investigation, 1925-1926. I. The fishes. Contrib. Can. Biol. Fish. 3(16):379-404.

Balon, E. K. 1975. Reproductive guilds of fishes: proposal and definition. J. Fish. Res. Board Can. 32(6):821-864.

Barton, B. A. 1980. Spawning migrations, age, and growth, and summer feeding of white and longnose suckers in an irrigation reservoir. Can. Field-Nat. 94(3):300-304.

Barton, B. A., and B. F. Bidgood. 1980. Competitive feeding habits of rainbow trout, white sucker, and longnose sucker in Paine Lake, Alberta. Fish. Res. Rep. Fish Wildl. Div., Alberta 16. 27 pp.

Bassett, H. M. 1958. Further lake history studies of two species of suckers in Shadow Mountain Reservoir, Grand County, Colorado. Colorado Coop. Fish. Res. Unit. Quarterly Rep. Vol. 4:28-30.

Black, E. C. 1953. Upper lethal temperatures of some British Columbia fresh-water fishes. J. Fish. Res. Board Can. 10(14):196-210.

Brown, C. J. D., and R. J. Graham. 1953. Observations on the longnose sucker in Yellowstone Lake. Trans. Am. Fish. Soc. 83:38-46.

Clemans, W. A., R. V. Broughton, and J. A. Rattenbury. 1968. A limnological study of Telsin Lake, Canada. British Columbia Fish Wildl. Branch, Vancouver. Manage. Publ. 12. 77 pp.

Committee on Water Quality Criteria. 1972. Water quality criteria 1972. A report of the Committee on Water Quality Criteria, Natl. Acad. Sci., Washington, DC. 594 pp.

Cooper, G. P., and J. L. Fuller. 1945. Maine Dept. Ind. Game Fish Surv. Rep. 6.

Cowardin, L. M., V. Carter, F. C. Golet, and E. J. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. U.S. Dept. Int., Fish Wildl. Serv. FWS/OBS-79/31. 103 pp.

Crawford, D. R. 1923. The significance of food supply in the larval development of fishes. Ecology 4:147-153.

Geen, G. H., T. G. Northcote, G. F. Hartman, and C. C. Lindsey. 1966. Life histories of two species of catostomid fishes in Sixteen Mile Lake, B. C., with particular reference to inlet stream spawning. J. Fish. Res. Board Can. 23(11):1761-1788.

Harris, R. H. D. 1962. Growth and reproduction of the longnose sucker Catostomus catostomus (Foster), in Great Slave Lake. J. Fish. Res. Board Can. 19(1):113-126.

Hayes, M. L. 1956. Life history of two species of suckers in Shadow Mountain Reservoir, Grand County, Colorado. M.S. Thesis. Colorado A&M College, Ft. Collins. 126 pp.

Hayes, M. L. 1957. Sucker life history information. Colorado Game Fish Dept. Fishery Leaflet 42. 2 pp.

Hubbs, C. L., and C. W. Creaser. 1924. On the growth of young suckers and the propagation of trout. Ecology 5:372-378.

Hubbs, C. C., L. Hubbs, and R. E. Johnson. 1943. Hybridization in nature between species of catostomid fishes. Contrib. Lab. Vertebrate Biol. 22. 79 pp.

Inskip, P. D. 1982. Habitat suitability index models: northern pike. U.S. Dept. Int., Fish Wildl. Serv. FWS/OBS-82/10.17. 40 pp.

Johnson, R. P. 1971. Limnology and fishery biology of Black Lake, Northern Saskatchewan. Fish Wildl. Branch, Dept. of Nat. Resour., Province of Saskatchewan. Fish. Dept. 9. 47 pp.

Jordan, D. S, and B. W. Everman. 1902. American food and game fishes. New York, Doubleday, Page and Co. 572 pp.

Lee, D. S., C. R. Gilbert, C. H. Hocutt, R. E. Jenkins, D. E. McAllister, and J. R. Stauffer, Jr. 1980. Atlas of North American freshwater fishes. North Carolina Biological Survey, Publ. 1980-12. 854 pp.

McPhail, J. D., and C. C. Lindsey. 1970. Freshwater fishes of northwestern Canada and Alaska. J. Fish. Res. Board Can. Bull. 173. 381 pp.

Middleton, W. H. 1969. Hybridization and distribution of catostomid fishes in Blue Mesa Reservoir and the upper Gunnison River drainage. M.S. thesis. Western College of Colorado, Gunnison. 121 pp.

Nelson, J. S. 1973. Occurrence of hybrids between longnose sucker Catostomus catostomus and white sucker Catostomus commersoni in upper Kanaskis Reservoir, Alberta. J. Fish. Res. Board Can. 30(4):556-560.

Nikolskii, G. V. 1954. Special Ichthyology. 2nd edition. Moscow, U.S.S.R. Trans. from Russian, Israel Program for Sci. Trans., Jerusalem. 538 pp.

Rawson, D. S. 1942. A comparison of some large alpine lakes in Western Canada. Ecology 23(2):143-161.

Rawson, D. S. 1959. Limnology and fisheries of Cree and Wollaston Lakes in northern Saskatchewan. Sask. Dept. Nat. Resour. Fish. Rep. 4. 73 pp.

Rawson, D. S., and C. A. Elsey. 1948. Reduction in the longnose sucker population of Pyramid Lake, Alberta, in an attempt to improve angling. Trans. Am. Fish. Soc. 78:13-31.

Ryan, P. M. 1980. Fishes of the Lower Churchill River, Labrador. Fish. Mar. Serv., Canada, Tech. Rep. 922.

Scott, W. B., and E. J. Crossman. 1973. Freshwater fishes of Canada. J. Fish. Res. Board Can. Bull. 184. 966 pp.

Simon, J. R. 1946. Wyoming fishes. Wyoming Game Fish Dept. Bull. 4. 129 pp.

Slastenenko, E. P. 1958. The freshwater fishes of Canada. Kiev Printers, Toronto. 388 pp.

Smith, P. W. 1979. The fishes of Illinois. Univ. of Illinois Press, Chicago. 313 pp.

Walton, B. D. 1980. The reproductive biology, early life history, and growth of white suckers, Catostomus commersoni, and longnose suckers, C. catostomus, in the Willow Creek - Chain Lakes System, Alberta. Fish Wildl. Div., Alberta. Fish Res. Rep. 23. 180 pp.

50272-101

REPORT DOCUMENTATION PAGE	1. REPORT NO. FWS/OBS-82/10.35	2.	3. Recipient's Accession No.
4. Title and Subtitle: Habitat Suitability Index Models: Longnose sucker			5. Report Date: September 1983
			6.
7. Author(s): E. A. Edwards			8. Performing Organization Rept. No.
9. Performing Organization Name and Address: Habitat Evaluation Procedures Group, U.S. Fish and Wildlife Service, Western Energy and Land Use Team, Creekside One Building, 2627 Redwing Road, Fort Collins, CO 80526-2899			10. Project/Task/Work Unit No.
			11. Contract(C) or Grant(G) No. (C) 98300-6930-81 (P.O.) (G)
12. Sponsoring Organization Name and Address: Western Energy and Land Use Team, Division of Biological Services, Research and Development, Fish and Wildlife Service, U.S. Department of the Interior, Washington, DC 20240			13. Type of Report & Period Covered
			14.

15. Supplementary Notes

16. Abstract (Limit: 200 words)

A review and synthesis of existing information was used to develop riverine and lacustrine habitat models for Longnose sucker (*Catostomus catostomus*) a freshwater species. The models are scaled to produce an index of habitat suitability between 0 (unsuitable habitat) and 1 (optimally suitable habitat) for freshwater areas of the continental United States. Habitat Suitability indices (HSI's) are designed for use with Habitat Evaluation Procedures previously developed by the U.S. Fish and Wildlife Service.

17. Document Analysis a. Descriptors

Mathematical models
Fishes
Aquatic biology
Habitability

b. Identifiers/Open-Ended Terms

Longnose sucker
Catostomus catostomus
Habitat Suitability Index

c. COSATI Field/Group

18. Availability Statement	19. Security Class (This Report)	21. No. of Pages
Release unlimited	Unclassified	21
	20. Security Class (This Page)	22. Price
	Unclassified	

(See ANSI–Z39.18) See Instructions on Reverse OPTIONAL FORM 272 (4–77) (Formerly NTIS–35) Department of Commerce

☆ U.S. GOVERNMENT PRINTING OFFICE: 1983—681-460/516 REGION NO. 8