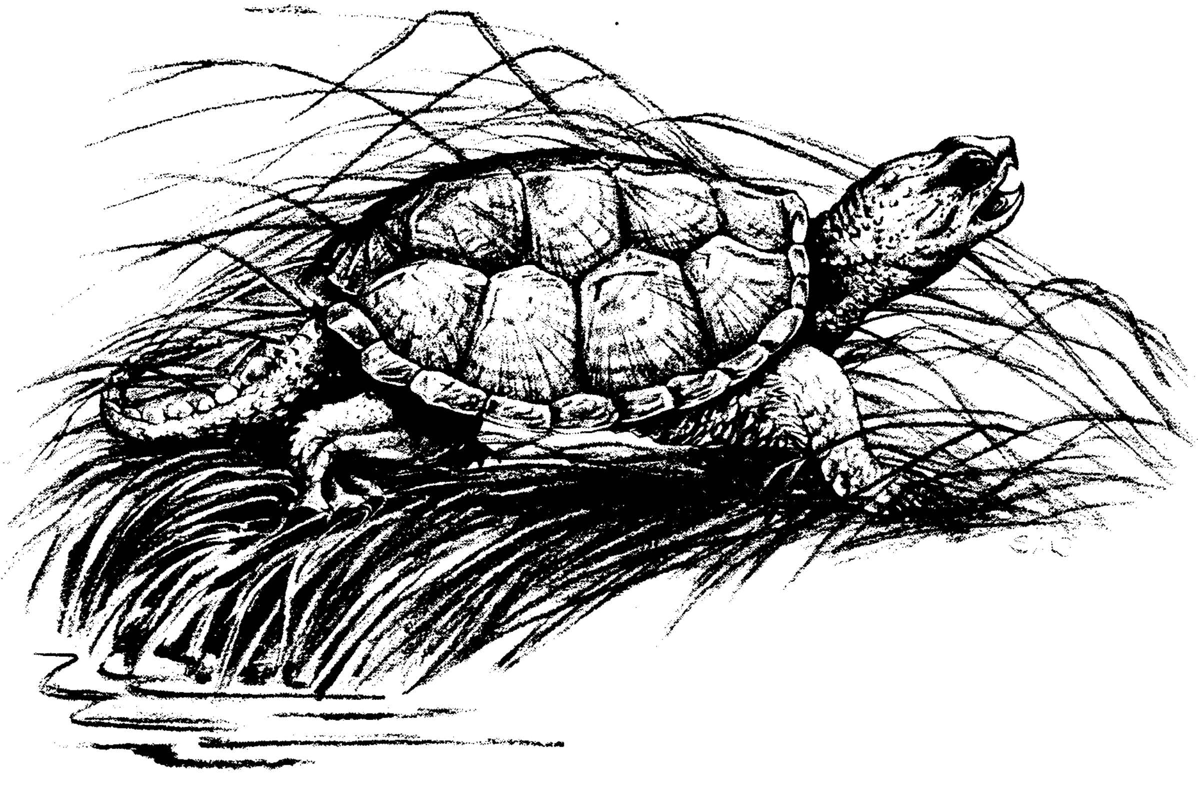
BIOLOGICAL REPORT 82(10.141)
JUNE 1987

HABITAT SUITABILITY INDEX MODELS: SNAPPING TURTLE



Fish and Wildlife Service

U.S. Department of the Interior

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HABITAT SUITABILITY INDEX MODELS: SNAPPING TURTLE

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This report should be cited as:

Graves, B.M., and S.H. Anderson. 1987. Habitat suitability index models: snapping turtle. U.S. Fish Wildl. Serv. Biol. Rep. 82(10.141). 18 pp.

PREFACE

This document is part of the Habitat Suitability Index (HSI) model series [Biological Report 82(10)], which provides habitat information useful for impact assessment and habitat management. Several types of habitat information are provided. The Habitat Use Information section is largely constrained to those data that can be used to derive quantitative relationships between key environmental variables and habitat suitability. This information provides the foundation for the HSI model and may be useful in the development of other models more appropriate to specific assessment or evaluation needs.

The HSI Model section documents the habitat model and includes information pertinent to its application. The model synthesizes the habitat use information into a framework appropriate for field application and is scaled to produce an index value between 0.0 (unsuitable habitat) and 1.0 (optimum habitat). The HSI Model section includes information about the geographic range and seasonal application of the model, its current verification status, and a list of the model variables with recommended measurement techniques for each variable.

The model is a formalized synthesis of biological and habitat information published in the scientific literature and may include unpublished information reflecting the opinions of identified experts. Habitat information about wildlife species frequently is represented by scattered data sets collected during different seasons and years and from different sites throughout the range of a species. The model presents this broad data base in a formal, logical, and simplified manner. The assumptions necessary for organizing and synthesizing the species-habitat information into the model are discussed. The model should be regarded as a hypothesis of species-habitat relationships and not as a statement of proven cause and effect relationships. The model may have merit in planning wildlife habitat research studies about a species, as well as in providing an estimate of the relative suitability of habitat for that species. User feedback concerning model improvements and other suggestions that may increase the utility and effectiveness of this habitat-based approach to fish and wildlife planning are encouraged. Please send suggestions to:

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FIGURES

ACKNOWLEDGMENTS

We would like to thank Michael Armbruster, Carl Armour, Adrian Farmer, and Mel Schamberger of the National Ecology Center, U.S. Fish and Wildlife Service, for professional and critical aid in development of this model. We also thank Carl Ernst, David Duvall, and John Legler for reviewing an early draft of this model.

The cover of this document was illustrated by Susan Strawn. Word processing was provided by Elizabeth Barstow, Patricia Gillis, Carolyn Gulzow, and Dora Ibarra. Funding for the development of this model was provided by the U.S. Fish and Wildlife Service and the Army Corps of Engineers.

SNAPPING TURTLE (Chelydra serpentina)

HABITAT USE INFORMATION

General

Snapping turtles (Chelydra serpentina) are large aquatic turtles that can be found in virtually any permanent or semipermanent lentic or slow-moving lotic body of water (Alexander 1943; Webb 1970; Feuer 1971). The species' range is from southern Canada to the Gulf of Mexico, and from the Atlantic Ocean to the Rocky Mountains (Conant 1975). A subspecies, Chelydra serpentina osceola, inhabits peninsular Florida, but there are no detectable differences in habitat preference between the subspecies (Feuer 1971). Perhaps, as a consequence of such a widespread distribution, there is large variation in the density of snapping turtle populations that different wetlands support (Froese and Burghardt 1975). Habitat features associated with such differences in an area's ability to support snapping turtle populations are the basis for this model.

Food

Much has been written about snapping turtle dietary preferences; however, there also is much discrepancy in reported findings even when stomach content analyses have been conducted (Pell 1941). Such disagreement is probably due to the omnivorous habits of snapping turtles. Indeed many authors have noted that snapping turtles will eat virtually anything organic that is available (Alexander 1943; Lagler 1943a; Hammer 1969, 1971; Feuer 1971; Punzo 1975). The above authors reported a variety of items within the general categories of aquatic vegetation, terrestrial vegetation, insects, mollusks, crustaceans, fish, amphibians, reptiles, birds, and mammals as food of snapping turtles. Specific food requirements likely do not play an important role in determining habitat quality and will not be discussed in detail here.

Pell (1941) stated that snapping turtles are mainly carnivorous in early spring, when they are often found wandering on land, because there is not yet sufficient aquatic vegetation in lakes and ponds. Later in spring and summer, the turtles eat mostly aquatic vegetation.

Young snapping turtles, perhaps due to their preference for smaller streams, are thought to be largely carnivorous, feeding on insects, small fishes, crayfish, small frogs, and various other invertebrates (Pell 1941; Lagler 1943a).

Water

Snapping turtles are not usually found out of the water, reflecting their highly aquatic nature, and body temperature closely approximates water temperature (Pell 1941; Punzo 1975). Mean preferred temperature is 28.1 °C (Schuett and Gatten 1980) and mean critical thermal maxima is 39.5 °C (range 37.4 to 40.6 °C) (Hutchinson et al. 1966). Obbard and Brooks (1981) stated that snapping turtles do not eat until the water temperature is at least 16 °C.

Many authors have reported that snapping turtles rarely bask in the sun (Pope 1939; Schmidt and Inger 1957; Ernst and Barbour 1972; Conant 1975); however, detailed investigations by Ewert (1976) and Obbard and Brooks (1979) indicated that basking out of the water is not exceptional. Basking significantly raises body temperature and, consequently, is most common in the northern part of the snapping turtle's range. Basking usually occurs on offshore logs and less frequently on offshore rocks and on shore.

Snapping turtles are most often found in shallow water (Cagle and Cheney 1950; Major 1975). Specific depths have been cited by Obbard and Brooks (1981); almost all turtles were found at <2.5 m depth (mean = 0.99 m in day, 0.42 m night). Lagler (1943a) found turtles in water no deeper than the length of head and neck extended for breathing while resting on the bottom. Hammer (1971) found turtles at depths from 0.6 to 1.8 m, and Toner (1960) seldom found turtles below 2.4 m. Pell (1941) stated that during hot weather snapping turtles move to deeper, cooler water and are usually found in water 0.6 to 0.9 m deep or more.

Lagler (1943a), Anderson (1965), Webb (1970), and Froese and Burghardt (1975) indicated that snapping turtles prefer turbid waters. This preference may be associated with better concealment or the affinity of snapping turtles for muddy substrates (Lagler 1943b; Anderson 1965; Feuer 1971; Minton 1972; Froese and Burghardt 1975; Punzo 1975; Froese 1978). Many researchers have noted that snapping turtles are most often found in waters with a slow current (Pell 1941; Lagler 1943a; Cagle and Cheney 1950; Feuer 1971; Hammer 1971).

Although snapping turtles can spend considerable time out of water, permanent bodies of water are required to maintain populations (Pell 1941; Webb 1970; Feuer 1971; Minton 1972). Snapping turtles can migrate considerable distances overland, but if potential habitat dries up frequently, alternative, more permanent sites, should be nearby (Cagle 1942; Klimstra 1951; Anderson 1965). Toner (1960) theorized that in the East snapping turtles are found in lakes, ponds, and marshes since these are often permanent or proximal to permanent water. In the more arid West, however, the species is restricted to the larger rivers, because these are the only permanent water bodies in the region. Such permanent bodies of water cannot be snapping turtle habitat if the water is saline, although snapping turtles can survive in saltwater for short periods (Feuer 1971). This may be important for migration to coastal islands. Dunson (1984) reported that large snapping turtles spend weeks at a time in coastal estuaries foraging on the abundant biota of such areas. However, adults must return to freshwater periodically to rehydrate, and small turtles, because of their high surface to volume ratio, cannot survive in brackish waters for even short periods.

Cover

Snapping turtles are reputed to use aquatic vegetation, stumps, logs, roots, holes, and other available obstructions as cover (Pell 1941; Cagle and Cheney 1950; Minton 1972; Major 1975). Froese (1978) showed that hatchling and juvenile snapping turtles prefer obstructed areas. Once a snapping turtle reaches maturity, however, it has virtually no predators other than man (Abbott 1941; Hammer 1971). Thus, cover is probably utilized by adults as a means of concealment from which to ambush prey, or because prey are found in such areas (Major 1975; Hammer 1971; Froese 1978).

Reproduction

Mating can occur at any time when turtles are active (Carr 1952; Minton 1972), and activity varies with latitude. Snapping turtles are active in Ontario from early May to early October (Obbard and Brooks 1981), in Ohio from April to December (Conant 1938), and in Illinois from February to late December (Smith 1961). Nesting occurs in early summer (Hamilton 1940; Hammer 1969; Minton 1972; Petokas and Alexander 1980), and Hammer (1971) claims that night air temperatures above 7 °C are required for such activity. Minton (1972) stated that some females may lay two clutches per season. Females often move up small streams to lay eggs (Ewert 1976) at nesting sites where soil is moist but well drained and loosely packed in unshaded areas (Norris-Elye 1949; Hammer 1971; Minton 1972; Punzo 1975; Ewert 1976; Petokas and Alexander 1980). Loncke and Obbard (1977) and Obbard and Brooks (1980) found that many females migrated to a nesting site on a dam from other lakes as far as 13.8 km away, and that individual females returned to the nest site year after year. This suggests that suitable nest sites may be scarce. Dikes, muskrat (*Ondatra zibethica*) houses, and beaver (*Castor canadensis*) lodges are frequently used for nesting as well (Ewert 1976). Incubation period varies from 70 to 120 days (Hammer 1971), and length of incubation is inversely proportional to temperature (Yntema 1978). Cool summers probably do not thwart reproduction, however, because eggs can survive through winter in the nest (Toner 1933, 1960; Minton 1972).

Predators are major factors influencing nest success. Petokas and Alexander (1980) found a 94% predation rate on snapping turtle nests in New York. Raccoons (*Procyon lotor*), skunks (*Mephitis mephitis*), foxes (*Vulpes fulva*), and mink (*Mustela vison*), in order of importance, are cited as the major predators of snapping turtle nests (Hamilton 1940; Hammer 1969; Wilhoft et al. 1979; Petokas and Alexander 1980).

Interspersion and Movements

Two factors should be considered in regard to interspersion: habitat for young and proximity of permanent habitat. A number of authors have stated that immature snapping turtles [maturity is reached at approximately 145 mm plastron length (White and Murphy 1973)] use different habitat than do adults

(Pell 1941; Toner 1960; Hammer 1971; Minton 1972). It is thought that juveniles remain in small streams until shortly before maturity, when they migrate to the ponds, rivers, marshes, and shallow areas of large lakes preferred by adult snapping turtles. Hence, small streams should be near to, and preferably empty into, the larger aquatic habitats used by adults. This is probably why females often move up small streams to lay eggs. Additionally, standing water is required for all life stages of the snapping turtle. Hence, although individuals are often found in semipermanent waters, permanent water should be nearby in the event of habitat desiccation (Cagle 1942; Klimstra 1951; Anderson 1965; Feuer 1971). Abbott (1941) kept a snapping turtle in the trunk of a car for 2 weeks, and the turtle appeared healthy afterwards. Apparently, turtles can spend considerable time out of water with no ill effects, which may allow extensive terrestrial migrations.

Snapping turtles may be territorial, which would limit population densities. Hammer (1969) and Raney and Josephson (1954) observed violent fighting between males. Pell (1941:5) states that "In only one case have I trapped more than one specimen in a single spot, and this only after a week's interval," and Feuer (1971) stated that only one or, at most, two snapping turtles will be found in ponds of <0.2 ha surface area. In contrast, Hammer (1969) expressed doubt that territoriality exists, based on his trapping data. Obbard and Brooks (1981) gave the mean home range size as 3.44 ha ($s = 2.18$; $n = 10$).

Special Considerations

During the winter, snapping turtles often aggregate in localized areas for hibernation. Frequent hibernation sites include muskrat houses and burrows, under logs, under banks, buried in the mud below ice level, and at the mouths of tributary streams and spring inlets (Cahn 1937; Pell 1941; Lagler 1943a; Anderson 1965; Hammer 1971; Froese 1978).

HABITAT SUITABILITY INDEX (HSI) MODELS

Model Applicability

Geographic area. This model can be used to assess habitat suitability throughout the geographic range of snapping turtles in North America (Figure 1).

Season. Variables included in this model should be measured in midsummer or as described. The model output will describe suitability of the area as year-round snapping turtle habitat.

Cover types. The model may be used to evaluate snapping turtle habitat suitability in and around any permanently or semipermanently flooded (defined as containing standing water year-round during a majority of years) riverine, lacustrine, or palustrine wetlands as defined by Cowardin et al. (1979).

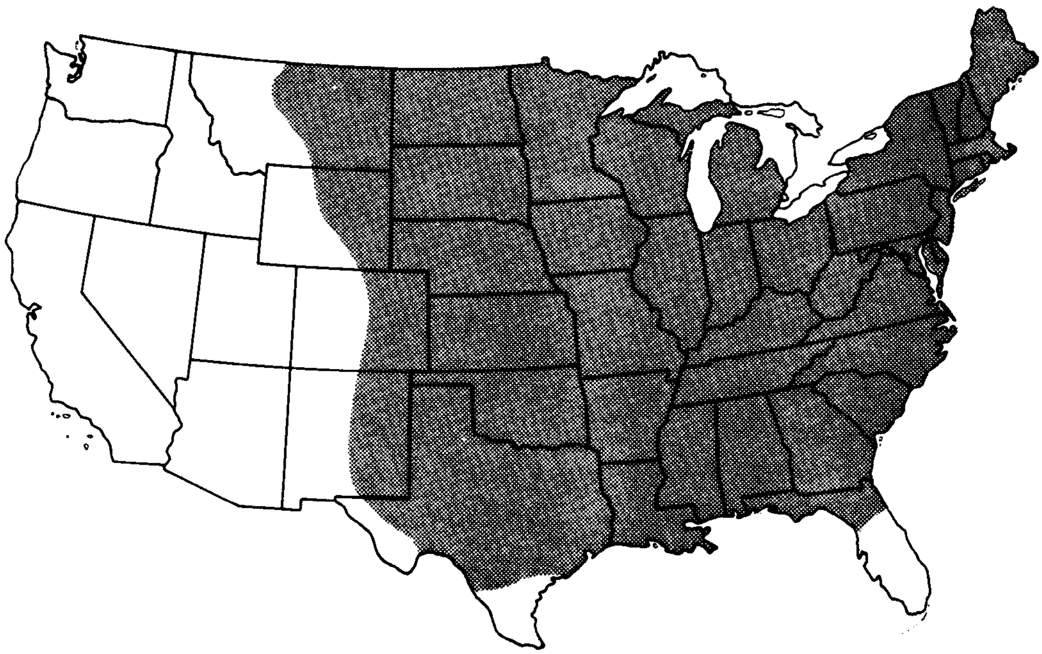

Figure 1. Geographic range of Chelydra serpentina in North America (after Stebbins 1966 and Conant 1975).

Minimum habitat area. No empirical studies have been conducted to investigate the minimum habitat area required by snapping turtles; hence, only anecdotal and speculative information are available. Those familiar with snapping turtles state that these animals (especially young) will live in even the smallest bodies of water provided food is available (Pell 1941; Lagler 1943a). Therefore, this model assumes that any permanent or semipermanent (see above) body of water will be large enough to support snapping turtles.

Verification level. The model is a set of hypotheses describing assumed snapping turtle-habitat relationships, but no attempt has been made to address all causal relationships affecting population densities. The standard of comparison for this model is year-round snapping turtle use of a site as reported in the literature and interpreted by the authors. Information is limited in several areas of this species' biology, but we have attempted to fill those voids with habitat characterizations that we assume will at least explain the potential for presence or absence of snapping turtles at a particular site within the species' current range. There are some indications in the literature that territorial behavior may limit densities. Until more definitive information becomes available, the potential presence or absence of snapping turtles at a particular wetland may be an appropriate level of resolution for most habitat assessments.

C. Ernst, D. Duvall, and J. Legler provided constructive reviews of an earlier draft of this model. Modifications suggested by these reviewers have been incorporated into the model where possible, and their assistance is gratefully acknowledged. Use of a reviewer's name, however, does not necessarily imply that he concurs with each section of the model, or the model in its entirety as presented here.

Model Description

Overview. Snapping turtles are generalists with respect to diet and cover type; however, certain variables can be used to assess habitat suitability for this species. Seven suitability criteria are organized into four components to characterize the year-round habitat requirements for snapping turtles. Relationships between criteria and suitability indices are drawn from empirical and anecdotal information in the literature review presented above and from the authors' general impressions and interpretations of that information.

The following sections provide documentation of the logic and assumptions employed to extrapolate model relationships from literature information. Specifically, these sections cover: (1) identification of habitat-related variables; (2) definitions and justifications of the suitability levels of each variable; and (3) descriptions of the assumed relationships between variables.

Food component. Although mature snapping turtles appear to consume a wide range of food items, we have assumed that there are criteria that can be used to characterize the suitability of permanently and semipermanently flooded wetlands in terms of potential food availability. These criteria include water temperature, current velocity, and abundance of aquatic vegetation.

Because snapping turtle body temperature is closely associated with water temperature, and body temperature directly affects metabolic rate (and hence, energy assimilation, ability to capture prey, reproductive processes, etc.), a consideration of water temperature is included. Water temperature must be above 16 °C for turtles to eat, and mean preferred temperature is 28.1 °C. For this model, critical thermal maxima is identified as 37 °C. Therefore, temperatures within this range may support snapping turtle populations. The shape of the suitability index graph (SIV1) in Figure 2 is derived by assuming that temperatures ≤0 °C or >37 °C are lethal to snapping turtles. Temperatures between 1 and 16 °C have minimal value, and optimum conditions occur in a narrow band around 28.1 °C.

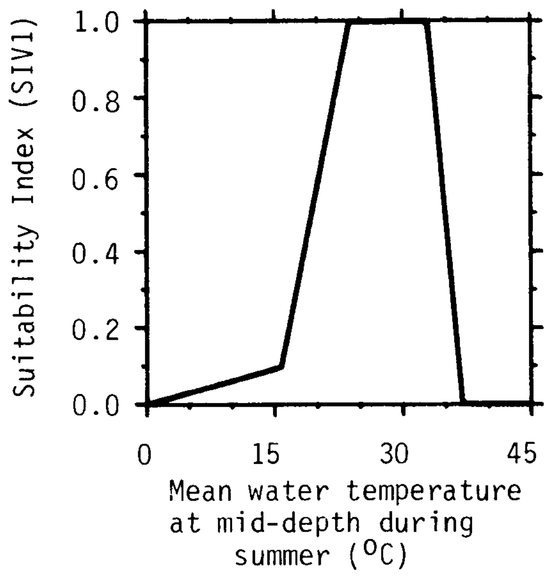

Figure 2. The assumed relationship between mean water temperature and food suitability of a wetland for snapping turtles.

Mature snapping turtles are most commonly found in permanently and semi-permanently flooded wetlands with still or slow-moving water. Although no empirical data are available, it is assumed that stationary water has the potential to supply optimum foraging conditions for a species characterized as an aquatic omnivore. Under stationary water conditions, it is assumed that turtles can maximize foraging efficiency by conserving energy that would otherwise be expended moving against flowing water or pursuing immobile but current-borne food items. We have assumed that suitability decreases as mean current velocity increases until some constant low value is reached (SIV2, Figure 3a). Inherent in this relationship is the assumption that even in streams yielding high measures of mean current velocities, refugia exist that can be used by turtles until more suitable conditions become available.

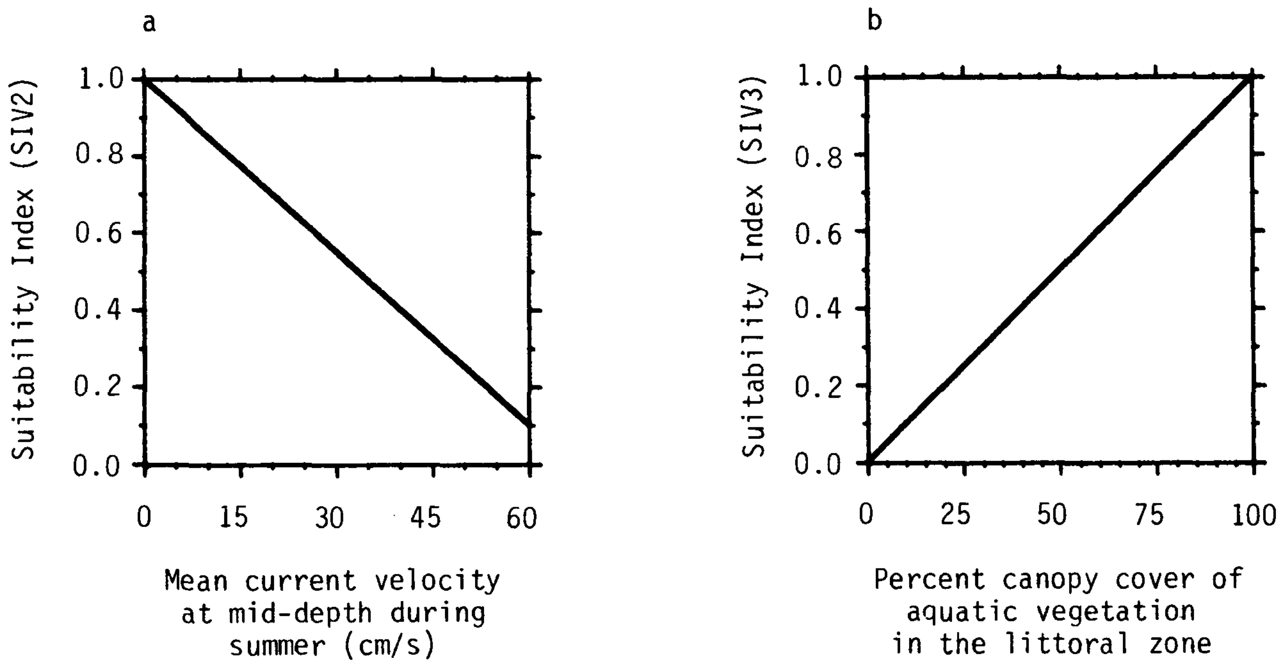

Figure 3. The assumed relationships between current velocity and aquatic vegetation, and their respective suitability indices.

Snapping turtles not only feed on aquatic vegetation, but also use it as a hiding place from which to ambush prey. Aquatic vegetation, stumps, logs, and other debris may also serve as habitat for prey species. We have assumed that the abundance of aquatic vegetation in the littoral zone can be used as a measure of the food suitability of a wetland for snapping turtles. A linear relationship between percent canopy cover of aquatic vegetation in the littoral zone and food suitability is assumed (SIV3, Figure 3b).

We believe that the potential for optimum food conditions for snapping turtles occurs in permanently and semipermanently flooded wetlands that can be characterized by water temperatures near the species mean preferred temperature, no current, and 100% coverage of aquatic vegetation within the littoral zone. Values for any of these suitability criteria that are less than optimum should lower the overall food suitability index (SIF), but receive some compensation from criteria with higher values. Because zero values for SIV1 and SIV3 would remove all food value for a wetland, we selected a geometric mean to represent our interpretation of food suitability (equation 1).

$$SIF = (SIV1 \times SIV2 \times SIV3)^{1/3} \qquad (1)$$

Winter cover component. Any characterization of year-round habitat for snapping turtles requires an attempt to address wetland suitability in terms of winter requirements. The snapping turtle literature is limited in its descriptions of winter requirements, and we have elected to address this aspect of the species' biology as winter cover needs. Although we assume that the first of the two criteria described below will be most appropriate to habitat assessments in the more northern reaches of the species' range, its use in areas where ice does not form in winter should not cause problems with interpretation of model output.

Water depth sufficient to prevent a wetland from freezing completely to its bottom is assumed to be necessary for winter survival of snapping turtles. This depth will vary with local conditions and must therefore be determined for each wetland in an evaluation area. We suggest that the relationship can be characterized with a binary variable (SIV4), providing values of either 1 or 0, depending upon the following conditions:

If winter water depth is greater than maximum ice depth then SIV4 = 1

If winter water depth is less than maximum ice depth then SIV4 = 0

Snapping turtles often burrow into the mud to hibernate, and we have assumed that composition of a wetland's substrate can influence suitability in terms of winter cover. Composition of the substrate can be represented by particle size, and, of all potential sized particles available, fine silt was selected to represent our interpretation of an ideal substrate for burrowing (a 63 µ-sieve allows passage of fine silt but not larger particles, such as sand and gravel). The exact composition of the substrate required to provide optimum burrowing composition is unknown. We have assumed a linear relationship between the percent of the substrate composed of silt (or finer particles) and the suitability of the substrate to provide winter cover for snapping turtles (SIV5, Figure 4).

It is assumed that the suitability of a wetland as winter cover for snapping turtles can be expressed as the product of the suitability indices for winter water depth (SIV4) and the percent silt in the substrate (SIV5). The suitability index for winter cover (SIWC) can be determined by using equation 2.

$$SIWC = SIV4 \times SIV5 \qquad (2)$$

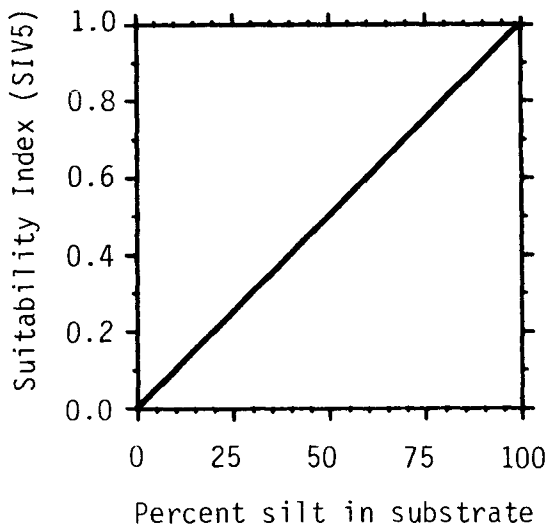

Figure 4. The assumed relationship between the percent silt in the substrate and the suitability of a wetland as winter cover for snapping turtles.

Reproduction component. Female snapping turtles often move up small streams to egg-laying sites, and young snapping turtles are frequently found in such streams. Female snapping turtles are known to make long migrations to suitable nesting sites and also nest along large lakes and in other locations, as well as along small streams. Therefore, unavailability of small streams is not seen as totally limiting. It is assumed that permanently and semi-permanently flooded wetlands with nearby small streams represent optimal snapping turtle nesting habitat, but as distance from the wetland to small streams increases, habitat suitability decreases in a linear manner. The suitability index for reproduction (SIR) is equal to SIV6, and can be obtained from the relationship depicted in Figure 5.

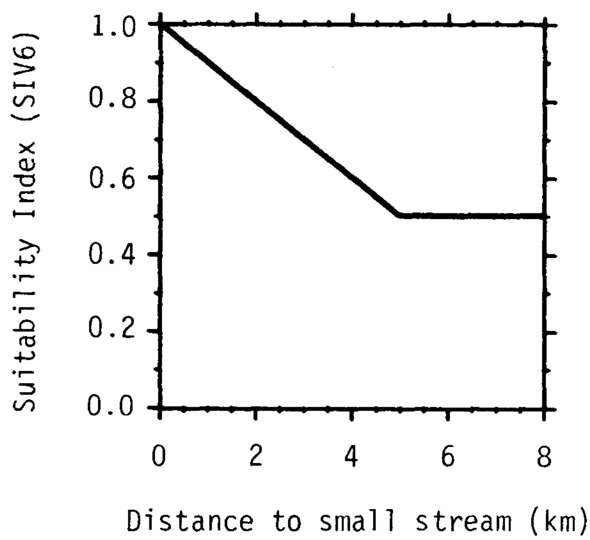

Figure 5. Relationship between distance to small stream and reproductive suitability for snapping turtles.

Interspersion component. When a wetland is permanently flooded, and some level of suitability >0 exists for food (SIF), winter cover (SIWC), and reproduction (SIR), that wetland can function as year-round habitat for snapping turtles. In semipermanently flooded wetlands, however, snapping turtles may be required to periodically migrate to other wetlands to avoid desiccation. In such situations, permanently flooded wetlands should be nearby to provide refuge until conditions improve. Quantitative information describing travel distances or suitable interspersion of wetlands was not located for snapping turtles, but it is assumed that permanent water should be close by. For the purposes of this model, it is assumed that permanently flooded wetlands should be located within 100 m of the evaluation site in order to provide optimum interspersion suitability (SIV7, Figure 6). A linear decrease in suitability is assumed as the distance from the wetland under evaluation to permanent water increases.

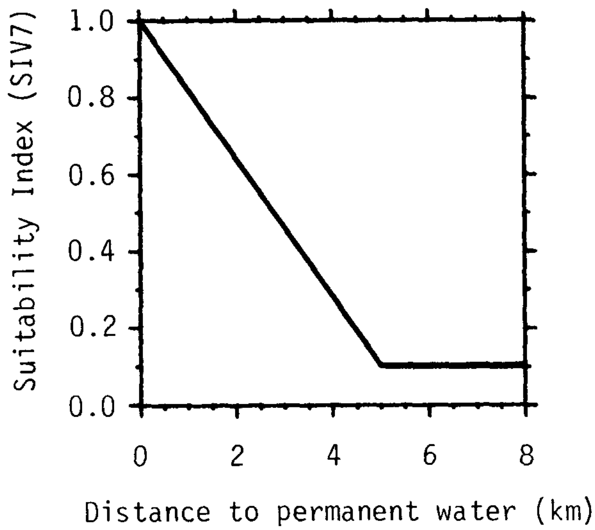

Figure 6. The assumed relationship between distance to permanent water and interspersion suitability for the snapping turtle.

HSI determination. We have assumed that year-round habitat suitability for the snapping turtle is a reflection of the characteristics of individual permanently or semipermanently flooded riverine, lacustrine, or palustrine wetlands (Cowardin et al. 1979). Year-round habitat in this model is defined by criteria characterizing the suitability of food (SIF), winter cover (SIWC), reproduction (SIR), and interspersion (SII). Limitations in one of the first three components are assumed to be compensated for by higher indices in the other two components, but a zero value for food or winter cover indicates a wetland that is unsuitable as year-round habitat for snapping turtles. Permanent water (SII) is assumed critical not only in terms of habitat suitability, but for basic survival of snapping turtle populations. Because of this assumed importance, the interspersion index (SII) is used to lower the value of a semipermanently flooded wetland that is not located within 100 m of a permanently flooded wetland that exhibits some habitat value for snapping turtles. These relationships are described by equation 3.

$$HSI = (SIF \times SIWC \times SIR)^{1/3} \times SII \qquad (3)$$

Application of the Model

Summary of model variables. Seven habitat variables are employed in this model to determine habitat suitability for snapping turtles. Relationships between habitat variables, component indices, and HSI value are summarized in Figure 7. Variable definitions and suggested measurement techniques are given in Figure 8.

Model assumptions. This model has been designed to assess the suitability of habitat for *Chelydra serpentina*. The model is not intended to reflect actual population densities, because many factors in addition to habitat suitability influence population densities. Furthermore, model variables and relationships are based on inferences drawn from the literature, much of which is anecdotal. Therefore, refinements of this model should be made as necessary to accommodate local conditions. It is important that sound judgment be used in applying and interpreting this model.

Users may wish to make some modifications before using the model. For example, in the more southern reaches of the snapping turtle's range, SIWC may be inappropriate. This component can be deleted from the model; however, its use in ice-free areas should not cause interpretational problems with model output. SIV4 will always be 1.0 in ice-free areas, thus, SIWC = SIV5, or the percent silt in the substrate, a criterion that appears related to turtle habitat use regardless of the location. Both distance relationships (SIV6 and SIV7) should be carefully scrutinized before use, as they are derived from limited empirical data. Other assumptions also may be inappropriate and the model should be carefully evaluated in its entirety before use.

SOURCES OF OTHER MODELS

No other models are known that are designed to assess snapping turtle habitat quality.

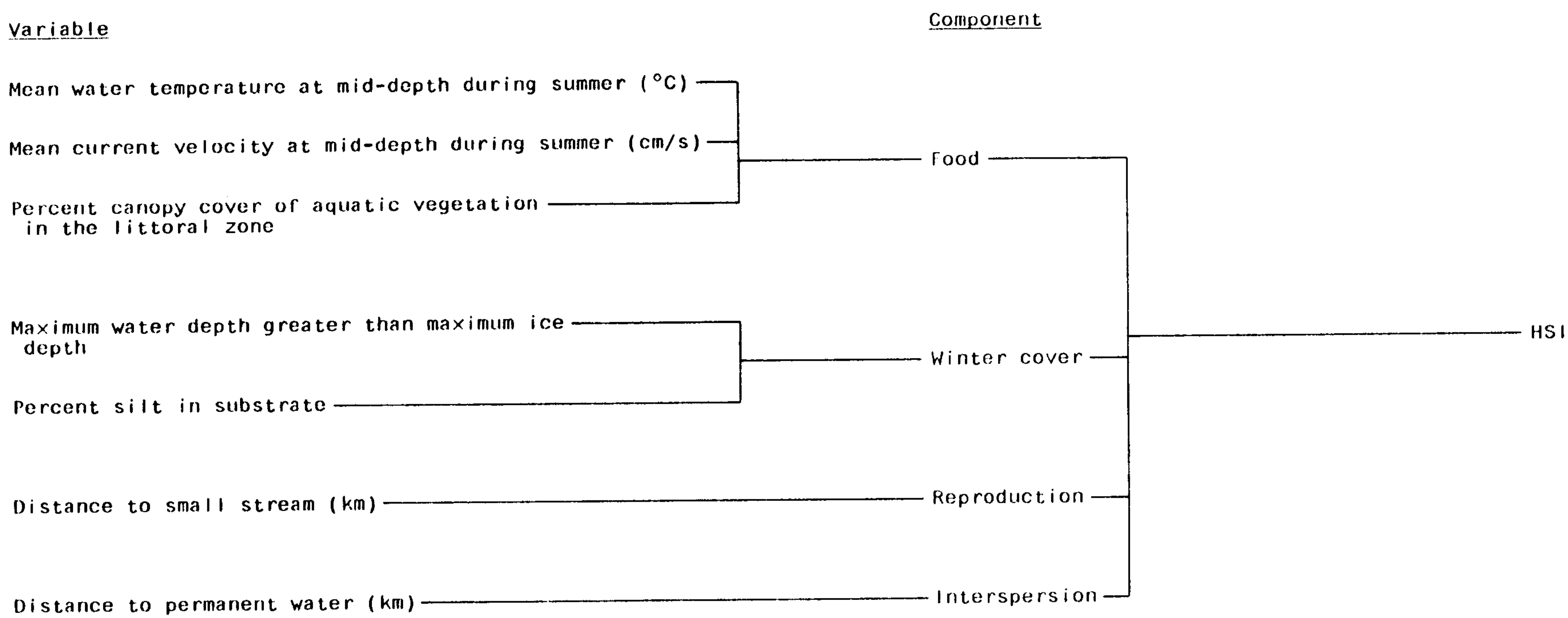

Figure 7. Relationships of variables, components, and habitat suitability index for the snapping turtle.

Variable definition	Suggested quantification technique
Mean water temperature at mid-depth during summer (°C).	Drop a temperature sensitive probe to the bottom then raise to mid-depth and read temperature from readout in boat.
Mean current velocity at mid-depth during summer (cm/s).	Speed of neutrally buoyant object in midstream.
Percent canopy cover of aquatic vegetation in the littoral zone (the percent of the aquatic substrate in the littoral zone that is shaded by a vertical projection of submergent and emergent vegetation).	Emergent vegetation can be observed from the shore but submergent vegetation distribution will be more difficult to assess. If water is clear, submergent vegetation may be mapped from a boat. Otherwise, wading and a tactile survey may be required. A convex polygon may be drawn around vegetation patches to segregate vegetation vs. no vegetation areas.
Maximum water depth greater than maximum ice depth.	Records or map depth of lake. Monitor ice thickness throughout several winters.
Percent silt in substrate (silt is defined as material 0.004-0.06 mm in diameter).	A spring loaded dredge (see Lind 1979) may be lowered on a line for sampling from deepest water areas within wetland. Samples should be thoroughly dried, then sifted through a 63-micron sieve. Weight of material passing through the sieve should be divided by the total sample weight to obtain a percent value.
Distance to small streams (km).	Pacing or measurement of distances.
Distance to permanent water (km).	Records to determine permanence of habitats. Pacing or measurement of distances.

Figure 8. Definitions of variables and suggested measurement techniques.

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50272-101

REPORT DOCUMENTATION PAGE	1. REPORT NO. Biological Report 82(10.141)	2.	3. Recipient's Accession No.
4. Title and Subtitle Habitat Suitability Index Models: Snapping Turtle			5. Report Date June 1987
			6.
7. Author(s) B. M. Graves and S. H. Anderson			8. Performing Organization Rept. No.
9. Performing Organization Name and Address University of Wyoming Laramie, WY 82071			10. Project/Task/Work Unit No.
			11. Contract(C) or Grant(G) No. (C) (G)
12. Sponsoring Organization Name and Address National Ecology Center Fish and Wildlife Service 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 were used to develop a Habitat Suitability Index (HSI) model for the snapping turtle (Chelydra serpentina). The model consolidates habitat use information into a framework appropriate for field application, and is scaled to produce an index between 0.0 (unsuitable habitat) and 1.0 (optimum habitat). HSI models are designed to be used with Habitat Evaluation Procedures previously developed by the U.S. Fish and Wildlife Service.

17. Document Analysis a. Descriptors

Turtles
Wildlife
Habitability
Mathematical models

b. Identifiers/Open-Ended Terms

Snapping turtle
Chelydra serpentina
Habitat suitability

c. COSATI Field/Group

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

(See ANSI–Z39.18) See Instructions on Reverse

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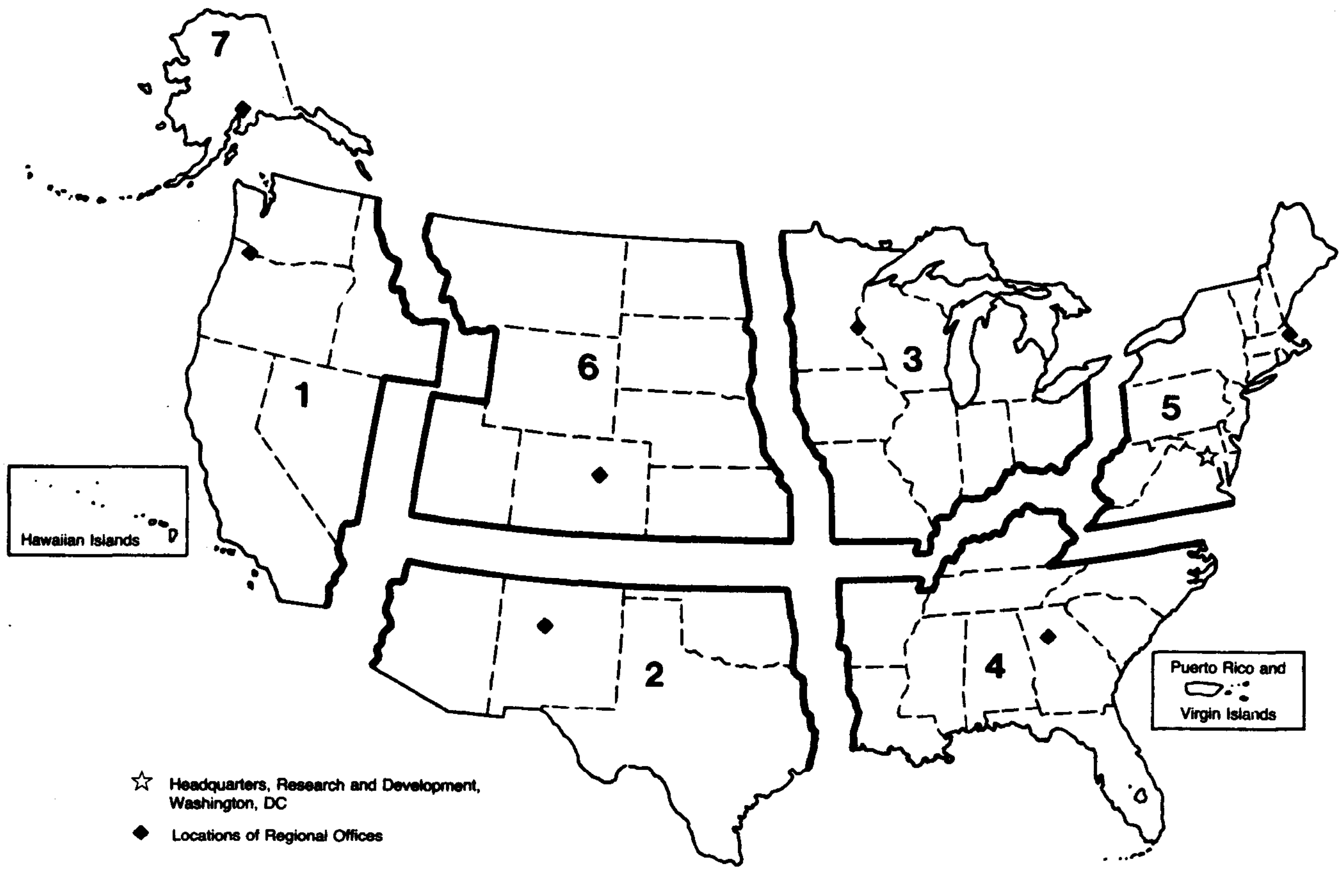

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