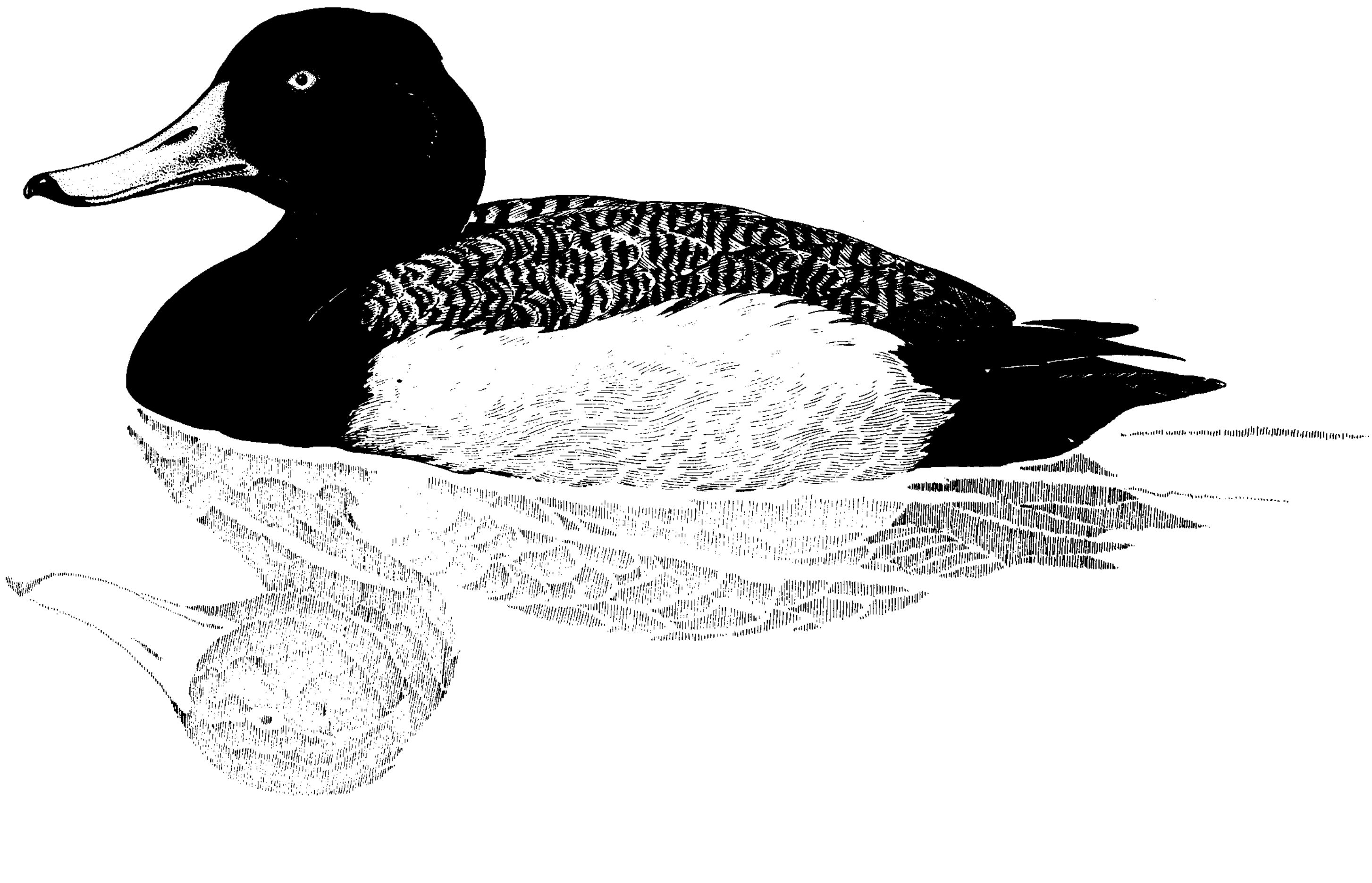
Biological Report 82(10.91)
APRIL 1985

HABITAT SUITABILITY INDEX MODELS: LESSER SCAUP (WINTERING)



and Wildlife Service

Department of the Interior

This model is designed to be used by the Division of Ecological Services in conjunction with the Habitat Evaluation Procedures.

This is one of the first reports to be published in the new "Biological Report" series. This technical report series, published by the Research and Development branch of the U.S. Fish and Wildlife Service, replaces the **"FWS/OBS"** series published from 1976 to September 1984. The Biological Report series is designed for the rapid publication of reports with an application orientation, and it continues the focus of the FWS/OBS series on resource management issues and fish and wildlife needs.

Biological Report 82(10.91)
April 1985

HABITAT SUITABILITY INDEX MODELS: LESSER SCAUP (WINTERING)

by

Rosemarie Mulholland
Florida Cooperative Fish and Wildlife Research Unit
School of Forest Resources and Conservation
117 Newins-Ziegler Hall
University of Florida
Gainesville, FL 32611

Project Officer

Rebecca J. Howard
National Coastal Ecosystems Team
U.S. Fish and Wildlife Service
1010 Gause Boulevard
Slidell, LA 70458

Performed for
National Coastal Ecosystems 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:

Mulholland, R. 1985. Habitat suitability index models: lesser scaup (wintering). U.S. Fish Wildl. Serv. Biol. Rep. 82(10.91). 15 pp.

PREFACE

The lesser scaup habitat suitability index (HSI) model is intended for use in the habitat evaluation procedures (HEP) developed by the U.S. Fish and Wildlife Service (1980) for impact assessment and habitat management. The model was developed from a review and synthesis of existing information and is scaled to produce an index of habitat suitability between 0 (unsuitable habitat) and 1 (optimally suitable habitat). Assumptions involved in developing the HSI model and guidelines for model applications, including methods for measuring model variables, are described.

This model is a hypothesis of species-habitat relationships, not a statement of proven cause and effect. The model has not been field-tested. For this reason, the U.S. Fish and Wildlife Service encourages model users to convey comments and suggestions that may help increase the utility and effectiveness of this habitat-based approach to fish and wildlife management. Please send any comments and suggestions you may have on the HSI model to the following address.

National Coastal Ecosystems Team
U.S. Fish and Wildlife Service
1010 Gause Boulevard
Slidell, LA 70458.

This page has been left blank intentionally.

CONTENTS

ACKNOWLEDGMENTS

The habitat suitability index model for the lesser scaup was reviewed and constructively criticized by Hugh A. Bateman, Louisiana Department of Wildlife and Fisheries, Baton Rouge; Robert H. Chabreck, School of Forestry, Wildlife, and Fisheries, Louisiana State University, Baton Rouge; and Frank Montalbano III, Okeechobee Field Station, Florida Game and Fresh Water Fish Commission. Thorough evaluations of model structure and functional relationships were provided by personnel of the U.S. Fish and Wildlife Service's (FWS) National Coastal Ecosystems Team. Supportive narrative and model reviews also were provided by Regional personnel of the FWS. Funding for model development and publication was provided by the FWS. The cover illustration was prepared by Patrick J. Lynch.

LESSER SCAUP (*Aythya affinis*)

INTRODUCTION

The lesser scaup (*Aythya affinis*), an indigenous North American waterfowl species, is the most numerous inland diving duck in North America and one of the most numerous of all ducks found on the continent (Palmer 1976). The majority of lesser scaup breed in North America's extreme northwestern portion and winter in the continent's southeastern portion. Fall migration is generally southeastward, along a central axis extending from Yukon Flats, Alaska, to Florida (Bellrose 1976).

Based upon the winter waterfowl survey conducted by the U.S. Fish and Wildlife Service in January 1979, about 57% (947,000) of the wintering scaup (greater and lesser) occurred in the Mississippi Flyway, 20% (338,000) in the Atlantic Flyway, 14% (230,070) in Mexico, 7% (111,658) in the Pacific Flyway, and 2% (29,000) in the Central Flyway (Voelzer et al. 1982). In the Mississippi Flyway, more than 90% of the lesser scaup winter in Louisiana (Bellrose 1976). They are usually found on large tidal lakes, bays, and offshore. In late winter, they may be abundant in marshes adjacent to the coast (Harmon 1962). Lesser scaup and greater scaup (*Aythya marila*), the most common wintering ducks in Mississippi's estuarine waters, gather in large rafts on bays and the Mississippi Sound and in smaller groups along bayous and streams (Christmas 1960). Lesser scaup also are the most common wintering duck in the Alabama coastal area (C. Dwight Cooley, U.S. Fish and Wildlife Service, Daphne, Alabama; pers. comm.). The largest number of lesser scaup wintering in the Atlantic Flyway are found in Florida (Bellrose 1976). More than 300,000 lesser scaup have been reported from Florida's Merritt Island area (Chamberlain 1960). The lesser scaup is also the most abundant wintering duck on the gulf coast of Mexico (Saunders and Saunders 1981), with the southern limit of wintering occurring on the northern coast of South America (Palmer 1976). This model is based primarily on habitat information from the Gulf of Mexico coast.

SPECIFIC HABITAT REQUIREMENTS

Food

Alexander and Hair (1979) found that lesser scaup wintering in coastal South Carolina foraged daily over large areas and did not defend foraging sites. Longcore and Cornwell (1964) found that during fall and winter captive lesser scaup mean daily food consumption was 0.22 kg (0.49 lb). Animal food predominated in the lesser scaup diet on wintering grounds in Louisiana marshes, making up nearly two-thirds of the total food volume (Rogers and Korschgen 1966). The most important food was fish (sheepshead minnow Cypringodon variegatus and unidentified fragments), which made up 41.8% of total food volume. The only other known report of lesser scaup consuming fish was that of Christmas (1960). He observed lesser and greater scaup taking advantage of an abundant food supply by feeding on discarded gulf menhaden (Brevoortia patronus) in a boat slip.

Several studies have documented the importance of mollusks in the winter diet of gulf coast lesser scaup. Harmon (1962) found that 99.8% of the food eaten by lesser scaup wintering off the Louisiana coast were little surf clams (Mulinia lateralis). The clams were from 6.4 to 9.5 mm long (0.25 to 0.37 inch). In a study from Laguna Madre, Texas, animal foods made up 64% of the identifiable foods, with the largest component of the animal diet being the pointed venus clam, Anomalocardia cuneimeris (McMahan 1970). Cottam (1933) observed a feeding flock of about 325 lesser scaup wintering near the North Carolina coast; finding no trace of plant material floating on the water, he concluded that they were probably feeding on mollusks. In 10 lesser scaup collected from Long Island Sound, plant material constituted 38.3% of total food volume and animal material the remaining 61.7% (Cronan 1957). In the majority of feeding areas that Cronan (1957) sampled, either little surf clams or blue mussels (Mytilus edulis) were the predominant animal. Mollusca made up all of the animal material in the gizzards. Of 90 lesser scaup collected on the gulf and Pacific coasts and the Laguna Madre of Mexico, gizzards contained an average of 46% plant and 54% animal foods (Saunders and Saunders 1981). Saunders and Saunders (1981) reported that the distribution of lesser scaup in Mexico was largely related to the presence of beds of small mollusks.

Gizzard contents tend to inflate the importance of hard food items over soft food items (Swanson and Bartonek 1970). In a study that considered the contents of both gizzards and esophageal tracts, Bowman (1973) examined 22 lesser scaup collected during the winter from Lake Pontchartrain, Louisiana. Pelecypods were found in 45.45% of the analyzed esophageal tracts and composed 96.11% of the total food in the esophageal tracts. Wedge rangia (Rangia cuneata) was the predominant clam and constituted 81.12% of the total food in-esophageal tracts. The platform mussel (Congeria leucopheata) was found in 27.27% of the tracts and constituted 13.95% of the total food and the ribbed mussel (Geukensia demissa) occurred in 9.09% and constitute: 1.04% of the total food. Plant material was found in 4.54% but only in trace amounts. Other mollusks which occurred but made up less than 1% of the total food were brown rangia (Rangia flexuosa), narrowmouth hydrobe (Texadina sphinctostoma), and delta hydrobe (Probythenella lacustris). The gizzard contents were similar to esophageal tract contents.

Although McMahan (1970) reported that lesser scaup collected in the Laguna Madre preferred animal foods, 36% of the identifiable foods were plant material. Of nine wintering lesser scaup collected from brackish marshes in southwestern Louisiana, all contained plant seeds (Chamberlain 1959). Plant foods constituted 38.3% of total volume in 10 lesser scaup collected from Long Island Sound (Cronan 1957). Plant foods made up an average of 46% of the foods in 90 lesser scaup gizzards from coastal Mexico (Saunders and Saunders 1981).

Lesser scaup food habits in freshwater areas are similar to those in brackish and saltwater areas. Lesser scaup gizzards collected during a migration stopover in Keokuk Pool on the Mississippi River showed a high occurrence of animal foods, especially mollusks (Thompson 1969). Unidentified gastropods appeared in 68% of the gizzards (N=429), unidentified pelecypods in 91%, and nearly 76% of the gizzards contained fingernail clams (Musculium sp. and Sphaerium sp.).

On a shallow freshwater impoundment in Louisiana, however, Takagi (1983) found that plant seeds were the major food item in the diet of 23 lesser scaup. Animal material occurred in only small amounts. On the upper Texas coast, lesser scaup have been reported to use small freshwater ponds which had no fish or pelecypods. While using these ponds the lesser scaup feed on vegetation, probably coast bacopa, Bacopa monnieri (H. Dale Hall, U.S. Fish and Wildlife Service, Houston, Texas; pers. comm.).

Away from tidewater, lesser scaup fed most actively in the early morning and then rested well away from the shore in a compact flock or in a raft of hundreds to thousands of birds. On tidewater, birds fed nearer the shore at high tide (Palmer 1976). Lesser scaup prefer diving in water 1 to 3 m (3.3 to 9.8 ft) deep (Palmer 1976). Lesser scaup have been reported to feed in water as shallow as 76 mm (3 inches) in the Laguna Madre, Texas (McMahan 1970), to water as deep as 4.6 to 6.0 m (15.1 to 19.7 ft) in other locations (Cottam 1933, 1939). Hirsch (1980) found that the average depth of open water used most frequently by wintering greater scaup on Puget Sound, Washington, was 4.18 m (13.7 ft). White and James (1978) reported that lesser scaup in freshwater habitats characteristically foraged in open water 1 to 2 m (3.3 to 6.6 ft) deep.

Cover

In the Gulf of Mexico, lesser scaup can spend an entire winter without coming ashore (Harmon 1962). However, they may rest on flats, mudbars, or even on ice (Palmer 1976). Lesser scaup may move to inland areas during January and February in Louisiana, but this inland movement does not occur every year, and birds have remained 5 to 6 km (3.1 to 3.7 miles) offshore for the entire winter (Harmon 1962). White (1975) observed that in freshwater habitats, lesser scaup used open areas covered with an average of 1.4% emergent vegetation.

Special Considerations

Disturbance. The extremes of currents, waves, or floating debris did not affect lesser scaup feeding on the Mississippi River (Thompson 1969). Cronan (1957) found that human activity had a strong effect on scaup feeding in Long Island Sound. During the hunting season, areas that were heavily hunted were not used by scaup as feeding sites. On the Mississippi River, Thornburg (1973) found that diving ducks (including lesser scaup) modified their feeding behavior by leaving areas of intensive hunting during the day and returning at night to feed.

Disease. Although red tide outbreaks usually occur in the summer when scaup have migrated north, Forrester et al. (1977) suggested that lesser scaup may be more susceptible to red tide toxins (*Gymnodinium breve*) than other species of waterfowl because they feed heavily on mollusks that concentrate large amounts of toxin. Schreiber et al. (1975) reported that several thousand scaup died during an outbreak of red tide in February and March of 1974 in Tampa Bay, Florida.

Oil pollution. Lesser scaup have suffered large losses due to oil pollution. Of 3,333 waterfowl killed by oil on the Mississippi River during the spring migration of 1963, lesser scaup made up 65% of the affected birds (Anderson and Warner 1969). Perry et al. (1978) reported that at least 1,510 scaup (species not specified) died as a result of five oil spills on the Delaware River and two on the Chesapeake Bay from 1973 to 1978. Stout and Cornwell (1976) reported that scaup were the most frequently (47%) reported victims of oiling among banded waterfowl. Clapp et al. (1982) believed that wintering lesser scaup in the Southeast were potentially at very high risk from oil-development activities.

HABITAT SUITABILITY INDEX (HSI) MODEL

Model Applicability

This model is applicable to estuaries, bays, and open water areas of the Gulf of Mexico and southern Atlantic coast as well as to brackish and freshwater areas along these coasts. The model can be used to evaluate habitat quality in marine, estuarine, and palustrine systems as defined by Cowardin et al. (1979). Habitat can be evaluated throughout the year, but lesser scaup only use these areas as wintering grounds from about November to April (Palmer 1976). The minimum habitat area required for successful overwintering is unknown. In this model, the minimum suitable area is assumed to be 0.5 ha (1.2 acres).

The acceptable model output is an index value between 0.0 and 1.0, reflecting the suitability of an area for lesser scaup wintering . A value of 1.0 represents optimum suitability and 0.0 represents unsuitability. Hypothetical data sets were used to demonstrate model calculations and output. The model was reviewed by the following biologists: Hugh A. Bateman, Louisiana Department of Wildlife and Fisheries, Baton Rouge; Robert H. Chabreck, School of Forestry, Wildlife and Fisheries, Louisiana State University, Baton Rouge; and Frank Montalbano III, Okeechobee Field Station, Florida Game and Fresh Water Fish Commission. Their comments have been incorporated when feasible, but the author is responsible for the final version of the model. The model has not been field-tested.

Model Description

Overview. The model applies only to lesser scaup wintering habitat and uses one life requisite (food, cover) to evaluate wintering habitat suitability. The model is based on four habitat variables: percentage of study area supporting pelecypods (V_1), percentage of area supporting emergent vegetation (V_2), water depth (V_3), and human disturbance to feeding area (V_4). The relationships among the habitat variables, life requisite, and study area HSI are illustrated in Figure 1.

Food component. Because the most important food for wintering lesser scaup seems to be the most prevalent pelecypod species of acceptable size, the suitability of an area is assumed to increase as the coverage of pelecypods (V_1) increases. Information is lacking on the density of pelecypods necessary to meet scaup nutritional requirements. Although pelecypod density (i.e., pelecypods/unit area) may vary considerably between areas, the percentage of coverage was considered to be the best current indicator of pelecypod availability. As the percentage of the study area covered increases, the suitability is assumed to increase; optimal suitability is 50% or greater coverage,

Lesser scaup use open water areas characterized by little or no emergent vegetation. As the percentage of emergent vegetation (V_2) increases, the suitability of an area for overwintering lesser scaup decreases. Less than 5% emergent vegetation is considered optimal.

Water depth (V_3) affects the availability of food resources to lesser scaup. Although scaup occur in deepwater areas, the energy costs of obtaining food become greater as depths, thus diving times, increase. The model assumes that water 1 to 3 m (3.3 to 9.8 ft) deep is optimal for lesser scaup feeding. Water depth is measured as mean sea level for tidal areas and average winter water depth for nontidal areas. Habitat suitability decreases as water depth increases beyond 3 m (9.8 ft). Water depth greater than 10 m (32.8 ft) is assumed to be unsuitable.

Feeding lesser scaup are affected by human disturbance (V_4), although the level of human disturbance necessary to prevent scaup from utilizing an area is difficult to quantify. The time of the disturbance also needs to be considered. Daytime disturbance may not preclude nighttime use of an area (see Thornburg 1973). Howard and Kantrud (1983) developed four disturbance classes to evaluate redhead (*Aythya americana*) wintering habitat: class 1 disturbance is light and has no effect on use of feeding areas; class 2 disturbance is moderate and causes birds to periodically leave the area but does not prevent their return; class 3 disturbance is heavy and prevents birds from returning for a significant portion of the day; class 4 disturbance is limiting and precludes use of the area.

Suitability Index (SI) Graphs for Model Variables

This section presents graphic representations of the relationship between the value of habitat variables and lesser scaup winterinq habitat quality in estuarine (E), marine (M), and palustrine '(P) areas.- The SI values are read directly from the graphs. Optimal suitability is indicated by an SI of 1.0; unsuitability is indicated by an SI of 0.0. The SI graphs are based on the assumption that the suitability of a particular habitat variable can be represented by a two-dimensional response surface and is

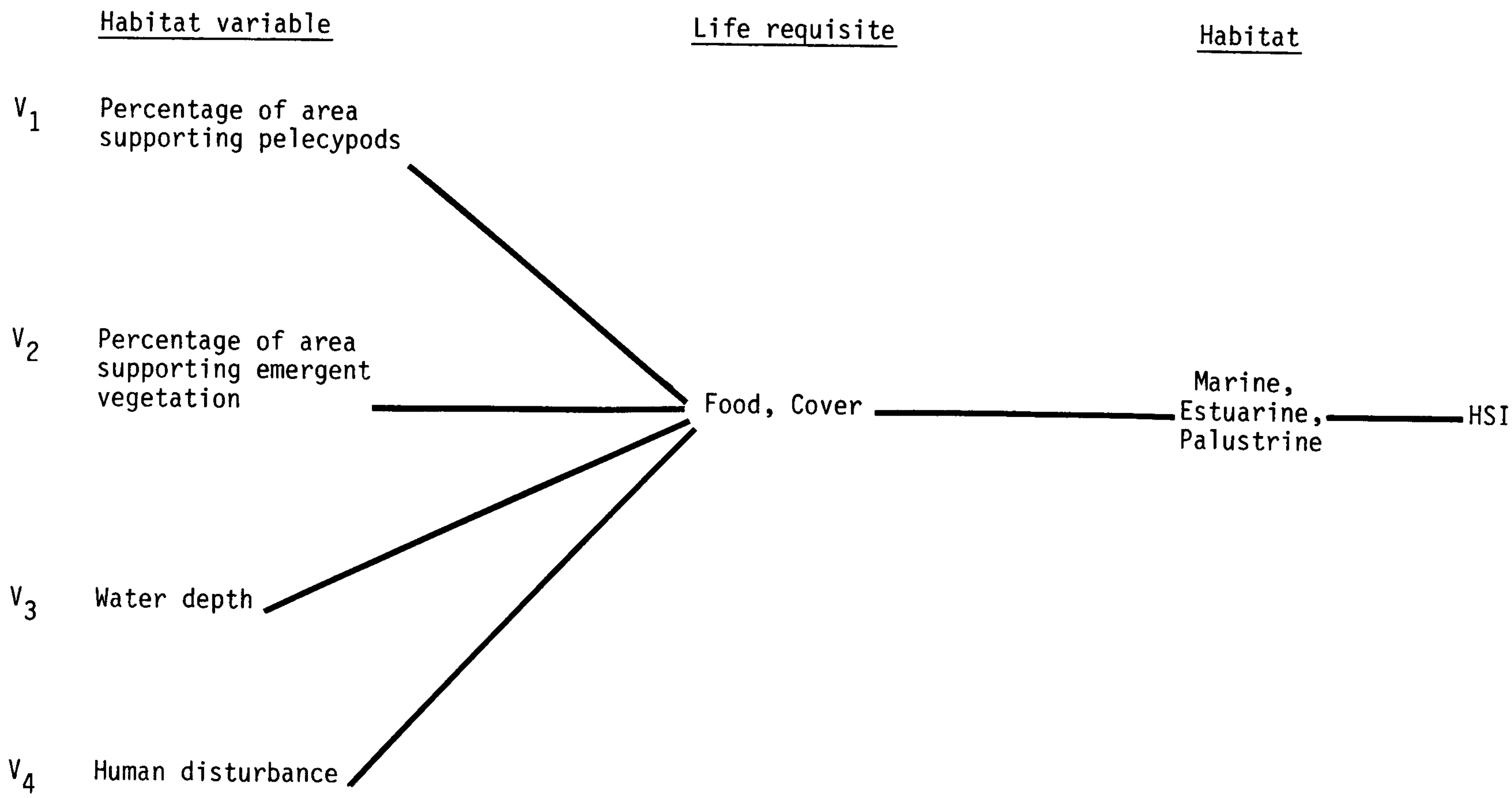
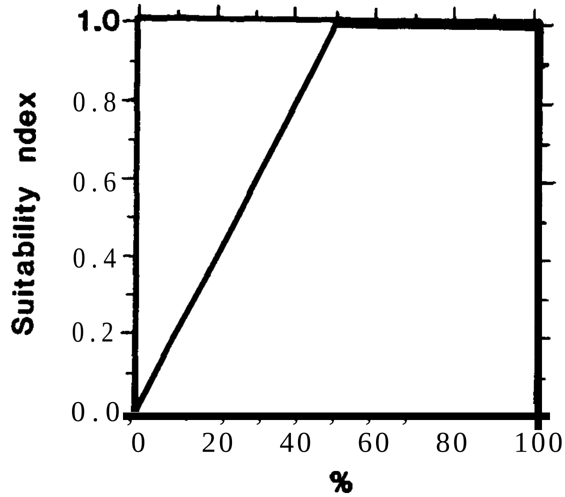
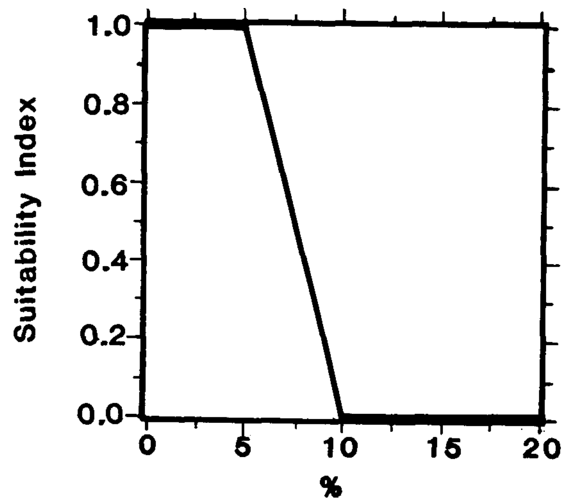
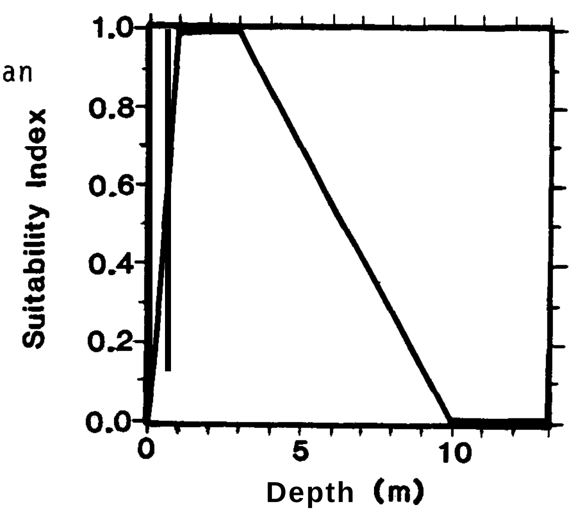


Figure 1. Relationship of habitat variables and life requisite components to the habitat suitability index for wintering lesser scaup.

independent of other variables that contribute to habitat suitability. Data sources and assumptions associated with SI graphs are listed in Table 1.

Habitat	Variable	Description	Suitability Graph
E,M,P	V_1	Percentage of area supporting pelecypods.	
E,M,P	V_2	Percentage of area supporting emergent vegetation.	
E,M,P	"3	Water depth at mean sea level or average winter water conditions.	

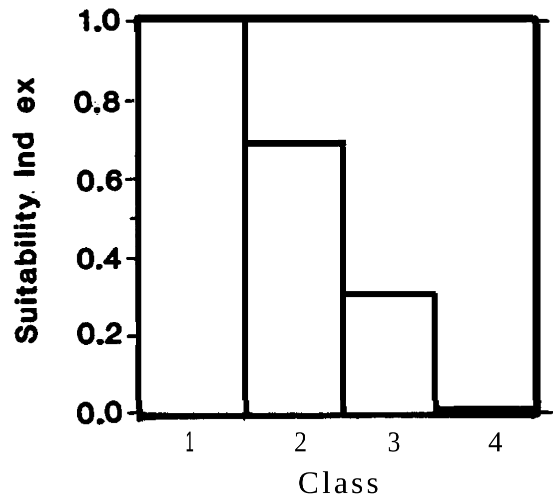
Habitat	Variable	Description	Suitability Graph
E,M,P	V_4	Human disturbance to feeding area. (1) None to light (2) Moderate (3) Heavy (4) Limiting	

Table 1. Variable sources and assumptions for wintering lesser scaup suitability indices.

Variable and source	Assumption
V_1 Cronan 1957; Harmon 1962; Thompson 1969; McMahan 1970; Bowman 1973	Major food item for wintering lesser scaup is pelecypods.
V_2 White 1975; Hirsch 1980	Lesser scaup prefer areas with little or no emergent vegetation.
V_3 McMahan 1970; Palmer 1976; White and James 1978	Shallower water reduces the energy cost of feeding. Lesser scaup prefer to feed in water less than 3 m (9.8 ft) deep.
V_4 Cronan 1957; Thornburg 1973	Human activity has a detrimental effect on lesser scaup feeding.

Habitat Suitability Index (HSI) Equation

To obtain an HSI for lesser scaup wintering habitats, the SI values for the habitat variables must be combined. The presence of pelecypods (VI) is considered to be the most important variable in the model. Hence, if the SI value for V_1 is less than the geometric mean of the SI's for V_2, V_3, and V_4, the HSI will equal SIVI. Otherwise, the habitat variables are combined in a single equation where SI_{V1} is squared to indicate its greater importance in comparison to the other three habitat variables. The equations for combining habitat variables follow.

$$\text{If } SI_{V1} < (SI_{V2} \times SI_{V3} \times SI_{V4})^{1/3}$$

$$\text{then } HSI = SI_{V1}$$

otherwise,

$$HSI = ((SI_{V1}^2) \times SI_{V2} \times SI_{V3} \times SI_{V4})^{1/5}$$

Sample data sets representing a range of habitat suitabilities for wintering lesser scaup are presented in Table 2. The data sets are hypothetical. The HSI values generated are believed to reflect the relative potential of the habitats to support wintering lesser scaup.

Field Use of Model

This model assumes that the percentage of an area supporting pelecypods (VI) influences habitat suitability. This is a poor substitute for density estimates. Although future predictions of this variable are necessary when using the model with the habitat evaluation procedures (HEP) developed by the U.S. Fish and Wildlife Service (1980), it will be difficult to predict such future values. Future predictions must be based on the assumption that V_1 will remain the same unless substrate is altered drastically or water quality degraded.

The HSI values will be most useful when the habitat variables are measured in the specific evaluation area. Any or all habitat variables may be estimated for preliminary application of this model, but subjective estimates should be made by experienced professionals and be accompanied by full documentation of the basis on which estimates were made. Use of subjective estimates will adversely affect the consistency of model outputs. Suggested methods for measuring model variables are described in Table 3.

Table 2. Suitability indices (SI) and habitat suitability indices (HSI) calculated for three sample data sets by the wintering lesser scaup HSI model variables (V) and equations.

Model component	Data set 1		Data set 2		Data set 3	
	Data	SI	Data	SI	Data	SI
V_1	100%	1.0	50%	1.0	10%	0.2
V_2	1%	1.0	10%	0.0	5%	1.0
V_3	1 m	1.0	3 m	1.0	5 m	0.7
V_4	Class 1	1.0	Class 3	0.3	Class 2	0.7
HSI		1.0		0.0		0.2

Table 3. Suggested method for measuring habitat variables included in wintering lesser scaup HSI model.

Habitat variable	Technique
V_1	The percentage of the area covered by pelecypods can be obtained by taking randomly distributed grab samples (3 samples/ha, minimum of 50, by using a 230-cm^2 Ekman dredge) and recording the percentage of total grabs with 5 or more clams. This percentage estimates V_1. A statistically valid subsampling scheme can be developed if area size is prohibitive. Use published data if available,
V_2	The percentage of the area with emergent vegetation can be estimated from aerial photographs or existing vegetation maps. Sampling should be done at mean low tide in tidally influenced areas.
V_3	Water depth can be determined from oceanographic charts or from direct measurement at mean sea level. In freshwater areas use published information or direct measurement.
V_4	The level of human disturbance to lesser scaup feeding habitat can be determined through discussion with local biologists or game wardens familiar with the area; from recreational, fishing, and hunting records; or from direct observation.

Interpreting Model Outputs

There is a paucity of studies on wintering lesser scaup and their habitat requirements. Numerous food habits studies have been published, but with only one exception, they analyze gizzard contents. Because gizzard contents are heavily biased against soft food items, the importance of plant material may be underrated in the lesser scaup diet. Vegetation may be especially important in freshwater habitats. The availability of food items in the habitat has not been adequately considered. The presence of pelecypods seems essential to the presence of lesser scaup, but no information is available on the density necessary to support lesser scaup.

A wintering lesser scaup HSI reflects a habitat's potential to support lesser scaup. HSI values are relative and should be used for comparison only. If two areas, or the same area at different times, have different HSI values, then the area with the higher HSI should be considered the one with the greater capacity for supporting more lesser scaup. A wintering lesser scaup HSI determined by this model may not reflect the actual population density of this species in the habitat being evaluated because factors other than habitat-related ones may be significant in determining population size. The model may need to be modified as more information becomes available.

Lesser scaup are extremely vulnerable to surface oil pollution because in the winter they spend virtually all their time on the water. Although oil development may not affect the quality of an area as feeding habitat, any feeding area located near oil development should be considered a high risk area to lesser scaup.

This page has been left blank intentionally.

REFERENCES

Alexander, W. C., and J. D. Hair. 1979. Winter foraging behavior and aggression of diving ducks in South Carolina. Proc. Southeast. Assoc. Fish Wildl. Agencies 31:226-232.

Anderson, B. W., and D. W. Warner. 1969. A morphological analysis of a large sample of lesser scaup and ring-necked ducks. Bird-Banding 40:85-94.

Bellrose, F. C. 1976. Ducks, geese and swans of North America. Stackpole Books, Harrisburg, Penn. 540 pp.

Bowman, P. E. 1973. Food habits of the lesser scaup (Aythya affinis) in Lake Pontchartrain. M.S. Thesis. Southeastern Louisiana University, Hammond. 21 pp.

Chamberlain, E. B., Jr. 1960. Florida waterfowl populations, habitats and management. Fla. Game Fresh Water Fish Comm. Pittman-Robertson Projects. Tech. Bull. No. 7. A contribution of Federal Aid Project W-19-R. 62 pp.

Chamberlain, J. L. 1959. Gulf coast marsh vegetation as food of wintering waterfowl. J. Wildl. Manage. 23:97-102.

Christmas, J. Y. 1960. Greater and lesser scaup feeding on dead gulf menhaden. Auk 77:346-347.

Clapp, R. B., D. Morgan-Jacobs, and R. C. Banks. 1982. Marine birds of the Southeastern United States and Gulf of Mexico. Part II: Anseriformes. U.S. Fish Wildl. Serv. Biol. Serv. Program FWS/OBS-82/20. 492 pp.

Cottam, C. 1933. Feeding habits of the lesser scaup duck. Condor 35:118-119.

Cottam, C. 1939. Food habits of North American diving ducks. U.S. Dep. Agric. Tech. Bull. No. 643. 140 pp.

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

Cronan, J. M., Jr. 1957. Food and feeding habits of the scaups in Connecticut waters. Auk 74:459-468.

Forrester, D. J., J.M. Gaskin, F. H. White, N. P. Thompson, J. A. Quick, Jr., G. E. Henderson, J. C. Woodward, and W. D. Robertson. 1977. An epizootic of waterfowl associated with a red tide episode in Florida. J.Wildl. Dis. 13:160-167.

Harmon, B. G. 1962. Mollusks as food of lesser scaup along the Louisiana coast. Trans. N. Am. Wildl. Nat. Resour. Conf. 27:132-137.

Hirsch, K. V. 1980. Winter ecology of sea ducks in the inland marine waters of Washington. M.S. Thesis. University of Washington, Seattle. 92 pp.

Howard, R. J., and H. A. Kantrud. 1983. Habitat suitability index models: redhead (wintering). U.S. Fish Wildl. Serv. FWS/OBS-82/10.53. 14 pp.

Longcore, J. R., and G. W. Cornwell. 1964. Consumption of natural foods by captive canvasback and lesser scaup. Mich. Acad. Sci. 49:207-215.

McMahan, C. A. 1970. Food habits of ducks wintering on Laguna Madre, Texas. J. Wildl. Manage. 34:946-949.

Palmer, R. S. 1976. Handbook of North American birds. Vol. III. Yale University Press, New Haven, Conn. 560 pp.

Perry, M. C., F. Ferrigno, and F. H. Settle. 1978. Rehabilitation of birds oiled on two mid-Atlantic estuaries. Proc. Southeast. Assoc. Fish Wildl. Agencies 32:318-325.

Rogers, J. P., and L. J. Korschgen. 1966. Foods of lesser scaups on breeding, migration, and wintering areas. J. Wildl. Manage. 30:258-264.

Saunders, G. B., and D. C. Saunders. 1981. Waterfowl and their wintering grounds in Mexico, 1937-64. U.S. Fish Wildl. Serv. Resour. Publ. No. 138. 151 pp.

Schreiber, R. W., F. M. Dunstan, and J. J. Dinsmore. 1975. Lesser scaup mortality in Tampa Bay, Florida, 1974. Fla. Field Nat. 3:13-15.

Stout, I. J., and G. W. Cornwell. 1976. Nonhunting mortality of fledged North American waterfowl. J. Wildl. Manage. 40:681-693.

Swanson, G. A., and J. C. Bartonek. 1970. Bias associated with food analysis in gizzards of blue-winged teal. J. Wildl. Manage. 34:739-746.

Takagi, T. 1983. Winter food habits of lesser scaups at Indigo Island, Iberville Parish, Louisiana. M.S. Thesis. Louisiana State University, Baton Rouge. 58 pp.

Thompson, J. D. 1969. Feeding behavior of diving ducks on Keokuk Pool, Mississippi River. M.S. Thesis. Iowa State University, Ames. 79 pp.

Thornburg, D. D. 1973. Diving duck movements on Keokuk Pool, Mississippi River. J. Wildl. Manage. 37:382-389.

U.S. Fish and Wildlife Service. 1980. Habitat evaluation procedures (HEP). ESM 102. Washington, D.C. n.p.

Voelzer, J. F., E. Q. Lauxen, S. L. Rhoades, and K. D. Norman. 1982. Waterfowl status report 1979. U.S. Fish Wildl. Serv. Spec. Sci. Rep. Wildl. No. 246. 96 pp.

White, D. H. 1975. Environments of fresh water feeding sites of waterfowl in autumn on the Welder Wildlife Refuge in southern Texas. Ph.D. Thesis. University of Arkansas, Monticello. 62 pp.

White, D. H., and D. James. 1978. Differential use of fresh water environments by wintering waterfowl of coastal Texas. Wilson Bull. 90:99-111.

50272-101

REPORT DOCUMENTATION PAGE	1. REPORT NO. Biological Report 82(10.91)	2.	3. Recipient's Accession No.
4. Title and Subtitle: Habitat Suitability Index Models: Lesser Scaup (Wintering)			5. Report Date: April 1985
			6.
7. Author(s): Rosemarie Mulholland			8. Performing Organization Rept. No.
9. Performing Organization Name and Address: Florida Cooperative Fish and Wildlife Research Unit, School of Forest Resources and Conservation, 117 Newins-Ziegler Hall, University of Florida, Gainesville, FL 32611			10. Project/Task/Work Unit No.
			11. Contract(C) or Grant(G) No. (C) (G)
12. Sponsoring Organization Name and Address: National Coastal Ecosystems Team, Division of Biological Services, Research and Development, U.S. Dept. of 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 model for evaluating wintering habitat quality for the lesser scaup (*Aythya affinis*). The model. is scaled to produce an index of habitat suitability between 0 (unsuitable habitat) and 1 (optimal' habitat) for Southern Atlantic and Gulf of Mexico coastal areas of the continental United States. Habitat suitability indices are designed for use with the Habitat Evaluation Procedures previously developed by the U.S. Fish and Wildlife Service. Guidelines for model application and techniques for measuring model variables are provided.

17. Document Analysis a. Descriptors

Mathematical models
Birds
Estuaries

b. Identifiers/Open-Ended Terms

Habitat
Habitat Suitability Index
Lesser scaup
Aythya affinis

c. COSATI Field/Group

18. Availability Statement	19. Security Class (This Report)	21. No. of Pages
Unlimited	Unclassified	15
	20. Security Class (This Page): Unclassified	22. Price

(See ANSI-Z39.18)

*U.S. GOVERNMENT PRINTING OFFICE: 1985 — 573-260

OPTIONAL FORM 272 (4-77)
(Formerly NTIS-35)
Department of Commerce