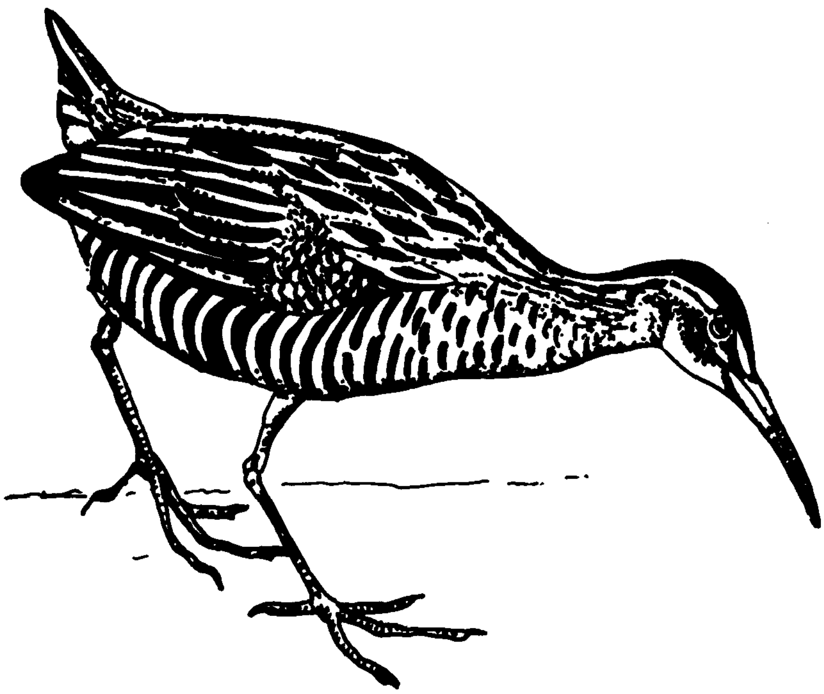
FWS/OBS-82/10.51
SEPTEMBER 1983

HABITAT SUITABILITY INDEX MODELS: CLAPPER RAIL



Fish and Wildlife Service

U.S. Department of the Interior

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

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September 1983

HABITAT SUITABILITY INDEX MODELS: CLAPPER RAIL

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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:

Lewis, J. C., and R. L. Garrison. 1983. Habitat suitability index models: clapper rail. U. S. Dept. Int. Fish Wildl. Serv. FWS/OBS-82/10.51. 15 pp.

PREFACE

The habitat use information and habitat suitability index (HSI) model for the clapper rail in this report are intended for use in 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) (U.S. Fish and Wildlife Service 1981). Assumptions used to transform habitat use information into the HSI model and guidelines for model application are described.

This model is a hypothesis of species-habitat relationships, not a statement of proven cause and effect relationships. The model has not been field-tested, but it has been applied to three sample data sets which are included. 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 or suggestions you may have on the clapper rail HSI model to:

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ACKNOWLEDGMENTS

Development of the habitat suitability index model and narrative for clapper rail was monitored, expertly reviewed, and constructively criticized by Dr. Robert B. Hamilton, Associate Professor of Wildlife Management, Louisiana State University, Baton Rouge; Tip Hon, Wildlife Biologist, Georgia Department of Natural Resources, Social Circle; and Fred Ferrigno, Wildlife Biologist, New Jersey Department of Environmental Protection, Tuckahoe. Thorough evaluations of model structure and functional relationships were provided by Dr. Carroll Cordes and Rebecca Howard of the U.S. Fish and Wildlife Service, National Coastal Ecosystems Team. Model and supportive narrative reviews were also provided by Regional personnel of the U.S. Fish and Wildlife Service. Model development and publication were funded by the U.S. Fish and Wildlife Service. Recent U.S. Department of Agriculture publications (Soil Conservation Service 1982a, 1982b) have been used to standardize the use of Latin names in this report.

CLAPPER RAIL (*Rallus longirostris*)

HABITAT USE INFORMATION

The clapper rail is a member of the order Gruiformes, family Rallidae. It inhabits estuarine tidal salt and brackish coastal marshes along the Atlantic, Gulf of Mexico, and Pacific coasts. Mangold (1977) listed seven subspecies in the coastal United States (Table 1). The light-footed and California subspecies are classified as endangered under the Endangered Species Act of 1973 with populations estimated at less than 250 (Wilbur et al. 1979; National Fish and Wildlife Laboratory 1980a) and 5,500 (National Fish and Wildlife Laboratory 1980b), respectively.

The clapper rail is grayish, gray-brown, or tan. It has a short neck, a slightly downcurved bill, flanks barred with white, and a short tail cocked upward, revealing a white patch. Overall length ranges from 33 to 48 cm (13.0 to 18.9 inches), and bill length is greater than 5 cm (2.0 inches).

Table 1. Range of coastal subspecies of clapper rail (*Rallus longirostris*) within the United States.

Common name (subspecies)	Range
Northern clapper rail (*R. l. crepitans*)	Maine to South Carolina
Wayne clapper rail (*R. l. waynei*)	South Carolina to southern tip of Florida
Mangrove clapper rail (*R. l. insularum*)	Southern tip of Florida and Florida Keys
Florida clapper rail (*R. l. scottii*)	Florida west coast
Louisiana clapper rail (*R. l. saturatus*)	Florida Panhandle to Mexico
Light-footed clapper rail (*R. l. levipes*)	Southern California coast
California clapper rail (*R. l. obsoletus*)	San Francisco Bay area, California

The northern and Wayne clapper rails are the only coastal migratory subspecies in the United States although some other subspecies undergo population shifts (Oney 1954; Stewart 1954; Adams and Quay 1958). The migratory subspecies primarily winter from South Carolina to Florida, a few hundred kilometers south of their nesting range. Northward migration begins about April, and southward migration begins in September.

Typical rail habitat in Georgia consists of 79% smooth cordgrass (*Spartina alterniflora*), 20% black rush (*Juncus roemerianus*), and 1% salt flats or salt meadows (Hon et al. 1977). Typical rail habitat of the west coast is salt marsh, broken up by tidal sloughs, where cordgrass (*Spartina foliosa*) and glasswort (*Salicornia*) are the conspicuous plants (National Fish and Wildlife Laboratory 1980a, 1980b). Salt marsh ecology has been reviewed by several authors (Teal 1958; Teal and Teal 1969; Johnson et al. 1974; Reimold and Queen 1974).

The clapper rail is monogamous, and some subspecies may produce more than one brood a year (Blandin 1963). Nesting occurs from February to late August; timing varies with geographic location. Average clutch size is 9 or 10 eggs (Bent 1963; Ferrigno 1966; Mangold 1974; Ripley 1977); clutch size is largest in the north. The incubation period is 18 to 22 days. Male and female incubate eggs and brood the young. After the young are able to feed themselves, usually at 35 to 42 days of age, their parents chase them from the parental territory (Johnsgard 1975). The young are precocial and fledge 9 - 10 weeks after hatching (Adams and Quay 1958). They are sexually mature in the first reproductive season after they fledge.

Food Requirements

Clapper rails feed on mud flats and along gently sloping banks of creeks, ditches, bayous, or shorelines at low tide and in the marsh proper among grasses. Rails feed by probing in mud or by picking up foods found on the ground surface or on vegetation. The diet consists of parasitic worms (Ascaridae), clam worms (*Nereis* spp.), snails (*Littorina irrorata*, *Melampus* sp., *Nassarius obsoleta*, *Polygyra* sp.), clams (*Molulidae*), crabs (*Sesarma* spp., *Uca* spp.), insects (Phalaenidae), spiders (*Lycosa* spp., *Clubiona* spp.), fish (Poeciliidae, *Fundulus* spp.), and rarely, plant material (Oney 1951, 1954). Martin et al. (1951) reported that the diet of 260 clapper rails was 96% animal matter.

The predominant food item for northern, Wayne, and Louisiana clapper rails seems to be fiddler crabs (*Uca pugnax*), a common species whose ecology has been discussed by Teal (1958) and Miller (1965). In New Jersey, fiddler crabs were most abundant in tall smooth cordgrass (Ferrigno 1966). Crayfish are also an important food of the western and southern subspecies of clapper rail. Important foods in the Savannah River Delta, South Carolina-Georgia, were fiddler crabs, small cancroid crabs (*Eurytium* and *Panopeus*), and periwinkle (*Littorina irrorata*). The Florida clapper rail eats crabs (*Sesarma reticulatum* and *Callinectes sapidus*), freshwater shrimp (*Palaemonetes exilipes*), fiddler crabs, mollusks, beetles, and earwigs (*Anisolabis maritima*). Little is known about the food habits of the mangrove clapper rail. The fall diet of 103 Louisiana clapper rails was mainly fiddler crabs and snails (*Littorina* spp.) (Batemen 1965).

The winter diet of 18 California clapper rails contained 85% animal matter, which included 56.5% plaited horse mussel (*Modiolus* {*Volsella*} *demissus*), 15% spiders (Lycosidae), 7.6% clams (*Macoma balthica*), and 3.2% yellow shore crabs

(Hemigrapsus oregonensis) (Moffitt 1941). Since Moffitt's work it has become clear that crabs are the staple diet of clapper rails in southern California (Jorgenson 1975; Sanford Wilbur, U.S. Fish and Wildlife Service, Portland, Oregon; pers. comm.).

Cover Requirements

Clapper rails tend to concentrate along tidal creeks of marshes during the breeding season. These concentration areas appear to be ancestral nesting grounds having a long tradition of use (Stone 1965). Nests are usually in dense cover near water and built well above the high tide mark. Ground nesting occurs in some areas, but most nests are about 20 to 35 cm (7.9 to 13.8 inches) above the ground and 10 to 50 m (32.8 to 164.0 ft) from other nests (Kozicky and Schmidt 1949; Stewart 1951).

Nest material consists of surrounding vegetation such as dried cordgrass. Many nests have vegetative ramps leading to them and the nests are covered with a roof. The nest is funnel shaped with an average inside diameter of about 14.2 cm (5.6 inches), inside depth of 5.3 cm (2.1 inches), and outside diameter of 23.6 cm (9.3 inches) (Kozicky and Schmidt 1949).

On Long Island (MacNamara and Udell 1970), clapper rails nested in smooth cordgrass, saltmeadow cordgrass (Spartina patens), and common reed (Phragmites australis). The favored nesting sites in New Jersey were along tidewater creeks where grasses were higher than in the rest of the marsh (38 - 51 cm, 15.0 - 20.1 inches). Presumably the tall grasses offered better protection to birds and nests (Stone 1965). A few nests were found in dry areas and one was located on a dune among bayberry (Myrica heterophylla) bushes 91 m (298.6 ft) from water. Kozicky and Schmidt (1949), also studying in New Jersey, noted that 71% of the nests were in smooth cordgrass more than 61 cm (24.0 inches) in height. In many instances these taller grasses were the only vegetation not submerged by high tides. Eighty percent of the nests in a Virginia study area were in tall (46 cm, 18.1 inches) smooth cordgrass within 5 m (16.4 ft) of the tidal creeks (Stewart 1951).

Three height zones of smooth cordgrass were recognized by Oney (1954) in Georgia. The most suitable rail nesting habitat (68% of nesting attempts) was medium height (61-122 cm, 24-48 inches) smooth cordgrass bordering tall (1.2-2.4 m, 3.9-7.9 ft) smooth cordgrass (Oney 1954). Tall zone smooth cordgrass, the second most important nesting habitat, was present along creeks or ditches. The medium height zone occurred on the gentle slope of levees away from drainage ditches. The short smooth cordgrass zone was present in the lowest part of the marsh and was not important for nesting.

In Florida, Howell (1932) found two nests of Wayne clapper rails in small mangrove bushes and a third in dense glasswort surrounded by mangroves. The primary habitat of the mangrove clapper rail is reported as mangrove (Rhizophora mangle and Avicennia germinans) forest, but the nesting habitat is not adequately described (Owre 1981). Kale (1981) reported that Florida clapper rails nest in cordgrass, rush, and possibly in shrubby mangroves. Thus, the three subspecies of clapper rail found in Florida may occasionally nest in mangroves (Howell 1932; Kale 1981; Owre 1981).

Bateman (1965) noted the similarity of the Louisiana clapper rail's ecology in Louisiana to that of clapper rails studied on the Atlantic coast. In Louisiana, smooth cordgrass at nest sites was taller and provided more cover than vegetation at random sites within the marsh (Sharpe 1976). Holliman (1978), studying the Louisiana clapper rail in Alabama, stressed the importance of smooth cordgrass and suggested that rough estimates of rail populations could be made by inspecting recent aerial photos and determining the area of smooth cordgrass marsh available as rail habitat. From the above observations it seems evident that smooth cordgrass provides critical nesting habitat along the gulf coast.

The California clapper rail nests in cordgrass, glasswort, or at the base of gumweed plants (*Grindelia* spp.) (DeGroot 1927; Wilbur and Tomlinson 1976; Gill 1979). The date of nesting and tides determine in part the species of vegetation used (Zucca 1954). Early nests are constructed in dense gumweed because cordgrass growth has not yet occurred. Where nesting is disrupted by tidal flooding the rails often renest in glasswort because it grows at higher elevations than gumweed or cordgrass. The light-footed clapper rail nests most often on the ground at the base of glasswort clumps on the elevated banks of tidal channels close to water (Wilbur and Tomlinson 1976). Population densities of light-footed clapper rails appear to be highest in those marshes with the most cordgrass (Jorgensen 1975).

For all subspecies, with the possible exception of the mangrove clapper rail, *Spartina* spp. are an important component of nest cover, and proximity to water is a characteristic of all nesting habitat.

Fall-Winter Habitat Requirements

Clapper rails are more dispersed within the marsh after nesting is completed although the preferred habitat continues to be *Spartina* marsh. Fall-winter habitat requirements have not been described in the literature. Tip Hon (Georgia Department of Natural Resources, Social Circle; pers. comm.) stated that during fall-winter in Georgia, rails concentrate in habitat that differs visually from habitat used for nesting. His banding studies indicated that rails disperse in September from the nesting areas and reside in other portions of the marsh that traditionally have provided good fall hunting opportunities. Rails spend more time in high areas of the marsh in winter, presumably to escape high storm tides. Winter habitat appears to be stands of medium-height *Spartina* near sounds and larger tidal creeks, and it contains fewer tidal streams and ditches than the nesting habitat. Large racks of floating, dead cordgrass, usually deposited along the marsh side of creek levees, are occupied by rails during high fall and winter tides. The lack of detailed descriptions of winter habitat limits our ability to describe year-round habitat needs.

Interspersion

Oney (1954) found that the average nest was about 7 m (23 ft) from the nearest change in cover. This cover change was represented by variation in cordgrass height and density rather than a plant species change. A general characteristic of *Spartina* marshes is a pattern of diminishing plant height and stem density at greater distances from tidally influenced bodies of water. Stewart (1951) found a correlation between the density of nests and the amount of edge between tall and medium-height smooth cordgrass (20-46 cm or 8-18 inches). This relationship was so important that reliable indices of nest density could be obtained by annually counting the number of occupied nests in 5-m (16.4-ft) wide strips of the tall growth smooth cordgrass along tidal creeks. Ferrigno (1966) stated that the tall *Spartina alterniflora* along ditches and ditched ponds provided more nesting cover, edge, and food for a given acreage of marsh than any other plant species. Fiddler crabs, the most important rail food in New Jersey, were most abundant in the tall smooth cordgrass edge of the short marsh (Ferrigno 1966). All of the above references indicate the importance of edge and interspersion for ideal rail habitat. The most attractive edge parallels tidal ditches, streams, and other open bodies of water.

Spatial Requirements

Clapper rails exhibit intraspecific territorial behavior during the nesting season (Johnsgard 1975). Holliman (1978) found that the minimum distance between active nests in Alabama was 10 m (32.8 ft). Clapper rails in Louisiana had an average minimum home range of 153.7 m (504 ft) along canals and tidal ditches in summer, and 487.3 m (1599 ft) in winter (Roth et al. 1972). In South Carolina clapper rails had a February through October home range not greater than 183-274 m (600-900 ft) in radius (Blandin 1963).

HABITAT SUITABILITY INDEX (HSI) MODEL

Model Applicability

Geographic area and season. This model was developed for Atlantic, Gulf of Mexico, and Pacific coastal areas within the range of clapper rails. The model is useful during any season.

Minimum habitat area. Minimum habitat area is defined as the minimum amount of contiguous suitable habitat required for a species to successfully live and reproduce. Little information about minimum habitat area was available in the published literature. Holliman (1978) reported the existence of clapper rail populations in two smooth cordgrass marshes less than 2 ha (5 acres) each and surrounded by vegetation characteristic of freshwater marsh. He found that the up-river distribution of clapper rails on three rivers was limited to small strips of cordgrass less than 50 m (164 ft) long and 10 m (32.8 ft) wide. Thus, these Alabama data suggest that a conservative minimum habitat area would be 2 ha (5 acres). The HSI will be zero if less than 2 ha are available.

Verification level. Review and evaluation of the clapper rail HSI model were provided by the following biologists: R. E. Hamilton, Louisiana State University, Baton Rouge; T. Hon, Georgia Department of Natural Resources, Social Circle; and F. Ferrigno, New Jersey Department of Environmental Protection, Tuckahoe. Their comments were considered during preparation of the final model.

Model Description

This HSI model evaluates two clapper rail life requisites: food and cover. Clapper rails are poor fliers and have small home ranges. It is assumed that food and cover needs must be met in the same general habitat area. Thus, a single equation simultaneously evaluates food and cover life requisites. Figure 1 shows how the HSI is related to the food/cover life requisite and specific habitat variables. The model is purposely designed to use variables that require a minimum of field work. Variable data usually can be collected from maps and aerial photographs.

Food/cover component. The primary feeding habitat requirements described in the literature are (1) mud flats and gently sloping banks of creeks, ditches, bayous, or shorelines at low tide and (2) the estuarine persistent emergent and scrub/shrub mangrove wetlands.

During low tides, mud flats and exposed channels provide feeding habitat. The literature does not specify the optimum amount of these tidal mud flats, but clapper rails are not expected to regularly use those flats that are more than 15 m (49.2 ft) from vegetative cover. Habitat is considered optimum when at least 50% of the shoreline of persistent emergent and scrub/shrub mangrove wetlands is bordered by tidal flats and exposed channels (V_1).

Scrub/shrub mangrove and persistent emergent wetland habitats meet the second feeding habitat requirement. Emergent wetland is a tract of periodically inundated vegetation described by Cowardin et al. (1979) as an estuarine intertidal wetland characterized by erect, rooted, herbaceous hydrophytes, mainly perennials. These marshes usually include species of Spartina, Juncus, Salicornia, and Grindelia. Shrubby mangrove wetland, the scrub/shrub wetland of Cowardin et al. (1979), is characterized by mangrove species not exceeding 6 m (19.7 ft) in height and is occasionally used by clapper rails. For any coastal unit being evaluated, the highest Suitability Index (SI) is attained when 100% of the land area is estuarine persistent emergent or scrub/shrub mangrove wetland (V_2).

The cover habitat requirements of clapper rails can be categorized into the nesting and the non-nesting needs. For example, cover needs from late summer through winter, when rails are more widely dispersed than during the nesting season, are met by the emergent wetland and scrub/shrub mangrove wetland. Cover requirements during the nesting season are more restricted.

The literature stresses that important nesting habitat is emergent or scrub/shrub mangrove wetlands bordering ditches and tidal creeks. Important nesting plants are Spartina, Salicornia, Grindelia, and possibly mangroves. These genera usually make up the vegetation bordering tidally influenced bodies of water. On the east coast, most nests are located within 5 m (16.4 ft) of water (Kozicky and Schmidt 1949; Stewart 1951), but the Louisiana rail nests at greater distances from water (Sharpe 1976; Holliman 1978). The vegetated wetland bordering tidally influenced water (streams, rivers, ditches, sloughs, bayous, embayments) is preferred nesting habitat; the optimum width of this fringe apparently varies with the subspecies or geographic location. This model uses a 15-m (49.2-ft) fringe, bordering a tidally influenced body of water, as the area most suitable for nesting (V_3). Coastal areas with a large water to vegetation interface (i.e., containing uneven shorelines and with many embayments, streams, rivers, and ditches) are assumed to provide the best nesting habitat. Areas with a high percentage of the total emergent and scrub/shrub mangrove wetlands within 15 m of water will have the highest SI.

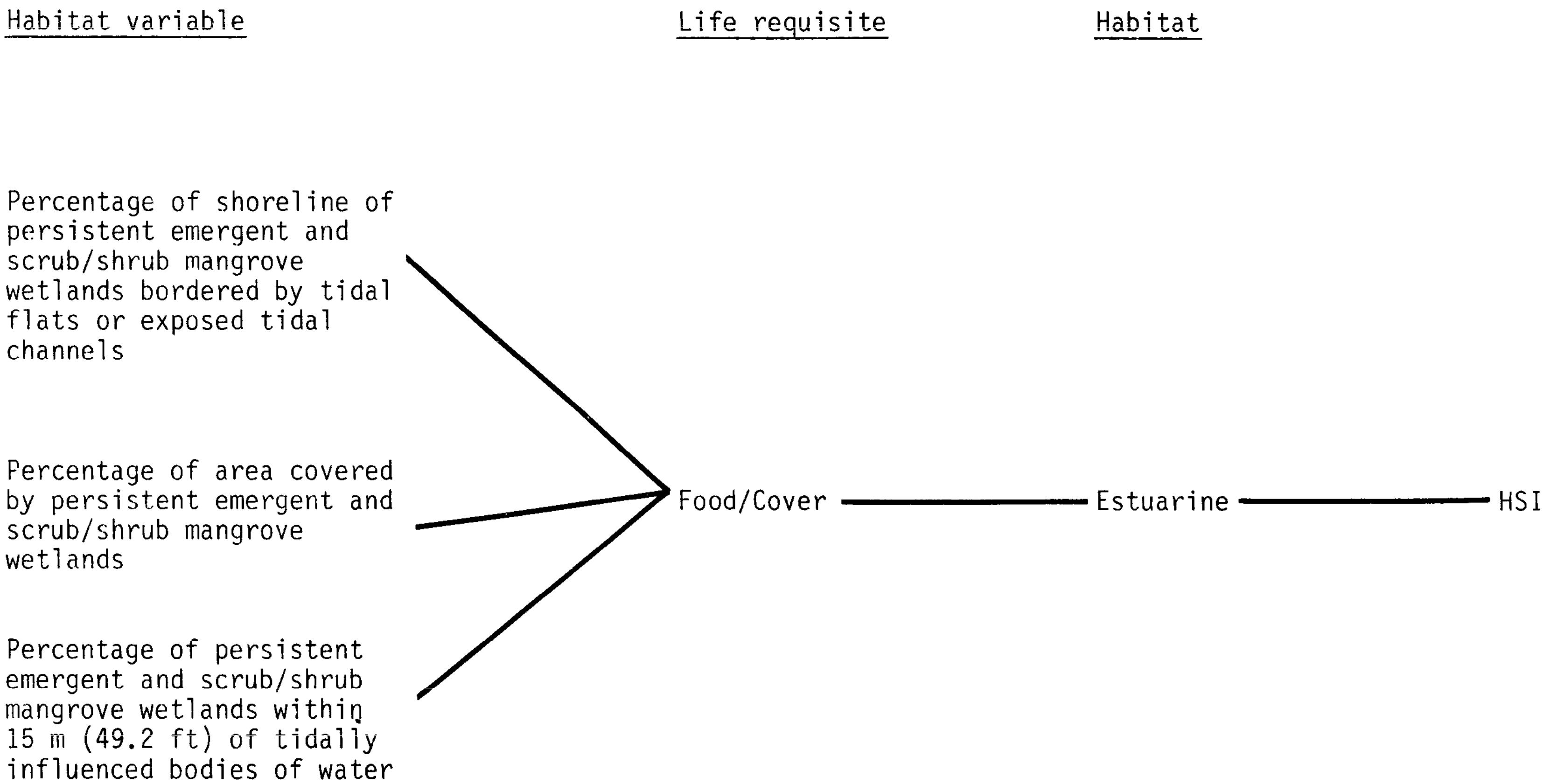


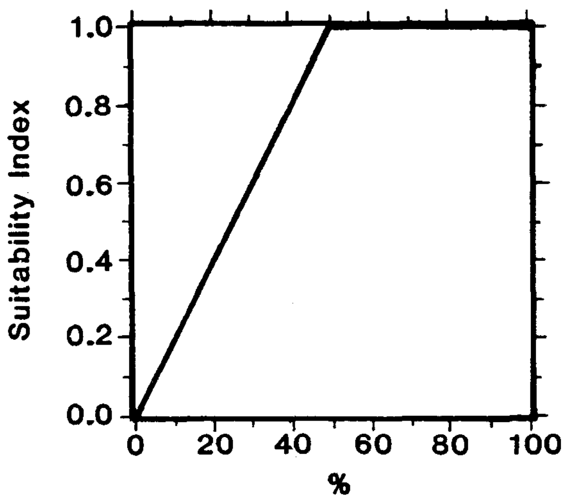
Figure 1. Relationship of habitat variables and life requisites to the HSI for clapper rail.

Plant height seems to be a factor in choice of nesting sites. But, the appropriate height varies with plant species, ground elevation, and local peak spring tides. It seems unlikely that optimum plant height guidelines can be set that will fit most locations and subspecies. Consequently, we do not include plant height as a variable.

Interrelationship of life requisite components. Edge is a common feature of the habitats that clapper rails select for feeding and reproduction. The wetland border within 15 m (49.2 ft) of open, tidally influenced, salt or brackish water seems optimum for food and nest sites. No other consideration is necessary except it is assumed that at least 2 ha (5 acres) of contiguous habitat, of the appropriate plant species, must be present to support a rail population.

Suitability Index (SI) Graphs for Model Variables

This section contains suitability index graphs and equations to quantitatively describe the relationships between estuarine habitat (E) variables and habitat suitability for clapper rails. These graphs and equations are used to produce an HSI. The data sources and assumptions associated with documentation of the SI graphs are shown in Table 2. Map or field data should be collected for each variable by using the techniques of Table 3.

Habitat	Variable		Suitability Graph
E	V_1	Percentage of shoreline of persistent emergent and scrub/shrub mangrove wetlands that is bordered by tidal flats or exposed tidal channels.	

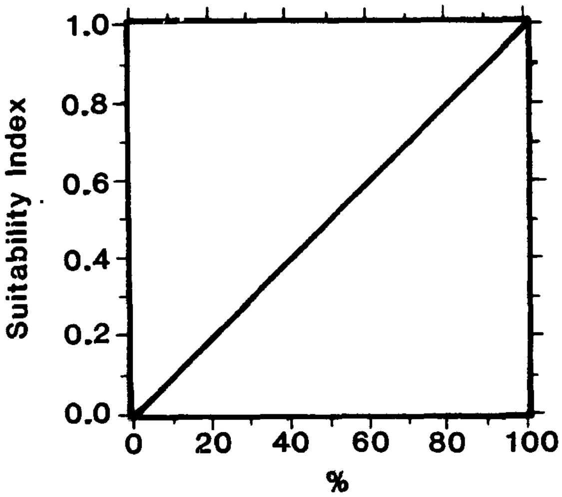
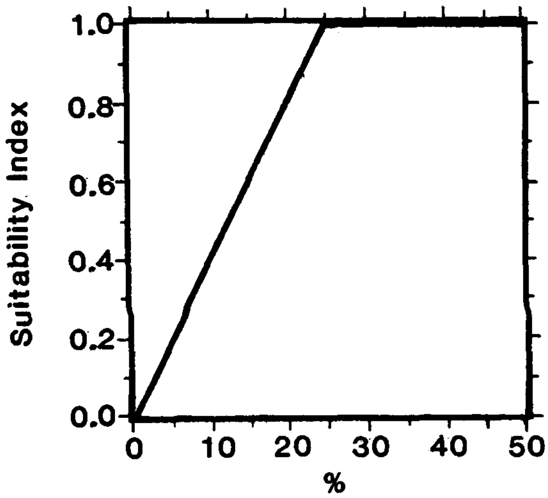
Habitat	Variable		Suitability Graph
E	V_2	Percentage of area covered by persistent emergent and/or scrub/shrub mangrove wetlands.	
E	V_3	Percentage of emergent and scrub/shrub mangrove wetland within 15 m (49.2 ft) of tidally influenced bodies of water.	

Table 2. Data sources and assumptions for clapper rail suitability indices.

Variables and source		Assumptions
V_1	Mangold (1977) National Fish and Wildlife Laboratory (1980a)	Barren tidal mud flats or mud banks are feeding areas. The best habitat is assumed to be that with at least 50% of the persistent emergent and scrub/shrub mangrove wetlands bordered by tidal flats or exposed tidal channels.
V_2	Kozicky and Schmidt (1949) Stewart (1951) Oney (1954) Bent (1963) Wilbur and Tomlinson (1976) Holliman (1978)	Clapper rails nest and feed in the persistent emergent and scrub/shrub mangrove wetlands. Survival depends upon the availability of such wetlands.
V_3	Kozicky and Schmidt (1949) Stewart (1951) Oney (1954) Stone (1965) Wilbur and Tomlinson (1976)	Preferred nesting sites are within the 15-m (49.2-ft) fringe of wetland bordering tidally influenced bodies of water. Coastal units with the highest percentages of persistent emergent and scrub/shrub mangrove wetland in the 15-m strip bordering water are assumed most suitable.

HSI Determination

To calculate an HSI, one must determine if the life requisites are provided at some level greater than zero. If the area lacks suitable contiguous habitat of at least 2 ha (5 acres) the HSI is zero.

In areas larger than 2 ha, the following steps must be taken to determine an HSI for any application.

1. Review the section on model applicability for validity of the model for the intended application.

2. Identify the boundaries of the evaluation area or areas and obtain data for each model variable used in the model. Calculate the SI for each habitat variable.

3. Calculate the HSI:

$$HSI = (SI_{V_1} \times SI_{V_2} \times SI_{V_3})^{1/3}$$

Table 3. Suggested measurement techniques and definition of habitat variables.

	Variable (definition)	Suggested techniques
V_1	Percentage of wetland shoreline that borders flat to gently sloping banks or tidal flats exposed at low tide. (Wetland shoreline is the persistent emergent or scrub/shrub mangrove wetlands that border sounds, rivers, streams, embayments, sloughs, and open coastline; tidal flats and banks are predominantly unvegetated soil substrate exposed at low tide; gently sloping is a slope of 15° or less.)	On maps or aerial photos use a map measurer (Hays et al. 1981) to determine the shoreline bordered by gently sloping banks or tidal flats exposed at low tide. Tidal flats are usually depicted on coastal maps, and the 1-m (3.3-ft) contour line indicates the presence of gently sloping banks. With this information and the mean tide fluctation data, predict which shorelines border banks or flats suitable for clapper rail feeding activities. Then measure the total shoreline edge and calculate the percentage of shoreline bordered by suitable feeding habitat.
V_2	Percentage of the total area that is salt or brackish emergent or scrub/shrub mangrove wetlands. (Emergent wetland is a class within Cowardin et al. [1979] estuarine-intertidal wetland system and is characterized by erect, rooted, herbaceous hydrophytes, predominantly perennials; the scrub/shrub wetland is characterized by species of mangroves less than 6 m [19.7 ft] tall.)	Refer to recent U.S. Geological Survey (USGS) photo quad maps, other coastal maps, or aerial photographs to identify emergent and mangrove wetlands. Use a stereoscope and photographs to determine mangrove height and identity. Use a dot grid or planimeter to calculate area of marsh. Divide acreage of marsh by area of entire study unit to determine percentage of the area that is marsh.
V_3	Percentage of area of emergent or scrub/shrub mangrove wetlands that is within 15 m (49.2 ft) of tidally influenced bodies of water. (Tidally influenced bodies include streams, rivers, ponds, embayments, sloughs, and ditches that rise and fall in response to tide.)	Measure total wetland-to-water edge with a map measurer. Multiply by 15 (the 15-m band) to determine square meters and then convert to hectares. Divide area within the wetland fringe by total area of emergent and mangrove wetland calculated for V_1.

The primary value of an HSI is for comparing areas. Table 4 provides three sample data sets that have been applied to the clapper rail model to calculate HSI's. The data sets are hypothetical, but represent realistic situations.

Table 4. Calculation of the suitability indices (SI) and the habitat suitability index (HSI) for three sample data sets using the clapper rail habitat variables (V) and model equation.

Model component	Data set 1		Data set 2		Data set 3	
	Data	SI	Data	SI	Data	SI
V_1	50%	1.00	10%	0.20	80%	1.00
V_2	90%	0.90	20%	0.20	60%	0.60
V_3	7%	0.28	12%	0.48	60%	1.00
HSI	0.63		0.27		0.84	

Field Use of the Model

Detailed laboratory or field sampling of habitat variables through time will provide the most reliable and replicable HSI values. The data used to calculate the SI values should be accompanied by appropriate documentation to insure that decisionmakers understand the quality of the data used in developing the HSI.

Interpreting Model Outputs

A clapper rail HSI determined by laboratory or field application of this model may not reflect the population density of clapper rail in the study area because other factors may have significant influence in determining species abundance. In coastal areas where clapper rail populations are primarily regulated by habitat-based factors, the model should yield HSI values that have positive correlations with long-term abundance. This correlation has not been tested, other than from inference drawn from the literature to support the model. The proper interpretation of the HSI is one of comparison. If two areas have different HSI's, then the area with the higher HSI should have the potential to support more clapper rails than the area with the lower HSI.

REFERENCES

Adams, D. A., and T. L. Quay. 1958. Ecology of the clapper rail in southeastern North Carolina. J. Wildl. Manage. 22(2):149-156.

Bateman, H. A., Jr. 1965. Clapper rail (Rallus longirostris) on Grand Terre Island, Jefferson Parish, Louisiana. M. S. Thesis. Louisiana State University, Baton Rouge. 144 pp.

Bent, A. C. 1963. Life histories of North American marsh birds. Smithsonian Institute, U.S. Natl. Mus. Bull. 135. Dover Publishers, Inc. reprint, New York. (First published in 1928.) 490 pp.

Blandin, W. W. 1963. Renesting and multiple brooding habits of marked clapper rails. Proc. Annu. Conf. Southeast. Assoc. Game Fish Comm. 17:60-68.

Cowardin, K. 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.

DeGroot, D. S. 1927. The California clapper rail: its nesting habits, enemies and habitat. Condor 29(6):259-270.

Ferrigno, F. 1966. Some aspects of the nesting biology, population dynamics, and habitat associations of the clapper rail. M. S. Thesis. Rutgers University, New Brunswick, N.J. 68 pp.

Gill, R., Jr. 1979. Status and distribution of the California clapper rail (Rallus longirostris obsoletus). Calif. Fish Game 65(1):36-49.

Hays, R. L., C. Summers, and W. Seitz. 1981. Estimating wildlife habitat variables. U.S. Fish Wildl. Serv. Biol. Serv. Program FWS/OBS-81/47. 111 pp.

Holliman, D. C. 1978. Clapper rail (Rallus longirostris) studies in Alabama. Northeast. Gulf Sci. 2(1):24-34.

Hon, T., R. R. Odum, and D. P. Belcher. 1977. Results of Georgia's clapper rail banding program. Proc. Annu. Conf. Southeast. Assoc. Fish Wildl. Agencies 31:72-76.

Howell, A. H. 1932. Florida bird life. Fla. Dep. Game and Fresh Water Fish Comm. and Bur. Biol. Surv., USDA. Coward-McCann, Inc., New York. 579 pp.

Johnsgard, P. A. 1975. North American game birds of upland and shoreline. University Nebraska Press, Lincoln. 183 pp.

Johnson, A. S., H. O. Hillestad, S. F. Shanholtzer, and G. F. Shanholtzer. 1974. An ecological survey of the coastal region of Georgia. Natl. Park Serv. Sci. Monogr. Ser. 3, U.S. Gov. Printing Office, Washington, D.C. 233 pp.

Jorgensen, P. D. 1975. Habitat preference of the light-footed clapper rail in Tijuana Marsh, California. M. S. Thesis. San Diego State University, Calif. 115 pp.

Kale, H. W., II. 1981. Florida clapper rail. Pages 112-113 in H. W. Kale II, ed. Rare and endangered biota of Florida. Vol. 2, Birds. University Presses of Florida, Gainesville. 121 pp.

Kozicky, E. L., and F. V. Schmidt. 1949. Nesting habits of the clapper rail in New Jersey. Auk 66:355-364.

MacNamara, E. E., and H. F. Udell. 1970. Clapper rail investigations on the south shore of Long Island. Linn. Soc. (N. Y.) 71:120-131.

Mangold, R. E. 1974. Research on shore and upland migratory birds in New Jersey: clapper rail studies, 1974 final report. U. S. Fish Wildl. Serv. Accelerated Res. Program, New Jersey Dep. Environ. Protect., Trenton. 17 pp.

Mangold, R. E. 1977. Clapper rail (Rallus longirostris). Pages 84-93 in G. C. Sanderson ed. Management of migratory shore and upland game birds in North America. Int. Assoc. Fish Wildl. Agencies. 358 pp.

Martin, A. C., H. S. Zim, and A. L. Nelson. 1951. American wildlife and plants: a guide to wildlife food habits. Dover Publ., Inc., New York. 500 pp.

Miller, D. C. 1965. Studies of the systematics, ecology, and geographic distribution of certain fiddler crabs. Ph.D. Dissertation. Duke University, Durham, N.C. 223 pp.

Moffitt, J. 1941. Notes on the food of the California clapper rail. Condor 43(6):270-273.

National Fish and Wildlife Laboratory. 1980a. Selected vertebrate endangered species of the seacoast of the United States: light-footed clapper rail. U.S. Fish Wildl. Serv. Biol. Serv. Program FWS/OBS-80/01.27. 7 pp.

National Fish and Wildlife Laboratory. 1980b. Selected vertebrate endangered species of the seacoast of the United States: California clapper rail. U. S. Fish Wildl. Serv. Biol. Serv. Program FWS/OBS-80/01.27. 6 pp.

Oney, John. 1951. Fall food habits of the clapper rail in Georgia. J. Wildl. Manage. 15(1):106-107.

Oney, John. 1954. Final report, clapper rail survey and investigations study. Georgia Game Fish Commission, Atlanta, 50 pp.

Owre, O. T. 1981. Mangrove clapper rail. Pages 113-114 in H. W. Kale, II, ed. Rare and endangered biota of Florida. Vol. 2, Birds. University Presses of Florida, Gainesville. 121 pp.

Reimold, R. J., and W. H. Queen, eds. 1974. Ecology of the halophytes. Academic Press, Inc., New York. 605 pp.

Ripley, S. D. 1977. Rails of the world. David R. Godine Publ., Boston, Mass. 406 pp.

Roth, R. R., J. D. Newsom, T. Joanen, and L. L. McNease. 1972. The daily and seasonal behavior patterns of the clapper rail (Rallus longirostris) in the Louisiana coastal marshes. Proc. Annu. Conf. Southeast. Assoc. Game Fish Comm. 26:136-147.

Sharpe, T. L. 1976. Productivity and distribution of the clapper rail in a Louisiana saltmarsh. M. S. Thesis. Louisiana State University, Baton Rouge. 91 pp.

Soil Conservation Service. 1982a. National list of scientific names. Vol. 1, List of plant names. U.S. Dep. Agric., SCS-TP-159. 416 pp.

Soil Conservation Service. 1982b. National list of scientific names. Vol. 2, Synonymy. U.S. Dep. Agric., SCS-TP-159. 438 pp.

Stewart, R. E. 1951. Clapper rail populations of the Middle Atlantic States. Trans. N. Am. Wildl. Conf. 16:421-430.

Stewart, R. E. 1954. Migratory movements of the northern clapper rail. Bird-Banding 25(1):1-5.

Stone, W. 1965. Bird studies at Old Cap May. Vol. 1. Dover Publ., Inc., New York. 484 pp.

Teal, J. M. 1958. Distribution of fiddler crabs in Georgia salt marshes. Ecology 39(2):185-193.

Teal, J. M., and M. Teal. 1969. Life and death of a salt marsh. Audubon/Ballantine Publ., New York. 274 pp.

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

Wilbur, S. R., and R. E. Tomlinson. 1976. The literature of the western clapper rails. U.S. Fish Wildl. Serv. Spec. Sci. Rep. Wildl. 194. Washington, D.C. 31 pp.

Wilbur, S. R., R. M. Jurek, R. Hein, and C. T. Collins. 1979. Light-footed rail recovery plan. Region 1, Endangered Species Program, U.S. Fish Wildl. Serv., Portland, Oreg. 33 pp.

Zucca, J. J. 1954. A study of the California clapper rail. Wasmann J. Biol. 12(2):135-153.

50272-101

REPORT DOCUMENTATION PAGE	1. REPORT NO. FWS/OBS-82/10.51	2.	3. Recipient's Accession No.
4. Title and Subtitle Habitat Suitability Index Models: Clapper Rail			5. Report Date September 1983 6.
7. Author(s) J. C. Lewis and R. L. Garrison			8. Performing Organization Rept. No.
9. Performing Organization Name and Address Georgia Cooperative Wildlife Research Unit School of Forest Resources University of Georgia Athens, GA 30602			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 Fish and Wildlife Service U.S. Department 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 suitable for evaluating the quality of coastal habitat of clapper rails (*Rallus longirostris*). The model is scaled to produce an index of habitat suitability between 0 (unsuitable habitat) and 1 (optimally suitable habitat) for coastal areas of the continental United States. Habitat suitability indices are designed for use with Habitat Evaluation Procedures previously developed by the U.S. Fish and Wildlife Service. Guidelines for clapper rail model applications and techniques for estimating model variables are discussed.

17. Document Analysis a. Descriptors

Mathematical models
Birds
Estuaries

b. Identifiers/Open-Ended Terms

Habitat
Habitat Suitability Index
Clapper rail
Rallus longirostris

c. COSATI Field/Group

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

(See ANSI-Z39.18)

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

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U.S. FISH AND WILDLIFE SERVICE

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