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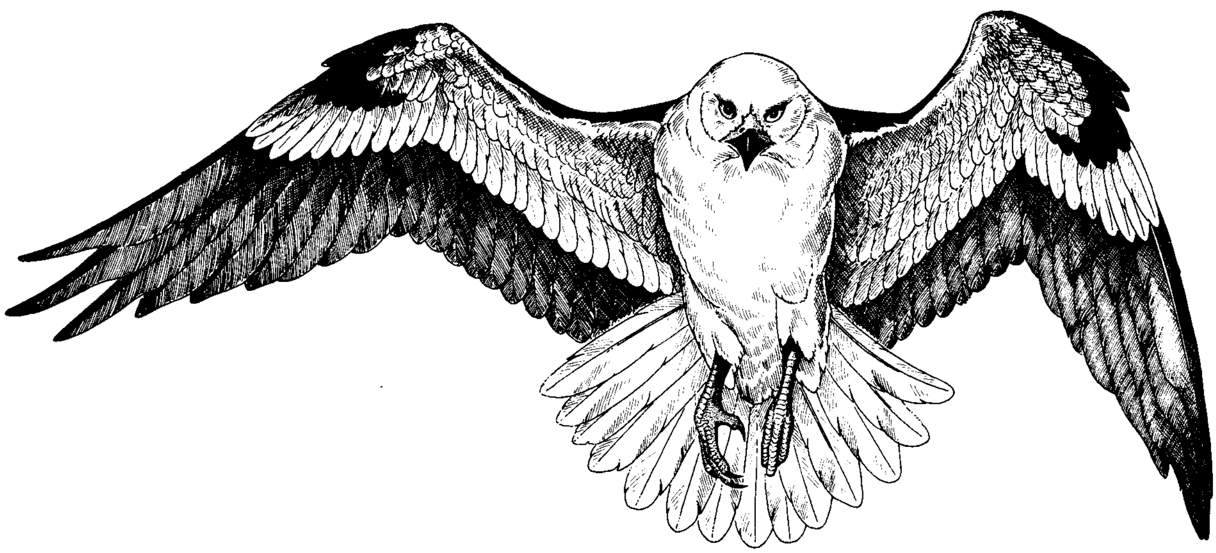

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HABITAT SUITABILITY INDEX MODELS: BLACK-SHOULDERED KITE

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PREFACE

The black-shouldered kite habitat suitability index (HSI) model is intended for use with 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 The model was developed from a review and synthesis of existing information, and includes unpublished information that reflects the opinions of persons familiar with black-shouldered kite ecology. It is scaled to produce an index of habitat suitability between 0 (unsuitable habitat) and 1.0 (optimally suitable habitat). Assumptions used to develop the HSI model and guidelines for model application, including techniques for measuring model variables, are described.

Model documentation is provided for several reasons. First, the documentation provides a means of explaining the model's structure and its inherent assumptions. Second, the model-building process involves considerable judgment on the part of the model builder, and documentation provides the insights necessary to modify the model when these judgments are inconsistent with local or new knowledge. Finally, the documentation should facilitate reformulation of the model to meet individual study constraints of time and human resources.

This model is a hypothesis of species-habitat relations, not a statement of proven cause and effect. The model has not been field tested. 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 black-shouldered kite HSI model to the following address.

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We would like to express our appreciation to Rey Stendell, Director of the U.S. Fish and Wildlife Service's (FWS) Northern Prairie Wildlife Research Center (NPWRC), Jamestown, North Dakota, for his many suggestions on model development, for sharing his thorough knowledge of black-shouldered kite biology, and for his willingness to provide editorial comments. Brian R. Chapman, Corpus Christi State University, Texas, provided unpublished information on kite feeding ecology in south Texas. Harold Kantrud and Douglas Johnson, NPWRC, provided helpful comments on earlier drafts of the manuscript. Evaluations of the structure and functional relationship of the model were provided by personnel of the FWS National Wetlands Research Center. Additional reviews were obtained from FWS Ecological Services personnel at Corpus Christi, Texas; Houston, Texas; and Sacramento, California. Funding for model development and publication was provided by the FWS. Patrick Lynch prepared the cover illustration.

BLACK-SHOULDERED KITE (*Elanus caeruleus*)

INTRODUCTION

The black-shouldered kite inhabits a disjunct range extending from California, Texas, and (formerly) Florida, south intermittently to Chile and Argentina (American Ornithologists' Union 1983). Prior to the 1960's, this species occurred in low numbers across much of its range. Population decreases appeared to be common during this time, especially in Mexico and Central America (Eisenmann 1971).

Populations of black-shouldered kite have changed considerably within the limited area of its U.S. range. Although considered common and widespread in California in the late 1800's, the species was largely extirpated from much of the State by the early 1900's (Grinnell and Miller 1944). In Texas, Oberholser (1971) considered this species to be restricted as a breeding bird to the southeastern region of the State.

Since 1960, the population status and range of this raptor in North America have improved markedly. The black-shouldered kite has also rapidly colonized habitats throughout much of Central America south to Panama (Eisenmann 1971), regions uninhabited just a few years ago. Today the black-shouldered kite in California is a common species of open and cultivated bottomland. During 1964-78, the mean number of kites recorded per hour in California increased from 0 to 10 (Pruett-Jones et al. 1980). Warner and Rudd (1975) concluded that, in California's Sacramento Valley, the black-shouldered kite increased predominantly in irrigated agricultural areas where the California meadow mouse (*Microtus californicus*) occurred.

In south Texas, Oberholser (1971) considered this species common to scarce in Cameron and Hidalgo Counties, although records of extralimital occurrence exist for Galveston and Brazoria (San Bernard National Wildlife Refuge) Counties. The known historic range in Texas included upstream portions of the Rio Grande to near Rio Grande City, and inland areas to Lee County (Oberholser 1971). Analysis of Christmas Bird Count data provides some indication of the gradual increase in numbers of black-shouldered kites in south Texas during the period 1962-65 (Pruett-Jones et al. 1980). At present, black-shouldered kites appear to be well-established in south coastal Texas and along the upper Texas coast. Although the California population has historically been considered the largest in North America, recent data (Larson 1980) suggest that the Texas population may now be larger.

SPECIFIC HABITAT REQUIREMENTS

Because there is a paucity of information on the black-shouldered kite in Texas, much of the following analysis is based on information from California and other portions of the range where this species has been more thoroughly studied.

Suitability of habitat for the black-shouldered kite is dependent on the availability of prey and nesting sites. Characteristics of the prey species that affect their suitability are size, behavior (activity period), and population density. Habitat characteristics affecting prey availability include vegetation type, density, and height.

Food and Foraging Habitat

The black-shouldered kite is an obligate predator on diurnal small mammals (Stendell 1967, 1972). Brown and Amadon (1968) suggested that movements and nesting by this species are largely governed by concentrations of mice, usually voles. Stendell (1972) found the black-shouldered kite to be nomadic, hunting where small mammals were abundant, and leaving when the prey population decreased. Hawbecker (1940) noted a correlation between the nesting of black-shouldered kite and vole density, and suggested that a high vole population was necessary for successful nesting by kites.

During a 3-year study in California, voles (primarily *Microtus californicus*) made up 83%, 85%, and 88%, respectively, of the items in regurgitated pellets although densities per acre during the same 3 years were 25, more than 45, and less than 1, respectively (Stendell and Myers 1973). Waian (1973) concluded from pellet analysis and direct observation that black-shouldered kites in his Santa Barbara Coastal Plain study area were nearly obligate predators on *M. californicus*; *M. californicus* was the most common species captured during small-mammal trapping efforts. Oberholser (1971) postulated that the meadow mouse (*Microtus* sp.), white-footed mouse (*Peromyscus* sp.), and house mouse (*Mus musculus*) were the principal food items of the black-shouldered kite in south Texas. Brian R. Chapman (Corpus Christi State University, Corpus Christi, Texas; pers. comm.), however, has suggested that the hispid cotton rat (*Sigmodon hispidus*) supplies most of the prey base for the black-shouldered kite in south Texas. In the southern portion of its range, *S. hispidus* exhibited biomodal annual population fluctuations (Cameron and Spencer 1981). Maximum population densities occurred during autumn, but there were spring peaks (Texas $\bar{x}$ = 14/ha). Minimum densities in Texas ($\bar{x}$ = 0.5/ha) occurred in winter and summer. *Mus musculus* may fill the void created by reduced numbers of *S. hispidus*.

The hispid cotton rat occurs most frequently in grass-dominated habitats (Odum 1955; Goertz 1964; Fleharty and Mares 1973; Kaufman and Fleharty 1974). Goertz and Long (1973) reported this species in perennial grasses and forbs near pond edges. Grass height and density are important components of cotton rat habitat (Goertz 1964; Kaufman and Fleharty 1974). Cameron (1977) captured *S. hispidus* in areas of mixed grass and brush in south coastal Texas. McClenaghan and Gaines (1978) trapped this species in old fields of cultivated brome (*Bromus* sp.) in early stages of secondary succession.

The use of S. hispidus by the black-shouldered kite is further supported by Raun's (1960) report that cotton rats were the primary food of common barn-owls (Tyto alba) in Texas. R.C. Stendell (U.S. Fish and Wildlife Service, Jamestown, North Dakota; pers. comm.) stated that common barn-owls are important predators on Microtus californicus in California areas that support black-shouldered kites. Given the general characteristics of S. hispidus, plus its habitat affinities, this species probably replaces M. californicus in the Texas portion of the black-shouldered kites' range.

Across much of its extensive range, the black-shouldered kite uses habitats that are surprisingly similar in structural terms. Thurber and Serrana (1972) reported that preferred habitat in El Salvador was "open country, usually pastures, dominated by occasional small trees such as ceibas (Ceiba pentandra)." These areas were originally lowland forest. In Humboldt County, California, this species occupied a mosaic of topography including tall and short growths of rank grass, salt marsh, and pasture (Bammann 1975).

Oberholser (1971) described the preferred south Texas habitat of black-shouldered kite as "open, usually rather dry, slightly brushy savannah or agricultural country with scattered clumps of trees and a permanent water source." He stated, "thus the coastal plain in the extreme southern tip of the state with its patches of grass, tilled fields, sand dunes, palm groves, and marshes, resacas and willow-lined streams of the Rio Grande system is primary white-tailed kite [black-shouldered kite] country in the Lone Star State." Rappole and Blacklock (1985) listed the black-shouldered kite as a species associated in the Texas coastal region with mesquite savanna and prairie habitat. Some use of mesquite chaparral habitat was also noted.

The black-shouldered kite appears to be one of few raptors that have benefited by human alteration of the landscape. Thurber and Serrana (1972) concluded that among the factors contributing to the black-shouldered kite population increase in El Salvador was "the introduction of cattle adapted to the hot lowlands, mechanization of agriculture, and the temporary control of malaria. All of these made profitable the clearing and drainage of the coastal plains." The authors also stated that small rodents multiplied in the human-created habitats.

Peter L. Ames (pers. comm., cited by Eisenmann 1971) believed that black-shouldered kites in the Sacramento-San Joaquin Delta of California benefited greatly from the "fragmented agricultural pattern" and from year-round irrigation, which not only provided new habitat, but also supported a high mouse population in lush pasturage throughout the winter. Pruett-Jones et al. (1980) postulated that "this long-term increase [in kite numbers] was possible because of favorable densities of meadow mice in agricultural areas, and perhaps less severe cycling of rodent populations." R.C. Stendell (pers. comm.) also believed that human disturbances may reduce the amplitude of microtine cycles. Waian (1973) stated, however, that "modern agricultural methods render land used in these ways [lemon and avocado orchards, vegetable farming and cattle grazing] unsuitable for mouse populations of sufficient size to support kites." Presumably, this statement refers to the large scale, highly intensive, and mechanized farming characteristic of southern

California. Waian (1973) believed that kites typically inhabit marsh margins, grasslands, and oak woodlands.

Kites foraged almost exclusively over grasslands in a San Diego County, California, study; areas of willow (Salix spp.) mulefat (Baccharis viminea) and Salicornia were virtually ignored (Henry 1983). The grassland was composed primarily of low vegetation less than 0.3 m tall. The willow/mulefat thickets were 2-3 m in height and were almost impassable by foot. The Salicornia marsh was also very dense with vegetation approximately 0.3-0.6 m tall.

Bammann (1975) provided data on cover types used by black-shouldered kites for hunting in Humboldt County, California. Black-shouldered kites were observed hunting over the following vegetation types: (1) tall rank grass, (2) short rank grass, (3) rush, (4) saltmarsh, (5) short grazed pasture, and (6) tall grazed pasture. The percentage of time black-shouldered kites spent hunting in each of these habitat types is listed in Table 1.

Table 1. Amount of time black-shouldered kites hunted in six habitat types in Humboldt County, California (from Bammann 1975).

Major vegetation type	% Total vegetated area[a]	% Total time hunted by kites
Tall rank grass	1.62	72.99
Short rank grass	1.58	12.29
Saltmarsh	3.35	7.43
Rush	1.61	4.70
Tall grazed pasture	3.32	0.40
Short grazed pasture	67.27	1.79

[a]These values do not total 100.0% because five other vegetation types occurred on the study area (sand dunes, pine forest, row crops, willow thickets, and brush) but were not used by hunting kites. Thus, their area was not used in the analysis.

Tall rank grass occurred primarily along berms and in several protected or occasionally flooded fields not subjected to grazing or cultivation. Herbaceous vegetation included ryegrass (Lolium perenne), Kentucky bluegrass (Poa pratensis), orchardgrass (Dactylis glomerata), velvetgrass (Holcus lanatus), and coastal saltgrass (Distichlis spicata). Associations of these plant species grew 15 to 45 cm tall. Grass clumps and seed stalks up to 2 m in height were present.

Short rank grass included perennial ryegrass, Kentucky bluegrass, orchardgrass, velvetgrass, and several forbs. Most short rank grass on Bammann's study area had been cut for hay during the previous summer. Grasses in these fields were used infrequently for cattle pasture. The vegetation of the pastures ranged in height from 10 to 30 cm, while that along fence lines was 30 to 60 cm tall.

Rush vegetation was found in poorly drained fields and along some drainage ditches. Vegetation made up primarily of Juncus patens and J. effusus and covering over 30% of the area was considered rush habitat. Those areas <30% were classified by their physiognomic characteristics. Generally, the principal plant species in this habitat grew 30 to 60 cm in height.

Salt marshes were dominated by pickleweed (Salicornia virginica) which covered mud flats above the high tide line. This vegetation was 5 to 20 cm tall. Associated with the pickleweed was a cordgrass-saltgrass type dominated by Spartina foliosa and Distichlis spicata. Vegetation in the cordgrass-saltgrass type ranged from 15 to 50 cm in height and was dense.

Short grazed pasture was the most extensive habitat on Bammann's study area. Common plant species included Italian ryegrass (Lolium multiflorum), Kentucky bluegrass, velvetgrass, bentgrass (Agrostis tenuis), orchardgrass, rush, and plantain (Plantago lanceolata). Because of constant heavy grazing, this vegetation type was generally <15 cm in height, litter accumulation was largely absent, and the area had the appearance of a mowed lawn.

The vegetative composition of tall grazed pasture was very similar to short grazed pasture except that Juncus spp., velvetgrass, and orchardgrass were the prevalent species. In general, the vegetation grew to 40 cm in height and was considered luxuriant.

No hunting was observed over residential sites, water, farm buildings, roads, pine forest, row crops (primarily pototoes), gravel, mud, willow thickets, or brush; these habitat types made up about 8% of the study area. However, kites hunt over small grain fields in the central valley of California (R.C. Stendell, pers. comm.).

Kites spent 97.4% of their time hunting over four vegetation types--tall rank grass, short rank grass, saltmarsh, and rushes (Table 1). These habitats were used by hunting kites to a greater extent than expected on the basis of relative amount of area. The percentage of attack success within three of the habitats was similar--55.5% in rush habitat, 52.8% in short rank grass, and 50.5% in tall rank grass. Kites expended the majority of their hunting effort and captured the bulk of their prey in tall rank grass, even though prey was probably more vulnerable in other habitats. Visual estimates of prey abundance suggested that small mammal populations were greatest in tall rank grass. Bammann (1975) believed that areas of tall rank grass about 10 ha in size were sufficient to support prey populations large enough to maintain several kites during winter.

Nesting Cover

The black-shouldered kite nesting season in south Texas ranges from March to September. Nesting birds have been found in areas extending from 0 to 198 m above mean sea level (Oberholser 1971). Nesting typically occurs in wetlands and open brushlands, usually near water or along streams. The nest, a rather frail platform of sticks, leaves, weed stalks, and similar materials, is usually located in a tree or bush (Oberholser 1971). Nesting by black-shouldered kites in California has been reported for the months of February through August with a peak in activity for March, April, and May (Waian 1973). Nesting habitat was described as oak woodlands or trees along marsh edges.

In San Diego County, California, Dixon et al. (1957) reported that black-shouldered kites nest in "any suitable tree of moderate height." Dixon et al. (1957) listed pepper (*Schinus molle*), avocado (*Persea gratissima*), orange (*Citrus sinensis*), eucalyptus (*Eucalyptus masculata*), and olive (*Olea europaea*) trees among the introduced species used for nest placement. Native tree species included cottonwood (*Populus fremontii*), black willow (*Salix nigra*), live oak (*Quercus agrifolia*), sycamore (*Platanus racemosa*), and toyon (*Photinia arbutifolia*). In the Santa Barbara Coastal Plain, black-shouldered kites built nests in eucalyptus, willow (*Salix* sp.), live oak, coyote bush (*Baccharis pilularis*), Monterey pine (*Pinus radiata*), and Monterey cypress (*Cupressus macrocarpa*) (Waian 1973). R.C. Stendell (pers. comm.) stated that nest sites are not a limiting factor for the kite because they select a wide array of tree species. Stendell also reported that black-shouldered kites place their nests at the top of dense shrubs or trees, 1-18 m above ground. Hawbecker (1942) stated that any suitable tree may be used for nesting if it is near the required food source. Henry (1983) noted that nest site distribution for black-shouldered kites tends to be loosely clumped in areas where prey is locally abundant in San Diego County, California.

Water

Little information exists on the dietary water requirements of the black-shouldered kite. R.C. Stendell (pers. comm.) stated that black-shouldered kites kept in captivity were never observed to drink. The assumption can be made, however, that much of their physiological water is obtained from their prey, as is the case for most raptors. Microtine rodents require free-standing water for reproduction, and their numbers are reduced during a drought (Church 1966). In addition, rodents probably respond to fluctuations in vegetation growth as influenced by the availability of water. In California, the number of kites recorded on Christmas Bird Counts during a year with heavy rainfall was significantly greater than the number of kites recorded the previous year (Pruett-Jones et al. 1980). Pruett-Jones et al. interpreted this relationship "as indicative of a very sensitive response of the (white-tailed) kite to environmental conditions and changing rainfall patterns as they affect the kite's prey species."

Special Considerations

There is some controversy over whether the black-shouldered kite is territorial. Hawbecker (1942) reported two pairs nesting within 122 m of each other for 3 years, and only once was the male of one pair seen driving away the male of the adjacent pair. Dixon et al. (1957) reported no territorial fighting among the kites they studied, and stated this species seems to be more tolerant of conspecifics than other raptors. Waian (1973), however, found that nesting pairs exhibited territorial behavior and hunted primarily within their territories. Territory size varied from 18 to 51 ha for 5 pairs studied. Henry (1983) believed that black-shouldered kites are highly territorial throughout the nesting cycle based on extensive observations of 11 nesting pairs. Territory size was determined for 5 pairs and ranged from 53 to 120 ha. He argued that previous reports of nonexistent or weakly developed territoriality were based on insufficient qualitative observations.

Foraging habitat is not necessarily adjacent to the nest site. Henry (1983) observed one nesting pair of black-shouldered kites that defended a small (0.06 km^2) foraging area in a basin located 1.9 km from their nest at the top of a mesa.

Black-shouldered kites are reported to hunt in group associations (Stendell 1972) and to use repeatedly the same area for roosting, especially in the non-nesting season. Group hunting is believed to be associated with unusually high or peak prey populations (Waian 1973). Bammann (1975) reported that, although the night roost on his study area was not located, the flight time from roost to hunting territory was about 30 min each way. Waian (1973) believed that black-shouldered kites traveled up to 32 km from their daytime hunting territories to a night communal roost during the winter on his study site near Santa Barbara. Birds rarely remained at nesting territories year round.

HABITAT SUITABILITY INDEX (HSI) MODEL

Model Applicability

The black-shouldered kite HSI model was developed from information on habitat use in California. Because little information exists on habitat use in Texas, the model must be used with caution in the Texas coastal prairies and pasturelands and the Rio Grande Delta region. The model was developed to evaluate the potential quality of black-shouldered kite habitat throughout the year. It is applicable in grassland, savanna, and emergent wetland habitats.

Minimum habitat area. Minimum habitat area is defined as the minimum amount of contiguous habitat required for an area to be occupied by a particular species. No specific data on minimum area requirements for the black-shouldered kite could be found in the literature. Henry (1983) and Waian (1973), however, did provide some data on home range (see Special Considerations). Based on their studies, it is recommended that this model only be applied to study areas larger than 20 ha.

Verification level. The model was reviewed by Rey C. Stendell, U.S. Fish and Wildlife Service (FWS), Northern Prairie Wildlife Research Center, Jamestown, North Dakota, and by Brian R. Chapman, Corpus Christi State University, Texas. Although reviewers' comments have been incorporated where possible, the authors are responsible for the final version of the model. The model has not been field-tested.

Model Description

Although black-shouldered kites appear to benefit from agricultural practices and associated increases in rodent populations, this model was developed for evaluating nonagricultural habitat (i.e., grasslands and wetlands) quality. It is not designed for application in agricultural habitats.

Little quantitative research has been done on habitat requirements of black-shouldered kites. The HSI model is based on information on habitat use by hunting black-shouldered kites provided by Bammann (1975). It considers the percentage of the study area that is composed of the four cover types hunted most frequently by kites in Bammann's (1975) California study: tall rank grass, short rank grass, rush, and salt marsh. Nesting cover is not included in the model. Because black-shouldered kites will nest in a variety of tree species at various heights from the ground, the model assumes that suitable nesting sites will be available.

Suitability Index (SI) Values for Model Variables

Suitability indices were assigned to each of the four cover types in the model based on preferential use of the cover types by hunting black-shouldered kites (Table 2). Preference was determined by comparing Bammann's (1975) information on the availability (percentage of total vegetated area) of the cover type and the percentage of time the cover type was hunted over. Descriptions of the cover types are provided in the Specific Habitat Requirements section.

Table 2. Suitability indices for cover types in the black-shouldered kite habitat suitability index model.

Cover type	Suitability index
Tall grasslands	1.0
Short grasslands(cut for hay the previous year)	0.5
Rush	0.3
Saltmarsh	0.25

HSI Determination

The presence of water must be considered before determining the HSI value for a site. As noted previously in this report, prey species of the black-shouldered kite are dependent on permanent sources of water. If such a source (e.g., wetlands, streams, or drainage ditches) is present, the model may be applied to the site. The following equation is used to determine the habitat suitability index value for black-shouldered kite habitat. (Note that percentage values should be expressed as decimals for use in the equation [e.g., 50% = 0.50]).

$$HSI = 1.0\ (A_1) + 0.5\ (A_2) + 0.3\ (A_3) + 0.25\ (A_4) \qquad (1)$$

where A_1 = percentage of study area that is tall grasslands,
A_2 = percentage of study area that is short grasslands,
A_3 = percentage of study area that is rush, and
A_4 = percentage of study area that is salt marsh.

Hypothetical data sets presented in Table 3 illustrate the determination of HSI values for black-shouldered kite habitat using Equation 1. The data sets were selected to represent high, moderate, and low quality habitats.

Table 3. Suitability indices (SI) and habitat suitability indices (HSI) for 3 hypothetical data sets.

	Data set 1		Data set 2		Data set 3	
Cover type	Percentage composition	SI	Percentage composition	SI	Percentage composition	SI
Tall grasslands	90%	1.00	25%	1.00	0%	1.00
Short grasslands	0%	0.50	25%	0.50	25%	0.50
Rush	10%	0.30	40%	0.30	0%	0.30
Saltmarsh	0%	0.25	10%	0.25	75%	0.25
HSI	0.93		0.52		0.31	

Field Use of Model

The black-shouldered kite HSI model is developed for evaluating nonagricultural habitat value only and should not be applied in agricultural areas. The study area for black-shouldered kites should consist of only grassland, savanna, and emergent wetland cover types. Composition of cover types within the study area can be determined by line transect sampling (Hays et al. 1981), from available cover maps, or from aerial photographs.

The model includes the major assumption that nesting and roosting sites for black-shouldered kites will be available and, therefore, do not need to be measured as a model variable. This assumption was made based on the following facts:

1. Several literature references indicate that this kite will nest in any species of tree or shrub that is of moderate height.
2. Nesting black-shouldered kites have been noted to fly 1.9 km from a nest tree to a foraging area (Henry 1983).
3. During the winter, communal night roosts may be as far as 32 km from daytime foraging territories (Waian 1973).

The user should evaluate the validity of the assumption for each field application. The model should not be applied if it appears that trees or shrubs for nesting and roosting are absent in the study area or within a 2 km distance. Similarly, if a development project has a significant impact on woody vegetation in an area where such vegetation is scarce and widely scattered, the project may eliminate black-shouldered kite use of the area.

Interpreting Model Outputs

The HSI value obtained by applying the black-shouldered kite model may have no relationship to the actual population level on a study area. Kite numbers may be regulated by nonhabitat factors (e.g., competition, disease) excluded from the HSI model. The model is useful in comparing the relative potential of two sites, or of a single site at two points in time, to support black-shouldered kites.

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16. Abstract (Limit: 200 words)

A review and synthesis of existing information were used to develop a model for evaluating black-shouldered kite habitat quality. The model is scaled to produce an index between 0 (unsuitable habitat) and 1.0 (optimal habitat). Habitat suitability index models are designed for use with the Habitat Evaluation Procedures previously developed by the U.S. Fish and Wildlife Service. Guidelines for model application are provided.

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