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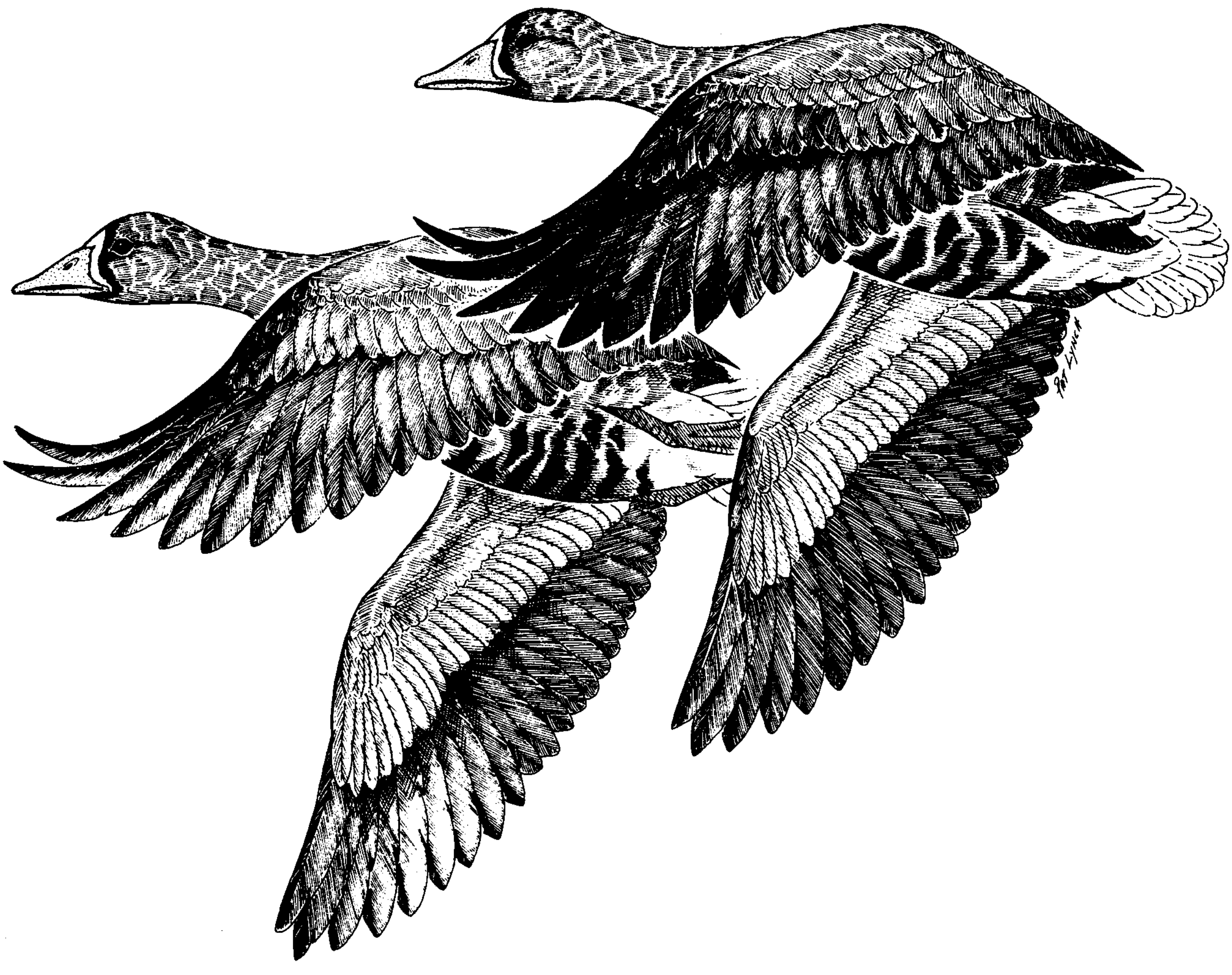
HABITAT SUITABILITY INDEX MODELS: GREATER WHITE-FRONTED GOOSE (WINTERING)



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HABITAT SUITABILITY INDEX MODELS:

GREATER WHITE-FRONTED GOOSE (WINTERING)

by

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PREFACE

The habitat suitability index (HSI) models for wintering white-fronted geese are intended for use in impact assessment and management of winter habitat. The models were developed from a review and synthesis of existing information and are scaled to produce indices of habitat suitability between 0 (unsuitable habitat) and 1 (optimal habitat) (U.S. Fish and Wildlife Service 1981). Assumptions used in developing the HSI models and guidelines for using models are described.

These models are hypotheses of species-habitat relations, not statements of proven cause and effect. The models have not been field-tested. The U.S. Fish and Wildlife Service (FWS) 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 comments or suggestions to the following address:

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GREATER WHITE-FRONTED GOOSE (*Anser albinfrons*)

INTRODUCTION

The white-fronted goose species is composed of four subspecies: (1) the Greenland white-fronted goose (*A. a. flavirostris*), (2) the Eurasian white-fronted goose (*A. a. albifrons*), (3) the Pacific white-fronted goose (*A. a. frontalis*), and (4) the tule goose (*A. a. gambelli*) (Dzubin et al. 1964; Palmer 1976; Ogilvie 1978). Pacific white-fronted geese and tule geese are indigenous to North America. Although Palmer (1976) and Ogilvie (1978) questioned the existence of tule geese, Krogman (1979) and Timm et al. (1982) presented geographical and/or morphological evidence substantiating existence of the subspecies.

The white-fronted goose ranks third in relative abundance among species of North American geese. Two populations of white-fronted geese are recognized in North America: the Pacific Flyway and the Mid-Continent populations. The Pacific Flyway and Mid-Continent populations number about 100,000 and 150,000 birds, respectively (Hobaugh 1982). Wege (1984) noted that about 50,000 white-fronted geese are harvested annually in the Pacific Flyway.

The primary breeding grounds of the Pacific Flyway population are the Yukon-Kuskokwim Delta and Bristol Bay regions of western Alaska (Bellrose 1976; Ogilvie 1978). Timm and Dau (1979) estimated that >90% of the Pacific Flyway population nests in these two regions. The Pacific Flyway population has declined >85% since 1967 while the Mid-Continent population has increased nearly 380% over the past 15 years (Raveling 1984).

Pacific Flyway birds migrate from their Alaskan breeding grounds across the Gulf of Alaska to near the mouth of the Columbia River between Washington and Oregon (Bellrose 1976; Palmer 1976; Ogilvie 1978). From there, white-fronted geese migrate overland to the Klamath Basin in northern California. Subsequently, most birds (ca. 136,000) move to their principal wintering grounds in the Central Valley of California, but some individuals (ca. 10,000) continue southward to the Imperial Valley of California and the western coast of Mexico (Bellrose 1976).

The primary breeding range of the Mid-Continent population extends from interior Alaska to the central Canadian Arctic (Bellrose 1976; Palmer 1976; Ogilvie 1978). Miller et al. (1968) suggested that this population comprises the following subpopulations: (1) a western component that nests in Alaska and the western Canadian Arctic, and (2) an eastern component that nests in the central Canadian Arctic. The western subpopulation migrates from its breeding grounds to staging areas in southeastern Alberta and southwestern

Saskatchewan near Kindersley, Saskatchewan (Miller et al. 1968). The birds then advance through Saskatchewan and the eastern Great Plains of the United States to the coastal marshes and inland prairies of western Louisiana, eastern Texas, and east-central Mexico. The eastern subpopulation departs its breeding grounds and stages in the Saskatchewan River Delta in east-central Saskatchewan, west-central and southwestern Manitoba, and the Dakotas before migrating to its principal wintering grounds in western Louisiana (Bellrose 1976).

For the period 1955-72, Bellrose (1976) reported that an average of approximately 75,000 white-fronted geese wintered throughout Louisiana, Texas, and Mexico with most birds (ca. 85%) occurring in Louisiana and Texas. Mid-winter inventories revealed that an average of approximately 71,000 white-fronted geese of the Mid-Continent population wintered annually in the United States between 1959 and 1979 (Leslie 1983).

Historically, most white-fronted geese wintered on the gulf coast marshes and adjacent prairies of the Outer Coastal Plain (as defined by Bailey 1978) in western Louisiana and the Prairie Parkland (as defined by Bailey 1978) in eastern Texas (Hobaugh 1982; Leslie 1983). Several authors (Bellrose 1976; Ogilvie 1978; Hobaugh 1982; Leslie 1983; Leslie and Chabreck 1984) reported a marked shift by the birds to inland habitats in response to development of intensive farming of rice (Oryza sativa) and soybeans (Glycine max) in these regions.

Differential use of agricultural lands by white-fronted geese of the Mid-Continent population was investigated by Hobaugh (1982) in Texas and Leslie (1983) and Leslie and Chabreck (1984) in Louisiana. Wege (1984) described the distribution and abundance of tule geese wintering in southern Oregon and California, and Raveling (1984) documented current population statuses of Pacific Flyway and Mid-Continent white-fronted geese. However, I am unaware of any study that has investigated habitat use by wintering white-fronted geese of the Pacific Flyway population. I am also unaware of any study on use of natural wetlands in North America by wintering white-fronted geese.

SPECIFIC HABITAT REQUIREMENTS

General Habitat Associations

Several authors have provided general information on habitat use by wintering white-fronted geese. Palmer (1976) reported that white-fronted geese use areas of extensive shallow water, croplands, pastures, open terrain with numerous ponds, and inland and coastal marshes. Ogilvie (1978) rated arable farmland and pastureland as primary wintering habitat for white-fronted geese and freshwater marshes as secondary habitats. Timm et al. (1982) stated that tule geese forage, roost, and rest in harvested rice fields but use emergent wetlands primarily for roosting and resting.

Food and Foraging Habitat

Available literature on food habits of wintering white-fronted geese is based on examinations of gizzard contents. Gizzard contents, however, do not accurately reflect the total composition of foods eaten by waterfowl because of bias towards less digestible foods (Swanson and Bartonek 1970). Nevertheless, the available literature on foods of wintering white-fronted geese was reviewed to provide an indication of the species' food habits.

In southeastern Texas, Glazener (1946) examined gizzard contents of 22 geese, some of which were white-fronted geese, and reported that domestic rice constituted 96% of the foods eaten. Martin et al. (1951) also found that rice occurred more frequently in the gizzards of white-fronted geese than did barnyardgrass (Echinochloa crusgalli) and sixrow barley (Hordeum vulgare).

McFarland and George (1966) tested the grain preferences of 12 captive adult geese, two of which were white-fronted geese, and reported that the group as a whole preferred rice 2:1 over barnyardgrass. Furthermore, they reported that barnyardgrass was preferred 5-6:1 over common sorghum (Sorghum vulgare), saltmarsh bulrush (Scirpus robutus), and safflower (Carthamus tinctorius), 9:1 over sixrow barley, and 12:1 over woollypod vetch (Vicia dasycarpa). McFarland and George (1966) also examined hunter-killed white-fronted geese in the Sacramento Valley of California and reported that the consumption of rice was 7 times greater than that of barnyardgrass, yet barnyardgrass was eaten nearly 2 times more than sorghum and sorghum 10 times more than sixrow barley.

White-fronted geese use shallow inland and coastal wetlands and open terrain containing numerous ponds (Palmer 1976). White-fronted geese feed on leaves, stems, seeds, or rhizomes of cattail (Typha spp.), spike rush (Eleocharis spp.), cordgrass (Spartina spp.), horsetail (Equisetum spp.), and bulrush (Scirpus spp.) (Ogilvie 1978). White-fronted geese also feed on forbs and grasses such as white clover (Trifolium repens), creeping buttercup (Ranunculus repens), common dandelion (Taraxacum officinale) (Owen 1976), barnyardgrass (Martin et al. 1951; McFarland and George 1966), barley (Hordeum secalinum) (Owen 1971, 1976), perennial ryegrass (Lolium perenne) (Owen 1971, 1976), bulbous foxtail (Alopecurus bulbosus) (Owen 1971, 1976), carpet bentgrass (Agrostis stolonifera) (Owen 1971, 1976), and perhaps Panicum spp. and Paspalum spp. as do snow geese (Chen caerulescens) (Hobaugh 1982).

Ogilvie (1978) ranked cereal grains, grass, and marsh plants as primary foods of wintering white-fronted geese but deemed seeds, roots, and tubers as secondary foods. Palmer (1976) and Ogilvie (1978) generalized the food habits of white-fronted geese wintering in California and Texas, indicating that the species feeds on waste grain (e.g., rice, barley), grasses, sprouting grain, and rhizomes of saltmarsh bulrush.

Esophageal contents of wintering white-fronted geese have not been documented. However, Hobaugh (1982) quantified the esophageal contents of lesser snow geese wintering in the rice-prairie region of southeastern Texas. Inasmuch as white-fronted geese and snow geese winter together in this region, their food habits may be similar. Esophageal contents of snow geese collected in October and November were almost exclusively rice kernels, whereas food items from January-March were predominantly new vegetation. Commonly ingested vegetation included barnyardgrass, spike rush, dock (Rumex spp.), flatsedge (Cyperus spp.), ryegrass, and other grasses (e.g., Panicum spp., Paspalum spp.).

Hobaugh (1982) researched diurnal habitat use by white-fronted geese in relation to availability of different upland habitats in southeast Texas. He showed that harvested rice fields were most preferred (i.e., use greater than availability) by wintering white-fronted geese. Nearly 54% of all white-fronted geese were seen in rice-stubble fields that covered only 14% of the study area. Geese used rice fields almost exclusively from early fall until late November. Furthermore, rice fields were the only habitat in which large numbers of white-fronted geese were consistently observed throughout the period between October and March.

Hobaugh (1982) also reported that soybean fields were preferred by white-fronted geese. Greatest use of soybean fields occurred between late November and December. Hobaugh (1982) did not observe white-fronted geese in cultivated (i.e., plowed) fields until mid-late December when sprouting plants became available. By early January, white-fronted geese foraged on sprouting vegetation in cultivated fields, rice fields, or native or planted pastures because the rice resource was nearly depleted through consumption by geese and deterioration.

Hobaugh (1982, 1984) concluded that the rice-prairie region of southeastern Texas provides important wintering habitat for thousands of geese annually. Agricultural practices in this region provide important food resources for geese. Moreover, the temporary water that naturally collects in agricultural fields or which is artificially applied to attract geese for hunting provides drinking water and roost-rest wetlands.

Leslie (1983) and Leslie and Chabreck (1984) reported that white-fronted geese wintering in southwestern Louisiana used flooded rice fields more frequently than other available habitats. White-fronted geese also preferred cultivated fields and harvested soybean fields periodically. They used planted pastures in proportion to their availability but avoided unflooded rice fields and fallow fields.

Leslie (1983) and Leslie and Chabreck (1984) reported that white-fronted geese did not use or used only minimally (<2% of all white-fronted goose flocks) several agricultural and natural habitat types. These habitats included unharvested soybean land, unharvested riceland, native pastureland, timberland, residential land, and other habitats (e.g., dredge spoil deposits, common sorghum, ridges, and shrubland).

Cover

Use of natural wetlands by white-fronted geese is generally restricted to freshwater habitats (Ogilvie 1978). Leslie and Chabreck (1984) reported that white-fronted geese used marsh habitat within the Lacassine National Wildlife Refuge in Louisiana. However, they did not include this habitat type in their analysis of goose-habitat associations, because the birds were difficult to observe in marshland. They reported that geese used marshland mainly for resting or roosting between field-feeding forays and as escape cover during periods of disturbance. Ogilvie (1978) reported that rather tall and robust emergent vegetation (e.g., *Scirpus* spp., *Typha* spp.) provides shelter and cover for white-fronted geese and other goose species in addition to providing food.

Leslie and Chabreck (1984) believed that preferred agricultural habitats provided nutritious foods (e.g., waste grain and new plant growth) and their openness afforded good visibility for wintering white-fronted geese. Therefore, in addition to providing foraging habitat, certain agricultural habitats may provide roost, rest, and escape covers for wintering white-fronted geese.

HABITAT SUITABILITY INDEX (HSI) MODELS

Model Applicability

Geographic area and season. The models described herein can be applied to the subtropical Outer Coastal Plain Forest ecoregion (Bailey 1978) of southwestern Louisiana and the subtropical Mixed Forest and Prairie-Parkland ecoregion (Bailey 1978) of southeastern Texas. Because of recent range expansion by white-fronted geese into northeastern and central Louisiana and southern Arkansas (Leslie 1983), the model for agricultural lands also may apply there. White-fronted geese occur on winter grounds in Louisiana and Texas from late September through late March (Bellrose 1976); hence, the models apply to this period.

Cover types. The model for agricultural lands applies to the following cover types: (1) harvested rice fields, (2) cultivated (plowed) lands, (3) harvested soybean lands, (4) winter pasture, and (5) fallow fields or rangeland. The natural wetlands model applies to freshwater (i.e., salinity <0.5 ppt) aquatic beds and emergent wetlands of the palustrine wetland system (Cowardin et al. 1979).

Verification level. A preliminary draft of this publication was reviewed by R. H. Chabreck, Louisiana State University, Baton Rouge; W. C. Hobaugh, Columbus, Texas; and several FWS biologists. Their suggestions were incorporated when possible. The author is responsible for the final version of the models. The models are hypotheses of white-fronted goose-habitat relationships and have not been field-tested.

Model Descriptions

Overview. Two HSI models for wintering white-fronted geese are described: a model for agricultural lands and a model for natural wetlands. The agricultural model is based on results presented by Leslie (1983), Leslie and Chabreck (1984), and Hobaugh (1982). The natural wetlands model is based on general information about wintering white-fronted geese obtained from the literature. The models are designed to produce indices of habitat suitability ranging between 0 and 1.0. A value of zero is assumed to represent unsuitable habitat for wintering white-fronted geese, whereas a value of 1.0 is assumed to represent optimal habitat.

Agricultural model. The model consists of two life requisite components: food and cover. White-fronted geese feed on waste grain and natural or planted vegetation in agricultural lands, such as harvested rice and soybean fields, cultivated fields, and winter pasture lands (e.g., rye, wheat, and oats). The value of these lands for foraging geese changes during the wintering period relative to food availability, food quality, and other factors. For example, cultivated fields are a major habitat used by white-fronted geese in late winter when newly sprouted grasses and forbs provide food following the reduced availability of waste rice and soybeans (Hobaugh 1982; Leslie and Chabreck 1984). Despite temporal variation in the value of different agricultural lands as feeding habitats for wintering white-fronted geese, this variation is not quantified in the model. The model indexes the potential suitability of agricultural lands for an entire wintering season based on the frequency at which Leslie and Chabreck (1984) reported different agricultural lands to be preferred, avoided, or neutrally used by white-fronted geese during two consecutive wintering seasons.

White-fronted geese can rest and roost in agricultural lands; therefore, the species' cover requirements could be satisfied in agricultural habitats. These habitats generally afford good visibility since residual and growing vegetation is usually short. Drinking water and grit are assumed to be available within the agricultural fields or elsewhere within the birds' home range. Furthermore, alternate habitats are assumed to be available to geese when disturbance causes emigration from currently used habitats.

The following agricultural lands are ranked in decreasing order of preference by wintering white-fronted geese: (1) harvested rice fields, (2) cultivated (plowed) fields, (3) harvested soybean fields, (4) winter pasture lands (e.g., ryegrass, winter wheat, oats), and (5) fallow fields or rangeland (Table 1). Ranks relate to the frequency that Leslie and Chabreck (1984) reported these agricultural habitats to be either preferred, avoided, or neutrally used by white-fronted geese over two consecutive winters. Leslie and Chabreck (1984) reported that white-fronted geese preferred flooded over unflooded rice fields; however, the relative suitability of rice fields for wintering white-fronted geese can change with the occurrence, depth, area, and duration of flooding (R. H. Chabreck, W. C. Hobaugh; pers. comm.). Because unflooded, harvested fields have the potential of becoming preferred areas for white-fronted geese when flooded, only the frequency of Leslie and Chabreck's (1984) preference rating for the habitat category "cut rice, wet" was used in determining the preference rank for harvested rice fields.

Preference, avoidance, and neutral use of agricultural habitats were numerically denoted by +1, -1, and 0, respectively. An aggregate score was computed for each agricultural habitat by multiplying each habitat's frequency of preference, avoidance, and neutral use by the respective numerical denotation and then summing the products (Table 1). Harvested soybean lands and winter pasture each had aggregate scores of 0; hence, both received the same preference rank. The preference ranks in Table 1 form the basis for calculation of the HSI value for agricultural lands (see HSI Determination).

Table 1. The frequency that different agricultural habitats were preferred, avoided, or neutrally used by wintering white-fronted geese over the 1981-82 and 1982-83 wintering seasons in southwestern Louisiana (Leslie 1983; Leslie and Chabreck 1984). Habitats are ranked from most (rank 4) to least (rank 1) preferred.

Habitat type	Frequency			Aggregate score	Preference rank
	Preferred	Avoided	Neutral		
Harvested rice	4	0	2	+4	4
Cultivated (plowed)	3	1	2	+2	3
Harvested soybean	1	1	4	0	2
Winter pasture	0	0	6	0	2
Fallow or rangeland	0	4	2	-4	1

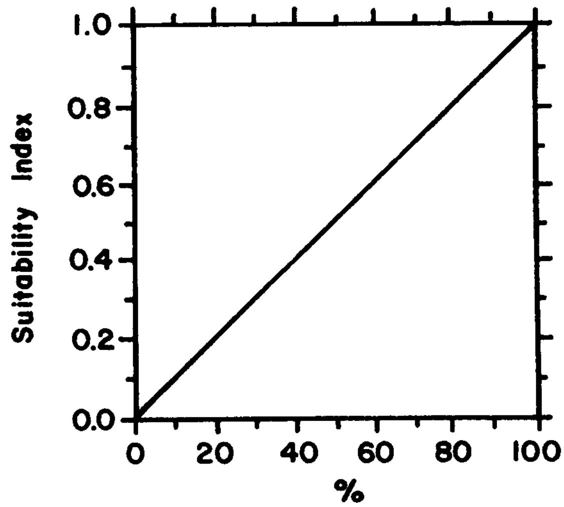
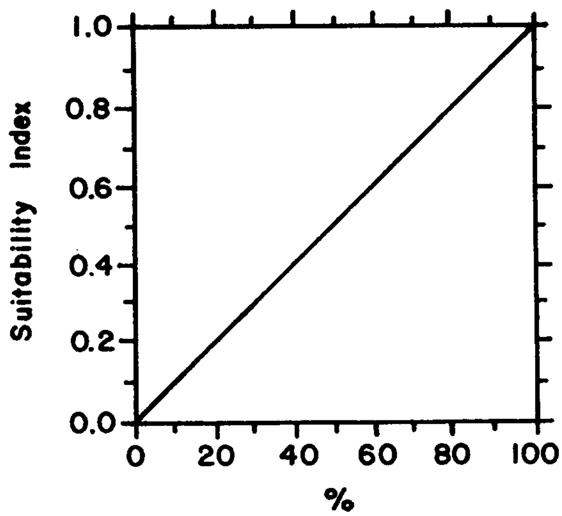
To investigate whether relative preferences of white-fronted geese for comparable agricultural habitats were similar between southwestern Louisiana and southeastern Texas, the preference ranks in Table 1 were compared with Hobaugh's (1982) white-fronted goose habitat use index values (i.e., use index = % use/% area) for comparable agricultural habitats in Texas. Hobaugh (1982) calculated habitat use index values for the following agricultural habitats: (1) rice stubble, (2) soybean field, (3) plowed ground, (4) fallow field or rangeland, and (5) improved pasture (ryegrass or oats). The preference ranks developed from Leslie and Chabreck's (1984) data and Hobaugh's (1982) habitat use index values (averaged for winters 1978-79 and 1979-80) were correlated ($r = 0.75$, $P = 0.07$, $N = 5$) for the five comparable agricultural habitat types, suggesting that white-fronted geese wintering in Louisiana and Texas exhibit similar levels of preference for these habitat types.

Wetlands model. The model consists of two life requisite components, food and cover, both of which can be available simultaneously within a study area. Thus, white-fronted geese can feed, rest, and roost within aquatic bed and/or emergent wetland portions of a study area. Although white-fronted geese apparently forage more efficiently in areas where vegetation is relatively short (Ogilvie 1978), white-fronted geese do forage within and otherwise use natural wetlands covered by relatively tall emergents (i.e., > 1 m). Because white-fronted geese use emergent wetlands containing vegetation of varying species composition, height, and density, these characteristics are not considered in the model. Drinking water and grit are assumed to be available within the birds' home range. Alternate habitats also are assumed to be available to geese when disturbance causes emigration from currently used habitats.

The model is composed of the following variables: (1) the percentage of the study area covered by shallow ($\leq$ m in depth) freshwater aquatic bed and/or emergent wetland habitat, and (2) the percentage of vegetative cover that is known food of the white-fronted goose. The relative suitability of a study area for white-fronted geese is assumed to increase with increasing percentages of both variables.

Suitability Index (SI) Graphs for Model Variables

This section provides suitability index graphs that quantify the relationship between the assumed suitability of natural wetlands for wintering white-fronted geese and both habitat variables. The SI values for Variables 1 and 2 (V_1 and V_2) are obtained directly from their respective graphs (1.0 = optimal habitat; 0 = unsuitable habitat). Because SI values for the agricultural habitat model are calculated and not obtained from SI graphs, no graphs for the agricultural model are presented.

Habitat	Variable		Suitability Graph
Palustrine aquatic bed and/or emergent wetland	V_1	Percentage of study area covered by water $\leq$ 1 m in depth and/or emergent vegetation.	
Palustrine aquatic bed and/or emergent wetland	V_2	Percentage of vegetative cover that is known food of white-fronted geese.	

HSI Determination

Agricultural model. Because food and cover life requisites can be available to wintering white-fronted geese simultaneously within these agricultural habitats, separate equations for calculation of component index values for food and cover are not required. The overall suitability of a study area is assumed to increase with increasing area of agricultural lands preferred by wintering white-fronted geese. Therefore, the proportional cover of the different agricultural habitats within a study area is incorporated into the calculation of HSI.

The following steps and calculations are necessary for determination of the HSI value:

1. Quantify the proportional cover (if any) of the five agricultural habitats in Table 1 for the study area. If none of the five habitats occur, HSI = 0 for the agricultural study area.
2. Multiply each proportion by its corresponding preference rank in Table 1.
3. Divide products of the multiplication(s) by 4 (the highest preference rank) to calculate separate SI values for each agricultural habitat. SI values can range from 0 to 1.0.
4. Sum the SI values to calculate the cumulative HSI value for the study area.

Three hypothetical data sets presented in Table 2 illustrate computation of SI and the HSI values. The data sets exemplify agricultural lands with supposedly high (0.92), intermediate (0.56), and low (0.29) HSI values.

Table 2. Suitability indices (SI) and habitat suitability indices (HSI) for 3 hypothetical data sets using computation procedures for SI and HSI.

	Data set 1		Data set 2		Data set 3	
Habitat type	Habitat availability (%)	SI	Habitat availability (%)	SI	Habitat availability (%)	SI
Harvested rice	73	0.73	6	0.06	0	0
Cultivated (plowed)	18	0.14	16	0.12	2	0.02
Harvested soybean	5	0.03	41	0.21	0	0
Winter pasture	4	0.02	30	0.15	10	0.05
Fallow or rangeland	0	0	7	0.02	88	0.22
Total	100	0.92	100	0.56	100	0.29
HSI	0.92		0.56		0.29	

Wetlands model. An arithmetic mean was selected for calculation of the HSI value rather than a geometric mean, which would entail multiplying values of habitat variables together, to prevent a study area from potentially receiving an HSI value of zero if one habitat variable happened to be absent. The following steps and calculations are necessary for determination of the HSI value:

1. Determine the values of V_1 and V_2.
2. Obtain the corresponding SI value for V_1 and V_2 from the suitability index graphs in the previous section.
3. Sum the SI values and divide by 2 to calculate the HSI for the wetland area.

Three hypothetical data sets presented in Table 3 illustrate quantification of SI and HSI values. Study areas 1, 2, and 3 exemplify habitats with presumably high (HSI = 0.9), intermediate (HSI = 0.5), and low (HSI = 0.1) suitabilities for wintering white-fronted geese.

Table 3. Suitability indices (SI) and the habitat suitability indices (HSI) for sample data sets using the habitat variables (V_n) and model calculation procedures.

Model component	Data set 1		Data set 2		Data set 3	
	Data	SI	Data	SI	Data	SI
V_1	100%	1.0	50%	0.5	20%	0.2
V_2	80%	0.8	50%	0.5	0%	0.0
HSI	0.9		0.5		0.1	

Field Use of Models

Suggested methods for quantification of habitat coverages and variables are presented for the agricultural and wetlands models in Table 4. If a study area contains agricultural and natural wetland habitat, an overall HSI value for the study area may be computed by averaging separate HSI values produced by use of each model. Production of higher HSI values from use of the agricultural model than from the natural wetlands model should not be considered justification for conversion of natural wetland habitat to agricultural land. The potential suitability of a study area may change within a wintering season as habitat changes occur (e.g., a harvested grain field may become a cultivated field). If the type and extent of habitat change(s) can be predicted beforehand, the habitat type with longest expected presence during a wintering season should be used in calculation of HSI values.

Interpreting Model Outputs

The models described herein have not been field-tested and many nonhabitat factors excluded from the models (e.g., predation, competition, demography, weather, disturbance, etc.) can influence population abundance. Thus, these models may not produce precise predictions of abundance of wintering

Table 4. Suggested methods for quantifying habitat coverages and variables used in the white-fronted goose models.

Model	Habitat or variable (V_n)	Method
Agricultural	Agricultural habitats in Table 1	Determine approximate coverages of different agricultural fields through aerial and/or ground reconnaissance following crop harvest. Crop coverages may also be determined from aerial photography available from local or regional offices of the Agricultural Stabilization and Conservation Service. Dialogue with farm operators may be helpful to quantify areas that will become cultivated, flooded, or planted during winter. Determine area (using planimetry or a dot grid) and calculate proportional coverages of existing or planned agricultural fields.
Wetlands	V_1	Use adequate bathymetric maps to determine the area within the 1-m depth contour that is composed of freshwater. If adequate bathymetric maps are lacking, depth sounding along systematically or randomly placed transects will be necessary. Salinity may be measured using a refractometer or calculated from the equation in Reid (1961:203) after determining chloride ion content using a Hach kit. Coverage of emergent wetland may be discerned from aerial photography and/or ground reconnaissance. Approximate coverages of aquatic bed and/or emergent wetland habitat can be quantified using planimetry or a dot grid.
	V_2	Plant species composition and coverage of dominant plant species may be discernable from available aerial photography, but ground reconnaissance along transects during the growing season probably will be required to accurately quantify coverage of potential food plants.

white-fronted geese. HSI values obtained from these models are intended to index an area's potential to provide wintering habitat for white-fronted geese. HSI values are used for comparing the potential suitability of different areas for wintering white-fronted geese and/or comparing the potential suitability of one or more areas over time. These models should be field-tested to validate their utility for predicting habitat use by wintering white-fronted geese.

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A review and synthesis of available information were used to develop models for indexing the potential suitability of agricultural and natural wetland habitats for wintering white-fronted geese (Anser albifrons). The model is scaled to produce indices of habitat suitability from 0 (unsuitable habitat) to 1.0 (optimal habitat) primarily for wintering habitat in southwest Louisiana and southwest Texas. Habitat suitability indices are designed for use with Habitat Evaluations Procedures previously developed by the U.S. Fish and Wildlife Service

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