Exhibit A: Habitat Evaluation Procedures models for target species selected for Columbia River Channel Improvement Study

HABITAT SUITABILITY INDEX MODEL: POND BREEDING AMPHIBIAN AND COVER MODEL

WDFW COLUMBIA RIVER CHANNEL DEEPENING PROJECT
HEP DRAFT MODEL, November 1997
ARMY CORPS OF ENGINEERS

This model addresses the habitat needs of selected amphibians occurring in standing water in riparian, agriculture and wetland habitats. In this particular model, the value of the standing water habitat is more important than surrounding habitat and is therefore weighted higher for native pond breeding amphibians. The focus of the model is on the following species:

Northwestern salamander (*Ambystoma gracile*)
Long-toed salamander (*Ambystoma macrodactylum*)
Roughskin newt (*Taricha granulosa*)
Red-legged frog (*Rana aurora*)
Pacific treefrog (*Hyla regilla*)
Oregon Spotted frog (*Rana pretiosa*)
Western toad (*Bufo boreas*)

HABITAT USE INFORMATION

Distribution/Elevation

<u>**Frogs and Toads**</u>
The **red-legged frog** (*Rana aurora)* is a common native ranid found west of the Cascade Mountains from southwestern British Columbia to northern California (Gordon 1939; Slater 1964; Dumas 1966; Nussbaum 1983; Stebbins 1985). This species ranges from sea level to 4680 ft (1427 m) in the Umpqua National Forest (Oregon) (Leonard et al. 1993). The **Pacific treefrog** (*Hyla regilla*) is the most widely distributed frog in Washington and Oregon and may be found at elevations ranging from near sea level to at least 5200 ft (1585 m) (Leonard et al. 1993). The **Western Toad** (*Bufo boreas*) can be found in all natural regions of Washington and Oregon with the exception of arid portions of the Columbia Basin, northern Coast Range in Oregon, and the Willamette Valley. They are known from near sea level to 7370 ft (2247 m) (Leonard et al. 1993). The **Oregon spotted frog** (*Rana pretiosa*) is currently found in southwest British Columbia, western Washington, and the Cascade Mountains of Washington and Oregon. Historically they were found in portions of the Puget Sound Lowlands and the Willamette Valley, and they appear to have been eliminated from most of this area (Leonard et al. 1993). They can be found at elevations ranging from near sea level to 4,900 ft (1500 m) (Hayes 1997).

Salamanders

The **northwestern salamander** (*Ambystoma gracile*) occurs along the Pacific coast from western British Columbia to northwestern California. In Washington and Oregon they are found from the coast to just over the Cascade crest (Leonard et al. 1993). They occur from sea level up to about 10,230 ft (3,100 m) elevation in humid coniferous forests and subalpine forests (Nussbaum et al. 1983). The **long-toed salamander** (*Ambystoma macrodactylum*) is distributed from southeast Alaska, British Columbia and western Alberta, through western Montana, Idaho, Washington, and Oregon into northern California (Leonard et al. 1993). They have the broadest distribution of any salamander in Washington and Oregon and occur in semiarid sagebrush deserts, dry woodlands, humid forests, alpine meadows, and all kinds of intermediate habitats (Nussbaum et al. 1983). They occur from sea level to 6190 ft (2030 m) (Leonard et al. 1993). The **roughskin newt** (*Taricha granulosa*) occurs primarily west of the Cascade Mountains from southeast Alaska through western British Columbia, Washington, and Oregon into northern California (Leonard et al. 1993). Habitats include: humid coastal forests and open grasslands within or near streams, lakes, ponds, and reservoirs (Stebbins 1954). They range from sea level up to 9240 ft (2800 m) (Nussbaum et al. 1983).

Food

Adult red-legged frogs prey on a variety of terrestrial invertebrates. Prey items include beetles (Coleoptera), caterpillars (Lepidoptera), sowbugs (Isopoda) (Stebbins 1972), earthworms (Annelida), and slugs (Gastropoda) (Lardie 1969). Tadpoles probably feed on decomposed plant and animal material, green algae, and bacteria (Morris and Tanner 1969). Adult red-legged frogs are primarily sit-and-wait predators. They forage in damp, well-shaded areas (Storm 1960). Dense shoreline vegetation is used during the breeding season; foraging areas during the non-breeding season include downed logs, ferns, and blackberry *(Rubus* sp.*)* thickets (Dunlap 1955; Porter 1961).

Insects are the main food of the Pacific treefrog. Beetles (Coleoptera) and flies (Diptera) composed 53% of the winter diet of this species in northern California (Johnson and Bury 1965). During the breeding season, adult treefrogs forage primarily above water (Carl 1943; Brattstrom and Warren 1955).

Oregon spotted frogs are opportunistic feeders, and may forage to some extent under water (Nussbaum et al. 1983). Adult spotted frogs feed primarily on invertebrates, generally within one-half meter of shore on dry days. During and after rains, they may move away from permanent water to feed in wet vegetation or ephemeral puddles (Licht 1986).

Long-toed salamander larvae eat zooplankton, immature insects, aquatic snails, and occasionally they are cannibalistic. Terrestrial long-toed salamanders eat spiders, lepidopteran larvae, crickets, earthworms, flies, snails and slugs, aphids, springtails, fly and beetle larvae, amphipods, and a variety of other invertebrates, both terrestrial and aquatic (Nusssbaum et al. 1983).

Water

Breeding habitats for red-legged frogs include marshes, bogs, swamps, ponds, lakes, and slow-moving streams (Leonard et al. 1993). Spotted frogs require water as breeding, foraging, and wintering habitat. These species are closely associated with standing water during the breeding season. In the central Willamette Valley, Oregon, and the Puget Lowland, Washington, they frequently use temporary waters, usually ponds or overflows that will be dry by late May or early June. However, connections to more permanent water must be present, allowing tadpoles to continue to develop to metamorphosis. In southwestern British Columbia, researchers studied red-legged frogs in a temporary pond (dried up in July) where they bred sympatrically with Oregon spotted frogs, in the slow part of a river, and in a small overflow pond of a large lake (Licht 1971). Slow-moving streams and large ponds were used for breeding in British Columbia (Licht 1969); breeding occurred in marshes in Oregon (Storm 1960). Standing water must be present long enough for eggs to hatch and tadpoles to transform. The period from egg deposition to metamorphosis in the red-legged frog was estimated at 180 days in western Oregon (Storm 1960). In Oregon spotted frogs this period lasted 135-232 days in Utah (Morris and Tanner 1969) and from 87-111 days in Yellowstone National Park (Turner 1958) depending on water temperatures.

In the early spring, adult long-toed salamanders can be seen at night in ponds and lakes, often in considerable numbers (Leonard pers. comm.). Eggs of northwestern salamanders are laid in a variety of wetlands, lakes, ponds, and slow-moving streams (Leonard et al. 1993).

Non-breeding adult red-legged frogs can be found in damp microhabitats up to 1000 yds. (914 m) from standing water (Porter 1961; Dumas 1966). The species may also range widely at night during warm rains (Storm 1960). Western toads occupy many habitats from sea level into the mountains, frequenting relatively dry to humid situations (Stebbins 1954). They are nocturnal during dry weather, but forage during daylight on rainy or overcast days (Nussbaum et al. 1983).

Cover

Adult red-legged frogs use emergent aquatic and shoreline vegetation for cover during the breeding season. Sedges (*Carex* sp.), rushes (*Juncus* sp.), and submerged vegetation provide cover during breeding activities (Licht 1969). Riparian vegetation may be used as escape cover by resting red-legged frogs; one population of frogs in British Columbia responded to predators by seeking dense vegetation on streambanks (Licht 1972). Another British Columbia population, however, escaped by leaping into the water when disturbed by a predator (Gregory 1979).

Young red-legged frog tadpoles use both mud and vegetation for cover (Calef 1973a). Optimal tadpole habitat is characterized by emergent willow (*Salix* sp.) stems, grasses, cattails (*Typha* sp.), submerged weed stems, and filamentous algae (Wiens 1970).

Oregon spotted frogs are highly aquatic, inhabiting marshes, and marshy edges of ponds, streams, and lakes. They usually occur in slow-moving waters, with abundant emergent vegetation, and a thick layer of dead and decaying vegetation on the bottom. The frogs take refuge in this layer when disturbed (Nussbaum et al. 1983).

Aquatic vegetation provides cover for the breeding activities of adult Pacific treefrogs (Jameson 1957; Whitney and Krebs 1975).

Larvae of the northwestern salamander lie hidden in the mud or under leaves, logs, and other cover on lake and pond bottoms during the day, but emerge at night to feed (Nussbaum et al. 1983). When on land, the northwest salamander is usually found in damp places beneath surface objects near streams or ponds (Stebbins 1954). Long-toed salamander adults can be found under pond-side debris during early spring, and recently metamorphosed juveniles can be found in late summer and autumn in mud, and under debris beside drying ponds (Nussbaum et al. 1983).

Reproduction

Near sea level, egg laying by red-legged frogs occurs December through February, and at any given locality the majority of eggs are laid over a period of two to seven weeks (Olson and Leonard 1997). Timing is influenced by latitude, elevation, and weather (Dumas 1966). Breeding habitats include marshes, bogs, swamps, ponds, lakes, and slow-moving streams (Leonard et al. 1993).

Most red-legged frog breeding males in British Columbia were found in weedbeds of pondweed *(Potamogeton* sp.*)* and quillwort *(Isoetes* sp.*)* (Calef 1973b). The courtship behavior of males is somewhat unusual in that they call from beneath the water; they will also call from among surface vegetation (Leonard et al. 1993). Males usually remained within the same weed bed, but they sometimes moved over 327 yds (300 m) during one breeding season (Calef 1973b).

Red-legged frog oviposition sites were usually located in the same microhabitat as male calling sites (Calef 1973b). Egg masses are deposited in quiet water with little or no current (Licht 1969; Stebbins 1972). Eggs are usually found attached to vegetation near the surface in water depths ranging between 20 in (50 cm) and 40 in (100 cm). However, in deep prairie potholes on Fort Lewis, Washington, eggs are often attached near the surface in water approximately 6.6 ft (2 m) deep (Hallock and Leonard 1997) . The female lays from 750 to 1300 eggs in a large (about 8-12 in or 20-30 cm), gelatinous cluster (Leonard et al. 1993). Flexible, herbaceous, and thin-stemmed emergent plants are ideal oviposition sites for northwestern salamanders, red-legged frogs and many other wetland breeding species (Richter and Roughgarden pers. comm.).

Towards the end of embryonic development, red-legged frog egg masses deteriorate and float to the surface. The embryos develop and hatch from their jelly covering after about four weeks of development. Tadpoles grow and develop over a period of three to four months, and in June or July the swimming tadpoles metamorphose into terrestrial froglets approximately 3/4 in (17-21 mm) long, snout-vent length (Leonard pers. comm). Limited evidence from western Oregon studies indicates that red-legged frogs become sexually mature in their second year after metamorphosis when males are about 2 in (50 mm), and females about 2.4 in (60 mm) snout-vent length (Nussbaum et al. 1983).

Breeding by Oregon spotted frogs occurs between February and April in western Washington. Oregon spotted frogs use the same locations for egg-laying in successive years, which may indicate unique characteristics at egg-laying sites (Licht 1969). Female Oregon spotted frogs tend to deposit their eggs on, or immediately next to, other spotted frog egg masses (Leonard et al. 1993). The rounded and globular masses are unattached to vegetation, and are in only a few inches of water at the margins of the breeding pools (Licht 1971).

Breeding sites for Pacific treefrogs in western Oregon include seasonal and perennial wetlands, semipermanent ponds, roadside ditches, and quiet pools along mountain streams (Jameson 1957). Frogs seemed to prefer the shallow portions of these ponds where vegetation cover was highest. Breeding in California often occurred in grassy, water-filled depressions (Brattstrom and Warren 1955).

Red-legged frogs first become active when air has been at least 41°F (5°C) for several days. Most movement to breeding sites occurs at night and seems to be stimulated by cloud cover and precipitation (Licht 1969).

Water temperature is an important factor in reproductive success for pond breeding amphibians. Breeding for red-legged frogs throughout the Pacific Northwest occurs when the water temperature of breeding ponds is 46 to 64° F (8 to 18° C) (Dumas 1966). The temperature range for normal development of red-legged frog embryos is 39 to 70° F (4 to 21° C) (Licht 1971). For Pacific treefrogs the optimal water temperature for egg-laying in California 54 to 59°F (12 to 15°C). Development and growth rates of embryos and larvae increase at warmer temperatures. The breeding strategy of the red-legged frog is adapted to cool, and permanent breeding waters (Brown 1975). For both red-legged and Oregon spotted frogs, more than 6 months may elapse between egg deposition and metamorphosis (Storm 1960; Morris and Tanner 1969). Red-legged frogs are capable of relatively rapid embryonic development at low temperatures, but larval development is protracted, and larvae grow to a large size prior to transformation (Brown 1975).

Western toad eggs are deposited in masses of as many as 16,500 eggs which are extruded in two strings; ordinarily laid in shallow water, not deeper than 12 in (30 cm) and usually less than 6 in (15 cm) (Stebbins 1954). The larvae are usually restricted to areas over muddy bottoms where they feed by filtering suspended plant material or feed on detritus on the bottom (Nussbaum et al. 1983). Embryos develop and hatch in 3-10 days depending on water temperature (Leonard et al. 1993).

During the breeding season adult long-toed salamanders may be found under logs, rocks, and other objects near ponds and lakes or may be seined from the water (Stebbins 1954). The method of egg laying is variable. In some places eggs are deposited singly, attached to vegetation in shallow water, and in other places clusters of 5-100 eggs are deposited in shallow to deep water, either attached to vegetation or under the surface of logs. Eggs may be placed loosely on the bottom (Nussbaum et al. 1983). They hatch in 5-15 days and may transform at sea level in July, while in the high mountain ponds most of the larvae do not transform until the beginning of their second year (Slater 1936).

Northwestern salamander eggs are laid in wetlands, ponds, and slow-moving streams (Bishop 1943). Females lay their gelatinous egg masses under the surface of the water, attaching them to thin branches of shrubs, trees, or thin-stemmed emergent plants (Leonard et al. 1993; Richter pers. comm.). They vary in size from small clusters containing 25-30 eggs to large elongate masses containing as many as 270 (Bishop 1943). The larvae hatch after about one month when they measure from .56-.6 in (14-15 mm) in total body length (Watney 1941). Metamorphosis may occur in the second summer (Watney 1941) but in some populations a high percentage of individuals may remain neotenic (Logier 1932; Slater 1936) especially at high altitudes (Snyder 1956).

Roughskin newts breed in quieter parts of streams and in lakes, ponds, and reservoirs (Stebbins 1954). This animal lays its eggs singly (Olson and Leonard 1977). Eggs are attached to grass stems, twigs, and other objects in water (Stebbins 1954). Eggs hatch in 20-26 days; the hatchlings are about .72 in (18 mm) total length after the yolk is gone. Larvae typically metamorphose late in their first summer at .92-3 in (23-75 mm) total length, but they may over-winter where growing seasons are short, metamorphosing in their second summer (Nussbaum et al. 1983).

Interspersion

Red-legged frogs utilize moist upland cover adjacent to wetlands during the non-breeding season. There is no information in the literature on home range size of this species. Individuals have been observed in upland areas 1000 yds (914 m) from potential breeding areas (Dumas 1966), but no quantitative study of movements between breeding and post-breeding habitats has been made.

The Pacific treefrog inhabits a variety of upland cover types as long as wetland areas for reproduction are available nearby. Adults in western Oregon wintered up to 1 mi (1.6 km) from breeding areas (Jameson 1957).

Special Habitat Requirements

The red-legged frog, Pacific treefrog, western toad and Oregon spotted frog are all ectotherms; environmental temperature has a strong influence on their activity patterns. The red-legged frog may be active almost year around in the warmer portions of its range. It is reported to breed in December along the coast and may remain active year around (Leonard pers. comm). In British

Columbia, this frog started breeding activities when water temperatures reached 41 to 43°F (5 to 6°C), but became inactive at temperatures of less than 50°F (10°C) during the non-breeding season (Licht 1969). Red-legged frogs seek protection in deep muck or silt at the bottom of permanent water; similar behavior has been described for the related spotted frog (Morris and Tanner 1969; McAllister pers. comm). May also overwinter in moist leaf litter, duff or beneath large woody debris in forested habitats, or at the muddy bottom of ponds (Leonard pers. comm.).

In Oregon spotted frogs, torpidity and hibernation occur at environmental temperatures below 41°F (5°C) (Middendorf 1957). Pacific treefrogs are active year-around along the coast of Washington and Oregon where winters are mild (Carl 1943; Cochran and Goin 1970). Elsewhere in the Pacific Northwest, treefrogs escape temperature extremes by hibernating in moist, well-protected sites, such as rock crevices, underground burrows, debris piles, and building foundations (Brattstrom and Warren 1955).

The tadpoles of the western toad seek out areas of warmer temperatures within a lake, and this behavior undoubtedly speeds up metamorphosis (Nussbaum et al. 1983).

Long-toed salamander adults spend most of the year underground or inside large rotting logs. Juveniles range from concentrating under debris, logs, and mats of dead vegetation on former pond bottoms to utilizing burrows as conditions change. Adults require heavy rainfall before emerging and moving to the breeding ponds (Anderson 1967). Northwestern salamanders are also found under bark and logs in damp situations, and utilize underground burrows (Bishop 1943; Leonard et al. 1993). Terrestrial forms are seldom seen except when they cross roads and trails on warm rainy nights (Nussbaum et al. 1983).

Roughskin newts are often found under logs, boards, rocks, and other surface objects or, in wet weather, crawling on the surface. During dry periods or at times of temperature extremes, they stay underground, in rotten logs, or in the water (Stebbins 1954).

Special Considerations

Severe water fluctuations in breeding areas may reduce hatching success, tadpole survival, and the quality of emergent vegetation, thereby, decreasing the success of lentic breeding amphibians. Northwestern salamanders, red-legged frogs, and roughskin newts were significantly absent from wetlands with high water level fluctuations in King County (Richter and Azous 1995).

Stream channelization, urbanization, logging, severe livestock grazing, and other alterations of stream courses and ponds may affect the availability of suitable oviposition sites, hibernacula, and cover (Olson and Leonard 1997). Red-legged frogs are sensitive to changes in environmental temperatures; water temperatures above 70° F (21°C) will cause high mortality among the young (Licht 1971).

In some instances, the red-legged frog may be absent from apparently suitable habitat in which there is a high population of bullfrogs (*Rana catesbeiana)* (Moyle 1973). This introduced species has similar habitat requirements and is an aggressive predator of frogs. Predation on all life stages of the red-legged frog may be high and is probably the strongest factor limiting population numbers (Licht 1974). Both common (*Thamnophis sirtalis*) and western terrestrial garter snakes (*Thamnophis elegans*) and bullfrogs are known to eat adult long-toed salamanders (Nussbaum et al. 1983). The more typical habitat for the bullfrog is exposed permanent shallow marshes with extensive emergent vegetation (Richter pers. comm). Bullfrogs are aquatic and require a permanent source of water, particularly in northern areas where larval development may take three years (Adams 1994).

Reed canarygrass (*Phalaris arundinacea*) is an introduced aquatic vascular plant that has become widespread and is difficult to control. It can eliminate all native plants where it grows by crowding them out. Its growth form is so dense as to be almost impenetrable and it tends to develop into a floating mat that displaces open water habitats. Reed canarygrass may significantly reduce the amount of cover and feeding habitat available for the larvae of native anurans (Adams 1994).

Recent research on the effects of fish introductions into the North Cascades ecosystem indicates that long-toed salamanders may be unable to coexist with introduced fish (larvae are preyed upon by the fish) (Liss et al. 1995). The introduction of exotic wildlife (i.e. , fishes, bullfrogs) may further degrade the suitability of waters for native amphibians (Olson and Leonard 1997).

HABITAT SUITABILITY INDEX (HSI) MODEL

Overview

This model has been developed to track changes in the quality of standing water and adjacent habitats of emergent, shrub-scrub, and forested wetlands used by pond breeding amphibians as reproductive and cover habitat. Breeding habitat of red-legged frogs include marshes, bogs, swamps, ponds, lakes, and slow-moving streams (Olson and Leonard 1997). Breeding sites for Pacific treefrogs in western Oregon include seasonal and perennial wetlands, semipermanent ponds, roadside ditches, and quiet pools along streams (Jameson 1957). Northwestern salamander eggs are laid in wetlands, lakes, ponds, and slow-moving streams (Leonard et al. 1993).

The successful breeding of amphibians is contingent on the following aquatic habitat elements: (1) water depth; (2) moderately dense emergent vegetation (excluding monotypic stands of reed canarygrass (*Phalaris arundinacea*) and purple loosestrife (*Lythrum salicaria*); (3) temporary and permanent bodies of water; (4) vegetative cover along wetland edge (5) water current and (6) associated habitats.

Model Applicability

Geographic Area

This model is applicable to standing water habitats supporting red-legged frogs, northwestern salamanders, long-toed salamanders, roughskin newts, Pacific treefrogs, western toads and Oregon spotted frogs in low lying areas (elevations < 2000 ft) of western Washington and Oregon.

Season

This model addresses the breeding and larval development periods (December through July) and covers habitat needs of pond breeding amphibians.

Cover Types

This model encompasses the aquatic habitats used by pond breeding amphibians for life requisite activities, including breeding and feeding. On the Columbia River Channel Deepening Study, habitats include standing water and adjacent habitats of palustrine emergent wetland (PEM), palustrine shrub-scrub wetland (PSS), palustrine forested (PFO), and associated cover types. Associated cover types consist of land use practices or habitats adjacent to the wetland or standing water. On this project they include forest woodland and shrub-scrub wetland, unmanaged grassland/herbaceous, grazed pasture, row crops, and development. Dense woody cover of trees and shrubs surrounding a wetland or standing water provides cover, hibernation sites, attenuates ambient air and water temperature, and enhances prey diversity.

Verification Level

This model was developed using available literature, professional expertise, and knowledge of the study area to determine appropriate values and parameters. The pond breeding amphibian HSI model will provide habitat information useful for impact assessment and habitat management. Previous drafts were reviewed by Kelly McAllister, Bill Leonard and Klaus Richter and their comments were incorporated into the current draft.

Habitat Components

Water presence is based on pond breeder requirements for standing water during the breeding season. All native lentic-breeding northwest amphibians use permanently flooded wetlands (Richter pers. comm.). Quiet, cool, and relatively deep permanent water is preferred breeding habitat for the red-legged frog (Licht 1969; Stebbins 1972). Standing water must be present long enough for eggs to hatch and tadpoles to transform. The period from egg deposition to metamorphosis in the red-legged frog was estimated at 180 days in western Oregon (Storm

1960). Northwestern salamanders, Oregon spotted frogs, and roughskin newts also require water permanence for at least six months to successfully reproduce (Leonard pers. comm). Six to twelve consecutive months of permanent water equals a SI value of 1.0.

Extensive temporary bodies of water (dries up by July) as part of a larger water system are very important in minimizing predation from bullfrogs (Leonard and McAllister, pers. comm.). Semi-permanence is beneficial to many species because it precludes the establishment of predators including bullfrogs (Richter pers. comm.). Bullfrog eggs and larvae will become stranded in ponds that dry up during summer, killing bullfrog eggs and larvae, and hence improving conditions for native pond breeding amphibians. Oregon spotted frogs are known to use non-permanent water bodies for egg laying (Turner 1958). Fifteen to thirty-five percent of an area with permanent water present will equal an SI value of 1.0 and will optimize native-amphibian habitat while minimizing same for the introduced bullfrog.

The optimal time frame to survey standing water conditions is January through June depending on rainfall for the winter/spring. Standing water assessments should not be taken between July 1 and December 1. Measurements taken in late May or June may under represent the total area and therefore need to be adjusted accordingly. It is recommended surveyors refer to the following for specific hydrology information to supplement their data: National Wetland Inventory (NWI), aerial photographs, soil maps, and field indicators. Field indicators include assessing drift lines, water marks, algae scum, water-stained leaves, drainage patterns within wetlands and sediment deposits to determine the extent of seasonal standing water.

Lentic-breeding amphibians spawn only in vernal ponds, depressional wetlands, or in slow-moving or quiescent water of riverine backwaters and slope wetlands (Savage 1961; Nussbaum et at. 1983; Blaustein et al. 1995). Water current at breeding sites is based on published literature which indicates that slow-moving and zero-current water is optimal for pond breeding amphibians (Storm 1960; Licht 1969; Leonard and McAllister pers. comm.). Egg masses are deposited in quiet water with little or no current (Licht 1969; Stebbins 1972). Increased discharge to riverine and slope wetlands can increase current velocity preventing breeding, reducing the success of fertilization, dislodging eggs from oviposition sites, or physically damaging eggs with suspended silt, sediment and large floating debris (Lind et al. 1996; Richter pers. comm.). Velocities exceeding 2 in/s (5 cm/s) precludes breeding by both red-legged frog and northwestern salamander (Richter and Roughgarden pers. comm.). Slow-moving water equals an SI value of 1.0 for breeding.

Moderately shallow water is required for breeding Oregon spotted frogs (Storm 1960; Licht 1969). Oviposition by most temperate amphibian species occurs at depths between 4-40 in (10-100 cm) (Cooke 1975; Seale 1982; Waldman 1982). Percent of a wetland area covered by water 4 to 40 in. (10 to 102 cm.) deep December through March pertains to the aquatic requirements of these species (Leonard and McAllister, pers. comm.). Wetlands that are completely flooded by this optimal water depth (approximately 100% = 1.0 SI) are more suitable than wetlands that do not have standing water or water depths that are not suitable.

Floating-aquatic, emergent, and woody macrophytes are used for cover by adults and tadpoles (Licht 1969; Calef 1973a) and for egg attachment sites (Storm 1960; Porter 1961). Oregon spotted frogs usually occur in slow-moving waters, with abundant emergent vegetation (Nussbaum et al. 1983; McAllister and Leonard 1997). Emergent vegetation is used by Pacific treefrogs in foraging, thermoregulation, and breeding (Whitney and Krebs 1975; Brattstrom and Warren 1955). Vegetation cover of ≥50% equals a value of 1.0 SI. One exception is the presence of a non-native invasive species such as reed canarygrass, in this case ≥75% equals SI of .1.

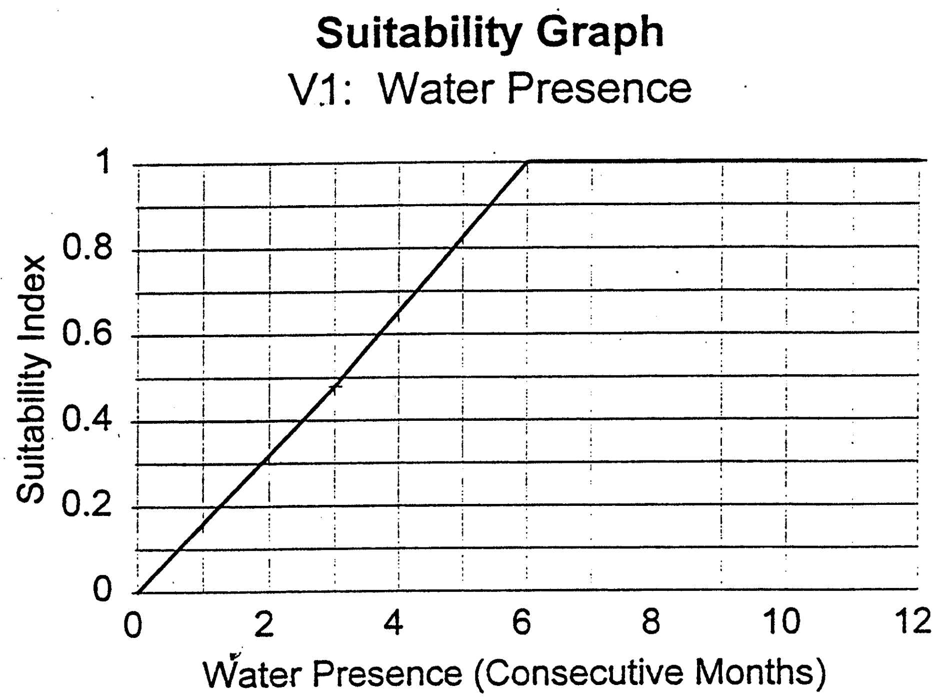
Shoreline vegetation provides important cover for breeding amphibians. Adults frogs and salamanders are often found among downed logs, ferns, blackberry thickets, and other dense cover during the non-breeding season (Dunlap 1955; Porter 1961). Optimum ground cover along the water edge is ≥75% which provides escape and thermal cover, or SI of 1.0.

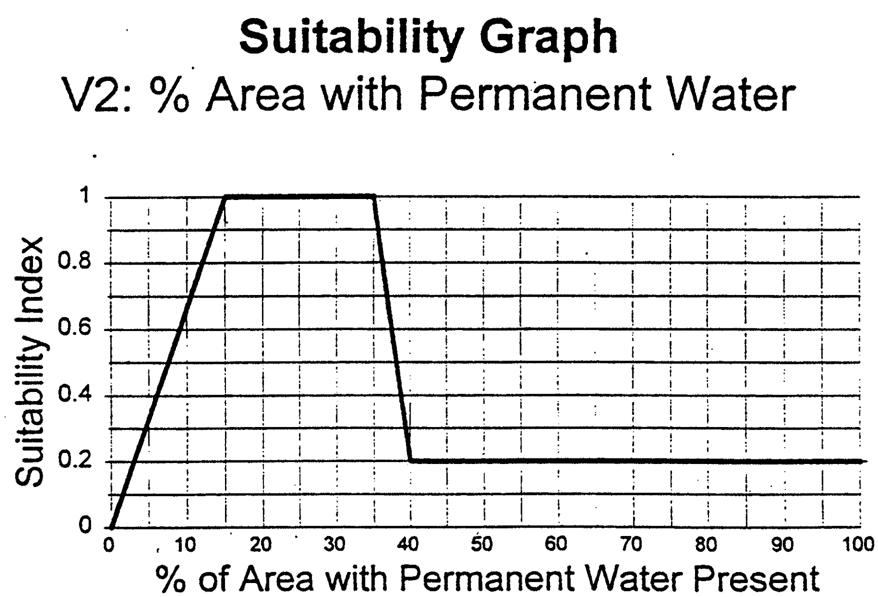
During the non-breeding season, red-legged frogs may occur at considerable distances from water. Nussbaum (1983), have encountered frogs in moist forest situations 656 to 984 ft (200 to 300 m) from any standing water. A measurement of 656 ft (200 m) surrounding the wetland should be adequate to measure the associated habitat value.

Habitat surrounding standing water and the value of the standing water influences the quality of the wetland system in terms of providing adequate cover and breeding habitat for native amphibians. Associated habitat on the Columbia River Channel Deepening Project would consist of either forested woodland/emergent wetland/shrub-scrub wetland (1.0 SI), unmanaged grassland/herbaceous (0.75 SI), grazed pasture (0.5 SI), row crops (0.1 SI) and/or development (0.0 SI). Forested woodlands and shrub-scrub wetlands provide the optimal habitat. This model assumes that sufficient cover must be adjacent to a water source in order to provide escape cover, thermal buffering, hibernation sites, and enhanced prey diversity. Because pond breeding amphibians use upland cover types during the non-breeding season, optimal habitat must also support suitable cover adjacent to the standing water. Application of this model and determination of habitat suitability index is based on evaluation of standing water quality for supporting pond breeding amphibians and associated habitats in a 656 ft (200 m) band surrounding standing water, and each will have a distinct HSI.

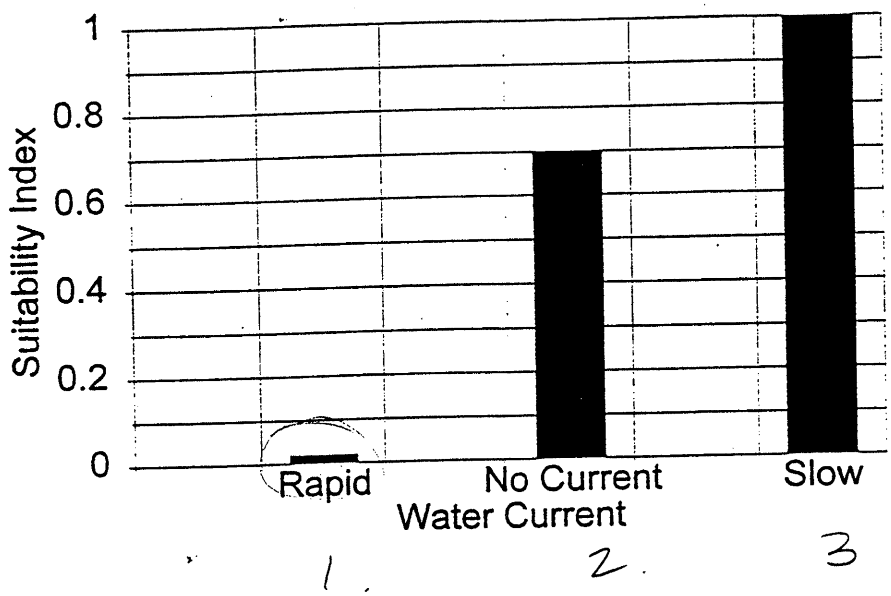
Model Relationships

This section contains the pond breeding amphibian Suitability Index (SI) graphs that illustrate the habitat relationships described in the previous section.

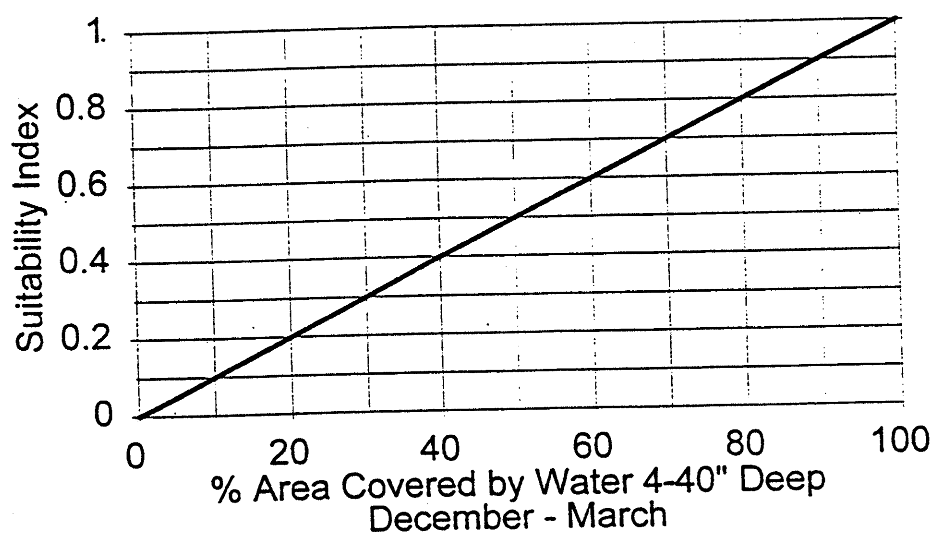




Suitability Graph
V3: Water Current

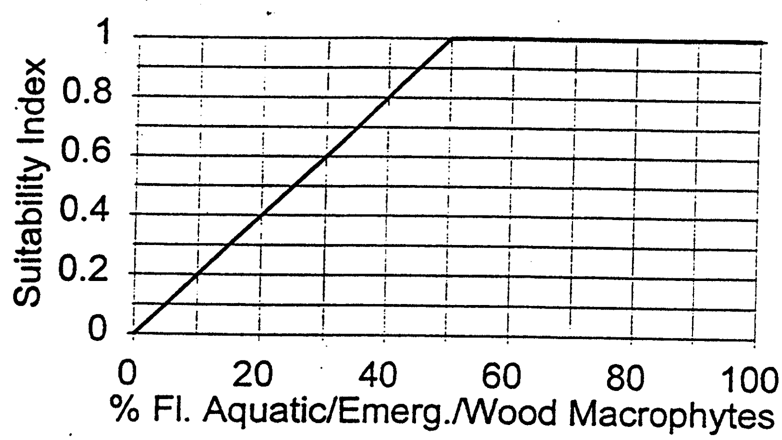


Suitability Graph
V4: % Area Covered by Water (4-40")



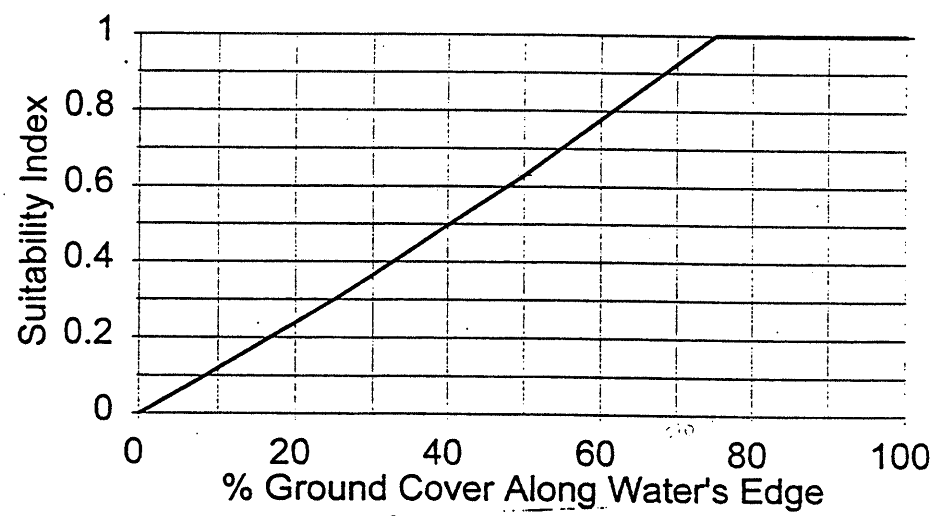
Suitability Graph

V5: % Area Wetland Vegetation



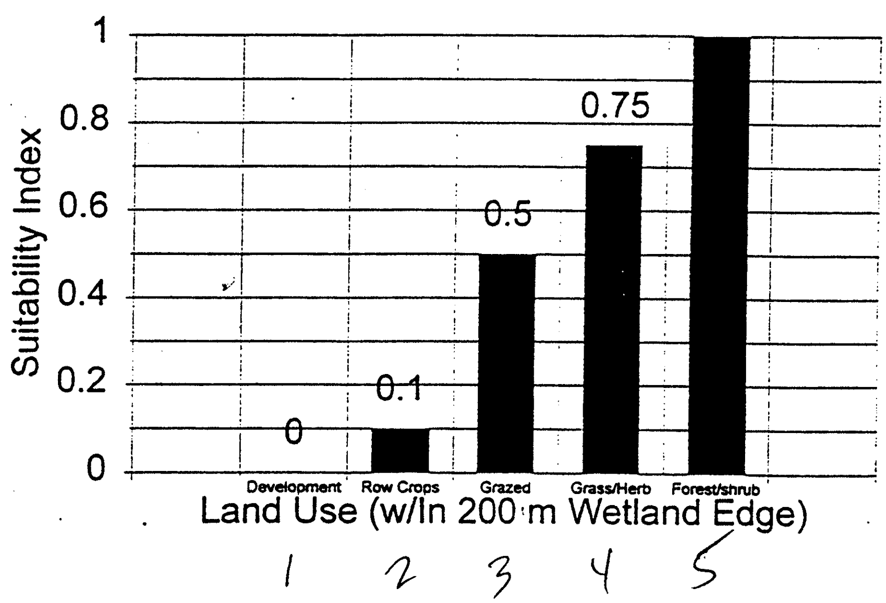
Suitability Graph

V6: % Ground Cover Along Water's Edge



Suitability Graph

V7: Associated Habitats



Equation

Habitat Suitability Index (HSI) values for pond breeding amphibians are based on two equations representing 1) either cover or reproductive habitat value found within standing water, and 2) the value of associated habitat surrounding the standing water.

Cover Types

Palustrine emergent wetland (PEM), palustrine shrub-scrub wetland (PSS), palustrine forested (PFO) and associated habitats within 656 ft (200 m) of wetland or standing water.

Variable Definitions

V_1: Water permanence (presence)

V_2: Percent of area with permanent water present.

V_3: Water Current

V_4: Percent of standing water area covered by water 4 to 40 in. deep December through March.

V_5: Percent of standing water with floating aquatic, emergent, and woody macrophytes.

V_6: Percent of ground cover along water's edge.

V_7: Associated Habitat Suitability Index

Model

1. HSI of standing water will equal the lowest life requisite value (reproductive or cover) whichever is lower:

$$\text{Reproductive HSI} = (V_1 \times V_2 \times V_3 \times V_4)^{1/4}$$

$$\text{Cover HSI} = (V_5 \times V_6)^{1/2}$$

2. Associated Habitats HSI $= (\text{HSI standing water} \times V_7)^{1/2}$

3. Calculate HU's for amphibians by combining standing water and associated habitats:

HSI of (standing water) x acres of (standing water) = HU (standing water)
HSI of (associated habitat) x acres of (associated habitat in 200 m band) = HU (associated habitat)
Amphibian HU's = HU (standing water) + HU (associated habitats)

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DRAFT CANADA GOOSE MODEL

LOWER COLUMBIA RIVER/WILLAMETTE VALLEY

WINTERING MODEL

Canada geese winter in significant numbers along the lower Columbia River and in the Willamette Valley of Oregon. Subspecies present in substantial numbers include the dusky, cackling and Taverner's Canada geese. Their numbers exceed 100,000 birds in this region. Taverner's and cackling Canada geese represent the bulk of wintering geese present. The western Canada goose is resident in these areas. Vancouver, lesser and Aleutian Canada geese also occur although their numbers generally are not significant.

Dusky Canada geese are depressed in numbers because of habitat changes associated with the 1964 Alaskan earthquake which resulted in land uplift in the Copper River delta. This delta is their principal nesting ground. This subspecies winters principally along the lower Columbia River and in the Willamette Valley. The decline in the dusky Canada goose population has led to restrictions on hunting of Canada geese along the lower Columbia River and in the Willamette Valley. These restrictions, which include a limited number of open days for goose hunting per week or a total ban on harvest in many areas, may have contributed to the increased winter use by Canada geese of this region. The substantial agriculture acreage present, including large tracts of grass fields, pastures and row crops, provides abundant winter forage for Canada geese. The presence of refuges, wildlife management areas, large rivers and lakes plus extensive ponding of water in fields also contributes to the natural attraction of the region for Canada geese.

Proposed disposal sites in the Corps' of Engineers feasibility study for the Columbia River Channel Deepening effort has the potential to impact acreage used by wintering Canada geese. These impacts may occur primarily where agricultural lands are used for disposal purposes. In order to evaluate these potential impacts, the following draft model has been proposed. The model is based upon personal observations of wintering Canada geese and has not been substantiated by literature or peer review. As currently proposed, the model is principally predicated upon expected use of habitats anticipated to be impacted by dredged material disposal and does not necessarily encompass all the habitats utilized by wintering Canada geese in this region. Habitat features such as large bodies of water are not included in the model because this habitat is ubiquitous along the lower Columbia River.

The first variable is intended to assess winter forage suitability for Canada geese. The species is primarily a grazer although they will take advantage of waste grain from agricultural harvest and will utilize crops intentionally left for waterfowl attraction purposes. Crop/forage habitat types evaluated include fallow ground (e.g. tilled ground that has not been planted), harvested corn (either field corn for silage or sweet corn for human consumption), cereal grain stubble (crop residue from summer harvest left standing), old field (former cropland not tilled in recent years), alfalfa, cereal grain growing refers to a fall planting of a cereal grain, generally wheat, pasture, grazed wetland and ungrazed wetland. Suitability indices vary substantially for these crop types (reference accompanying graph).

Fallow ground is assigned a value of 0.1 to reflect the lack of forage associated with this agricultural practice. Land lying fallow has been tilled in late summer or fall, often only to a rough surface condition. No crop has been seeded; planting occurs the following spring. Vegetation is typically limited to volunteer plants, typically herbaceous weeds and grasses. Plant cover is sparse and provides limited forage for wintering geese.

Harvested corn, either field corn harvested for silage or sweet corn harvested for human consumption, provides forage in the form of waste grain and volunteer grasses and forbs post-harvest. Waste corn is generally a short term available food typically consumed by Canada geese shortly after their arrival in the fall with waste corn much less available after early December. Because of the limited duration that waste corn is present and the limited amount of volunteer grasses and forbs that occurs, this agricultural crop was assigned a suitability indice value of 0.4.

Cereal grain stubble represents the residual vegetative material left after harvest. Some waste grain is present and may be utilized early in the fall. Volunteer grain becomes available after fall rains and provides some forage value for wintering geese. Forage is not of high quality normally as volunteer grain is not fertilized nor is the quantity of material necessarily substantial. Canada geese will utilize these fields throughout the winter period although pastures and fall planted cereal grain fields are of much higher value. An indice value of 0.4 was assigned to this agricultural field type.

Old field habitat is typically former agricultural ground that has not been cultivated for a number of years. Vegetative cover is volunteer in nature and tends to be tall and generally coarse in nature. Forage value can be limited, both in quality and quantity. An indice value of 0.2 was assigned to this field type.

Alfalfa represents a crop that receives limited use by Canada geese. Their use of this crop generally occurs in early spring (March 1 - April 15); the latter date represents the general departure date for most Canada geese wintering in this area. Geese normally begin arriving in the Pacific Northwest around the first of October with a major influx in late October-early November. A negligible amount of foraging of alfalfa occurs in the fall as the crop exhibits little growth then and is headed toward dormancy. Around the first of March, alfalfa resumes growing and use by Canada geese begins. Consequently, Canada geese graze alfalfa for approximately 25 percent of the time the crop is present and available to geese. A suitability indice value of 0.4 for an alfalfa stand is recommended.

Cereal grain - growing refers to a fall planted cereal grain crop, typically winter wheat. Newly established stands of cereal grains are very attractive to wintering Canada geese and will be used extensively if permitted. The crop is attractive to Canada geese as forage is young, short, very palatable and generally very nutritious as fertilizer is applied in the fall to boost crop production. Because of the concern for damage that may result from flocks of geese numbering into the thousands grazing new plantings of cereal grain to the ground, repeatedly, farmers often haze Canada geese from this crop type. This crop provides an optimum forage for Canada geese and is assigned an indice value of 1.0.

Pasture also provides an optimum forage for wintering Canada geese. Cattle grazing normally keeps this crop in a very short growing form. Fall application of fertilizer boosts the nutrition value of grass increasing attractiveness of this crop. Concern over grazing intensity by wintering Canada geese can lead to hazing by landowners in an effort to maintain this forage for their cattle. This crop provides an optimum forage for Canada geese and is assigned an indice value of 1.0.

Grazed wetland refers to lands within diking districts that typically are poorly drained and support wetland plants, principally rushes and reed canarygrass. These sites are grazed however and thus vegetation height is generally sufficiently low that grazing by geese occurs. Ungrazed wetlands are dominated by tall, dense and coarse vegetation, often residual vegetation from the previous growing season. They do not offer substantial low height, palatable, growing vegetation until spring. The tall, dense cover is also not attractive to geese because of lack of visibility for predator detection.

Field size is another variable that influences wintering Canada goose usage. The accompanying chart reflects the estimated influence of field size. Fields five acres in size generally receive limited use because field edges are close and may provide cover features (e.g. trees, tall vegetation) for predators. As field size increases, these features become less restrictive to goose usage.

The disturbance variable is an attempt to address the hazing pressure faced by wintering Canada geese in this region. Hazing results from landowner attempts to keep geese off their cropland. It occurs normally for fall planted cereal grains and pasture. Some signs of hazing are very evident such as scarecrows or propane cannons. Direct hazing is less evident as an observer would have to be present to observe this activity. For sites where hazing is very prevalent (high), the index value for goose use was assigned a 0.2. This value anticipates that geese will make some use of the crop although that use will not be extensive. Hazing would generally be negligible for most other crop categories.

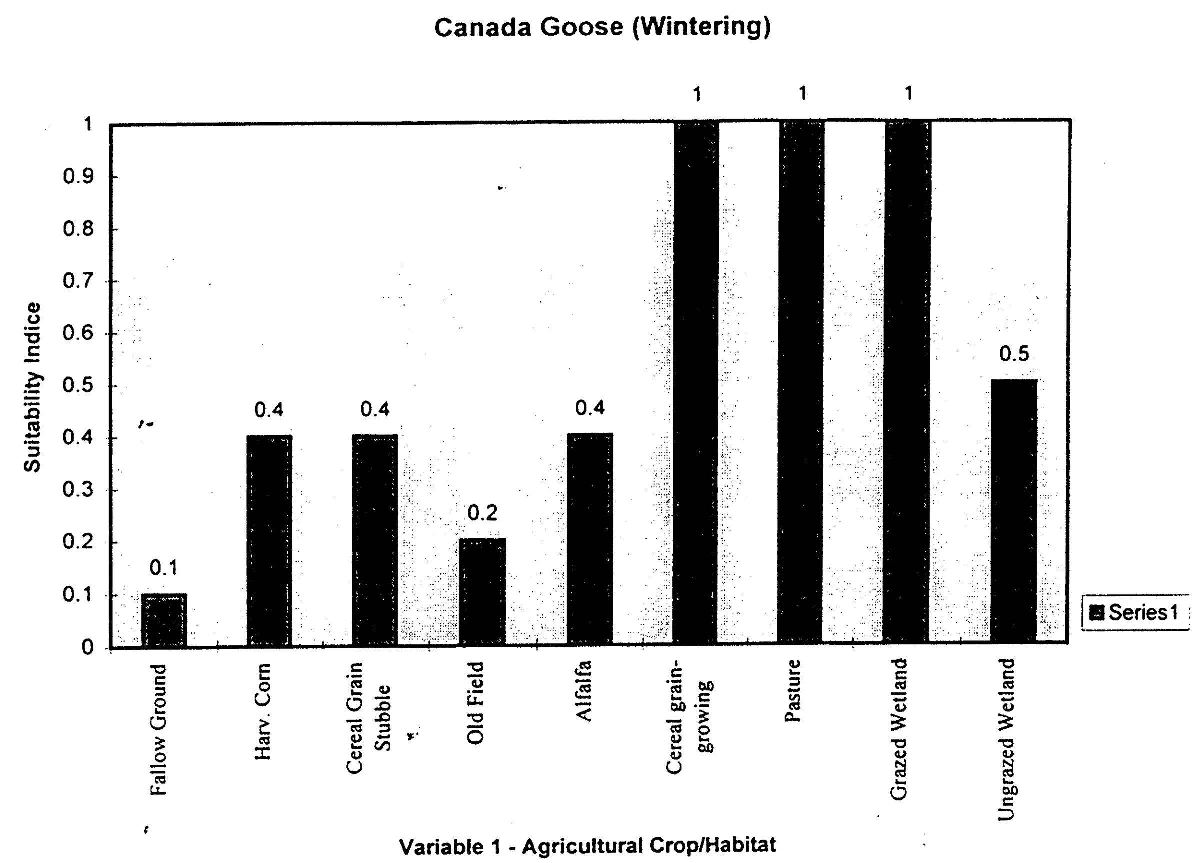
Forage height is addressed by variable 4. Low growing grasses and cereal grains are preferred by Canada geese as they are more palatable and nutritious. Tall, coarse vegetation is less palatable and nutritious plus it provides cover for predators and lessens the ability of geese to detect predators.

Notes:

Excel File MallCanm.xls identifies SI values by variable for Canada geese. The printout for this file is attached.

Habitat Suitablility Index values are calculated using the following formula:

$$HSI = (V_1+V_2+V_3+V_4)/4$$



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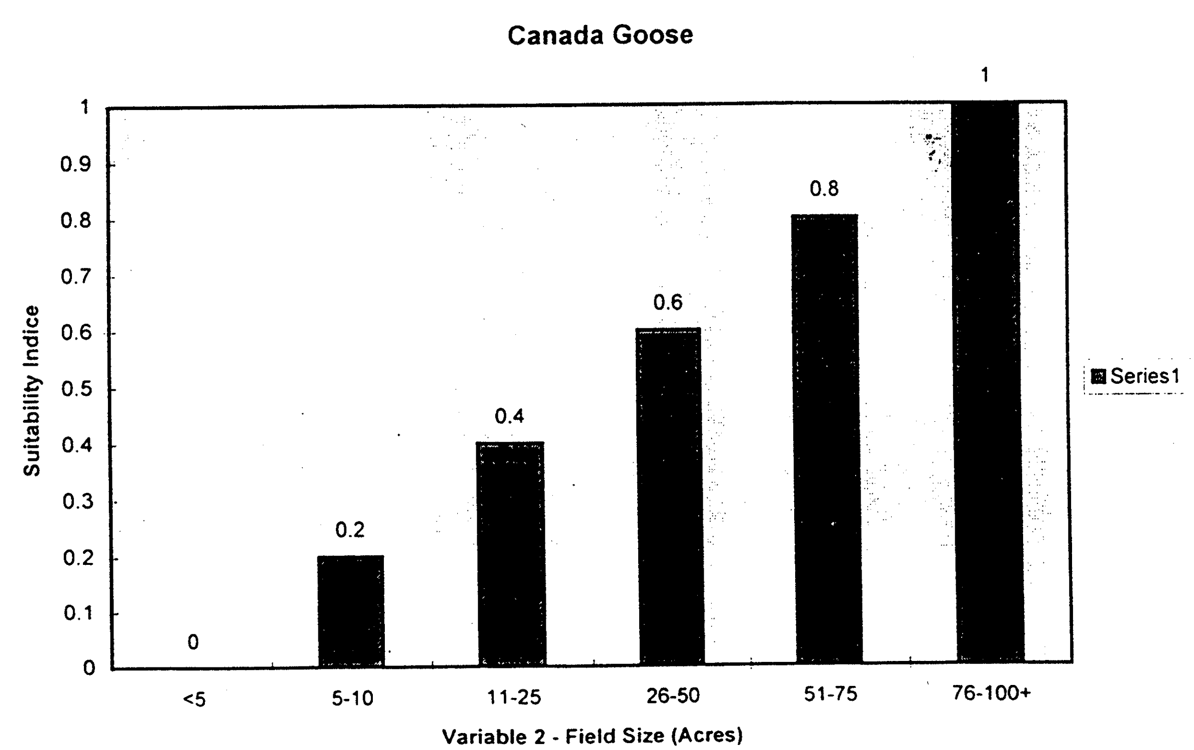

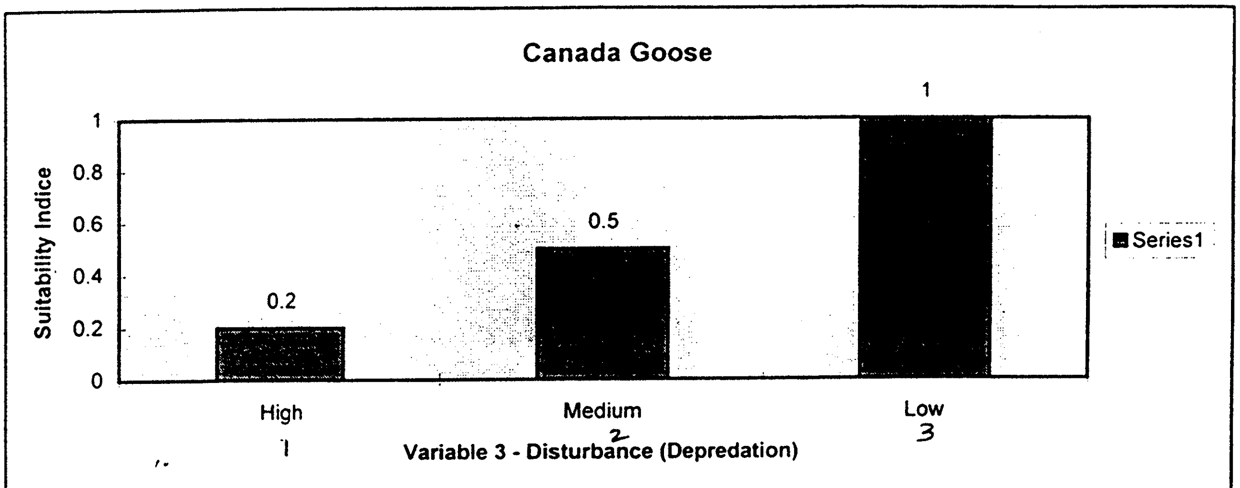

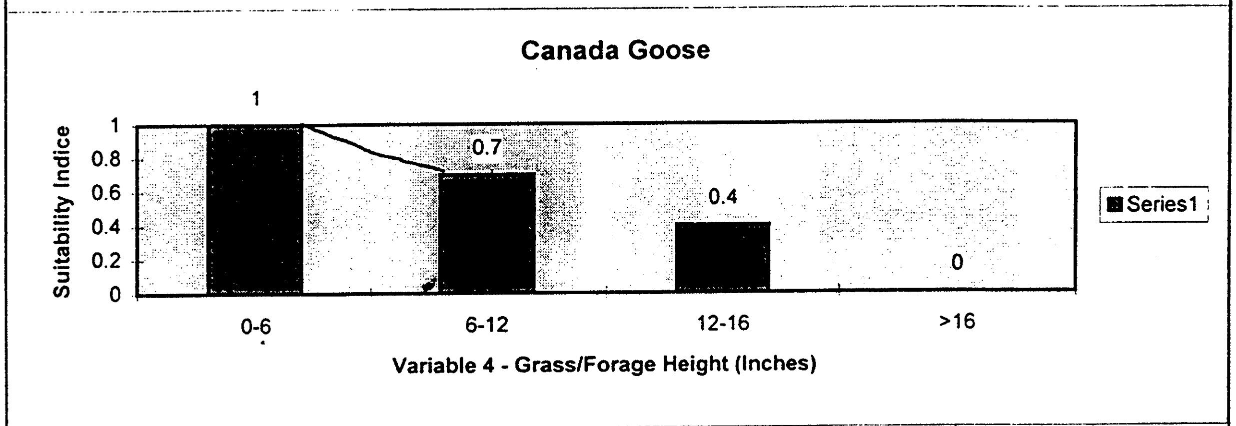

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Mallard Model

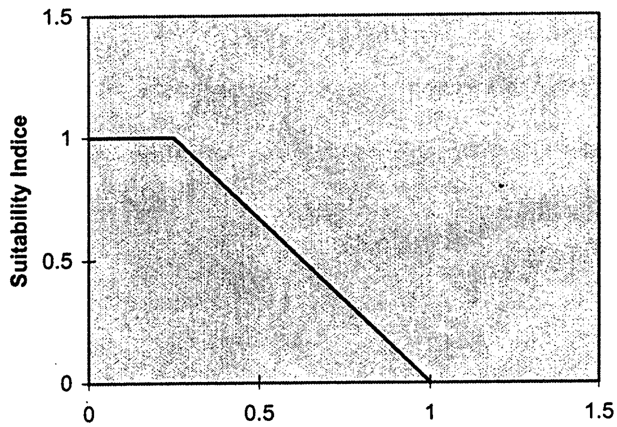
The mallard model used for determination of average annual habitat units gained or lost from either disposal or mitigation actions associated with the Columbia River Channel Improvement Study was based upon two draft models and HEP team discussions. The Mallard *Anas Platyrhynchos* Habitat Suitability Index Model 1997 and Mallard (Anas platyrhynchos) Model D3105 dated September 2, 1986 were used for background information and supplied several variables for modeling purposes. These models are attached to this model for reference purposes.

Mallard use along the lower Columbia River primarily entails use by wintering birds although a population of resident, breeding mallards is present in the area. The variables, as selected, were intended to address use by wintering and nesting mallards plus brood rearing habitat. The 7 variables assessed were:

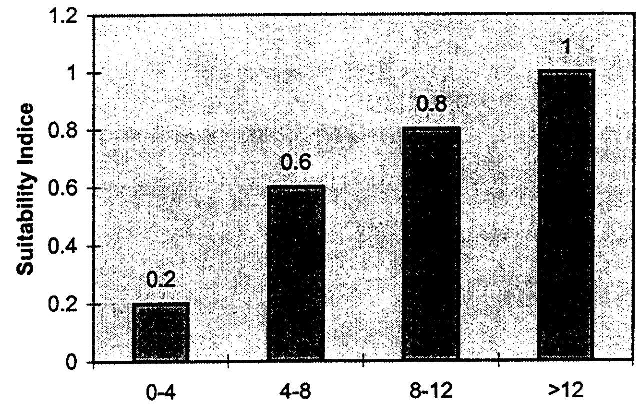
Variable 3 – Distance between nest and water with emergent vegetation (miles);
Variable 4 – Height of nesting cover (inches);
Variable 5 – Percent herbaceous canopy cover;
Variable 6 – Herbaceous vegetation height in wetlands (inches);
Variable 7 – Percent herbaceous cover:percent open water for wetlands;
Variable 8 – Area of wetlands (acres) less than or equal to two feet in depth; and
Variable 9 – Agricultural/crop habitat.

Suitability indice graphs for each variable are attached to this model. The suitability indice for nesting value (SINV) was based upon the equation: (V3 + V4 + V5)/3. The SI for brood habitat value (SIBH) was based upon the equation: (V6 + V7 + V8)/3. The SI for wintering habitat value (SIWH) was V9. The overall habitat suitability index was based upon the formula: (SINV + SIBH = 2SIWH)/4. The 2x factor for SIWH was based upon the greater importance of the lower Columbia River area for wintering mallards than resident, nesting mallards.

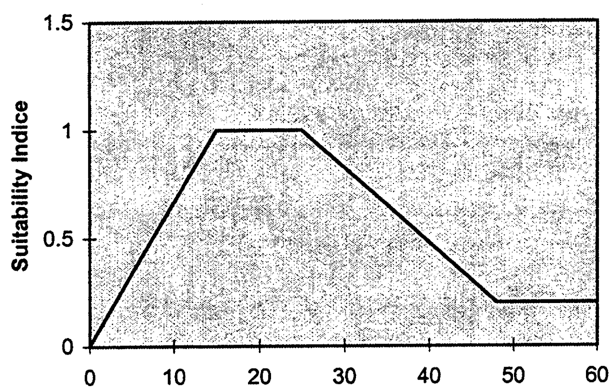
Mallard Model
Suitability Indices by
Variable



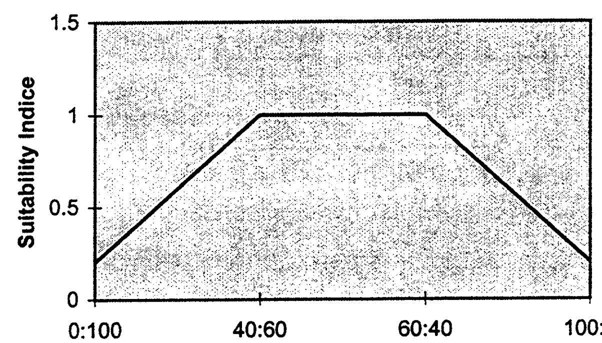
Variable 3 - Distance between nest and water with emergent vegetation (miles)



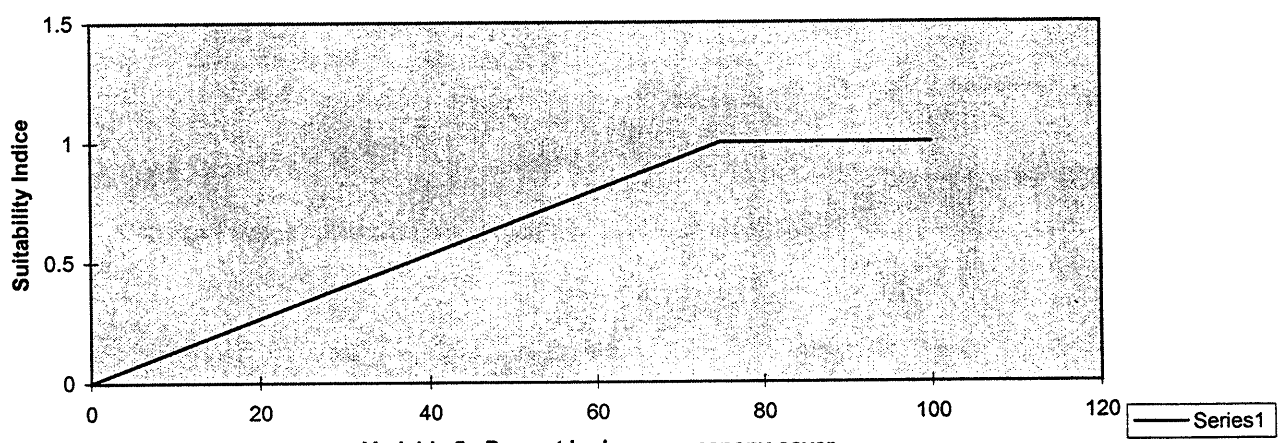
Variable 6 - Herbaceous vegetation height in wetlands (inches)



Variable 4 - Height of nesting cover (inches)

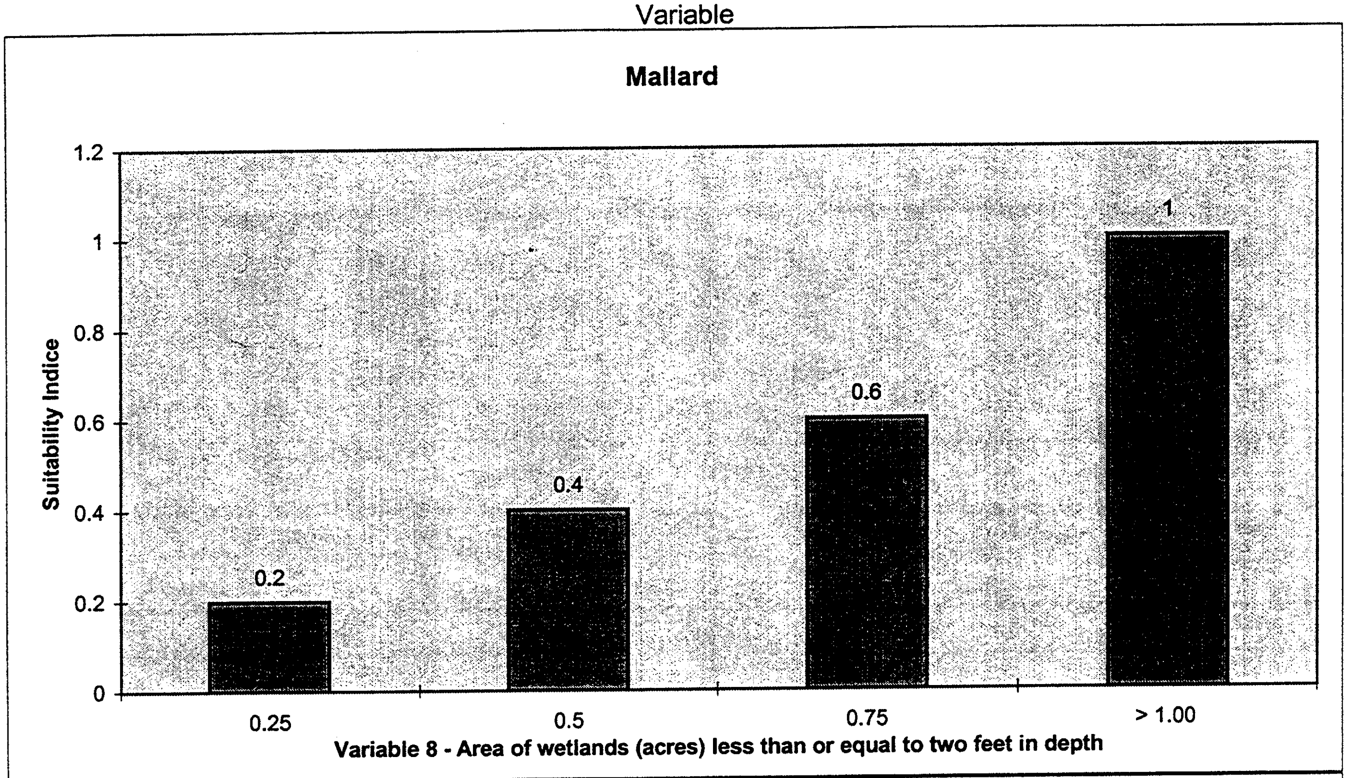


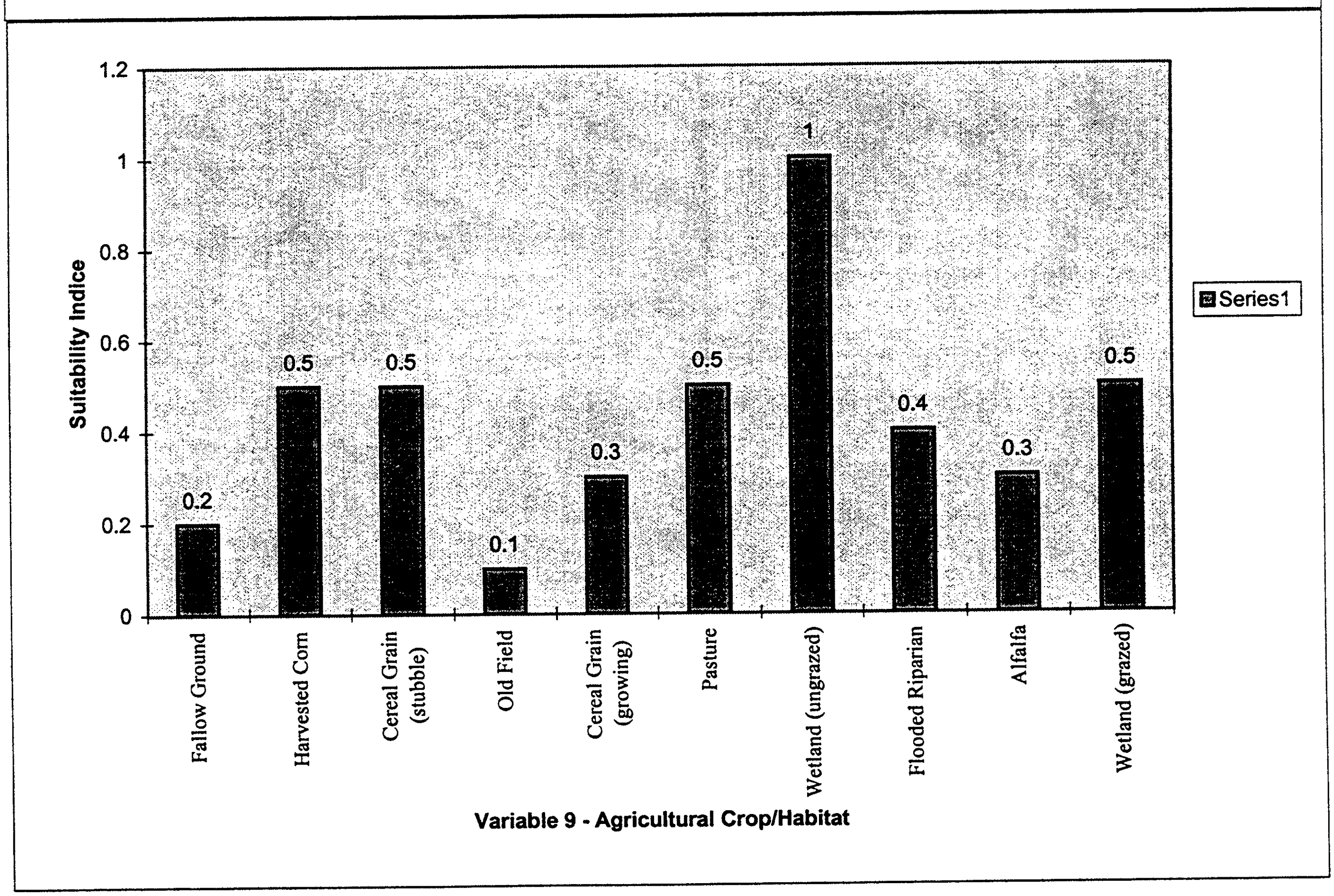
Variable 7 - Percent herbaceous cover: percent open water for wetlands

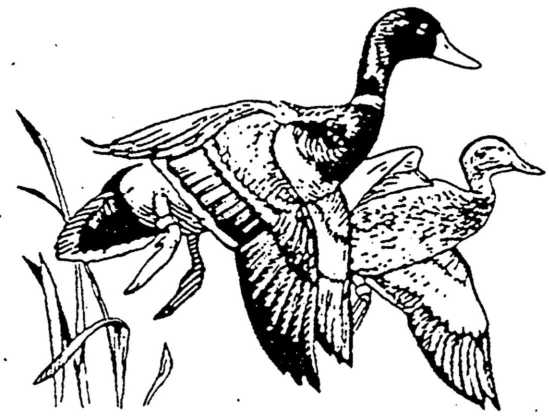


Variable 5 - Percent herbaceous canopy cover

Mallard Model
Suitability Indices by
Variable



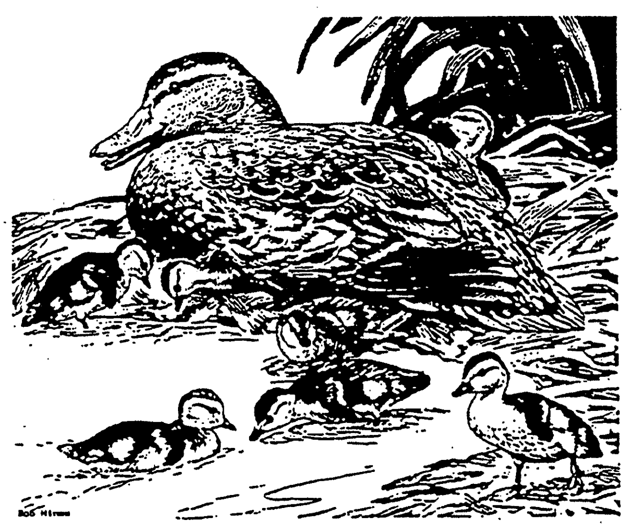




MALLARD

Anas Platyrhynchos

Habitat Suitability Index MODEL 1997



General:

The mallard (*Anas platyrhynchos*) utilizes the lower Columbia River Basin for both nesting and wintering habitat. Typical mallard habitats include riparian plants, emergent wetlands, agricultural lands, and open water areas.

Food Requirements:

Mallards are freshwater ducks that prefer to feed in small areas such as sloughs, ponds, marshes, streams, and swamps. Food is picked up at or just below the water surface. The presence of shallow water feeding areas is, therefore, a critical factor for dabbling ducks in general.

About 90% of the mallard diet is plant material, primarily consisting of marsh and aquatic macrophytes. Plants eaten may include sedges (*Carex* spp.), smartweeds (*Polygonum* spp.), pondweeds (*Potamogeton* spp.), duckweeds (*Lemna* spp.) and many other aquatic plants. Grain crops including corn, sorghum, barley, and wheat are also a significant food source along with grasses. Mallards do consume a limited amount of aquatic invertebrates such as aquatic beetles and their larvae, dragonfly and damselfly nymphs and mayfly, stonefly, and caddisfly larvae. Other foods may include tadpoles, fish fry, and crustaceans. Juvenile mallards (less than three weeks old) consume an abundance of these invertebrates.

Water Requirements:

Mallards prefer sloughs, ponds, marshes, slow-moving streams and rivers for feeding, loafing, nesting, and over-wintering. These areas should include variable water depths to provide for loafing (resting areas), shallow waters for emergent vegetation and aquatic invertebrates (food sources), as well as deeper, open water areas to allow for predator avoidance by adults and juveniles. Emergent vegetation areas are utilized for multiple purposes, i.e., as feeding and cover areas for juvenile and adult mallards.

Wintering Requirements:

Wintering populations of mallards are often congregated around the shallow backwater areas associated with islands where they are protected from human distuurbance and predation. Mallards also utilize backwater areas of lakes and forested wetlands and slower velocity areas of rivers. The presence and abundance of suitable water bodies is a limiting factor which largely determines habitat suitability. If water is unavailable, the habitat suitability index will equal zero. Fast flowing water is less suitable than slow flowing water. Over-wintering mallards are dependent on large, unfrozen water bodies.

Daily flights to nearby agricultural crops (corn, wheat, barley) provide a significant food source for wintering mallards. Winter food value of an area is a function of distance between grain crops and suitable water bodies. The amount of waste grain available will also effect winter food value.

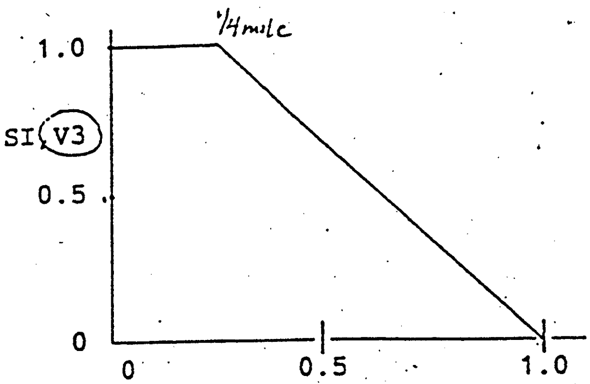
Nesting Requirements:

Nesting commonly occurs in close proximity to emergent wetlands in areas with mature, relatively dense grasses, rushes, shrubs, and other riparian vegetation. Herbaceous vegetation between 15 and 24 inches in height with at least 75% canopy cover is preferred. Mallard nests are found in greater numbers and have a higher success rate if they are within 1/4 mile of water with emergent vegetation. The emergent vegetation provides cover and rearing area for the juvenile ducks. Emergent wetlands with a 40 to 60 percent vegetative cover ratio (relative to open water) are preferred. Nesting success in otherwise optimum nesting areas can be significantly reduced by disturbance from humans and dogs.

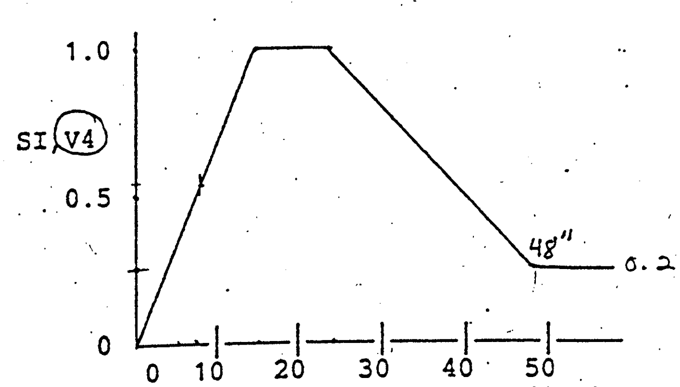
MALLARD HABITAT SUITABILITY INDEX

NESTING

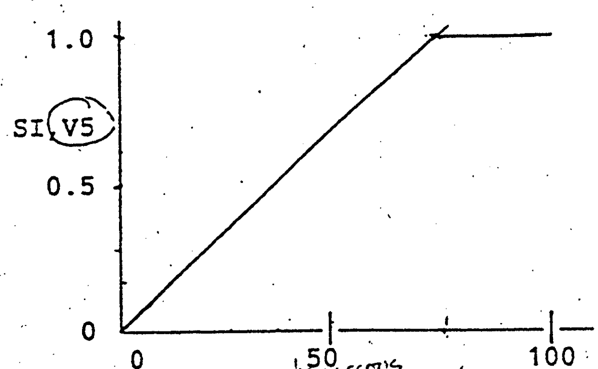
Cover Types: Riparian Herb and ~~Shrub/Steppe/Grassland~~ Emergent wetland



Distance between nest and water with emergent vegetation (miles)



Height of nesting cover (in.)

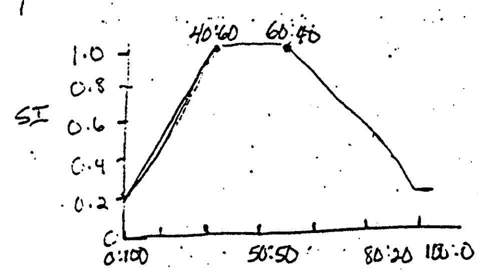


Percent herbaceous canopy cover

V6 Disturbance by people and dogs

	S.I.
Low	0.8-1.0
Medium	0.4-0.7
High	0.0-0.3

V_7



% cover : % open water

Model Equation

HSI = ~~V3 + V4 + V5~~ + V7 ~~x V6~~ / ~~3~~ 4

$$HSI = \frac{V_3 + V_4 + V_5 + V_7}{4} \times V_6$$

Mallard Habitat Suitability Index

Wintering

Cover Types: Open water (ponds, lakes, river, backwaters)

V_1 - Velocity of open water

Type of water body present: I_1

a) Lentic (ponds, lakes, backwaters, etc.)	0.6–1.0 SI
b) Lotic (river)	0.1–0.5 SI
c) None	0.0 SI

Size of water body: I_2

a) 1-8 ha (3-20A)	0.8–1.0 SI
b) > 8 ha (20A)	0.5–0.8 SI
c) < 1 ha (3A)	0.1–0.4 SI

Water value $(I_1 \times I_2)^{1/2} = V_1$

Winter Food Value

Cover Types: Pasture, cropland

V_2 – Distance between grain crops and suitable water bodies

a) < 5 miles	0.8–1.0 SI
b) 5-15 miles	0.4–0.7 SI
c) 15-25 miles	0.1–0.3 SI

Model Equation:

$$HSI = \frac{V_1 + V_2}{2}$$

$\frac{.715 + .8}{2} = .75$

$\sqrt{.715 \times .8} = .50$

MALLARD
(Anas platyrhynchos)

Sultan Basin HEP

D3105
9/2/86

Mallard

(*Anas platyrhynchos*)

General

- The mallard, (*Anas platyrhynchos*) is a widespread freshwater waterfowl species, common throughout the year in western Washington.
- Approximately 50,000 mallards winter in the Puget Sound region.

Food Requirements

- Plants comprise 90 percent of diet. Plants eaten include sedges, pondweed, duckweed, and many kinds of seeds (Martin *et al*. 1951, Pehrsson, 1984).
- Juveniles less than three weeks old feed primarily on animal matter. Aquatic beetles, larvae and nymphs of mayflies, stoneflies, caddisflies, dragonflies, damselflies, tadpoles, fish fry, and crustaceans are important animal food (Bent 1923, Yocum 1957).
- Seeds are important food sources during spring migration and during brood rearing (Krapu 1981).
- Food is picked up from the surface or just below the surface.
- Must have open, shallow water areas for feeding (Johnsgard 1975).
- Grain crops (including corn, wheat, and barley) and pastures are heavily utilized in winter (Yocum 1957).

Water/Cover Requirements

- Found in freshwater, prefer sloughs, ponds, marshes, slow-moving streams and rivers and swamps (Johnsgard 1975).
- Long narrow sloughs, floating islands, and gradually sloping shorelines are used for loafing (Girard 1941). Areas with dense vegetation are avoided for loafing (Sowls 1955).
- Seasonal wetlands are preferred feeding habitat by laying hens (Krapu *et al*. 1983; Cowardin *et al*. 1985
- Reservoirs are utilized during winter months and during migration periods in western Washington. (WDG 1982, Walters 1986).
- Broods utilize wetlands having sparse to dense emergent vegetation and open water. Wetlands without emergent vegetation or open water are usually avoided. Shorelines bare of emergent vegetation are seldom used (Berg 1956, Rumble and Flake 1983).

- Artificial islands and environments with reduced numbers of predators significantly increase nesting densities and hatching success (Duebbert and Lokemoen 1980).

Reproductive Requirements

- Nesting density (pairs/acre) is higher in seasonal wetlands than deep marshes and permanent water areas (Duebbert et al. 1983). Seasonal wetlands without fish populations provide larger-sized insects and greater overall insect abundance (Pehrsson 1984).

- Deep marshes and permanent water areas are used for rearing of young (Duebbert et al. 1983). These areas are preferred during migration and rearing, when vegetation and seeds are the primary food source (Pehrsson 1984).

- Beaver impoundments often create suitable nesting habitat (Beard 1953).

- Nests are placed in relatively tall herbaceous vegetation in close proximity to water. Vegetation height varies between 8 in. and 30 in. in nesting areas. Most nests are within 300 ft. of water (Bellrose 1976, Lokemoen et al. 1984).

- Mature, relatively dense grasses, rushes, and shrubs are preferred for nesting. In areas with high breeding densities, thicker, dense shrub vegetation (nearly 100 percent visual obscurity) is preferred (Lokemoen et al. 1984).

Interspersion Requirements

- Home ranges during the breeding season can be as large as 700 acres (Brown 1985).

- Home ranges often overlap (Lokemoen et al. 1984), though pairs may defend nesting ponds against other mallards (Dzubin 1969).

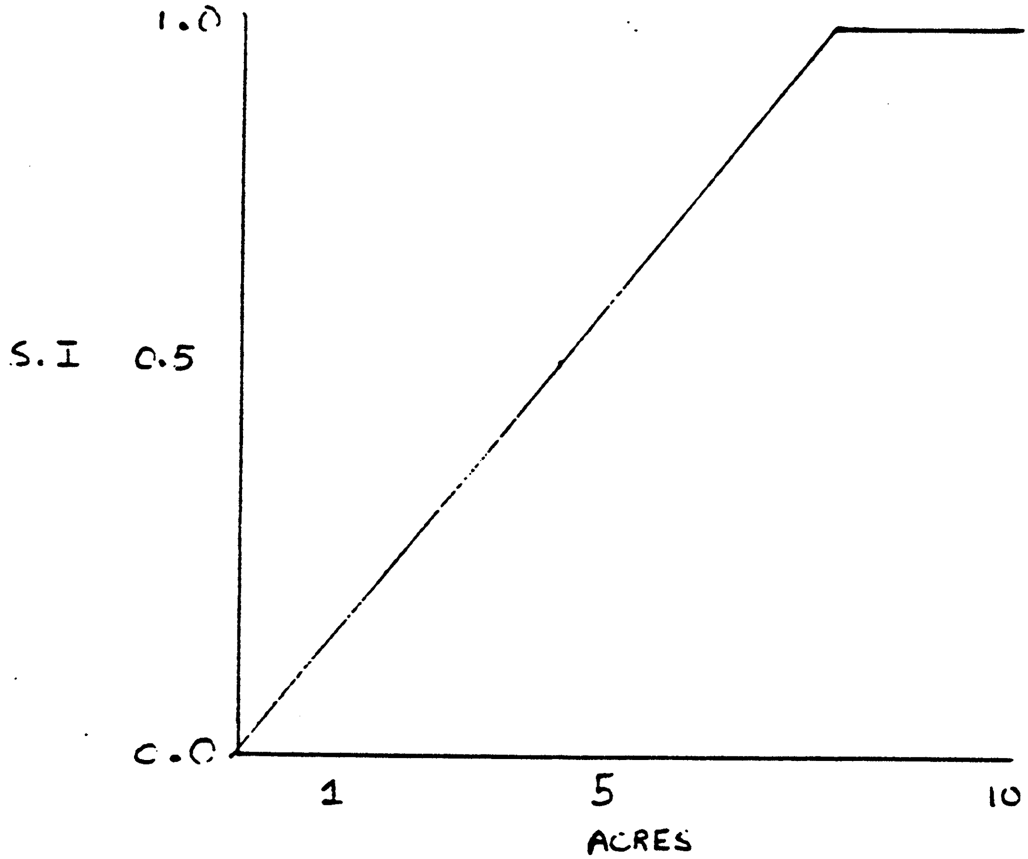
- A minimum of three acres of nesting and rearing wetland habitat is needed within hen breeding home range to support one mallard pair. Maximum production will result from the proximity and interspersion of nesting and rearing habitat (Dzubin 1969).

- Deep marshes should be within a 1 mile radius of shallow marshes (Jahn and Hunt 1964).

APPENDIX A

Suitability index obtained from the USFWS draft Habitat Suitability Index Models - mallard (USFWS 1985).

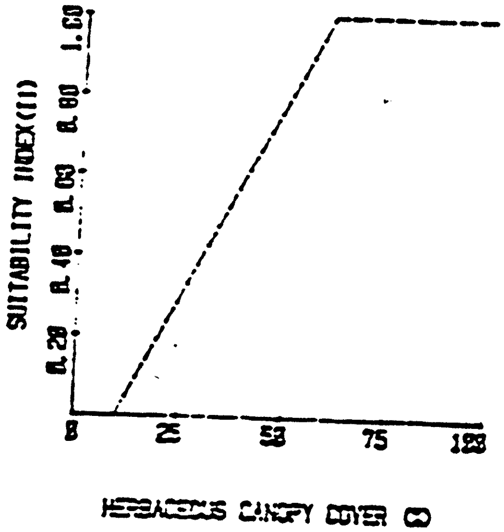
Size of Water Body (Winter & Migration)
(USFWS 1985)

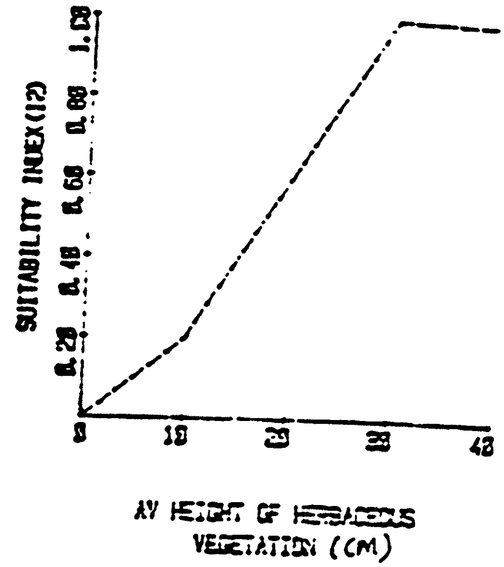


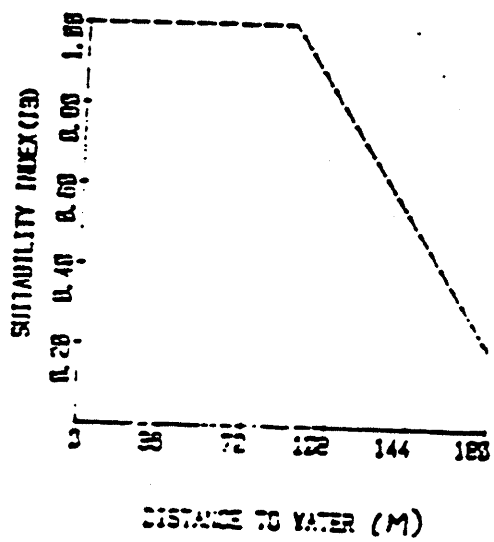
MALLARD

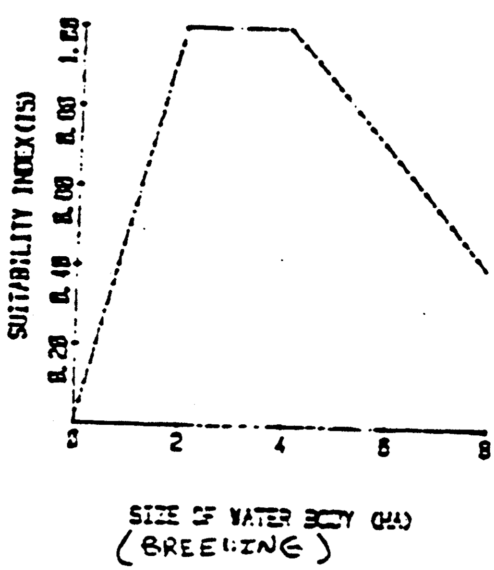
TREE-DOMINATED WETLAND

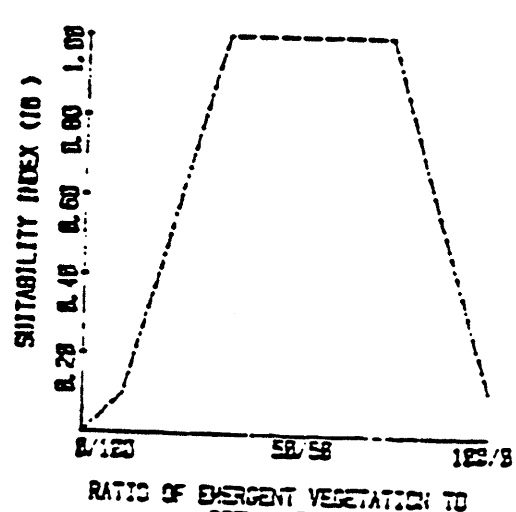
MARCH 1979
REVIEW COPY
ECORPEDIC 2410











SAVANNAH SPARROW
Grassland/Agricultural Type

General

Open grasslands are the preferred habitat of the savannah sparrow (Passerculus sandwichensis) (Gabrielson and Jewett 1940). Within this Ecoregion it occurs primarily as a summer breeder in the transition zone, and is commonly found in open fields, plains, and meadows at lower elevations throughout western Washington and Oregon (Larrison and Sonnenberg 1968).

Food Requirements

The savannah sparrow eats mostly grass seed and insects (Norris 1960; Wiens 1969). Dragonflies (Odonata), butterflies (Lepidoptera), true bugs (Hemiptera), wasps, ants, and bees (Hymenoptera), aphids (Homoptera), spiders (Arachnida) and oligochaete worms were invertebrates eaten by the savannah sparrow in Wisconsin (Wiens 1969). Wiens (1973) stated that savannah sparrows concentrated their feeding around the perimeter of grass clumps and foraged primarily in low grass cover that was mostly under four inches (10 cm) in height (Wiens 1969). Cody (1968) found that savannah sparrows foraged on vegetation below 3 inches (7.6 cm) in height.

Water Requirements

No specific drinking water requirements were found in the literature. Moisture seems to be a factor through its influence on the density of low vegetation (Wiens 1969).

Cover Requirements

No specific information on cover requirements, other than for reproduction, was found in the literature. In most inland locations, cover needs seem to be satisfied by low-lying, moist, open grassy fields with scattered forbs in which the ground layer vegetation (grasses and accumulated litter) is fairly dense (Tester and Marshall 1961). Litter was found to be one of the most important features of savannah sparrow habitat. Linsdale (1938) concluded that the factor determining the local presence of the savannah sparrow in the Great Basin was the dense cover of low vegetation.

Reproductive Requirements

Male savannah sparrows establish territories during the breeding season (Wiens 1973). Territory size on a Wisconsin field ranged from .4 to 4.3 acres (.2-1.7 ha) with a mean size of 1.7 acres (.7 ha) (Wiens 1969). The breeding territory must satisfy all of the life requirements of the mated pairs and their young throughout the nesting season, as they will not travel outside their territorial boundaries. Scattered tall forbs, low shrubs, or fence posts and fence lines, if available, are used by the male bird to advertise and defend his territory through singing displays. Where sufficiently tall forbs are not present, small deciduous shrubs may be used as song perches (Johnsgard and Rickard 1957).

Wiens (1969) found an average of 600 forbs per .01 acre (.004 ha) on the savannah sparrow territories in his Wisconsin study. The mean percentage of forb cover on savannah sparrow territories ranged from 20 to 35% depending on the time of territorial establishment with a range of approximately 15 to 42% (Wiens 1973). Wiens (1969) found that forb height within breeding territories ranged from 2.7 to 19.6 inches (7 to 50 cm) with a mean of 7.8 inches (20 cm). Savannah sparrow nests were constructed on the ground in dense grass vegetation and were well concealed. Nineteen of 27 nests were either partially domed or well placed under overhanging litter. All nests were located in areas having 100% litter cover. The entire nesting territory had greater than 64% litter coverage. The mean litter depth for nests was 3 inches (7.8 cm) with the majority of nest sites in litter greater than .4 inches (1 cm) in depth. The percentage of grass cover over most of the nesting territories ranged from 62 to 100% with a mean of 88%.

Special Habitat Requirements

No special habitat requirements were found in the literature.

Interspersion Requirements

Savannah sparrows remain within the grassland vegetation type throughout the year and they show no special need for any adjacent cover types.

Special Considerations

Hayfields and grain fields are utilized by savannah sparrows in place of natural grasslands (Larrison and Sonnenberg 1968). Of the three subspecies of the savannah sparrow that occur in western Washington, Brook's Savannah Sparrrow (*P. sandwichensis brooksi*) is the subspecies which breeds within the ecoregion. The three subspecies are listed as winter visitors West of the Cascades (Sonneberg and Larrison 1968).

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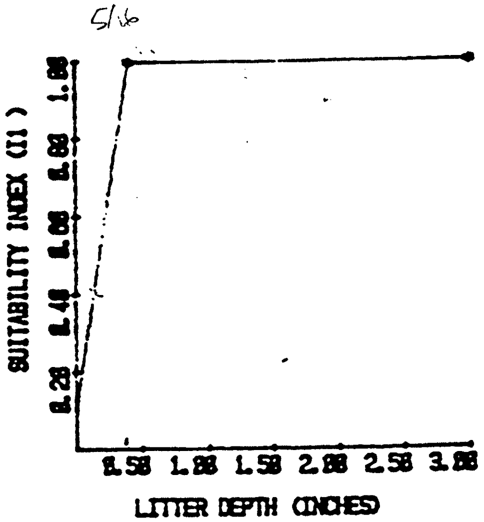
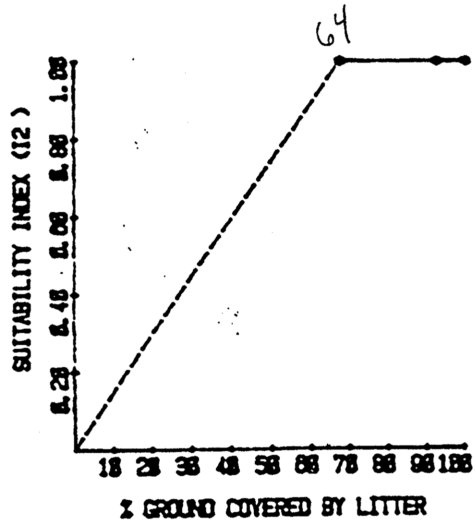
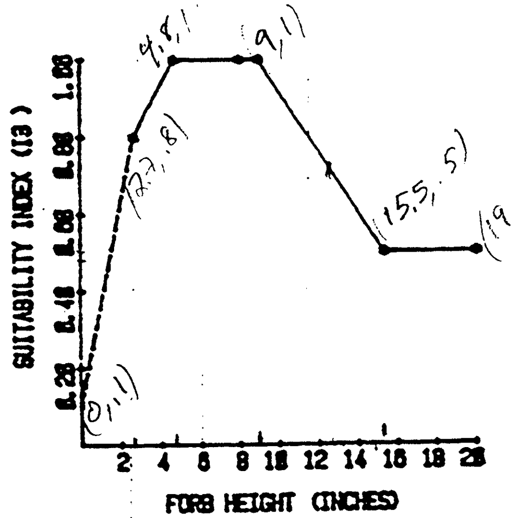
DRAF

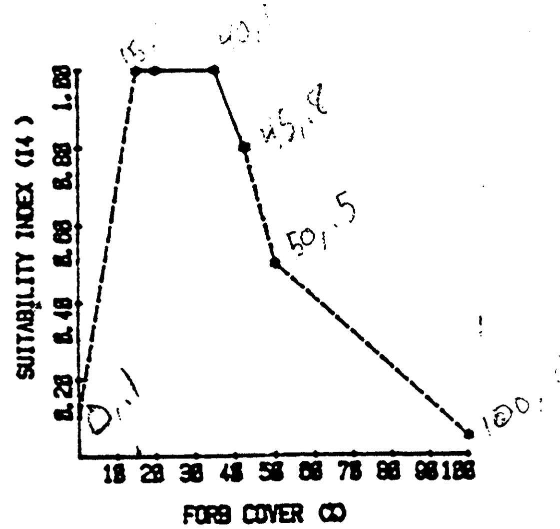
SAVANNAH SPARROW

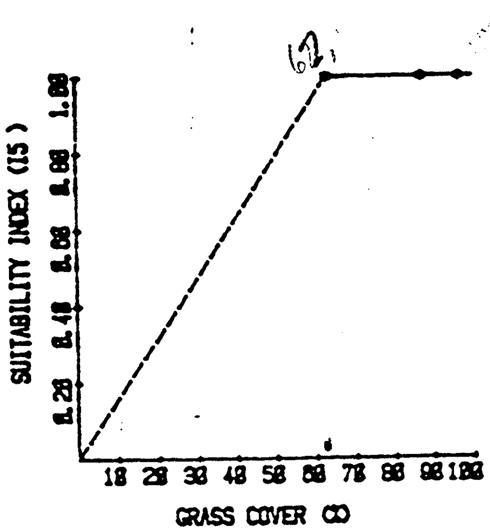
GRASSLAND/AGRICULTURAL











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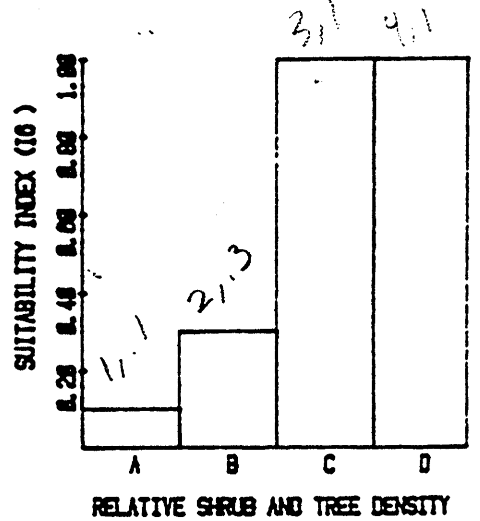
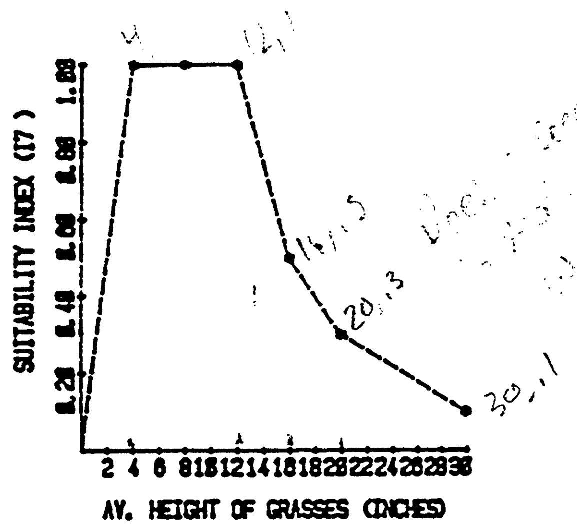
SAVANNAH SPARROW

GRASSLAND/AGRICULTURAL



A=TREES OR SHRUBS PREVALENT THROUGHOUT SAMPLE SITE
B=WIDELY SCATTERED TREES OR SHRUBS THROUGHOUT SAMPLE SITE (SAVANNAH)
C=NO TREES OR TALL SHRUBS PRESENT; A FEW LOW SHRUBS SCATTERED THROUGHOUT SAMPLE SITE
D=NO TREES OR SHRUBS PRESENT ON SAMPLE SITE



DRAF

June 1978

HABITAT SUITABILITY INDEX

Savannah Sparrow in Grassland/Agricultural Type

Ecoregion 2410

Reproductive Value * $(X_1) = \left[\frac{(I_1 + I_2 + I_3 + I_4 + I_7)}{5} \times \frac{(I_5 + I_6)}{2}\right]^{1/2}$

Where: I_1 = Suitability Index (SI) of litter depth.

I_2 = SI of percent of ground covered by litter.

I_3 = SI of forb height.

I_4 = SI of percent forb cover.

I_5 = SI of percent grass cover.

I_6 = SI of relative shrub and tree density.

I_7 = SI of average height of grasses.

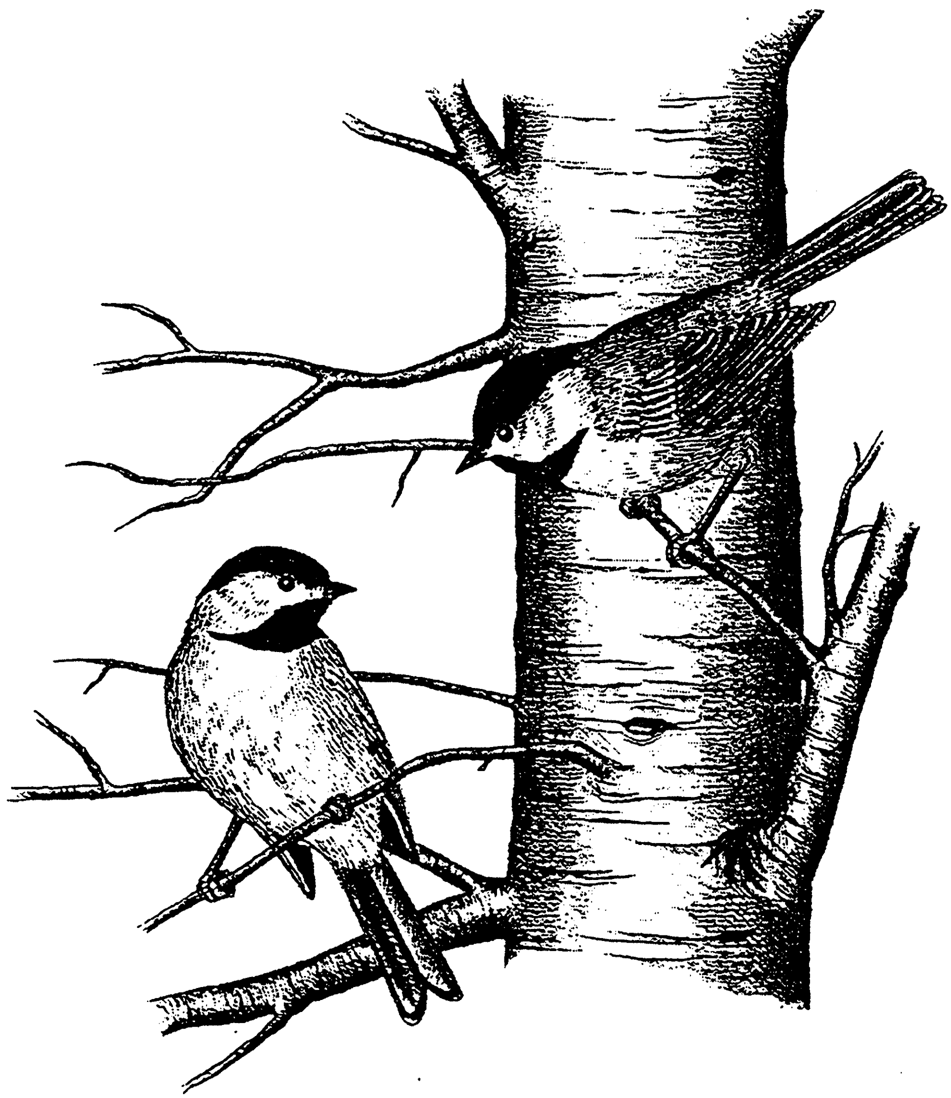
* If reproductive needs are satisifed, all other food and cover needs will also be satisfied.

The Habitat Suitability Index is X_1.

DRAF

FWS/OBS-82/10.37
APRIL 1983

HABITAT SUITABILITY INDEX MODELS: BLACK-CAPPED CHICKADEE



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.

FWS/OBS-82/10.37
April 1983

HABITAT SUITABILITY INDEX MODELS: BLACK-CAPPED CHICKADEE

by

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Washington, DC 20240

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PREFACE

This document is part of the Habitat Suitability Index (HSI) Model Series (FWS/OBS-82/10), which provides habitat information useful for impact assessment and habitat management. Several types of habitat information are provided. The Habitat Use Information Section is largely constrained to those data that can be used to derive quantitative relationships between key environmental variables and habitat suitability. The habitat use information provides the foundation for HSI models that follow. In addition, this same information may be useful in the development of other models more appropriate to specific assessment or evaluation needs.

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

In essence, the model presented herein is a hypothesis of species-habitat relationships and not a statement of proven cause and effect relationships. Results of model performance tests, when available, are referenced. However, models that have demonstrated reliability in specific situations may prove unreliable in others. For this reason, feedback is encouraged from users of this model concerning improvements and other suggestions that may increase the utility and effectiveness of this habitat-based approach to fish and wildlife planning. Please send suggestions to:

Habitat Evaluation Procedures Group
Western Energy and Land Use Team
U.S. Fish and Wildlife Service
2627 Redwing Road
Ft. Collins, CO 80526

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BLACK-CAPPED CHICKADEE (*Parus atricapillus*)

HABITAT USE INFORMATION

General

The black-capped chickadee (*Parus atricapillus*) inhabits wooded areas in the northern United States, Canada, and the higher elevations of mountains in southern Appalachia (Tanner 1952; Brewer 1963; Merritt 1981). The black-capped chickadee nests in cavities in dead or hollow trees (Nickell 1956), in a variety of forest types (Dixon 1961).

Food

Black-capped chickadees are insectivorous gleaners (Brewer 1963; Sturman 1968b) that select prey in proportion to its availability (Brewer 1963). Insect food is mostly gleaned from tree bark on twigs, branches, and boles; or from the foliage, fruits, and flowers of trees (Brewer 1963). Caterpillars are an important food for nestling chickadees (Odum 1942; Kluyver 1961; Sturman 1968a). Insect and spider eggs make up a large portion of the winter diet, and, although the use of plant material for food is low during much of the year, seeds of trees and shrubs may account for about half of the winter diet (Martin et al. 1961). Seeds of weedy plants, such as giant ragweed (*Ambrosia* spp.), are favorite winter foods (Fitch 1958).

Black-capped chickadees are versatile in their foraging habits and forage from the ground to the tree tops in a variety of habitats, although they prefer to forage at low or intermediate heights in trees and shrubs (Odum 1942). Chickadees in British Columbia showed a preference for foraging within 1.5 m (5.0 ft) of the ground (Smith 1967).

Black-capped chickadees in western Washington selected their territories before the amount of insect food (especially caterpillars) was apparent, and it appeared that canopy volume of trees was the proximate cue used by the chickadees to determine potential food supply, since chickadee abundance showed a strong positive correlation with canopy volume (Sturman 1968a). Caterpillars eat foliage and their abundance should vary directly with total foliage weight. There was a strong positive correlation between total foliage weight and canopy volume, and, hence, canopy volume provided a good estimate of potential insect abundance. The highest chickadee densities occurred at canopy volumes of about 10.2 m^3 of foliage/1 m^2 of ground surface (33.5 ft^3/ft^2).

Water

Drinking water requirements are met with surface water and snow (Odum 1942).

Cover

The black-capped chickadee occurs in both deciduous and evergreen forests in the eastern United States, although it is restricted to deciduous forests along streams in the Northern Great Plains, northern Rocky Mountains, and Great Basin areas (Dixon 1961). In some areas where the ranges of the black-capped chickadee and Carolina chickadee (*P. carolinensis*) come together, apparently suitable habitat exists where neither chickadee occurs (Tanner 1952; Brewer 1963; Merritt 1981). Deciduous forest types are preferred in western Washington (Sturman 1968a) and commonly used in Oregon (Gabrielson and Jewett 1940). Fall and winter roosts in New York were mostly on dense conifer branches, with some use of cavities (Odum 1942). Black-capped chickadees in Oregon and Washington excavated winter roost cavities in snags (Thomas et al. 1979). Winter roosts in deciduous forests of Minnesota were on the branches of trees and bushes that had retained their foliage (Van Gorp and Langager 1974).

Black-capped chickadee populations in Kansas tended to concentrate along edges between forest and early successional areas (Fitch 1958). The availability of suitable tree cavities for roosting may have been a limiting factor in this study area.

Reproduction

The black-capped chickadee nests in a cavity, usually in a dead or hollow tree (Nickell 1956). The presence of available nest sites, or trees that could be excavated, appeared to determine the chickadee's choice of nesting habitat. Two important factors affecting the use of stub trees in Michigan were height and the suitability of the tree for excavation (Brewer 1963). Willows (*Salix* spp.), pines (*Pinus* spp.), cottonwoods and poplars (*Populus* spp.), and fruit trees of the genera *Pyrus* and *Prunus* are frequently chosen for nest sites (Brewer 1961).

Black-capped chickadees are only able to excavate a cavity in soft or rotten wood (Odum 1941a, b). Trees with decayed heartwood, but firm sapwood, are usually chosen (Brewer 1961). Black-capped chickadees almost always do some excavation at the nest site (Tyler 1946), although they will use existing woodpecker holes, natural cavities, man-made nest boxes, and open topped fence posts (Nickell 1956). The average tree diameter at nest sites was 11.4 cm (4.5 inches), and preferred tree stubs apparently ranged from 10 to 15 cm (3.9 to 5.9 inches) in diameter (Brewer 1963). The minimum dbh of cavity trees used by black-capped chickadees is 10.2 cm (4 inches) (Thomas et al. 1979). Heights of 18 nests in New York ranged from 0.3 to 12.2 m (1 to 40 ft), although only three nests were higher than 4.6 m (15 ft) and 11 nests were under 3.0 m (10 ft) (Odum 1941b).

Nests in New York were usually located in open areas, commonly in young forests, hedgerows, or field borders (Odum 1941a). Willow, alder (Alnus spp.) and cottonwood trees were common nest trees in Washington (Jewett et al. 1953). Black-capped chickadees used second growth alder for nesting sites in British Columbia (Smith 1967).

Interspersion

Black-capped chickadees maintain a territory during the breeding season and flock in the winter months (Odum 1941b; Stefanski 1967). Territory size during nest building in Utah averaged 2.3 ha (5.8 acres) (Stefanski 1967).

Territory size in New York varied from 3.4 ha to 6.9 ha (8.4 to 17.1 acres), with an average size of 5.3 ha (13.2 acres) (Odum 1941a). The larger territories were in open or sparsely wooded country; the size of the territory decreased as the nesting period progressed. The mean home range size of winter flocks was 9.9 ha (24.4 acres) in Kansas (Fitch 1958), 15.0 ha (37 acres) in Michigan (Brewer 1978), and 14.6 ha (36 acres) in New York (Odum 1942) and in Minnesota (Ritchison 1979).

Black-capped chickadees nesting on forest islands in central New Jersey did not nest in forests less than 2 ha (4.8 acres) in size (Galli et al. 1976). However, this apparent dependency on a minimum size forest may have been due to a lack of nesting cavities.

HABITAT SUITABILITY INDEX (HSI) MODEL

Model Applicability

Geographic area. This model was developed for the entire breeding range of the black-capped chickadee.

Season. This model was developed to evaluate the breeding season habitat needs of the black-capped chickadee.

Cover types. This model was developed to evaluate habitat in Deciduous Forest (DF), Evergreen Forest (EF), Deciduous Forested Wetland (DFW), and Evergreen Forested Wetland (EFW) areas (terminology follows that of U.S. Fish and Wildlife Service 1981). It should be noted that, although the chickadee occurs in both deciduous and evergreen forests over much of its range, apparently there are geographic differences in use of cover types that limit the use of evergreen forests in parts of its range. Users should be familiar with the chickadee's major cover type preferences in their particular area before applying this model.

Minimum habitat area. Minimum habitat area is defined as the minimum amount of contiguous habitat that is required before an area will be occupied by a species. Although Galli et al. (1976) report that black-capped chickadees may be dependent on certain forest sizes, other studies state that these chickadees will nest in hedgerows and field borders. This model assumes that forest size is not an important factor in assessing habitat suitability for the black-capped chickadees.

Verification level. Previous drafts of this model were reviewed by Peter Merritt, and his specific comments have been incorporated into the current draft (Merritt, pers. comm.).

Model Description

Overview. This model considers the ability of the habitat to meet the food and reproductive needs of the black-capped chickadee as an indication of overall habitat suitability. Cover needs are assumed to be met by food and reproductive requirements and water is assumed not to be limiting. The food component of this model assesses vegetation conditions, and the reproduction component assesses the abundance of suitable snags. The relationship between habitat variables, life requisites, cover types, and the HSI for the black-capped chickadee is illustrated in Figure 1.

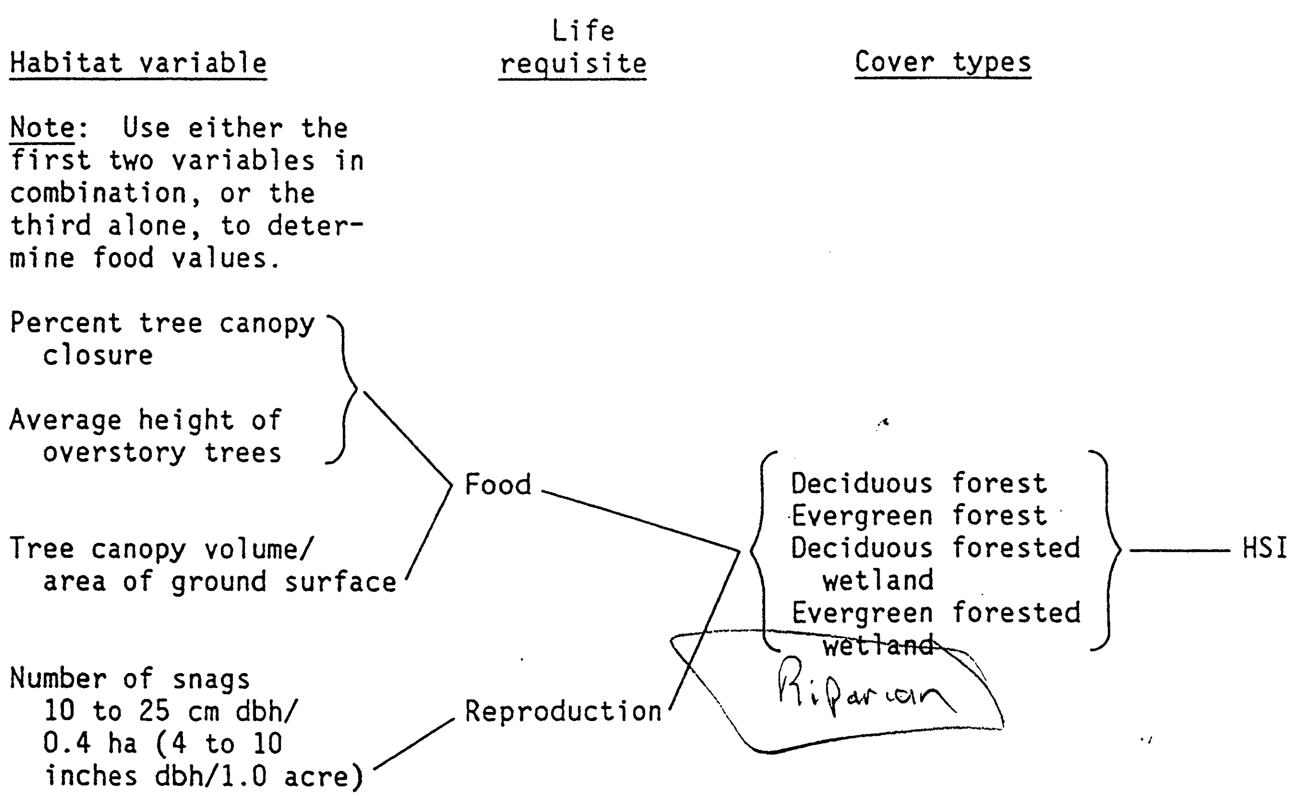


Figure 1. Relationship of habitat variables, life requisites, and cover types in the black-capped chickadee model.

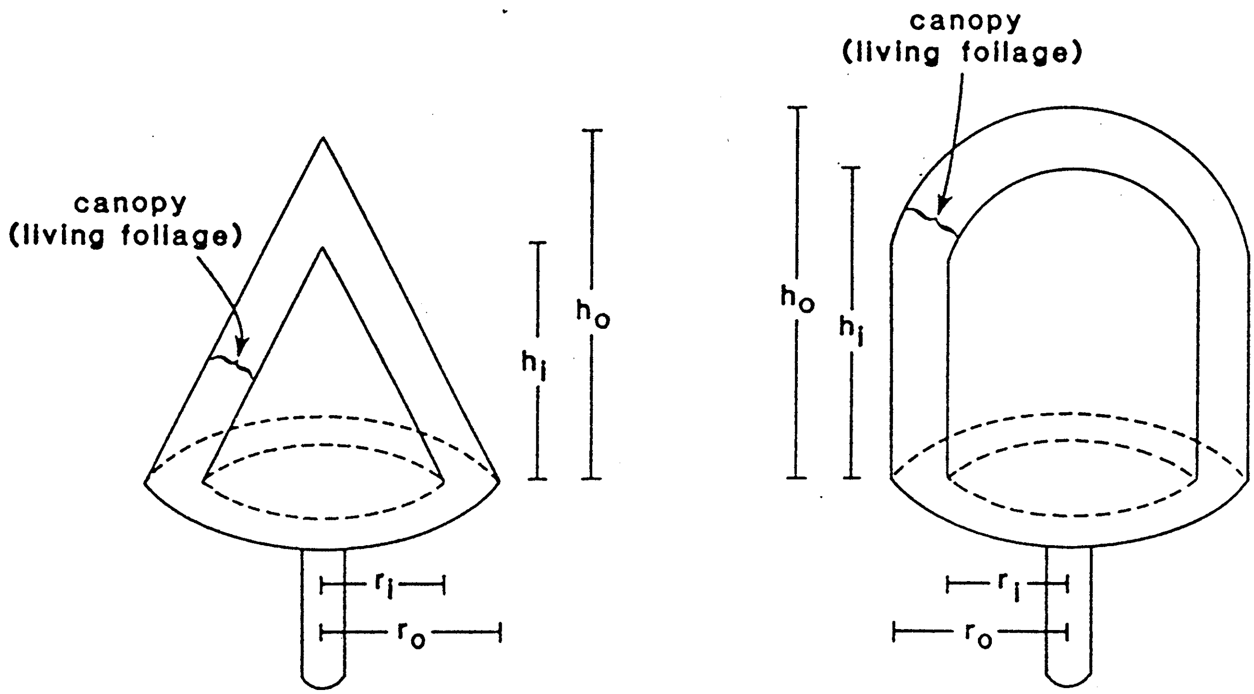
The following sections provide a written documentation of the logic and assumptions used to interpret the habitat information for the black-capped chickadee in order to explain the variables and equations that are used in the HSI model. Specifically, these sections cover the following: (1) identification of variables that will be used in the model; (2) definition and justification of the suitability levels of each variable; and (3) description of the assumed relationship between variables.

Food component. The majority of the year-round food supply of the black-capped chickadee is associated with trees. It is assumed that an accurate assessment of food suitability for the chickadee can be provided by a measure of either: (1) tree canopy closure and the average height of overstory trees; or (2) canopy volume of trees per area of ground surface. It is assumed that optimum canopy closures occur betwen 50 and 75%. A completely closed canopy will have less than optimum value due to an assumed lack of foliage in the middle and lower canopy layers. It is assumed that optimum habitats contain overstory trees 15 m (49.2 ft) or more in height. Habitats with a low canopy closure can provide moderate suitability for black-capped chickadees if tree heights are optimum. Likewise, habitats with short trees may have moderate suitability if canopy closures are optimum.

The canopy volume of an individual tree is equal to the area occupied by the living foliage of that tree, as shown in Figure 2 for deciduous and coniferous trees. Optimum canopy volume per area of ground surface exceeds 10.2 m^3 of foliage/m^2 of ground surface (33.5 ft^3 of foliage/ft^2 of ground surface). Suitability will decrease to zero as canopy volume approaches zero.

The field user should measure either: (1) tree canopy closure and tree height; or (2) tree canopy volume per area of ground surface. Tree canopy closure and tree height measurements are probably the most rapid method to assess food suitability. However, the suitability levels of these variables were not based on strong data sources. The suitability levels of tree canopy volume were based on data from Sturman (1968a).

Reproduction component. Black-capped chickadees nest primarily in small dead or hollow trees and can only excavate a cavity in soft or rotten wood. Therefore, reproduction suitability is assumed to be related to the abundance of small snags. It is assumed that snags between 10 and 25 cm (4 and 10 inches) dbh are required. Thomas et al. (1979) and Evans and Conner (1979) provide methods to estimate the number of snags required for cavity nesting birds. Assuming a territory size of 2.4 ha (6.0 acres) and a need for one cavity per year per chickadee pair, the method of Thomas et al. (1979) estimates that optimum habitats provide 5.9 snags/ha (2.4/acre), and the method of Evans and Conner (1979) estimates that 4.1 snags are needed per ha (1.67/acre) to provide optimum conditions. This model assumes that optimum suitability exists when there are five or more snags of the proper size per ha (2/acre), and that suitability will decrease to zero as the number of snags approaches zero.



CONIFEROUS

$$CV = \pi/3(h_o r_o^2 - h_i r_i^2)$$

DECIDUOUS

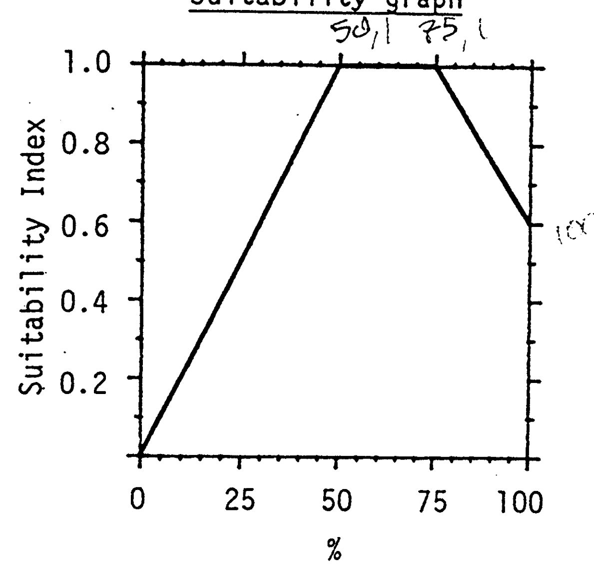
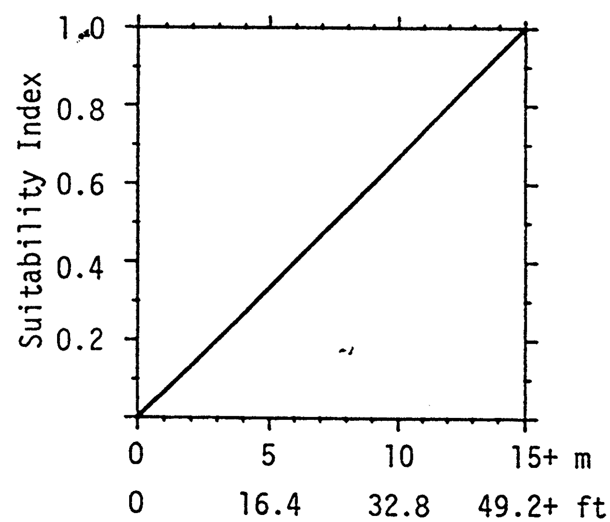
$$CV = 2\pi/3(h_o r_o^2 - h_i r_i^2)$$

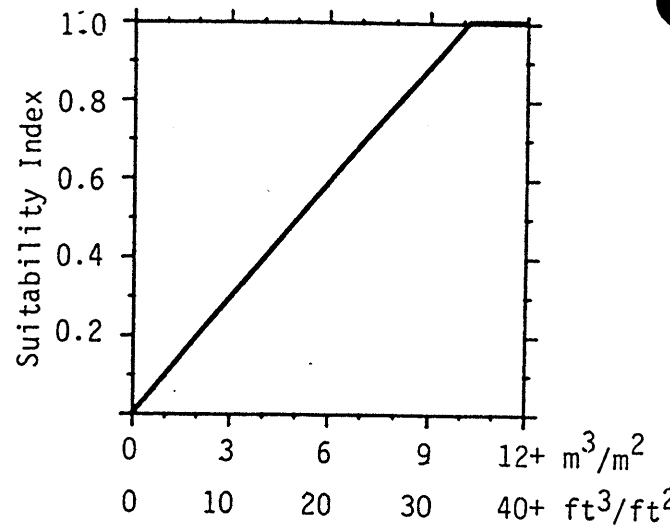
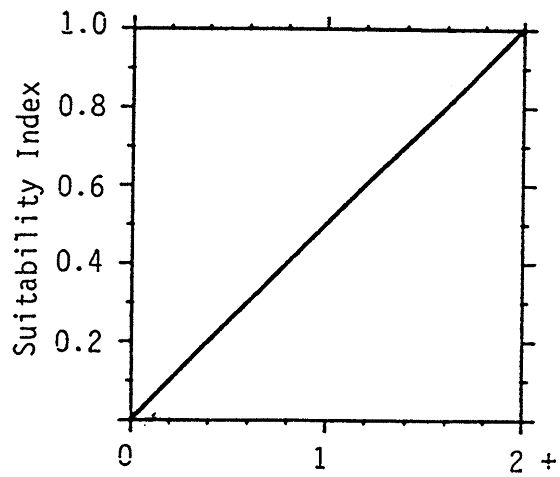
where: h_i = inner height
h_o = outer height
r_i = inner radius
r_o = outer radius

Figure 2. Tree shapes assumed and formulae used to calculate canopy volume (CV). (From Sturman 1968a).

Model Relationships

Suitability Index (SI) graphs for habitat variables. This section contains SI graphs that illustrate the habitat relationships described in the previous section.

Cover type	Variable		Suitability graph
DF, EF, DFW, EFW	V_1	Percent tree canopy closure.	
DF, EF, DFW, EFW	V_2	Average height of overstory trees.	

DF,EF, DFW,EFW	V_3	Tree canopy volume/ area of ground surface.	
DF,EF, DFW,EFW	V_4	Number of snags 10 to 25 cm dbh/ 0.4 ha (4 to 10 inches dbh/1.0 acre).	

Equations. In order to determine life requisite values for the black-capped chickadee, the SI values for appropriate variables must be combined through the use of equations. A discussion and explanation of the assumed relationships between variables was included under Model Description, and the specific equations in this model were chosen to mimic these perceived biological relationships as closely as possible. The suggested equations for obtaining food and reproduction values are presented below.

Life requisite	Cover type	Equation
Food	DF,EF,DFW,EFW	$(V_1 \times V_2)^{1/2}$ or V_3 (See page 5 for discussion on which to use)
Reproduction	DF,EF,DFW,EFW	V_4

HSI determination. The HSI for the black-capped chickadee is equal to the lowest life requisite value.

Application of the Model

Definitions of variables and suggested field measurement techniques (from Hays et al. 1981, unless otherwise noted) are provided in Figure 3.

Variable (definition)		Cover types	Suggested technique
V_1	Percent tree canopy closure [the percent of the ground surface that is shaded by a vertical projection of the canopies of all woody vegetation taller than 5.0 m (16.5 ft)].	DF,EF,DFW,EFW	Line intercept
V_2	Average height of overstory trees (the average height from the ground surface to the top of those trees which are ≥ 80 percent of the height of the tallest tree in the stand).	DF,EF,DFW,EFW	Graduated rod, trigonometric hypsometry
V_3	Tree canopy volume/area of ground surface (the sum of the volume of the canopies of each tree sampled divided by the total area sampled).	DF,EF,DFW,EFW	Quadrat and refer to Figure 2 on page 6

Figure 3. Definitions of variables and suggested measurement techniques.

Variable (definition)		Cover types	Suggested technique
V_4	Number of snags 10 to 25 cm dbh/0.4 ha (4 to 10 inches dbh/1.0 acre) [the number of standing dead trees or partly dead trees in the size class indicated that are at least 1.8 m (6 ft) tall. Trees in which at least 50% of the branches have fallen, or are present but no longer bear foliage, are to be considered snags].	DF,EF,DFW,EFW	Quadrat

Figure 3. (concluded).

SOURCES OF OTHER MODELS

Sturman (1968a) developed a multiple regression model for the black-capped chickadee in western Washington in which the canopy volume of trees accounted for 79.6% of the variation in chickadee abundance. Canopy volume of bushes and canopy volume of midstory trees were the next two most important variables, and their addition into the regression accounted for over half of the residual variation remaining after the canopy volume of trees was entered.

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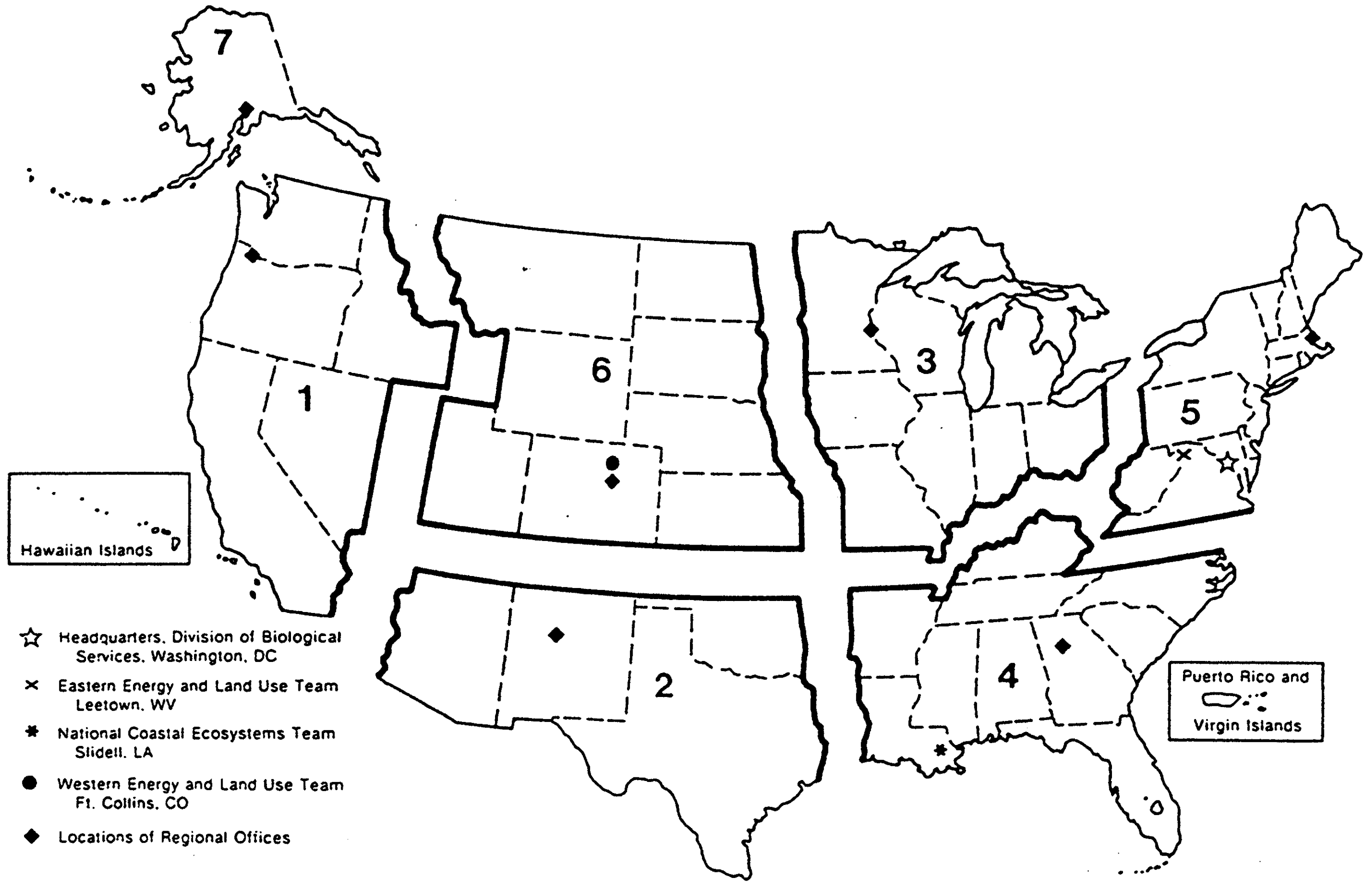

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A review and synthesis of existing information was used to develop a habitat model for the black-capped chickadee (Parus atricapillus). The model is scaled to produce an index of habitat suitability between 0 (unsuitable habitat) and 1 (optimally suitable habitat) for areas of the continental United States. Habitat suitability indexes are designed for use with Habitat Evaluation Procedures previously developed by the U.S. Fish and Wildlife Service.

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HABITAT SUITABILITY INDEX MODELS: YELLOW WARBLER

Fish and Wildlife Service

U.S. Department of the Interior

FWS/OBS-82/10.27
July 1982

HABITAT SUITABILITY INDEX MODELS: YELLOW WARBLER

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PREFACE

This document is part of the Habitat Suitability Index (HSI) Model Series (FWS/OBS-82/10), which provides habitat information useful for impact assessment and habitat management. Several types of habitat information are provided. The Habitat Use Information Section is largely constrained to those data that can be used to derive quantitative relationships between key environmental variables and habitat suitability. The habitat use information provides the foundation for HSI models that follow. In addition, this same information may be useful in the development of other models more appropriate to specific assessment or evaluation needs.

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

In essence, the model presented herein is a hypothesis of species-habitat relationships and not a statement of proven cause and effect relationships. Results of model performance tests, when available, are referenced. However, models that have demonstrated reliability in specific situations may prove unreliable in others. For this reason, feedback is encouraged from users of this model concerning improvements and other suggestions that may increase the utility and effectiveness of this habitat-based approach to fish and wildlife planning. Please send suggestions to:

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YELLOW WARBLER (*Dendroica petechia*)

HABITAT USE INFORMATION

General

The yellow warbler (*Dendroica petechia*) is a breeding bird throughout the entire United States, with the exception of parts of the Southeast (Robbins et al. 1966). Preferred habitats are wet areas with abundant shrubs or small trees (Bent 1953). Yellow warblers inhabit hedgerows, thickets, marshes, swamp edges (Starling 1978), aspen (*Populus* spp.) groves, and willow (*Salix* spp.) swamps (Salt 1957), as well as residential areas (Morse 1966).

Food

More than 90% of the food of yellow warblers is insects (Bent 1953), taken in proportion to their availability (Busby and Sealy 1979). Foraging in Maine occurred primarily on small limbs in deciduous foliage (Morse 1973).

Water

Dietary water requirements were not mentioned in the literature. Yellow warblers prefer wet habitats (Bent 1953; Morse 1966; Stauffer and Best 1980).

Cover

Cover needs of the yellow warbler are assumed to be the same as reproduction habitat needs and are discussed in the following section.

Reproduction

Preferred foraging and nesting habitats in the Northeast are wet areas, partially covered by willows and alders (*Alnus* spp.), ranging in height from 1.5 to 4 m (5 to 13.3 ft) (Morse 1966). It is unusual to find yellow warblers in extensive forests (Hebard 1961) with closed canopies (Morse 1966). Yellow warblers in small islands of mixed coniferous-deciduous growth in Maine utilized deciduous foliage far more frequently than would be expected by chance alone (Morse 1973). Coniferous areas were mostly avoided and areas of low deciduous growth preferred.

Nests are generally placed 0.9 to 2.4 m (3 to 8 ft) above the ground, and nest heights rarely exceed 9.1 to 12.2 m (30 to 40 ft) (Bent 1953). Plants used for nesting include willows, alders, and other hydrophytic shrubs and trees (Bent 1953), including box-elders (Acer negundo) and cottonwoods (Populus spp.) (Schrantz 1943). In Iowa, dense thickets were frequently occupied by yellow warblers while open thickets with widely spaced shrubs rarely contained nests (Kendeigh 1941).

Males frequently sing from exposed song perches (Kendeigh 1941; Ficken and Ficken 1965), although yellow warblers will nest in areas without elevated perches (Morse 1966).

A number of Breeding Bird Census reports (Van Velzen 1981) were summarized to determine nesting habitat needs of the yellow warbler, and a clear pattern of habitat preferences emerged. Yellow warblers nested in less than 5% of census areas comprised of extensive upland forested cover types (deciduous or coniferous) across the entire country. Approximately two-thirds of all census areas with deciduous shrub-dominated cover types were utilized, while shrub wetland types received 100% use. Wetlands dominated by shrubs had the highest average breeding densities of all cover types [2.04 males per ha (2.5 acre)]. Approximately two-thirds of the census areas comprised of forested draws and riparian forests of the western United States were used, but average densities were low [0.5 males per ha (2.5 acre)].

Interspersion

Yellow warblers in Iowa have been reported to prefer edge habitats (Kendeigh 1941; Stauffer and Best 1980). Territory size has been reported as 0.16 ha (0.4 acre) (Kendeigh 1941) and 0.15 ha (0.37 acre) (Kammeraad 1964).

Special Considerations

The yellow warbler has been on the Audubon Society's Blue List of declining birds for 9 of the last 10 years (Tate 1981).

HABITAT SUITABILITY INDEX (HSI) MODEL

Model Applicability

Geographic area. This model has been developed for application within the breeding range of the yellow warbler.

Season. This model was developed to evaluate the breeding season habitat needs of the yellow warbler.

Cover types. This model was developed to evaluate habitat in the dominant cover types used by the yellow warbler: Deciduous Shrubland (DS) and Deciduous Scrub/Shrub Wetland (DSW) (terminology follows that of U.S. Fish and Wildlife Service 1981). Yellow warblers only occasionally utilize forested habitats and reported population densities in forests are low. The habitat requirements in forested habitats are not well documented in the literature. For these reasons, this model does not consider forested cover types.

Minimum habitat area. Minimum habitat area is defined as the minimum amount of contiguous habitat that is required before an area will be occupied by a species. Information on the minimum habitat area for the yellow warbler was not located in the literature. Based on reported territory sizes, it is assumed that at least 0.15 ha (0.37 acre) of suitable habitat must be available for the yellow warbler to occupy an area. If less than this amount is present, the HSI is assumed to be 0.0.

Verification level. Previous drafts of the yellow warbler habitat model were reviewed by Douglass H. Morse and specific comments were incorporated into the current model (Morse, pers. comm.).

Model Description

Overview. This model considers the quality of the reproduction (nesting) habitat needs of the yellow warbler to determine overall habitat suitability. Food, cover, and water requirements are assumed to be met by nesting needs.

The relationship between habitat variables, life requisites, cover types, and the HSI for the yellow warbler is illustrated in Figure 1.

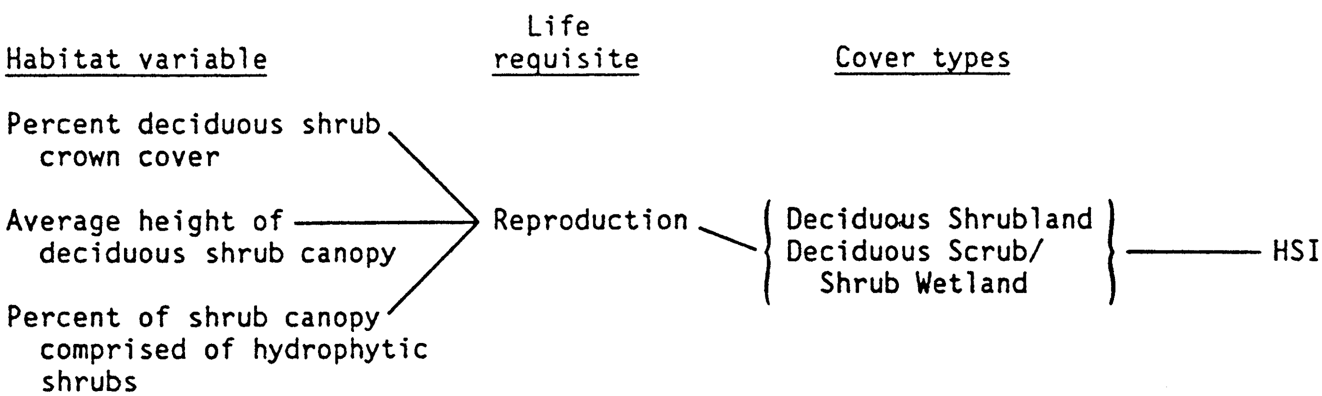


Figure 1. Relationship between habitat variables, life requisites, cover types, and the HSI for the yellow warbler.

The following sections provide a written documentation of the logic and assumptions used to interpret the habitat information for the yellow warbler and to explain and justify the variables and equations that are used in the HSI model. Specifically, these sections cover the following: (1) identification of variables that will be used in the model; (2) definition and justification of the suitability levels of each variable; and (3) description of the assumed relationship between variables.

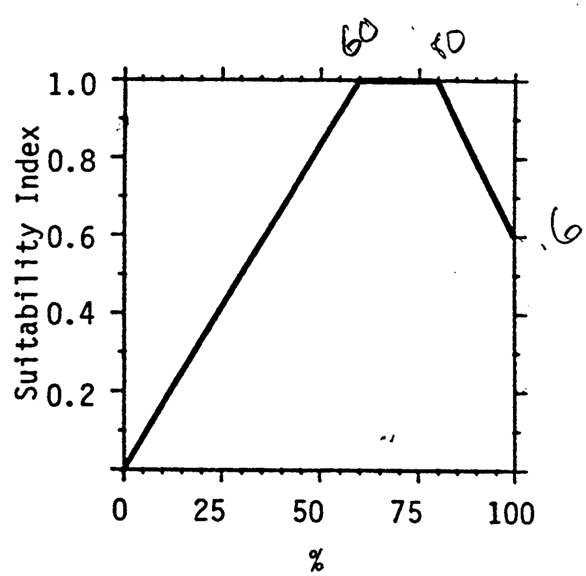
Reproduction component. Optimal nesting habitat for the yellow warbler is provided in wet areas with dense, moderately tall stands of hydrophytic deciduous shrubs. Upland shrub habitats on dry sites will provide only marginal suitability.

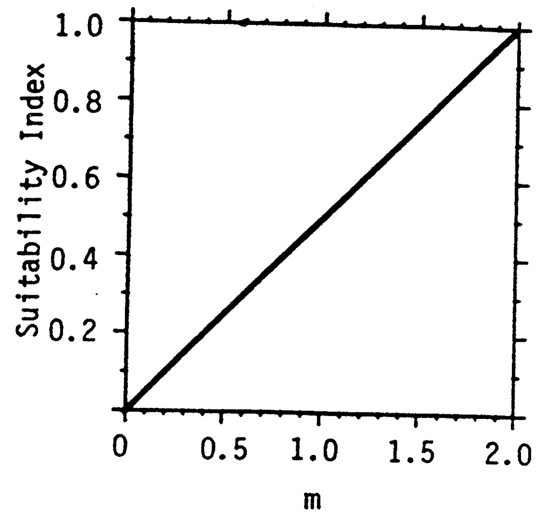
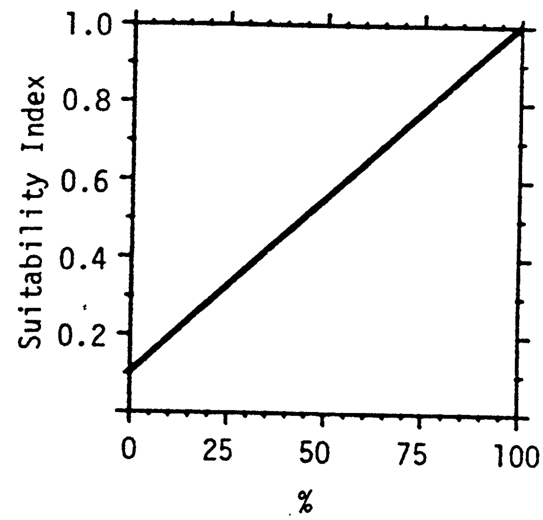
It is assumed that optimal habitats contain 100% hydrophytic deciduous shrubs and that habitats with no hydrophytic shrubs will provide marginal suitability. Shrub densities between 60 and 80% crown cover are assumed to be optimal. As shrub densities approach zero cover, suitability also approaches zero. Totally closed shrub canopies are assumed to be of only moderate suitability, due to the probable restrictions on movement of the warblers in those conditions. Shrub heights of 2 m (6.6 ft) or greater are assumed to be optimal, and suitability will decrease as heights decrease to zero.

Each of these habitat variables exert a major influence in determining overall habitat quality for the yellow warbler. A habitat must contain optimal levels of all variables to have maximum suitability. Low values of any one variable may be partially offset by higher values of the remaining variables. Habitats with low values for two or more variables will provide low overall suitability levels.

Model Relationships

Suitability Index (SI) graphs for habitat variables. This section contains suitability index graphs that illustrate the habitat relationships described in the previous section.

Cover type	Variable		
DS,DSW	V_1	Percent deciduous shrub crown cover.	

DS,DSW	V_2	Average height of deciduous shrub canopy.	
DS,DSW	V_3	Percent of deciduous shrub canopy comprised of hydrophytic shrubs.	

Equations. In order to obtain life requisite values for the yellow warbler, the SI values for appropriate variables must be combined with the use of equations. A discussion and explanation of the assumed relationship between variables was included under Model Description, and the specific equation in this model was chosen to mimic these perceived biological relationships as closely as possible. The suggested equation for obtaining a reproduction value is presented below.

$(V1 * V2 * \frac{V4}{V1})^{1/3}$ hydro shrub

Life requisite	Cover type	Equation
Reproduction	DS;DSW	$(V_1 \times V_2 \times V_3)^{1/2}$

HSI determination. The HSI value for the yellow warbler is equal to the reproduction value.

Application of the Model

Definitions of variables and suggested field measurement techniques (Hays et al. 1981) are provided in Figure 2.

Variable (definition)		Cover types	Suggested technique
V_1	Percent deciduous shrub crown cover (the percent of the ground that is shaded by a vertical projection of the canopies of woody deciduous vegetation which are less than 5 m (16.5 ft) in height).	DS,DSW	Line intercept
V_2	Average height of deciduous shrub canopy (the average height from the ground surface to the top of those shrubs which comprise the uppermost shrub canopy).	DW,DSW	Graduated rod
V_3	Percent of deciduous shrub canopy comprised of hydrophytic shrubs (the relative percent of the amount of hydrophytic shrubs compared to all shrubs, based on canopy cover).	DS,DSW	Line intercept

Figure 2. Definitions of variables and suggested measurement techniques.

SOURCES OF OTHER MODELS

No other habitat models for the yellow warbler were located.

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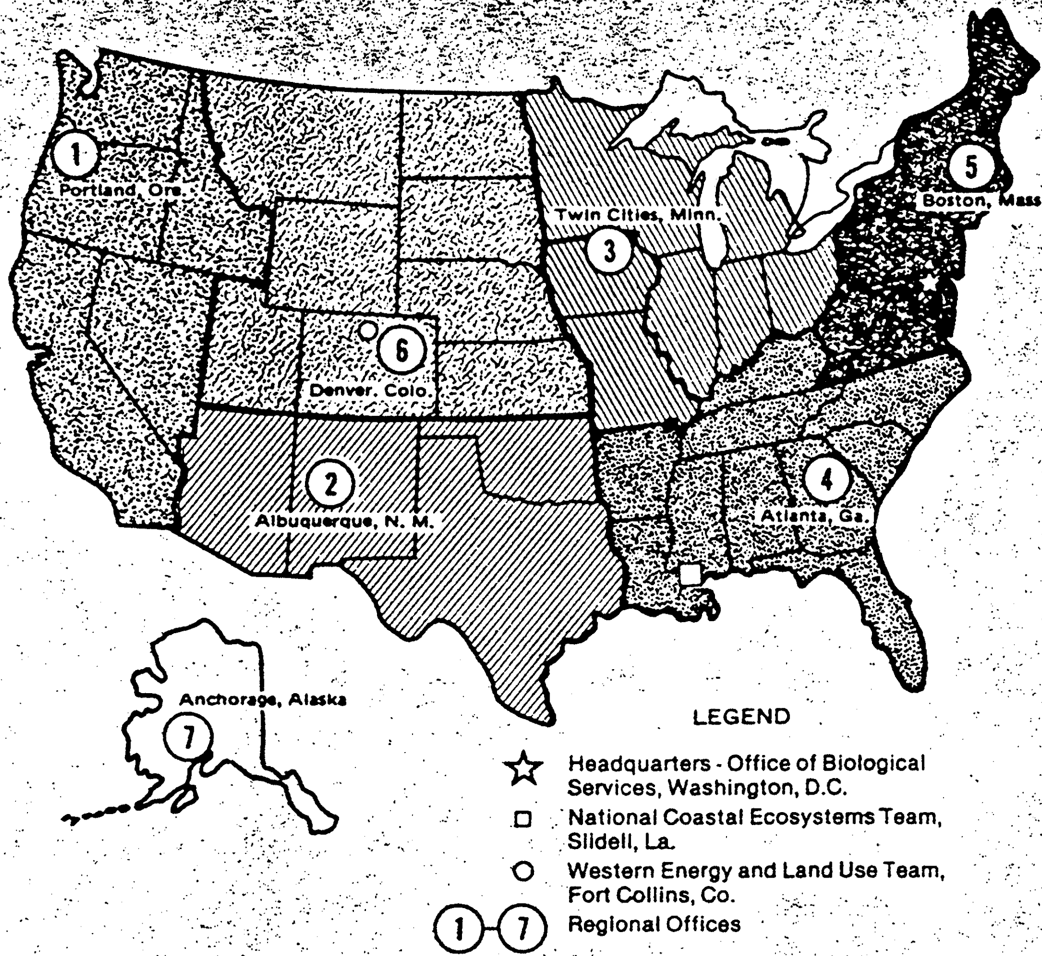

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Habitat preferences of the yellow warbler (Dendroica petechia) are described in this publication. It is one of a series of Habitat Suitability Index (HSI) models and was developed through an analysis of available information on the species-habitat requirements of the species. Habitat use information is presented in a review of the literature, followed by the development of an HSI model, designed for use in impact assessment and habitat management activities.

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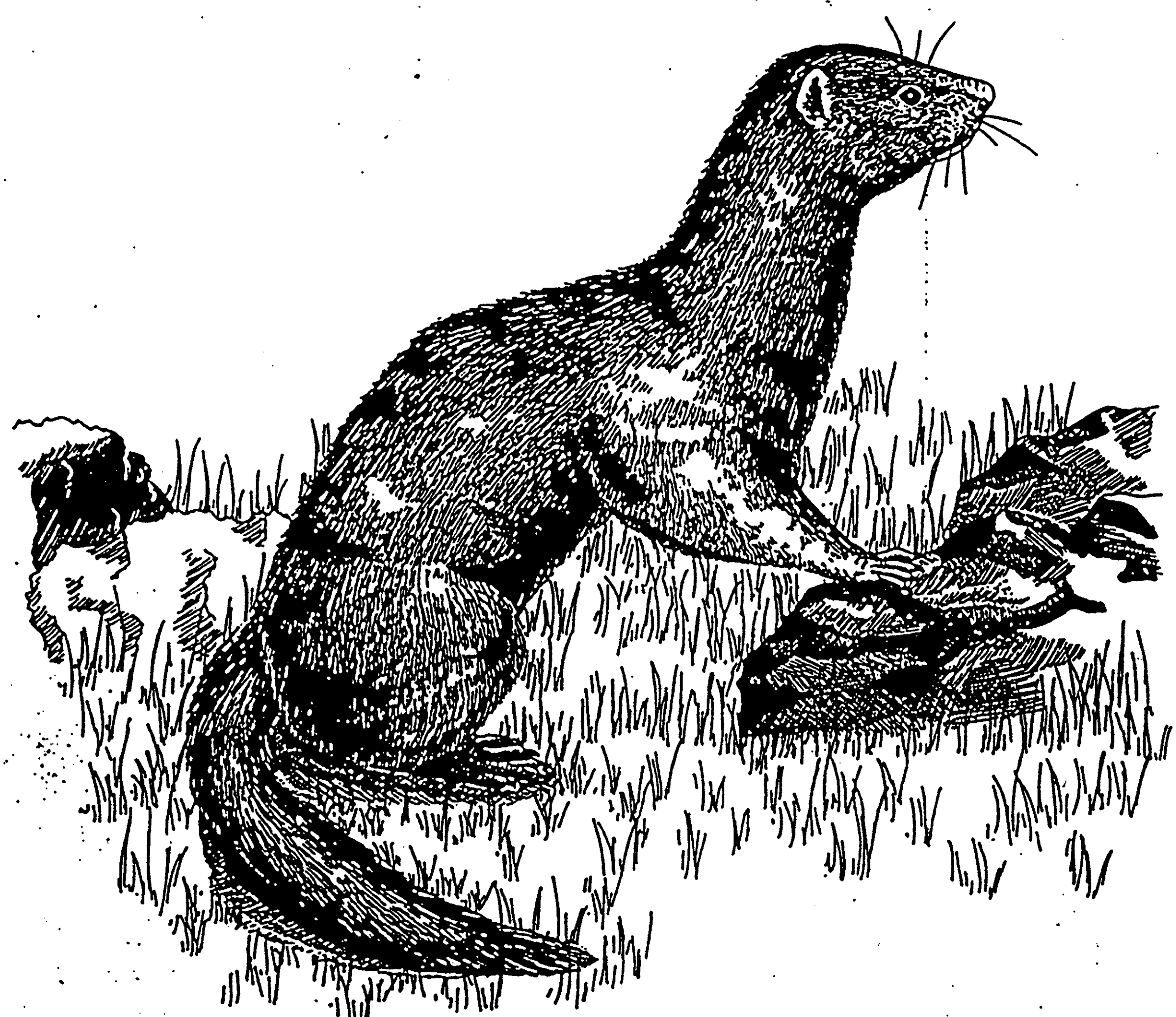

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HABITAT SUITABILITY INDEX MODELS: MINK

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PREFACE

This document is part of the Habitat Suitability Index (HSI) Model Series (FWS/OBS-82/10), which provides habitat information useful for impact assessment and habitat management. Several types of habitat information are provided. The Habitat Use Information Section is largely constrained to those data that can be used to derive quantitative relationships between key environmental variables and habitat suitability. The habitat use information provides the foundation for HSI models that follow. In addition, this same information may be useful in the development of other models more appropriate to specific assessment or evaluation needs.

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

In essence, the model presented herein is a hypothesis of species-habitat relationships and not a statement of proven cause and effect relationships. Results of model performance tests, when available, are referenced. However, models that have demonstrated reliability in specific situations may prove unreliable in others. For this reason, feedback is encouraged from users of this model concerning improvements and other suggestions that may increase the utility and effectiveness of this habitat-based approach to fish and wildlife planning. Please send suggestions to:

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MINK (Mustela vison)

HABITAT USE INFORMATION

General

The mink (Mustela vison) is a predatory, semiaquatic mammal that is generally associated with stream and river banks, lake shores, freshwater and saltwater marshes, and marine shore habitats (Gerell 1970). Mink are chiefly nocturnal and remain active throughout the year (Marshall 1936; Gerell 1969; Burgess 1978). The species is adaptable in its use of habitat, modifying daily habits according to environmental conditions, particularly prey availability (Linn and Birks 1981; Wise et al. 1981; Birks and Linn 1982). The species is tolerant of human activity and will inhabit suboptimum habitats as long as an adequate food source is available; however, mink will be more mobile and change home ranges more frequently under such conditions (Linn, pers. comm.).

Food

The mink's foraging niche is typically associated with aquatic habitats (Gerell 1969; Eberhardt and Sargeant 1977; Chanin and Linn 1980; Wise et al. 1981). The species exhibits considerable variation in its diet, according to season, prey availability, and habitat type (Burgess 1978; Chanin and Linn 1980; Melquist et al. 1981; Wise et al. 1981; Linscombe et al. 1982; Smith and McDaniel 1982). Habitat quality influences the distribution, density, and reliability of prey, which, in turn, directly affect mink population density and distribution (King 1983). Management practices intended to enhance mink populations should address the maintenance or improvement of habitat diversity to sustain or increase the abundance and diversity of prey, rather than attempting to manage prey species themselves (Casson and Klimstra 1983). Predation by mink in North Dakota appeared to be directed toward the most vulnerable individuals among available prey species (Sargeant et al. 1973). Preferred mink prey can be broadly categorized into three groups: (1) aquatic [e.g., fish and crayfish (Cambarus spp.)]; (2) semiaquatic [e.g., waterfowl and water associated mammals, such as the muskrat (Ondatra zibethicus)]; and (3) terrestrial [e.g., rabbits (Lagomorpha) and rodents (Rodentia)] (Chanin, pers. comm.). If prey in any of these categories is available throughout the year, the habitat may be suitable for mink.

Fish occurred more frequently (59%) in the mink's diet in Idaho than did any other prey category (Melquist et al. 1981). Unidentified cyprinids (Cyprinidae), ranging in length from 7 to 12 cm were the major group of prey fish. Larger fish, represented by salmonids (Salmonidae), accounted for 9% of the diet. These larger fish were believed too large for mink to prey on and were probably scavenged. Fish, shellfish, and crustaceans were the major food items of mink inhabiting coastal habitats of Alaska and British Columbia (Harbo 1958, cited by Pendleton 1982; Hatler 1976).

Eberhardt and Sargeant (1977) reported that birds, mammals, amphibians, and reptiles accounted for 78%, 19%, 2%, and 1%, respectively, of the vertebrate prey consumed by mink in North Dakota prairie marshes. Waterfowl accounted for 86% of the avian prey, with coots (Fulica americana), ducks (Anatidae), and grebes (Podicipedidae) comprising 70%, 11%, and 5% of the total. The relative amount of each prey species eaten closely paralleled the relative abundance of the species. The high use of avian prey in North Dakota prairie marshes was believed to be a result of high waterfowl densities and the scarcity of other prey species, particularly fish and crayfish. Talent et al. (1983) concluded that predation by mink was the principle cause of duckling mortality in their North Dakota study. Waterfowl were also an important component of the diet of mink in Idaho during spring and early summer when young ducks were abundant (Melquist et al. 1981). Fish, crayfish, rodents, and birds are the principal prey of mink in Sweden (Gerell 1969). Fish are preferentially consumed in winter and spring due to their increased vulnerability, resulting from low water levels and low temperatures. Crayfish occurred most frequently in the mink's diet during the summer months in Sweden (Gerell 1967). Crayfish were also the most important component of the mink's summer diet in Quebec (Burgess 1978). Crayfish are a prominent component of the mink's diet in Louisiana and, when abundant, support high mink populations (Lowery 1974; Linscombe and Kinler, pers. comm.). Mink populations in Louisiana are believed to cycle with, or slightly behind peaks in crayfish populations (Linscombe and Kinler, pers. comm.).

With the approach of fall, small terrestrial mammals play an increasingly important role in the mink's diet (Gerell 1967, 1969; Burgess 1978; Casson and Klimstra 1983). Small mammals associated with riparian habitats accounted for 43% of the mink's diet in Idaho (Melquist et al. 1981). Small mammals accounted for more than 20% of the fall/winter diet in North Carolina (Wilson 1954). Terrestrial prey species in Great Britain may be of equal importance in the mink's diet as are aquatic prey species (Birks, pers. comm.). Rabbits are of major importance in the mink's diet even in areas where aquatic prey is abundant (Birks and Dunstone 1984). Muskrats have been reported to be a notable part of the mink's diet throughout its range (Hamilton 1940). However, Errington (1943) believed that muskrats became a significant food source for mink only during periods of muskrat overpopulation, epidemic diseases of muskrats, or drought. Sealander (1943) reported that muskrats were a major component of the winter diet of mink in southern Michigan. Muskrats were the most important component of the mink's diet in Ontario (McDonnell and Gilbert 1981). Predation on muskrats increased during the fall months as marsh water level decreased. Melquist et al. (1981) believed that only adult male mink were large enough to consistently prey upon muskrats.

Female mink in Illinois consumed greater numbers of small mammals [e.g., mice and voles (Cricetidae)] than did males, which tended to prey on larger mammals, such as muskrats and rabbits (Casson and Klimstra 1983). Birks and Dunstone (1985) concluded that female mink, because of their relatively small size, predominantly prey on items that are small and of aquatic origin, whereas males are apparently large enough to specialze on larger prey, such as rabbits. Predation by female mink on rabbits did increase during summer when juveniles were available.

Water

The majority of mink activity in Quebec was within 3 m of the edges of streams (Burgess 1978). All of the mink observations in a Michigan study were within 30.4 m of the water's edge (Marshall 1936). The majority of mink den sites recorded in a British study were within 10 m of the water's edge (Birks and Linn 1982). Mink den sites in Minnesota were within 69.9 m of open water (Schladweiler and Storm 1969). Den sites in Idaho were 5 to 100 m from water, and mink were never observed further than 200 m from water (Melquist et al. 1981). Mink activity in Quebec dropped sharply as stream flow increased (Burgess 1978). Korschgen (1958) reported that the use of aquatic foods by mink in Missouri increased as water levels decreased.

Cover

Mink in Michigan (Marshall 1936) and Sweden (Gerell 1970) are most commonly associated with brushy or wooded cover adjacent to aquatic habitats. Mink in a Quebec study were normally most active in wooded areas immediately adjacent to a stream channel (Burgess 1978). During the latter part of the summer, when terrestrial foods became a more significant component of the mink's diet, this relationship became less well defined. In England, mink movements of up to approximately 200 m from water are not uncommon, particularly when aquatic prey is scarce (Linn and Birks 1981). When upland habitats are used by mink, ecotones receive most use due to increased cover and small mammal availability. Mink generally avoid exposed or open areas (Gerell 1970; Burgess 1978). Shrubby vegetation furnishing a dense tangle provides suitable cover for mink (Linn, pers. comm.). Grasses, even if very tall, usually do not provide adequate year-round cover for the species. However, harvest data in Louisiana suggest that marshes containing dense stands of sawgrass (Cladium jamaicense) support high densities of mink (Linscombe and Kinler, pers. comm.). Thick stands of sawgrass are believed to provide excellent cover, elevation above the water level, and prey for mink. However, significantly more mink are captured in southern Louisiana swamps than marshes (Nichols and Chabreck 1981). The greater abundance of mink in cypress-tupelo (Taxodium distichum - Nyssa aquatica) swamps is partially attributed to a greater abundance of food resources and potential den sites than are present in marsh habitats. These findings are consistent with the belief that cypress-tupelo swamps are Louisiana's best mink producing areas (St. Amant 1959, cited by Nichols and Chabreck 1981).

Gerell (1970) characterized mink habitat in Sweden as small, oligotrophic lakes with stony shores, and streams surrounded by marsh vegetation. The shores of wetland habitats with dense vegetation are the most suitable mink habitat in Michigan (Marshall 1936) and England (Linn and Stevenson 1980; Mason and MacDonald 1983). Virtually all mink locations recorded in a North Dakota study were within 20 m of emergent vegetation (Eagle, pers. comm.). Evaluating duckling mortality in North Dakota, Talent et al. (1983) found that predation by mink typically occurred in semipermanent wetlands. Based on a lower rate of predation and less mink sign associated with seasonal wetlands, they believed that semipermanent wetlands provided more suitable mink habitat than did less permanent wetland types.

Wetlands with irregular and diverse shorelines provide more suitable mink habitat than do wetlands with straight, open, exposed shorelines (Croxton 1960; Waller 1962; Gray and Arner 1977). Rapid declines in mink activity along Ontario lake shores were recorded where relatively small increases in human development had taken place (Racey and Euler 1983). The construction of cottages adjacent to lake shorelines typically resulted in reduced vegetative cover and diminished shoreline complexity due to the removal of snags, large rocks, aquatic vegetation, and the development of sand beaches. The decreased complexity of shoreline habitats was believed to reduce the amount of shelter available to crayfish resulting in decreased availability of mink prey.

Decreased diversity in shoreline configuration, elimination of aquatic vegetation, and decreased abundance and diversity of riparian vegetation caused by channelization reduced habitat quality, prey availability, and mink use of riverine habitats in Mississippi and Alabama (Gray and Arner 1977). Casson and Klimstra (1983) concluded that the abundance of suitable mink prey is reduced when shallow, detritus-rich, sloughs associated with meandering streams are replaced with an abrupt, monotypic, interface between aquatic and terrestrial cover types as a result of channelization. Habitats associated with small streams are preferred to those associated with large, broad rivers (Davis 1960). Mink are most common along streams where there is an abundance of downfall or debris for cover and pools for foraging. Log jams provide excellent foraging cover for mink because they provide shelter for aquatic organisms and security for mink (Melquist et al. 1981). Burgess (1978) recorded a 52.5% increase in mink activity along a stream reach in Quebec that had undergone habitat improvement. Stream alterations consisted of the creation of pools up to 1 m deep in 50% of the stream channel and the placement of logs and other cover within the channel. Dunstone and O'Connor (1979) attributed the mink's use of stream and lake edges to the inability of mink to efficiently forage in open water. Cover associated with aquatic ecotones allowed a stealthier approach and development of specific search strategies by mink (Dunstone 1978). Open water was believed to provide potentially suitable foraging areas only during periods of reduced water volume or high fish density. Shallow water depth and low flow rates contribute to effective aquatic foraging by mink (Dunstone 1983). Smith and McDaniel (1982) recorded greater use of fish by mink in Arkansas during drought, which tended to concentrate prey as a result of decreasing water levels.

The availability of suitable dens may limit the ability of a habitat to support mink (Errington 1961; Gerell 1970; Northcott et al. 1974; Birks and Linn 1982). The absence of dry den sites may limit the mink's use of some wetlands (Linn, pers. comm.). Mink typically select den sites that are close to preferred foraging areas or concentrations of prey items (Linn and Birks 1981; Melquist et al. 1981; Birks and Linn 1982). Mink use several dens within their home range for concealment, shelter, and litter rearing (Marshall 1936; Schladweiler and Storm 1969; Gerell 1970; Eberhardt 1973; Eberhardt and Sargeant 1977; Linn and Birks 1981; Melquist et al. 1981; Birks and Linn 1982). Maximum consecutive days of occupation of single dens in North Dakota was approximately 40 days (Eberhardt and Sargeant 1977). After kits became more mature, individual dens were used briefly and irregularly. The majority of den stays in England were less than 1 day in duration (Birks and Linn 1982). The mean distance covered for 12 den moves in North Dakota was 234 m (Eberhardt and Sargeant 1977). The mean distance between dens used for two or more consecutive days in Sweden was 544 m (Gerell 1970). The mean interden distance recorded in England was 492 m (Birks and Linn 1982). Movements of male mink to new den sites tended to be greater than those recorded for females. New mink dens in Wisconsin were usually within 90 m of the previous den site (Schladweiler and Storm 1969).

The majority of interden movements are made at night and typically occur in, or along, linear habitat features, such as lake shores, river banks, stream courses, or hedge-rows (Birks and Linn 1982). Gerell (1970) reported that the most "commonly" used dens were located in cavities beneath tree roots at the water's edge. However, "more preferred," but less common, den sites were within cavities or piles of rocks well above the water line. Birks and Linn (1982) also identified cavities within, or beneath, waterside trees as being an important source of den sites for mink. More than 50% of den sites of mink inhabiting coastal habitats in Scotland were situated in rock scree and outcrops (Dunstone and Birks 1983). Slightly more than 87% of all dens located were <50 m from the high water mark of normal spring tides.

Mink dens adjacent to lake shorelines in Ontario were located in sites with higher than average numbers of deadfalls and stumps and greater shrub and tree stem densities (Racey and Euler 1983). Log jams accounted for 53% of the mink dens located in Idaho (Melquist et al. 1981). Fallen branches, brush, and other debris provided additional den sites. The use of log jams increased during December, probably as a result of decreased accessibility to other den sites due to increasing snow depth. All mink dens located in North Dakota were situated on marsh shorelines and appeared to be in abandoned or seldom used muskrat burrows (Eberhardt 1973; Sargeant et al. 1973; Eberhardt and Sargeant 1977). The availability of dens for mink use was believed to be related to the suitability of the wetland for muskrats and the amount of shoreline grazing by livestock. Active mink dens were not located on heavily grazed shorelines. Errington (1954) characterized prime mink habitat in the north-central region of the United States as being choice muskrat habitat. Extremely high mink harvests have occurred in association with high muskrat populations in Louisiana (Linscombe and Kinler, pers. comm.). The highest densities of muskrats in Louisiana occur in association with bulrush (Scirpus olneyi).

Reproduction

No information relating specifically to habitat needs for reproduction was found in the available literature.

Interspersion

The home ranges of mink tend to approximate the shape of the water body along which they live (Gerell 1970; Linn and Birks 1981). A mink's use of its home range varies in intensity due to varying prey availability. During daily activity periods, mink move back and forth in a restricted "core area," which typically does not exceed 300 m in shoreline length (Gerell 1970). Eventually, the mink will use another den within the home range as a base and will intensively forage within an associated core area. Linn and Birks (1981) found that the mink's home range in England typically contained one or two core areas that were associated with prey concentrations. Although core areas generally occupied a small proportion (mean = 9.3%) of the home range area, mink spent approximately 50% of their time within these areas (Birks and Linn 1982). When prey was abundant throughout the home range, the core areas were not as well defined. When the aquatic aspect of the habitat was nonlinear (e.g., marshes), the home range was smaller and less linear in shape.

The mink's use of its home range also shows variation in response to seasonal differences in prey availability (Birks and Linn 1982). Movements recorded in England indicated a general reduction in activity in winter relative to summer. Fewer den sites were used, occupancy at individual dens was of longer duration, and daily travel distances were shorter. Mink home range size in British Columbia was believed to be inversely related to the quality of forage areas (Hatler 1976). The overall mink population was believed to be limited by the number of high quality, year-long foraging areas. Harbo (1958, cited by Pendleton 1982) attributed higher mink populations and smaller activity areas along coastal Alaska to a relatively consistent year-round food supply in the intertidal zone. The smaller home range size of mink inhabiting coastal areas, in comparison to mink associated with inland freshwater habitats, may be a consequence of prey concentrations in tidal pools and the regular replenishment of prey as a result of the tidal cycle (Dunstone and Birks 1983). Over 68% of the observations of active mink were recorded in and within a 100 m band shoreward of the littoral zone.

Vegetative cover had a significant impact on mink home range size in Montana (Mitchell 1961). The home range size for female mink within a heavily vegetated area was estimated to be 7.7 ha, while the home range of a female within a sparsely vegetated, heavily grazed area was 20.1 ha. Female mink home ranges in Michigan did not exceed 8 ha (Marshall 1936). Mink in Idaho were believed to be able to sustain themselves in a 1 to 2 km section of stream length (Melquist et al. 1981). Mink population densities along the coast of Vancouver Island, British Columbia, ranged from 1.5 to more than 3 animals/km of shoreline (Hatler 1976). Mink home range size in the prairie pothole region of North Dakota ranged from 2.59 km^2 to 3.8 km^2 and typically included numerous wetlands (Eagle, pers. comm.).

Female mink have the smallest and most well defined home ranges, while those of males tend to be more extensive and less well defined (Marshall 1936). The home range size for female mink in England was, on an average, 85.4% of a male's home range size (Birks and Linn 1982). Intrasexual and intersexual home range overlap was rare in a North Dakota study except during the 2- to 3-week breeding season in April (Eagle, pers. comm.). Female mink in Sweden were found to be more restricted to riparian habitats, while males transiently exploited upland areas (Gerell 1970). Male mink in England tended to forage away from aquatic habitats, while females typically remained near water (Birks and Linn 1982). Mink concentrating on aquatic prey tended to utilize larger core areas than individuals exploiting terrestrial prey species. Solely terrestrial foraging was exclusively a male activity and typically occurred where aquatic prey and prey associated with riparian habitats were scarce.

HABITAT SUITABILITY INDEX (HSI) MODEL

Model Applicability

Geographic area. This HSI model has been developed for application within inland wetland habitats throughout the range of the species. Figure 1 displays the approximate geographic distribution of mink in North America.

Season. This HSI model was developed to evaluate the potential quality of year-round habitat for the mink.

Cover types. This model was developed to evaluate the quality of mink habitat in the following wetland cover types (terminology follows that of Cowardin et al. 1979): Riverine (R), Lacustrine (L), and Palustrine Forested (PFO), Palustrine Scrub/Shrub (PSS), and Palustrine Emergent (PEM) wetlands.

Figure 1. Approximate distribution of the mink in North America (adapted from Linscombe et al. 1982).

Minimum habitat area. Minimum habitat area is defined as the minimum amount of contiguous habitat that is required before an area will be occupied by a species. Information on the minimum habitat area for the mink was not found in the literature. The size and shape of mink home ranges vary in response to topography, food availability, and sex. Although home ranges of female mink are smaller than those of males, home ranges of both sexes tend to parallel the configuration of a body of water or wetland basin. Based on this information, it is assumed that any wetland, or wetland associated habitat, large enough to be identified and evaluated as such, has the potential to support mink.

Verification level. This HSI model provides habitat information useful for impact assessment and habitat management. The model is a hypothesis of species-habitat relationships and does not reflect proven cause and effect relationships. Earlier drafts of this model were reviewed by the following individuals:

Dr. Johnny Birks, University of Durham, Durham, Great Britain.
Dr. Paul Chanin, University of Exeter, Devon, Great Britain.
Dr. Thomas Eagle, University of Minnesota, Minneapolis.
Mr. John Hunt, Maine Department of Inland Fisheries and Wildlife, Augusta.
Mr. Noel Kinler, Louisiana Department of Wildlife and Fisheries, New Iberia.
Mr. Ian Linn, University of Exeter, Hatherly Laboratories, Exeter, Great Britain.
Mr. Greg Linscombe, Louisiana Department of Wildlife and Fisheries, New Iberia.
Mr. John Major, Maine Cooperative Wildlife Research Unit, University of Maine, Orono.
Mr. Barry Saunders, Ministry of Environment, British Columbia, Canada.

Improvements and modifications suggested by these individuals have been incorporated into this model.

Model Description

Overview. The year-round habitat requirements of mink can be satisfied within wetland cover types if sufficient vegetation or cover is present to support an adequate prey base. Although not totally restricted to wetland or wetland-associated cover types, the mink usually is dependent on aquatic organisms as a food source for a large portion of the year. Transient use of upland cover types may occur, particularly during the fall and winter months, when terrestrial prey plays an increasingly important role in the mink's diet. The majority of mink activity (foraging, establishment of dens, and litter rearing) occurs in close proximity to open water. This model assumes that sufficient cover must be interspersed with, or adjacent to, relatively permanent surface water in order to provide the maximum number and diversity of prey species. It is assumed in this model that potential food availability and cover for the mink can be described by the same set of habitat characteristics. The reproductive habitat requirements of the mink are assumed to be identical to its cover requirements.

The following sections provide documentation of the logic and assumptions used to translate habitat information for the mink to the variables and equations used in the HSI model. Specifically, these sections identify important habitat variables, define and justify the suitability levels of each variable, and describe assumed relationships between variables.

Water component. Mink are not totally dependent on aquatic or wetland-associated prey species. However, these species typically form the largest portion of the annual diet. It is assumed that surface water must be present for a minimum of 9 months of the year to provide optimum foraging habitat and prey availability for mink (Figure 2). Cover types with less permanent surface water are assumed to be indicative of less suitable mink habitat as a result of lower prey diversity and availability when considered on an annual basis. Wetland cover types consisting only of saturated soils, or lacking surface water, are assumed to be of no value as year-round mink habitat, due to the assumed absence of an adequate aquatic prey base.

The value calculated using Figure 2 is used in equation 1 to represent the water suitability index (SIW) for mink.

$$SIW = SIV1 \quad (1)$$

Equation 1 and the relationships between the permanence of surface water (SIV1) and habitat quality for mink are based on the following assumptions. Cover types that have surface water present <25% of the year are assumed to be unsuitable year-round mink habitat due to the absence of aquatic prey species. Abundance and availability of aquatic prey are assumed to increase as the permanence of surface water increases. Cover types that maintain surface water for >75% of the year are assumed to provide conditions conducive to maximum availability of aquatic prey.

Several reviewers of this model have commented that eutrophic lakes have greater potential productivity than do oligotrophic lakes. Eutrophic lakes may be capable of supporting larger populations of mink due to a more diverse and abundant aquatic prey base. The primary productivity of a lake depends in part upon the nutrients received from the surrounding drainage, geological age, and water depth. Oligotrophic lakes are typically deep, with the hypolimnion larger than the epilimnion, littoral zone vegetation is scarce and organic content and plankton density are low. In contrast, eutrophic lakes are typically shallow and have high concentrations of plant nutrients (e.g., nitrogen, phosphorus), high organic content, and abundant littoral zone vegetation. Although this model does not take into account a specific evaluation of a lake's potential ability to produce food organisms, it should be realized that a lake's ability to provide abundant aquatic prey for mink may vary based on its' physical and chemical characteristics.

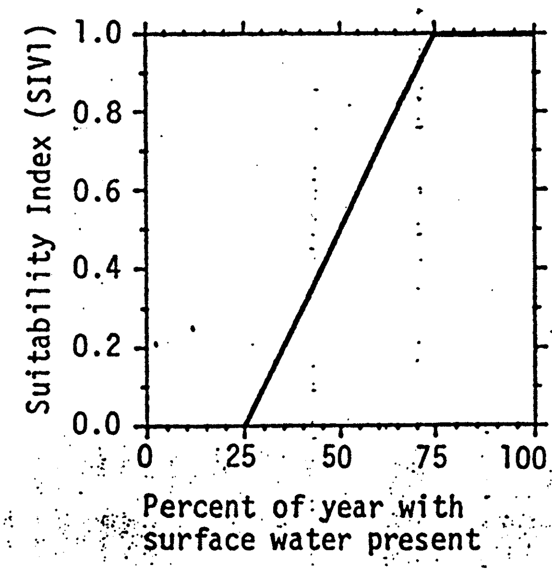

Figure 2. The relationship between percent of the year with surface water present and a suitability index of mink habitat quality.

Cover component. Although mink will use upland cover types, they are most often found in close association with wetlands and the vegetative communities immediately adjacent to streams, rivers, and lakes. Small terrestrial mammals become an important component of the mink's diet during the fall and winter months. Terrestrial mammals may be an important component in the diet of male mink throughout the year. Sufficient vegetative cover interspersed with, or immediately adjacent to, water is assumed to provide an adequate source of prey species to supplement the aquatic portion of the mink's diet. Dense woody cover of trees and shrubs provides the mink with potential den sites, escape cover, and foraging cover. Persistent herbaceous vegetation also may provide mink with sufficient cover for foraging and shelter. It is assumed that nonpersistent herbaceous vegetation, by itself, will not provide sufficient cover for mink during winter.

a. Palustrine forested and scrub/shrub wetlands. Suitable cover conditions for mink within forested and scrub/shrub wetlands are assumed to be a function of the total canopy closure of trees (Figure 3a), shrubs (Figure 3b), and emergent herbaceous vegetation (Figure 3c). Optimum conditions for cover, denning, and foraging are assumed to occur when the combined canopy cover of woody or persistent herbaceous vegetation is ≥75%. Forested or scrub/shrub wetlands with lower vegetative canopy closures are assumed to be less suitable mink habitat as a result of lower cover availability for both mink and their prey. Woody vegetation ≤100 m from a wetland's edge also is assumed to

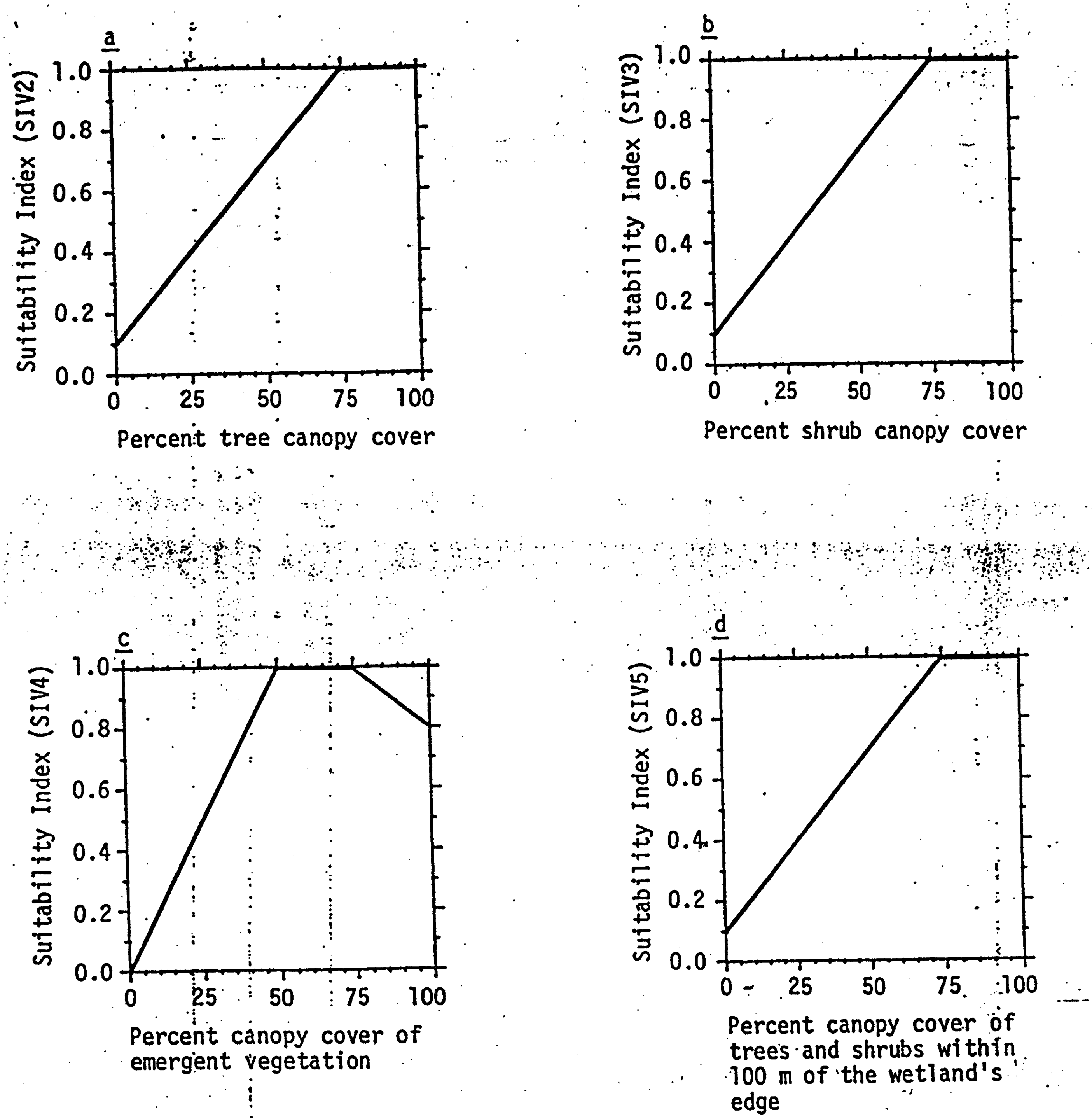

Figure 3. The relationships between tree, shrub, and emergent herbaceous vegetation canopy closure and suitability indices of mink habitat quality.

influence mink habitat quality. However, the degree to which vegetative cover in a 100 m band surrounding forested or scrub/shrub wetlands influences habitat quality for mink depends on the size of the wetland basin. In small forested or scrub/shrub wetlands the adjacent upland cover is assumed to play a relatively important role in defining overall habitat quality for the species. In contrast, the majority of mink inhabiting large, expansive forested or shrub wetlands probably are not influenced to a great degree by the quality of adjacent upland cover types.

In large forested or scrub/shrub wetlands cover quality for mink is assumed to be a function only of the amount of woody and emergent herbaceous vegetation present within the wetland basin. In small, or linear, forested and scrub/shrub wetlands cover quality is assumed to be a function of the canopy cover of woody and emergent herbaceous vegetation in the wetland basin and the canopy cover of woody vegetation in a 100 m band adjacent to the wetland (Figure 3d). Trees and shrubs adjacent to a wetland are believed to enhance the value of the wetland basin by providing cover for prey species and foraging cover for mink. Downfall and debris provided by woody vegetation also provides den sites in close association with the wetland cover type. Ideal conditions are assumed to occur when the canopy cover of trees or shrubs is ≥75%. Lower density of trees and shrubs is assumed to be indicative of less suitable cover conditions. However, the complete absence of woody cover adjacent to forested and scrub/shrub wetlands will not indicate totally unsuitable conditions since herbaceous vegetation, rocks, and other nonvegetative features may provide for mink and their prey.

For the purposes of this model large wetland basins are assumed to be ≥405 ha (1,000 acres). However, this is an arbitrary figure used to separate small and large wetlands for application of the model. Users may wish to redefine this value based on experience with regional cover type classifications.

The suitability index values from Figure 3 are used in equation 2 to determine a cover index (SIFS1) for mink in palustrine forested and scrub/shrub wetlands ≥405 ha. Equation 3 is intended for determination of a cover index for forested and scrub/shrub wetlands <405 ha.

$$SIFS1 = MIN(1.0; SIV2 + SIV3 + SIV4) \quad (2)$$

$$SIFS2 = \frac{MIN(1.0; SIV2 + SVI3 + SIV4) + SIV5}{2} \quad (3)$$

Equations 2 and 3 are based on the following assumptions. The suitability of canopy cover of trees (SIV2), shrubs (SIV3), and emergent vegetation (SIV4) are assumed to have equal weight in defining cover quality within forested and scrub/shrub wetlands. Ideal cover conditions may be provided by ≥75% canopy cover of trees, ≥75% canopy cover of shrubs, or 50% to 75% canopy cover of herbaceous vegetation. A combined canopy cover of trees shrubs, and emergent herbaceous vegetation also is assumed to be indicative of ideal cover conditions when total density is ≥75%. In situations where the sum of index values for SIV2, SIV3, and SIV4 is >1.0 the value used in the equation is 1.0.

Within forested and scrub/shrub wetlands <405 ha, the density of trees and shrubs <100 m from the wetland's edge (SIV5) is assumed to have equal influence in defining cover quality as does the density of vegetation within the wetland basin. Forested and scrub/shrub wetlands lacking woody cover adjacent to the basin reflect lower cover quality for mink, regardless of vegetative cover within the basin, than do wetlands surrounded by dense woody vegetation.

b. Palustrine emergent wetlands. Suitable cover for mink in palustrine emergent wetlands is assumed to be a function of the amount of the wetland basin supporting emergent herbaceous vegetation (Figure 3c) and, to a lesser extent, the amount of woody cover immediately adjacent to the wetland basin (Figure 3d). Ideal cover conditions are assumed to occur when the wetland basin supports 50% to 75% canopy cover of emergent herbaceous vegetation. Emergent wetlands with <50% canopy cover of emergent vegetation are assumed to be indicative of less suitable habitat as a result of lower cover availability for mink and prey species. Wetlands totally devoid of vegetation are assumed to have minimum value as year-round mink habitat due to the absence of suitable cover in the wetland basin. The cover value for mink in palustrine emergent wetlands may be enhanced if woody vegetation (trees and shrubs) is present within 100 m of the wetland's edge. Tree and shrub cover adjacent to the wetland basin is assumed to enhance prey diversity and increase cover and den sites for mink.

The suitability index value from Figures 3c and 3d are used in equation 4 to determine a cover index (SIPE) for palustrine emergent wetlands.

$$SIPE = \frac{4SIV4 + SIV5}{5} \quad (4)$$

Equation 4 is based on the following assumptions. The abundance of emergent herbaceous vegetation (SIV4) is assumed to be the major characteristic defining the quality of cover for mink in palustrine emergent wetlands, and has been weighted in the equation to reflect this assumption. Wetlands surrounded, or bordered, by trees and shrubs will reflect higher cover quality than will wetlands with equivalent amounts of emergent vegetation but lacking adjacent woody cover. Conversely, palustrine emergent wetlands with little to no emergent vegetation are assumed to be indicative of cover conditions of low quality regardless of the amount of woody cover adjacent to the wetland basin.

c. Riverine and lacustrine wetlands. Within riverine and lacustrine cover types, suitable cover for mink is assumed to be related to the density of woody vegetation within 100 m of the water's edge and the availability of foraging and security cover at the land/water interface. Ideal cover conditions are assumed to exist when tree canopy cover and shrub canopy cover either singly or in combination account for ≥75% canopy cover (Figure 3d). Less dense vegetative cover adjacent to lakes and river or stream channels characterize less suitable cover conditions for mink as a result of decreased foraging cover, den sites, and cover for prey species. Riverine and lacustrine wetlands lacking adjacent woody vegetation are assumed to have low value as mink habitat due to the absence of cover for both mink and their terrestrial prey.

Mink foraging activity in riverine and lacustrine cover types is concentrated along the shoreline or land/water interface as compared to palustrine forested or emergent wetlands, where foraging activity may occur throughout the wetland basin. Therefore, the amount of cover or vegetative and structural diversity along shorelines has a major influence on the definition of habitat quality for mink inhabiting these cover types. Shorelines with a high degree of cover, which may be provided by overhanging or emergent vegetation, exposed roots, debris, log jams, undercut banks, boulders, or rock crevices, provide cover for prey species as well as secure foraging cover for mink. Conversely, shorelines that are straight, open, exposed, have little structural cover, and have an abrupt, monotypic edge between water and land provide virtually no cover for mink or their prey. It is assumed that ideal cover for mink is present where 100% of the shoreline provides dense foraging and security cover (Figure 4). As the amount of shoreline cover decreases cover quality for mink in riverine and lacustrine cover types is assumed to diminish. Shorelines devoid of vegetative or structural cover are assumed to have extremely low value as mink habitat, as a result of decreased prey availability and less than ideal foraging conditions.

The suitability index values from Figure 3d and Figure 4 are used in equation 5 to determine a cover index (SIRL) for riverine and lacustrine cover types.

$$SIRL = (SIV5 \times SIV6)^{1/2} \qquad (5)$$

Equation 5 is based on the following assumptions. The suitability of the abundance of woody vegetation within 100 m of the water's edge (SIV5) and the suitability of the percentage of the shoreline with suitable cover (SIV6) are assumed to have equal value in defining cover quality for mink in riverine and lacustrine cover types. These variables are assumed to be compensatory in that a low value for one variable may be offset by a higher value for the remaining variable. Optimum conditions in terms of cover for prey species and mink foraging will be obtained only when the tree and shrub canopy cover within 100 m of the water's edge is ≥75%, and 100% of the shoreline provides cover within 1 m of the water's edge. Lower values for either variable will result in a SIRL of <1.0.

HSI determination. The calculation of an HSI for the mink considers life requisite values for water and cover. The HSI is equal to the lowest value calculated for either life requisite.

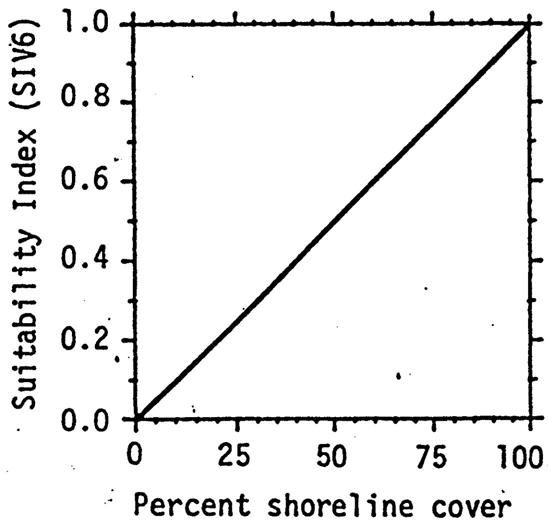

Figure 4. The relationship between shoreline cover and the suitability index for mink cover quality in riverine and lacustrine cover types.

Application of the Model

Delineation of cover types. Potential mink habitat must contain a relatively permanent source of surface water. Because of the mink's use of upland cover types for denning and foraging, optimum habitat must also support suitable cover adjacent to the water body or wetland. Therefore, application of this model and determination of Habitat Units (U.S. Fish and Wildlife Service 1980) is based on an evaluation of the quality of the wetland cover type and a 100 m band surrounding the wetland. Figure 5 illustrates the relationship of wetland cover types and suggested evaluation area.

Summary of model variables. Six habitat variables are used in this model to evaluate water and cover conditions for mink. Not all variables are used to evaluate each cover type. The relationships between habitat variables, cover types, life requisite values, and HSI are summarized in Figure 6. Definitions and suggested measurement techniques (Hays et al. 1981) for the variables used in the mink HSI model are provided in Figure 7.

Cover type	Area for evaluation
Lacustrine HSI determined only for area contained within 100 m (328 ft) band around lake.	
Riverine HSI determined for area within 100 m band on both sides of river plus area of river.	
Palustrine [emergent wetlands forested wetlands, or scrub/shrub wetlands less than 405 ha (1,000 acres) in size]. HSI determined for area contained within cover type plus area within 100 m band around wetland cover type.	
Palustrine [forested wetlands or shrub wetlands ≥405 ha (1,000 acres) in size] HSI determined for area contained only within cover type.	

Figure 5. Guidelines for determining the area to be evaluated for mink habitat suitability in various wetland cover types.

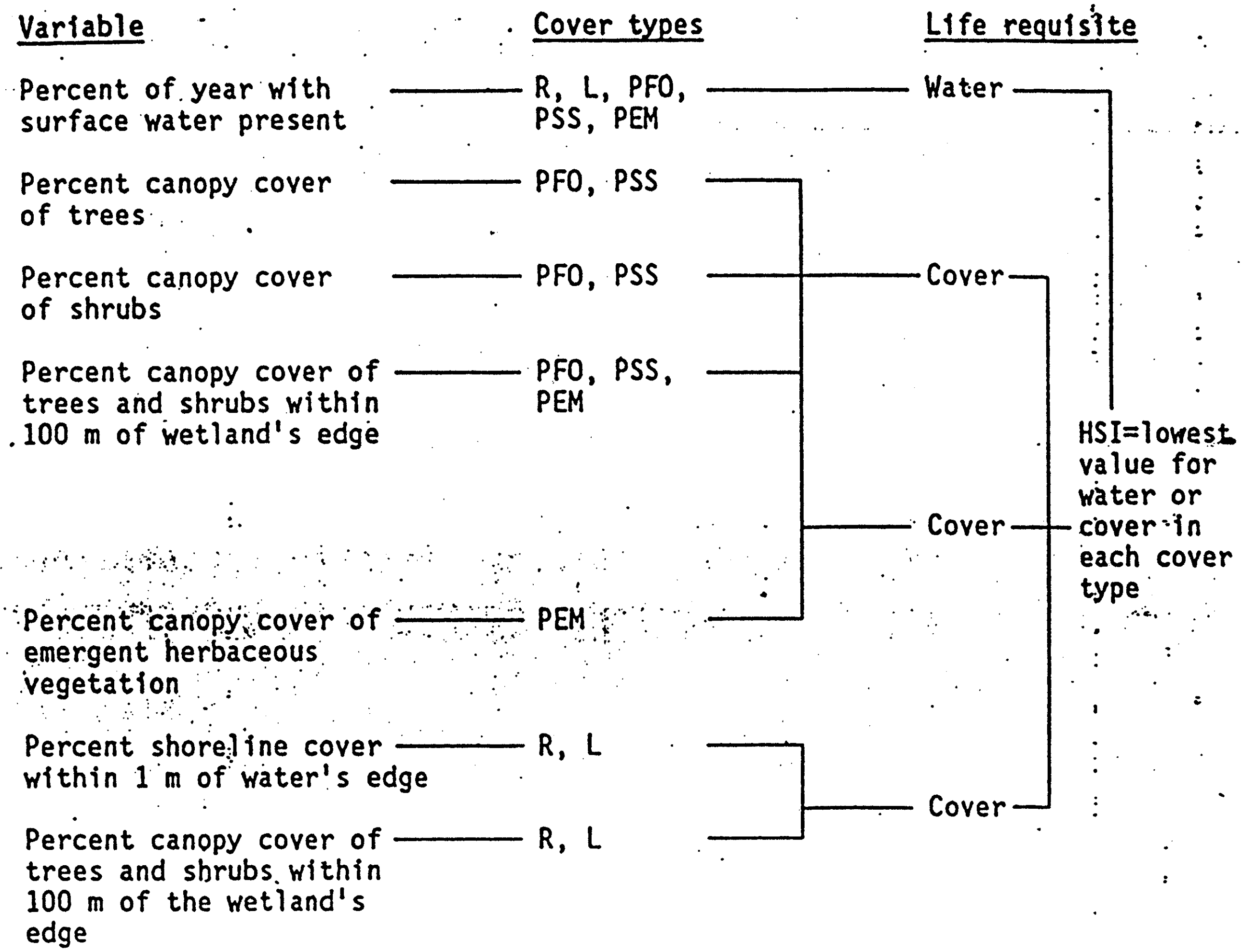

Figure 6. Relationships of habitat variables, cover types, life requisite values, and HSI in the mink HSI model.

Variables (definition)	Cover types	Suggested technique
Percent of year with surface water present (the percent of the year in which wetland cover types have surface water present).	R, L, PFO PSS, PEM	On site inspection, historical records
Percent canopy cover of trees [the percent of the ground surface that is shaded by a vertical projection of the canopies of all woody vegetation ≥6 m (20 ft) tall].	PFO, PSS	Line intercept, quadrat, remote sensing
Percent canopy cover of shrubs [the percent of the ground surface that is shaded by a vertical projection of the canopies of woody vegetation <6 m (20 ft) tall].	PFO, PSS	Line intercept, quadrat, remote sensing
Percent canopy cover of emergent herbaceous vegetation (the percent of the water surface shaded by a vertical projection of the canopies of emergent herbaceous vegetation, both persistent and nonpersistent).	PFO, PSS PEM	Line intercept, quadrat, remote sensing
Percent canopy cover of trees and shrubs within 100 m (328 ft) of the wetlands edge [the percent of the terrestrial ground surface within 100 m (328 ft) of a wetland's edge that is shaded by a vertical projection of the canopies of all woody vegetation].	PFO <405 ha PSS <405 ha PEM, R,L	Line intercept, quadrat, remote sensing
Percent shoreline cover within 1 m (3.3 ft) of water's edge [An estimate of the vegetative and structural complexity at the land/water interface (≤1 m from water's edge). Cover may be provided by overhanging or emergent vegetation, undercut banks, logjams, debris, exposed roots, boulders or rock crevices].	R, L	On-site inspection, line intercept, quadrat

Figure 7. Definitions of variables and suggested measurement techniques.

<u>Model assumptions</u>. The mink HSI model is based on the following key assumptions.

1. Mink habitat use is centered around wetland cover types. Surface water must be present for a minimum of 9 months per year to provide optimum habitat conditions.

2. Cover furnished by vegetation and structural diversity provides shelter and habitat for prey species as well as foraging and security cover for mink. Relatively dense vegetative cover must be present within wetlands and adjacent upland cover types in order to provide maximum prey diversity, foraging opportunities, and cover for mink. The density of woody vegetation in upland cover types is assumed to have no influence on mink habitat quality in extensive (≥405 ha) forested and scrub/shrub wetlands.

3. The availability of surface water and cover are assumed to indirectly address the availability of suitable mink prey and to directly address cover quality for mink.

SOURCES OF OTHER MODELS

No other habitat models for mink were located in the literature.

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COOPER'S HAWK

Species Narrative

General. The Cooper's hawk (*Accipiter cooperii*) is a rare summer resident of the Dan River Basin and is uncommon throughout the rest of the year (Lee and Browne 1979).

The Cooper's hawk is a diurnal predator and inhabits mixed and deciduous woodlands and edges (Wattell 1973). It has been reported to prefer mature broadleaved forests (Brown and Amadon 1968), second-growth timber (Bailey 1918), woodlots and open farm country (Mengel 1965) and even brush grown pastures near water (Bailey 1918).

Food Requirements. Most authorities report a predominately avian annual diet for the Cooper's hawk. The most extensive study (McAtee 1935) reported that birds were found in 87% of 261 stomachs examined, mammals were found in 16%, and slight contributions were made by herpetofauna and insects. Earlier studies were based on hawks killed at game farms or near poultry farms, and were biased towards a poultry or game bird diet (Meng 1959).

Nestling studies have both supported and refuted this largely avian diet. Nestlings in New York and Pennsylvania were brought 82% birds (by occurrence) and 18% mammals (Meng 1959). Nestling diets in Michigan were 90% birds and 10% mammals (Craighead and Craighead 1969). However, a current study in the Appalachians indicates a high proportion of mammals in the nestling diet (Mosher, pers. comm.).

Hunting habits of the Cooper's hawk have been described as a sudden swift dash towards the prey (Bent 1937). This hawk usually perches in an inconspicuous place and waits for prey (Brown and Amadon 1968). Hunting occurs in forests and over open fields, where prey may be pursued and captured in the air.

<u>Water Requirements</u>. The Cooper's hawk satisfies its water requirement through its vertebrate diet (Roddy 1888).

<u>Cover Requirements</u>. Habitat characteristics of Cooper's hawk cover have not been well described in available literature. The species is typically called a woodland species, and appears to prefer dense second growth timber (Fisher 1893; Bailey 1918). In large forests, this species is more associated with the forest edge, or with openings in the canopy created by roads, clearings and streams (Wattel 1973). Cooper's hawks seek out conifers for roosting (Brown and Amadon 1968).

Winter habitat has been described as any type of parkland where trees or scrub offer sufficient shelter (Wattel 1973).

<u>Reproductive Requirements</u>. Nests are located in either conifers or hardwoods. Second growth oaks and hickories were common nest trees in Iowa with the nests placed between 6 to 12 m (20 to 40 ft) in height (Bailey 1918). White pines were commonly used as nest trees in Massachusetts (58%) and nests were located between 6 to 18 m (20 to 60 ft) in height (Bent 1937). In conifers, the nest is built on two or three horizontal branches and against the tree trunk; nests in deciduous trees are generally built in upright crotches of main branches.

Cover and Reproductive Value in evergreen forests, deciduous forests, and deciduous forested wetlands is a function of V_1, V_2, and V_3. V_1 and V_2 are interactive and are combined in a geometric mean. Either this combined value or V_3 have the ability to limit the cover and reproductive value. The suggested function is:

$$(V_1 \times V_2)^{1/2}, \text{ or } V_3, \text{ whichever is lowest.}$$

Determination of the Habitat Suitability Index. The HSI is equal to the cover and reproductive value.

Model Assumptions and Limitations. It is assumed that food will not be more limiting than the cover and reproductive value. It is assumed that the Cooper's hawk is primarily a forest bird and therefore need not be evaluated in openland cover types.

Several major limitations exist in this habitat model. There is very little quantitative data on which to base the evaluation criteria. The Cooper's hawk is a declining species, probably due to pesticide contamination and human disturbances. These factors are not accounted for in this habitat model which is based on plant structure.

Defense of the nest territory against great horned owls occurs to at least 100 m (330 ft) (Errington 1932). New nests are generally built each year (Brown and Amadon 1968). Nests are often located within 100 m (330 ft) of a forest opening (Mosher, pers. comm.).

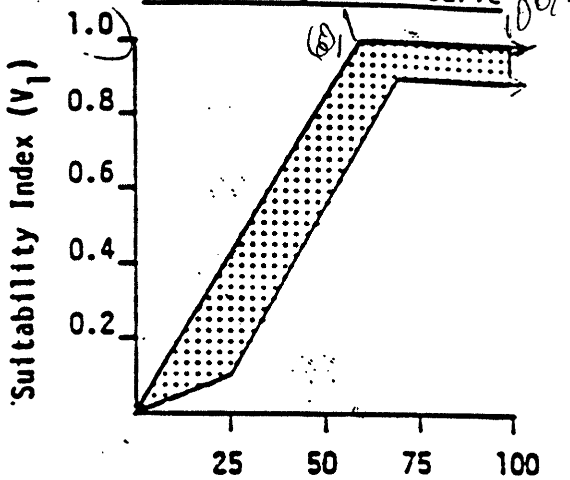
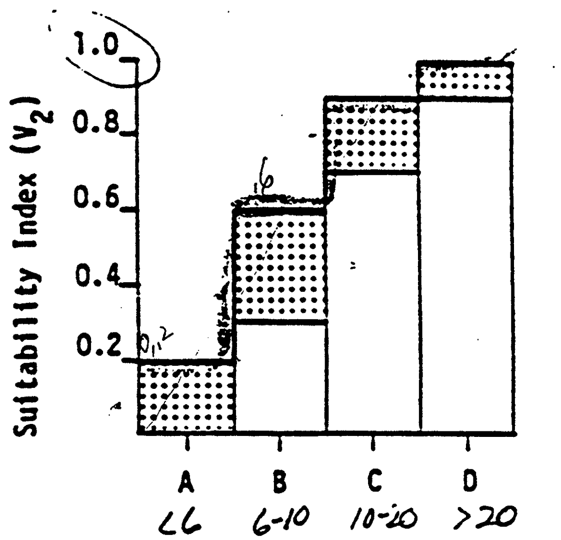
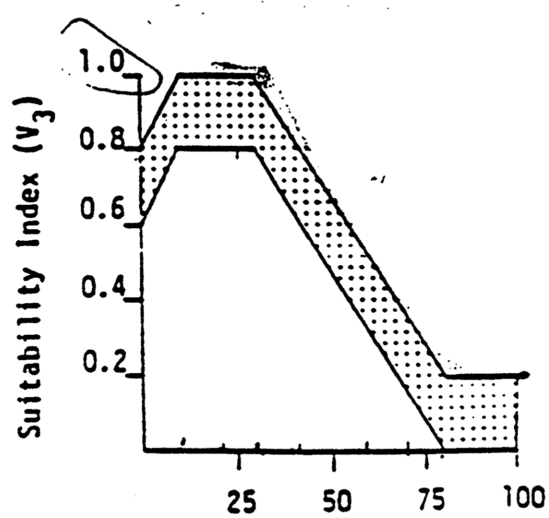
Cooper's hawks nest in a wide variety of habitats across their range (Jones 1979). Characterization of nesting habitat is especially difficult in eastern deciduous forests due to a lack of quantified nest site data (Titus and Mosher, in press). It appears that areas with large overstory trees, mature understory, and dense ground cover are preferred.

Interspersion Requirements. The Cooper's hawk is typically found in mature deciduous woods, but apparently prefers some coniferous cover for roosting (Brown and Amadon 1968).

Breeding territories (n=16) in Michigan averaged 200 ha (500 ac) for Cooper's hawks (Craighead and Craighead 1969). However, ranges in or near dense mixed stands of conifers and hardwoods averaged 36 ha (90 ac), apparently due to abundant prey in these habitats.

Winter territories (n=4) in Michigan averaged 192 ha (475 ac) but is an underestimate of the actual area according to Craighead and Craighead (1969). The diameter of the winter range was considered a better indicator, and averaged 3.0 km (1.9 mi) in diameter.

Special Considerations. Populations of Cooper's hawks have generally declined since the 1940's (Schriver 1969; Spofford 1969) and this species

Cover Type	Variable		Suitability Index Curve
EF, DF, DFW	[V_1]	% tree canopy closure.	
EF, DF, DFW	[V_2]	Forest overstory size class. A) Saplings (< 15 cm (6 in) dbh) B) Pole timber (> 15 cm (6 in) to 25 cm (10 in) dbh) C) Sawtimber (> 25 cm (10 in) to 50 cm (20 in) dbh) D) Mature trees (≥ 50 cm (20 in) dbh)	
EF, DF, DFW	[V_3]	% canopy closure of evergreen trees.	

Habitat Suitability Index (HSI) Model for the Cooper's Hawk

General Information

Species Information

Species:	Cooper's Hawk (*Accipiter cooperii*)
Habitat Use Pattern:	Single cover type user
Status:	Resident
Cover Types:	Evergreen Forest (EF), Deciduous Forest (DF), Deciduous Forested Wetland (DFW)
Ecoregion:	2320 North
Model Type:	Uncalibrated Index Model

Threshold Range Size. Information on the minimum size of suitable habitat required to support a population of Cooper's hawks was not found in the literature. A rough estimate, based on reported home range studies, is that a minimum of 100 ha (250 ac) of suitable habitat must be available or the HSI will equal 0.0.

Habitat Composition. Mature deciduous forests are the preferred habitat of Cooper's hawks.

Evaluation Criteria (by cover types)

Food Value. It is assumed that food value will never be more limiting than cover value.

Water Value. Free water is not required by the Cooper's hawk.

Cover and Reproductive Value. Cover and reproductive needs are provided by mature, dense forests, with patches of evergreens.

ranks first in support on the 1980 Blue List (Arbib 1979). Prior to 1947, populations were high and mortality was primarily due to heavy hunting pressure (Henny and Wight 1972). The decline since 1947 has generally been attributed to eggshell thinning caused by organochlorine pesticides in the hawks' diet (Peterson 1969; Henny and Wight 1972; Henny 1977). Another factor in the decline of Cooper's hawks in Pennsylvania was attributed to a massive winter kill during 1959-1960 (Schriver 1969). Recent reports indicate that the Cooper's hawk may be recovering in the northeastern U.S. (Conservation Committee 1977).

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SONG SPARROW
Riparian Communities

General

The song sparrow (Melospiza melodia) is a common year-around resident of this Ecoregion. Its preferred habitat is moist thickets (Gabrielson and Jewett 1940; Larrison and Sonnenberg 1968).

Food Requirements

Two-thirds of the song sparrow's diet is seeds and berries (Nice 1943). Weed and grass seeds were the major foods of the song sparrow from late summer to early spring in British Columbia (Tompa 1964). Late winter foods were green buds and the fresh tips of grasses and blackberries (Rubus spp.) and saskatoon berries (Amelanchier florida) were eaten in July. Nestlings were fed exclusively insects. The seeds of pigweeds (Chenopodium spp.) were the most important food item in the Pacific states (mainly California) although grasshoppers and crickets (Orthoptera), beetles (Coleoptera), caterpillars (Lepidoptera), ants (Hymenoptera), and bugs (Hemiptera) were also eaten (Martin et al. 1961).

Song sparrows forage on the ground along shrub edges and animal trails within the shrubbery, and in grasslands adjacent to cover (Tompa 1964). Shrub thickets in which the twigs form a dense tangle at ground level inhibit the song sparrow's ability to forage successfully (Marshall 1948; Tompa 1964).

Water Requirements

The presence of free water in a song sparrow's territory is of critical importance in drier habitats east of the Cascades (Larrison and Sonnenberg 1968). Song sparrows west of the Cascades can at least partially fulfill their drinking water requirements from dew (Marshall 1948; Larrison and Sonnenberg 1968).

Cover Requirements

The song sparrow prefers areas of compact, homogeneous shrub cover with an abundance of small clearings. Low, dense shrub thickets, hedges, tall grass and weeds, fallen branches, and marsh vegetation provide the song sparrow with escape and hiding cover (Marshall 1948; Tompa 1964). A continuous high leafy canopy in a dense coniferous or closed canopy deciduous forest, as well as tall dense willow growth, will limit the usefulness of an area for song sparrows even if a suitable understory is present (Marshall 1948). Song sparrows prefer areas with a dense, but relatively low, vegetative canopy or with a thin, widely spaced canopy (Tompa 1964).

Reproductive Requirements

Male song sparrows defend a territory from spring until the fall moult (Nice 1937). Elevated perches within this territory are used for singing. The vegetation must be heterogeneous enough in height to provide elevated perches and other singing posts above the level of the general vegetation (Marshall 1948; Tompa 1964). One of the critical factors in song sparrow habitat selection is the relative number and quality of perches and singing posts (Miller 1942).

Song sparrows build nests at or near ground level in dense concealing vegetation (Gabrielson and Jewett 1940; Marshall 1948; and Tompa 1964). Shrub edges, hedges, tufts of tall grass, and weed patches can provide suitable nesting habitat although shrubs are preferred (Tompa 1964).

Special Habitat Requirements

No special habitat requirements were found in the literature.

Interspersion Requirements

Song sparrow territories in Ohio ranged from 0.5 to 1.5 acres (0.2-0.6 ha) with an average size of 0.7 acres (0.3 ha) (Nice 1947). Song sparrows in the San Francisco Bay area were rarely found more than 10 yards (9.1 m) from cover (Marshall 1948). The presence of surface water within or adjacent to the territory will greatly enhance its suitability for song sparrows. Larger territories are found in drier areas (Marshall 1948).

Special Considerations

Song sparrows remain within their territorial boundaries through the fall and winter if sufficient food and cover are available (Nice 1937). They may assemble into flocks during the winter, particularly in severe weather and snow. Human interference may be an important factor in song sparrow mortality and nest destruction around populated areas.

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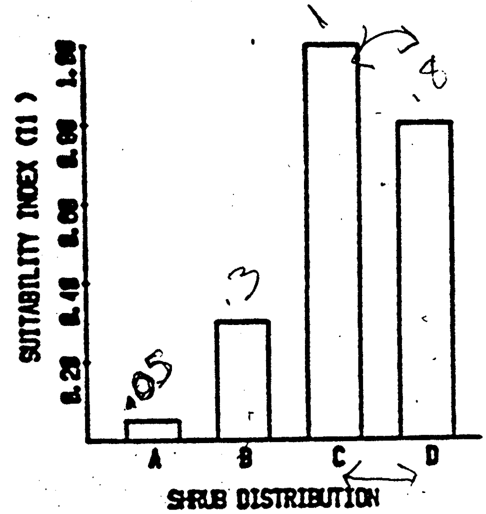
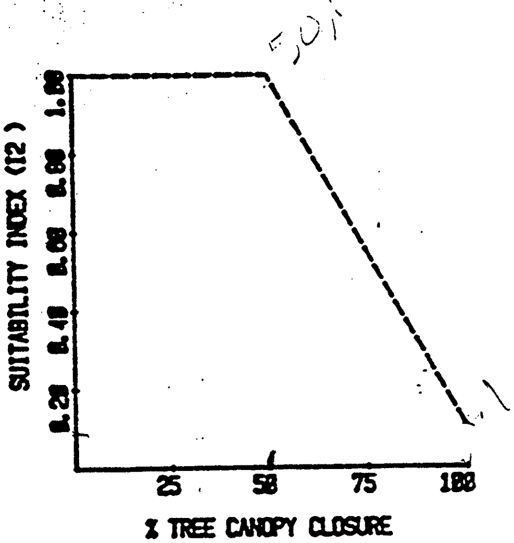
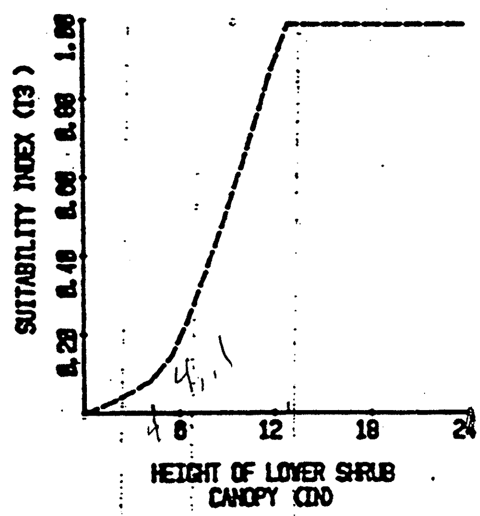
SONG SPARROW

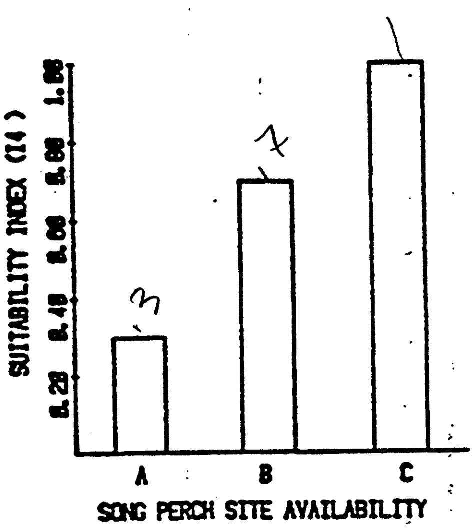
RIPARIAN COMMUNITIES



A=NO SHRUBS PRESENT
B=SCATTERED SINGLE SHRUBS
C=SCATTERED GROUPS OF SHRUBS
D=CONTINUOUS DENSE SHRUBBY VEGETATION







A=SHRUB CANOPY HEIGHT HOMOGENEOUS. NO TREES OR OTHER PERCHING OBJECTS AVAILABLE JUST ABOVE GENERAL SHRUB LAYER
B=SHRUB CANOPY HEIGHT SOMEWHAT HETEROGENEOUS. A FEW SHRUBS, SMALL TREES, OR OTHER PERCHING OBJECTS AVAILABLE JUST ABOVE GENERAL SHRUB LAYER
C=SHRUB CANOPY HEIGHT IRREGULAR, HIGHLY HETEROGENEOUS. AN ABUNDANCE OF SCATTERED SHRUBS, SMALL TREES, OR OTHER PERCHING OBJECTS AVAILABLE JUST ABOVE GENERAL SHRUB LAYER

HABITAT SUITABILITY INDEX

Song Sparrow in Riparian Communities

Ecoregion 2410

Food Value (X_1) = I_3

Where: I_3 = Suitability Index (SI) of height of lower shrub canopy.

Cover Value (X_2) = $(I_1 \times I_2)^{1/2}$

Where: I_1 = SI of shrub distribution.

I_2 = SI of percent tree canopy closure.

Reproductive Value (X_3) = $(I_1 \times I_4)^{1/2}$

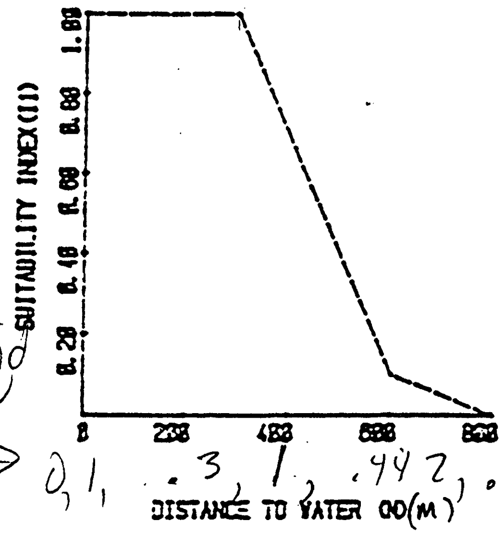
Where: I_1 = SI of shrub distribution.

I_4 = SI of song perch site availability.

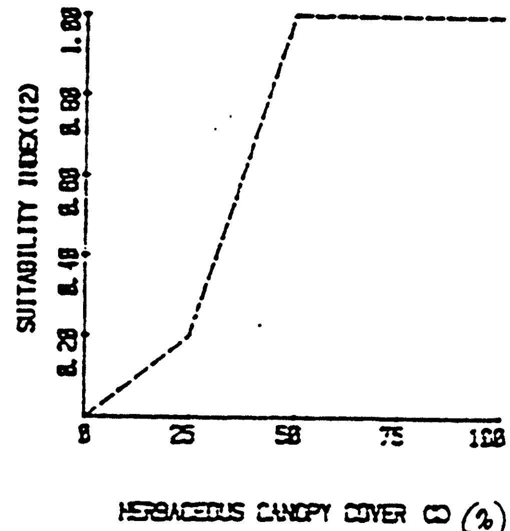
The Habitat Suitability Index is the lowest X_n value.

SONG SPARROW

HERB-DOMINATED WETLAND



Converted to miles → 0,1, .3, 1, .442, .1, .55, 0



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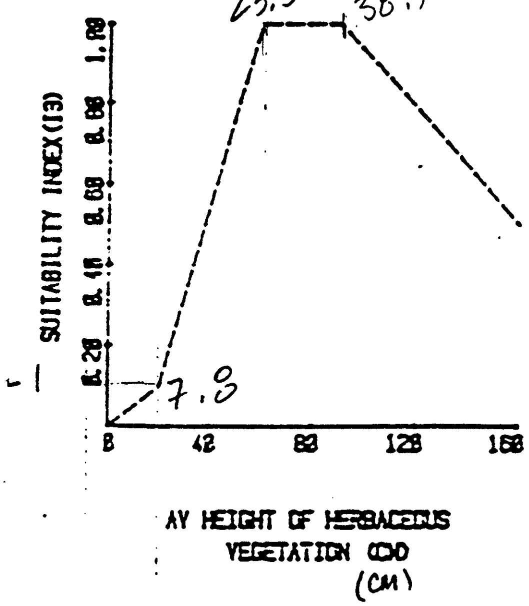

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0, 0, 7.8, .1, 23.3, 1, 38.9, 1, 62.3, .5

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HABITAT SUITABILITY INDEX

Song Sparrow in Herb-dominated Wetland

Ecoregion 2410

Water Value (X_1) = I_1

Cover and Reproductive Value (X_2) = $(I_2 \times I_3)^{1/2}$

Where: I_1 = Suitability Index (SI) of distance to water.

I_2 = SI of herbaceous canopy cover.

I_3 = SI of average height of herbaceous vegetation.

The Habitat Suitability Index is the lowest X_n value.

SONG SPARROW

General

The song sparrow (*Melospiza melodia*) is a common resident in Ecoregion 2410 (Gabrielson and Jewett 1940). Song sparrows occupy varied habitats but are generally associated with water or in close proximity to water (Gabrielson and Jewett 1940; Jewett et al. 1953).

Food Requirements

The diet of the song sparrow is composed of approximately 34% animal matter and ~~66% vegetable~~ matter (Nolan 1968). Animal foods include beetles (Coleoptera), grasshoppers and locusts (Orthoptera), cutworm and armyworm larvae (Lepidoptera), ants and wasps (Hymenoptera), flies (Diptera), bugs (Hemiptera) and leaf-hoppers (Homoptera). Plant foods include grass seeds, knotweeds (*Polygonum* spp.), sunflowers (*Helianthus* spp.), gromwell (*Lithospermum* spp.), purslane (*Portulaca* spp.), amaranth (*Amarantha* spp.), chickweed (*Stellaria* spp.), dock (*Rumex* spp.), ragweed (*Ambrosia* spp.), wood sorrel (*Oxalis* spp.), fruits and berries, and numerous other plants (Nolan 1968). The seeds of pigweeds (*Chenopodium* spp.) were the most important food item in the Pacific coast states (Martin et al. 1961). Nestlings are fed primarily insects (Knight 1908 cited by Nolan 1968).

Song sparrows ~~forage on the ground~~ along shrub edges and animal trails within the shrubbery, and in grasslands adjacent to cover (Tompa 1964). Shrub thickets in which the twigs form a dense tangle at ground level inhibit the song sparrow's ability to forage successfully (Marshall 1948; Tompa 1964).

Water Requirements

Song sparrows require nearby water for drinking and bathing (Nice 1937). Song sparrows can partially fulfill their drinking water requirements with dew (Marshall 1948; Larrison and Sonnenberg 1968). Birds in territories without permanent water will leave several times daily for watering purposes (Nice 1937). The distance a bird will travel for water is unknown, but is at least 550 m (1,800 ft).

Cover Requirements

Song sparrows require a dense brush layer or a rank herbaceous layer and are found in a number of different habitats (Dumas 1950). Stream-side thickets are the preferred habitat of the song sparrow (Nice 1943) and they are common in moist areas with low, irregular plant coverage exposed to the sun (Nolan 1968). Song sparrows are found along stream banks, brushy shores of ponds, brushy fence rows, and in shrubby wet meadows or cattail swamps, as well as in gardens and yards in suburbs and small towns. Low, dense shrub thickets, hedges, tall grass and weeds, fallen branches, and marsh vegetation provide the song sparrow with escape and hiding cover (Marshall 1948; Tompa 1964). A continuous high leafy canopy in a dense coniferous or closed canopy deciduous forest, as well as tall dense willow growth will limit the usefulness of an area for song sparrows even if a suitable understory is present

(Marshall 1948). Song sparrow distribution in Wisconsin was strongly correlated with decreasing canopy cover and weakly correlated with an increasing proportion of trees in the 25 to 51 cm (10 to 20 in) diameter class (DeJong 1976). Song sparrows were found in several habitats in southeastern Washington, but exhibited the highest density index in the floodplain forest type which was characterized by a closed tree canopy, well-developed secondary tree layer, and a dense scrub layer (Dumas 1950). Song sparrows roost at night in weeds, hedges, and small evergreens (Nice 1943).

Reproductive Requirements

Two main requirements for song sparrow nest sites include secure nest support and concealment (Nice 1943). Shrub edges, hedges, tufts of tall grass, and weed patches can provide suitable nesting habitat although shrubs are preferred (Tompa 1964). Song sparrows build their nests at ground level early in the breeding season, under tufts of grass, weed stalks or thistles (Nice 1937). Later in the season, as more vegetative cover becomes available, song sparrows prefer nest sites 61 to 89 cm (24 to 35 in) above the ground. Elevated nest sites include small evergreens, vines, or piles of debris (Nice 1943). Song sparrow nests are rarely located more than 1.8 m (6 ft) above the ground (Preston and Norris 1947). Nests are constructed largely of dead grass and weeds and are lined with finer material (Nice 1937).

Special Habitat Requirements

Variation in vegetative height of the habitat appears to be important for the song sparrow (Nice 1943). Trees, shrubs, fences, and boulders, 2.1 to 4.6 m (7 to 15 ft) above the ground, provide singing perches and lookouts for male song sparrows (Nolan 1968).

Interspersion Requirements

Territories of the song sparrow must provide cover for nesting, roosting, protection from enemies, and singing posts (Nice 1943). Territories in an area of Ohio with a high density of song sparrows ranged from 0.2 to 0.6 ha (0.5 to 1.5 ac) with an average size of 0.27 ha (0.67 ac). The maximum territories along lake shores in Minnesota varied from 0.12 to 0.26 ha (0.3 to 0.65 ac) (Suthers 1960), while on small islands the minimum territory may be as small as 0.02 ha (0.04 ac) (Beer et al. 1956). Resident song sparrows in California are very sedentary (Halliburton and Mewaldt 1976). The median dispersal distance for juvenile song sparrows on the California coast was only 225 m (738 ft) and 78% of the juveniles settled within 400 m (1,312 ft) of their first capture site. Adult males apparently had a greater year-around attachment to specific territories than did adult females, as evidenced by movement data. Song sparrows in the San Francisco Bay area were rarely found more than 9 m (10 yd) from cover (Marshall 1948). Larger territories are found in drier areas.

Special Considerations

Song sparrows remain within their territorial boundaries through the fall and winter if sufficient food and cover is available (Nice 1937). Human interference may be an important factor in song sparrow mortality and nest destruction around populated areas. Song sparrow nests located in cultivated areas may be destroyed by plowing. Domestic cats may prey heavily on sparrow nesting.

Summary

Song sparrows inhabit various surface cover types that provide a dense scrub layer or rank herbaceous vegetation, and a nearby water source. Food consists of insects and seeds of various plants. Adequate food supplies will be provided by an abundant herbaceous layer. Cover and reproductive needs can be met in habitats with either a dense scrub layer or rank herbaceous vegetation. A tall, sparse scrub layer may not provide enough vegetative volume to satisfy cover and reproductive needs and a low dense scrub layer may prevent ground foraging. A scrub stratum with a variable height profile will provide singing and lookout perches. A dense tree canopy in forested habitats may prevent the development of the necessary scrub and herbaceous strata. All of the life requisites of the song sparrow can be provided in a single surface cover type as long as the internal interspersion of scrub and herbaceous vegetation is present.

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HABITAT SUITABILITY INDEX

Song Sparrow in Deciduous Scrubland
Scrub-dominated Wetland
Tree-dominated Wetland

Ecoregion 2410

Water Value $(X_1) = I_1$

Cover and Reproductive Value $(X_2) = (I_2 \times I_3)^{1/2}$

Where: I_1 = Suitability Index (SI) of distance to water.

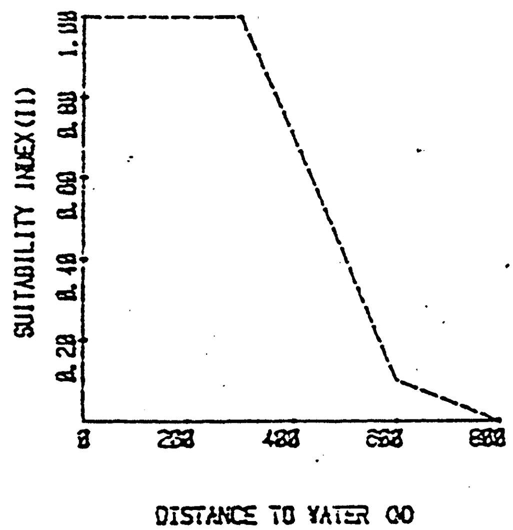
I_2 = SI of scrub crown cover.

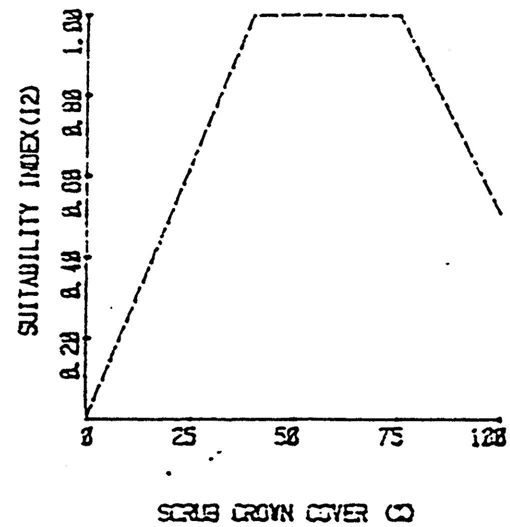
I_3 = SI of average height of overstory scrubs.

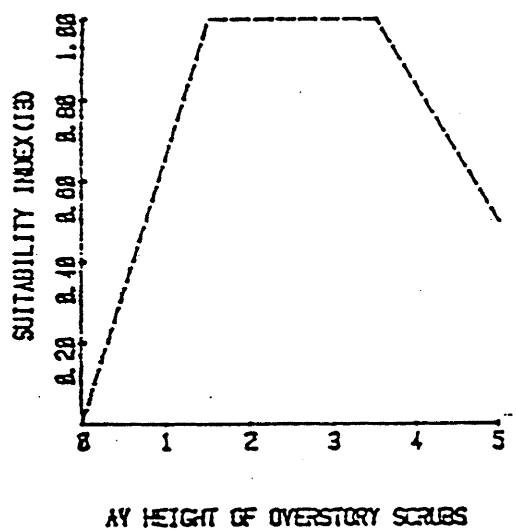
The Habitat Suitability Index is the lowest X_n value.

SONG SPARROW

TREE-DOMINATED WETLAND SCRUB-DOMINATED WETLAND
DECIDUOUS SCRUBLAND







(M) = meters

Review Copy
March 1979

HABITAT SUITABILITY INDEX

Song Sparrow in Herb-dominated Wetland

Ecoregion 2410

Water Value $(X_1) = I_1$

Cover and Reproductive Value $(X_2) = (I_2 \times I_3)^{1/2}$

Where: I_1 = Suitability Index (SI) of distance to water.

I_2 = SI of herbaceous canopy cover.

I_3 = SI of average height of herbaceous vegetation.

The Habitat Suitability Index is the lowest X_n value.

SONG SPARROW

HERB-DOMINATED WETLAND