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BIOLOGICAL REPORT 82(10.95)
MAY 1985

HABITAT SUITABILITY INDEX MODELS: RED-WINGED BLACKBIRD

Fish and Wildlife Service
U.S. Department of the Interior

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

MODEL EVALUATION FORM

Habitat models are designed for a wide variety of planning applications where habitat information is an important consideration in the decision process. However, it is impossible to develop a model that performs equally well in all situations. Assistance from users and researchers is an important part of the model improvement process. Each model is published individually to facilitate updating and reprinting as new information becomes available. User feedback on model performance will assist in improving habitat models for future applications. Please complete this form following application or review of the model. Feel free to include additional information that may be of use to either a model developer or model user. We also would appreciate information on model testing, modification, and application, as well as copies of modified models or test results. Please return this form to:

Habitat Evaluation Procedures Group
U.S. Fish and Wildlife Service
2627 Redwing Road, Creekside One
Fort Collins, CO 80526-2899

Thank you for your assistance.

Species _____ Geographic Location _____

Habitat or Cover Type(s) _____

Type of Application: Impact Analysis ____ Management Action Analysis ____
Baseline ____ Other _____

Variables Measured or Evaluated _____
_____
_____
_____

Was the species information useful and accurate? Yes ____ No ____

If not, what corrections or improvements are needed?_____
_____
_____
_____

Were the variables and curves clearly defined and useful? Yes ____ No ____

If not, how were or could they be improved? _____

_____

_____

_____

Were the techniques suggested for collection of field data:

Appropriate? Yes ____ No ____

Clearly defined? Yes ____ No ____

Easily applied? Yes ____ No ____

If not, what other data collection techniques are needed? _____

_____

_____

_____

Were the model equations logical? Yes ____ No ____

Appropriate? Yes ____ No ____

How were or could they be improved? _____

_____

_____

_____

Other suggestions for modification or improvement (attach curves, equations, graphs, or other appropriate information) _____

_____

_____

_____

Additional references or information that should be included in the model:

_____

_____

_____

_____

_____

Model Evaluater or Reviewer _____ Date _____

Agency _____

Address _____

_____

_____

Telephone Number Comm: _____ FTS _____

Biological Report 82(10.95)
May 1985

HABITAT SUITABILITY INDEX MODELS: RED-WINGED BLACKBIRD

by

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PREFACE

This document is part of the Habitat Suitability Index (HSI) Model Series [Biological Report 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. This information provides the foundation for the HSI model and may be useful in the development of other models more appropriate to specific assessment or evaluation needs.

The HSI Model Section documents the habitat model and includes 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 HSI Model Section includes information about the geographic range and seasonal application of the model, its current verification status, and a list of the model variables with recommended measurement techniques for each variable.

The model is a formalized synthesis of biological and habitat information published in the scientific literature and may include unpublished information reflecting the opinions of identified experts. Habitat information about wildlife species frequently is represented by scattered data sets collected during different seasons and years and from different sites throughout the range of a species. The model presents this broad data base in a formal, logical, and simplified manner. The assumptions necessary for organizing and synthesizing the species-habitat information into the model are discussed. The model should be regarded as a hypothesis of species-habitat relationships and not as a statement of proven cause and effect relationships. The model may have merit in planning wildlife habitat research studies about a species, as well as in providing an estimate of the relative quality of habitat for that species. User feedback concerning model improvements and other suggestions that may increase the utility and effectiveness of this habitat-based approach to fish and wildlife planning are encouraged. 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 80526-2899

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RED-WINGED BLACKBIRD (*Agelaius phoeniceus* L.)

HABITAT USE INFORMATION

General

The red-winged blackbird (*Agelaius phoeniceus* L.) nests in fresh-water and brackish herbaceous wetlands, bushes and small trees along watercourses, and certain upland cover types from (American Ornithologists' Union 1983:723):

> ... east-central, south-coastal and southern Alaska ..., southern Yukon, west-central and southern Mackenzie, northwestern and central Saskatchewan, central Manitoba, central Ontario, southern Quebec ..., New Brunswick, Prince Edward Island, Nova Scotia and southwestern Newfoundland south to northern Baja California, through Mexico ... and along both coasts of Central America to Nicaragua and northern Costa Rica ..., and to southern Texas, the Gulf coast and southern Florida. [This blackbird winters] from southern British Columbia, Idaho, Colorado, Kansas, Iowa, the southern Great Lakes region, southern Ontario and New England ... south throughout the remainder of the breeding range, with the southwestern and most of Middle American populations being sedentary.

The red-winged blackbird traditionally was considered to be a wetland nesting bird. It has adapted, within the last century, to habitat changes brought about by man; it now commonly nests in hayfields, along roadsides and ditches, and in other upland sites (Dolbeer 1980).

Food

Red-winged blackbirds vary their diet throughout the year, presumably in response to the nutritive demands of reproduction. The percent of waste grain and seeds in the diet of male blackbirds in one study in Ontario, Canada, was at least 80 to 87% in March and April, 46% in May, only 10% in July, and 85% in late July to October (McNicol et al. 1982). Insects amounted to 51 to 84% of the diet during May and July. The diet of female red-winged blackbirds varied between 67 and 79% insect parts in May and July but was only 15% insectivorous in late July-October, after fledging had occurred.

Water

References describing the dependency of the red-winged blackbird on surface water for drinking and bathing were not found in the literature. Nesting occurs in herbaceous wetlands and upland habitat near surface water and in suitable vegetation distant from free water. Red-winged blackbirds seem to prefer habitats near wetlands for foraging. Communal roosting, which occurs after fledging is completed, is either in herbaceous wetlands or dense communities of young trees with thick canopies growing on moist sites (Micacchion and Townsend 1983).

Cover

The red-winged blackbird nests in a variety of habitats. Blackbirds in southern Michigan prefer old and new hay fields, pastures, old fields, and wetlands with robust vegetation capable of supporting nests and dense cover that provides protection for nests (Albers 1978). They avoid cut or fallow fields, woodlots, agricultural croplands, open water, and tilled soil.

Areas with tall, dense, herbaceous vegetation seem to provide preferred nest sites. Blackbirds that nest early in the breeding season select tall, dense, old-growth herbaceous vegetation while blackbirds that nest late in the breeding season select tall, dense, new-growth herbaceous vegetation (Albers 1978). Upland nest sites of red-winged blackbirds in Ontario were in plant communities commonly dominated by goldenrod (*Solidago* spp.), alfalfa (*Medicago sativa*), fleabane (*Erigeron* spp.), clover (*Trifolium* spp.), various thistles (*Cirsium* spp.), and similar herbaceous weeds (Joyner 1978). Blackbirds in fresh water sites selected old- and new-growth of broad-leaved monocots, like cattails (*Typha* spp.) and broad-leaved sedges (*Carex* spp.), and commonly rejected old- and new-growth of narrow-leaved monocots and forbs (Albers 1978). Woody species, such as hightide bush (*Iva frutescens*) and groundselbush (*Baccharis halimifolia*), and robust herbaceous plants, like cattails, supported the most nests in tidal herbaceous wetlands (Meanley and Webb 1963).

The density of preferred plant cover is not adequately described either in the literature or in this model. The height of preferred plant cover is inferred, below, from descriptions of nest sites.

Red-winged blackbirds frequently use scattered trees and fence posts near their breeding territories as observation posts. Blackbirds use both herbaceous wetlands and trees for communal roosts after fledging is completed. Roost trees characteristically are young, occur at high densities, provide thick canopies, and are adapted to moist sites (Micacchion and Townsend 1983).

Reproduction

Red-winged blackbirds are migratory in the northern portion of their range. Males migrate to or congregate at future nesting habitats in late winter, and females arrive at the territories in early spring (Case and Hewitt 1963). In areas with resident populations, individuals of both sexes may remain near breeding territories throughout the year, even though the areas are not actively defended or used in winter except, perhaps, as roosting sites (Orians pers. comm.). Males are polygynous, and up to six females commonly nest within a male's territory (Holm 1973). Harem size was larger in herbaceous wetlands with open stands of cattails than in herbaceous wetlands dominated by bulrushes (*Scirpus* spp.) or by closed stands of cattails (Holm 1973). Harem size has sometimes been observed to exceed 10 to 12 females and, in one instance, numbered 32 females (Orians pers. comm.).

Males do not participate in nest building, incubation, or feeding of the incubating female (Orians pers. comm.). Males may help feed nestlings and are likely to help feed fledglings. The timing of breeding varies throughout the range of the red-winged blackbird. Nesting frequently begins in March or April and is completed by mid-July in the more temperate habitats. Most young in North America are fledged by late July.

Herbaceous wetlands dominated by cattails generally seem to be the most productive habitats for red-winged blackbirds in terms of nests/ha or number of young fledged/ha (Robertson 1972). Favorable herbaceous wetland sites produce more suitable food per unit area and have higher nest densities, highly synchronous nesting, higher nest survival rates, and lower nest predation rates than do upland nest sites.

Nests of red-winged blackbirds are placed on the edges of cattail clumps that border areas of open water (Wiens 1965). Herbaceous wetlands that are dominated by cattails and have open, permanent water have the optimum number of available nest sites. Early nests are placed in the old growth vegetation remaining from past growing seasons, while late nests may be built on new growth. Nest success in one herbaceous wetland habitat seemed related to: (1) increased depth of permanent water (up to 50 cm or more), which apparently reduced mammalian predation on nests; (2) nest placement close to water (greater nest success was observed for nests 20 cm above water than nests 100 cm above water); (3) nest placement in herbaceous wetland vegetation interspersed with open water, rather than in herbaceous wetland vegetation where no open water was present; and (4) nest placement in marsh grass and loosestrife (*Decadon verticillatus*), rather than in sweet gale (*Myrica gale*) and sedges (Weatherhead and Robertson 1977). Other studies have indicated that nests placed at 1.2 m heights were more successful than nests placed at 0.6 m heights in tidal herbaceous wetlands on Chesapeake Bay (Meanley and Webb 1963) and that nest success was higher when permanent water levels were greater than 25 cm (Robertson 1972).

Nests of red-winged blackbirds in upland sites typically are wound between and attached to stalks of herbaceous vegetation (Bent 1958). Early nests are entwined with old growth stems and late nests with the sturdiest stems of the new growth. Activities, such as intensive livestock grazing, mowing, and burning of old growth stubble, make herbaceous uplands unavailable for early nest placement. Mowing hayfields during the nesting season disrupts nesting success on upland sites (Albers 1978). Red-winged blackbirds seem to prefer areas with the densest, tallest herbaceous vegetation for nest placement. Vegetation that restricted visibility was more important than the number of plant stems and leaves per unit area. Trees greater than 5.0 m in height were in most territories (Albers 1978). The mean height of nest placement was 15 cm in monotypic stands of reed canarygrass (*Phalaris arundinacea*) 58 cm high (Joyner 1978). Nest sites often are close to open water (Joyner 1978), although no specific descriptions of acceptable distances of upland nest sites from open water were found in the literature.

Interspersion

The red-winged blackbird seems to be closely associated with the presence of standing water (Bent 1958) and certain types of dense herbaceous vegetation for nest placement. Herbaceous wetlands or sloughs, with extensive cattails, bulrushes, sedges, reeds (*Phragmites* spp.), or tules (*Scirpus* spp.), historically have provided important nesting habitat for the blackbird (Bent 1958). However, blackbirds also nest in dense herbaceous cover in hayfields, along roadsides and ditches, and in other upland sites (Dolbeer 1980). Red-winged blackbirds forage for insects in understory, midstory, and overstory canopies (Snelling 1968) during the nesting season.

The blackbird is primarily a seed eater, except during fledging. The species sometimes forms large communal flocks in wetland herbaceous habitats or in trees and brushlands and these birds may forage on agricultural crops or on understory seed sources (Mott et al. 1972; Johnson and Caslick 1982). After the autumn migration from the northern portion of their range, red-winged blackbirds frequently roost in herbaceous wetland habitats, trees, or shrubs and feed on seeds within understory vegetation.

Special Consideration

Red-winged blackbirds shift from a dispersed insectivorous feeding behavior during the nesting season to a communal granivorous feeding habit after fledging has occurred. They frequently move into agricultural areas at this time. Costs related to their consumption of grain can become high and may exceed the benefits of insect control related to their foraging habits during fledging (Bendell et al. 1981). Damage to ripening corn (*Zea mays*) occurs during August and September (Somers et al. 1981; Stehn and de Becker 1982), when blackbirds often congregate at night in herbaceous wetlands or in roosts in young deciduous trees in great concentrations (perhaps up to 1 million birds) (Stehn and de Becker 1982). The distance from these autumn roosts to corn fields and the proximity of corn fields to traditional flight-lines strongly influences the amount of damage inflicted on individual corn fields. Bird damage to crops in Ohio diminished consistently as distances from communal roosts increased from 3.2 to 8 km, and the level of damage remained constant and low at distances of 8 to 19.2 km (Dolbeer 1980).

HABITAT SUITABILITY INDEX (HSI) MODEL

Model Applicability

Geographic area. This model will produce an HSI for nesting habitats of the red-winged blackbird. The breeding range and the year-round range of the blackbird occur throughout the contiguous 48 States.

Season. The model will produce an HSI for nesting habitat throughout the nesting season, which generally occurs from March to late July.

Cover types. This model was developed to evaluate habitat in herbaceous wetlands (HW) and upland herbaceous cover types, such as pasture and hayland (P/H), forbland (F), and grassland (G) (terminology follows that of U.S. Fish and Wildlife Service 1981).

Minimum habitat area. Minimum habitat area is defined as the minimum amount of contiguous habitat that is required before a species will live and reproduce in an area. Specific information on minimum areas required for red-winged blackbirds was not found in the literature. It is assumed, however, that a wetland area must contain at least 0.10 ha in emergent herbaceous vegetation, like cattails, to be considered nesting habitat for the blackbird. Several studies have described the minimum territory for male red-winged blackbirds as 0.02 ha (Weatherhead and Robertson 1977; Orians 1980). A 0.10 ha area of emergent herbaceous vegetation might, therefore, potentially provide territories for up to five male blackbirds. Territories in upland habitats

are much larger than those in wetland habitats. It is assumed that a block of upland habitat must be at least 1.0 ha in area to provide adequate breeding habitat for red-winged blackbirds.

Verification level. This model was developed from descriptive information about nesting cover and species-habitat relationships identified in the literature. The HSI derived from the use of this model describes the potential of an area for providing nesting habitat for the red-winged blackbird. The model is designed to rank the suitability of nesting habitat as would a biologist with expert knowledge about the reproductive requirements of the blackbird. The model should not be expected to rank habitats in the same way as population data because many nonhabitat-related criteria can significantly impact populations of wildlife species.

Model Description

Overview. The red-winged blackbird uses a variety of habitat layers throughout the year. Tall, dense, herbaceous vegetation seems to satisfy nesting, foraging, and cover requirements. The red-winged blackbird readily uses midstory and overstory layers of habitat at times but does not seem to be dependent on the presence of these layers.

The red-winged blackbird typically nests in tall (over 0.5 m), dense (undefined) herbaceous vegetation, although it occasionally nests in shrubs and trees. This nest site requirement is best met in herbaceous wetland habitats where nest sites are available in sturdy cattails over open, permanent water. Nesting requirements also can be met by suitable herbaceous vegetation in upland sites. Tall, sturdy, herbaceous stems or midstory or overstory components are used as display perches or observation posts. Red-winged blackbirds nesting in herbaceous wetland habitats may feed on insects associated with shrub, tree canopy, or herbaceous vegetation within the wetland or on insects associated with midstory and overstory canopies or in the grass understory outside the wetland boundary (Snelling 1968). Birds nesting in upland sites typically forage for insects in understory vegetation near the nest site.

This model attempts to evaluate the ability of a habitat to meet the food and reproductive needs of the red-winged blackbird during the nesting season. The logic used in this species-habitat model is described in Figure 1. The following sections document this logic and the assumptions used to translate habitat information for the red-winged blackbird into the variables selected for the HSI model. These sections also describe the assumptions inherent in the model, identify the variables used in the model, define and justify the suitability level of each variable, and describe the assumed relationships between variables.

Food and reproductive components (herbaceous wetland cover types). There are three conditions (A, B, and C) included in Figure 1. Condition A wetlands, with a minimum of 0.10 ha in emergent herbaceous vegetation, can be very productive nesting habitats for red-winged blackbirds if water is present throughout the year, water chemistry is favorable for photosynthesis, and abundant, persistent, emergent vegetation suitable for nest placement is

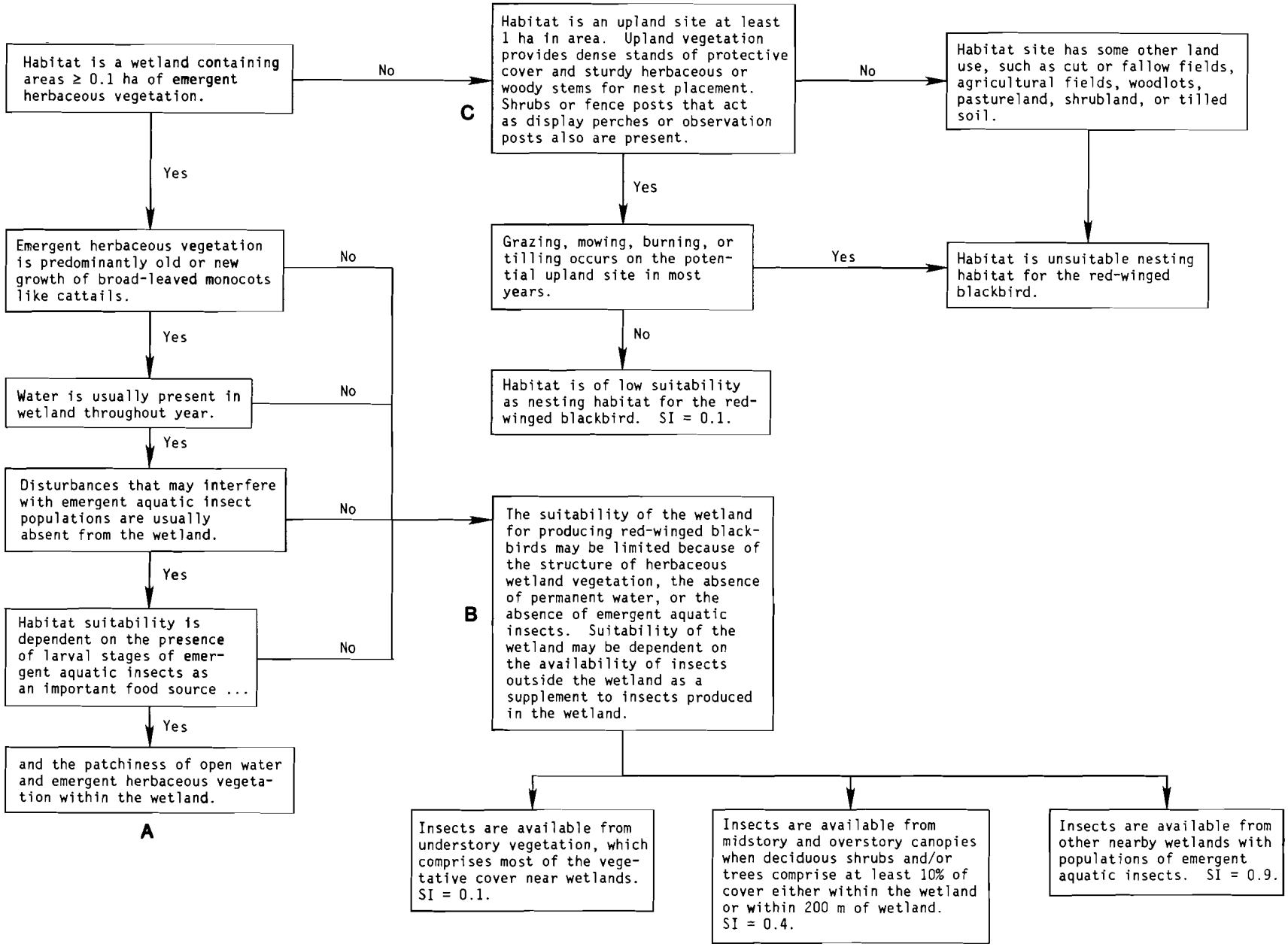

Figure 1. Nesting habitat relationships for the red-winged blackbird.

present. The quality of such a wetland as nesting habitat for red-winged blackbirds can be estimated with the following five habitat variables.

Variable 1 (V1) refers to the type of emergent herbaceous vegetation available in the wetland.

V1 = 1.0 if emergent herbaceous vegetation is predominantly old or new growth of broad-leaved monocots, like cattails.

V1 = 0.1 if emergent herbaceous vegetation is predominantly narrow-leaved monocots or other herbaceous materials.

Variable 2 (V2) considers the water regime of the wetland. The suitability index of V2 is 1.0 if the wetland is permanently flooded or intermittently exposed with water usually present throughout the year. This is a desirable condition because permanent water is necessary to support persistent populations of invertebrates that overwinter in various larval instars, maximizing the production of aquatic insects that emerge throughout the next spring and early summer. These insects seem to be the favored food source for blackbirds nesting in herbaceous wetlands (Orians 1980). The presence of permanent water within the wetland may reduce mammalian predation on nests of red-winged blackbirds (Robertson 1972).

V2 = 1.0 if water usually is present in the wetland throughout the year.

V2 = 0.1 if the wetland usually is dry during some portion of the year.

Variable 3 (V3) pertains to the abundance of carp (*Cyprinus carpio*) within the wetland. Carp disturb submergent vegetation within the wetland, which may destroy habitat for emergent aquatic insects (like Odonates) and reduce wetland food sources for blackbirds.

V3 = 1.0 if carp are absent from the wetland.

V3 = 0.1 if carp are present within the wetland.

Variable 4 (V4) in the model measures the abundance of larvae of emergent aquatic insects. The adult form of these species provides a potentially important food source for red-winged blackbirds nesting in wetland habitats. The biomass of these benthic invertebrates is variable within a herbaceous wetland at any one time, as well as between sampling periods (Hynes 1972). This biomass should not be regarded as a direct measure of productivity because production, in terms of both numbers and weight, is many times larger than that present at any one sample periods, and the assessment of numbers or biomass per unit of area presents formidable, perhaps insurmountable, difficulties (Hynes 1972). The presence or absence of suitable benthic invertebrates can be determined by sampling with a sieve net (Needham and Needham 1970) along the edge of clumps of emergent vegetation. Sampling is more likely to be accurate than inferences about the presence of benthic invertebrates based on measures of water chemistry that may inadequately consider pollutants that impact aquatic food chains. Inferences about the presence of benthic invertebrates based on the appearance of aquatic vegetation also are less accurate than sampling (Orians pers. comm.). Therefore, sampling to

determine the presence or absence of important benthic invertebrates is the preferred assessment technique.

V4 = 1.0 if larvae of damselflies and dragonflies (Order Odonata) are present in the wetland.

V4 = 0.1 if larvae of damselflies and dragonflies are not present in the wetland.

Dense stands of emergent vegetation in wetlands prevent sunlight from penetrating to the water surface, which reduces aquatic productivity. A mat of vegetation can form a wetland "floor", which reduces the availability of arthropods to red-winged blackbirds and may result in increased nest predation. Open water, interspersed throughout the emergent herbaceous vegetation, supports submergent vegetation within the wetland boundary that can be used by aquatic insects as food and cover. The openings also provide an interface between emergent vegetation and open water, which increases the vegetation surface area available to emerging insects and foraging red-winged blackbirds and may increase the presence of potential nest sites. Blackbirds frequently nest on the edge of cattail clumps that border open water (Wiens 1965). They are highly territorial, and the number of territories in a wetland is assumed to be dependent on the quantity of edge between emergent vegetation and open water that is available for nest sites. An exact measure of the amount of edge within a wetland can be difficult and unreliable because of the highly dynamic nature of the herbaceous vegetation, resulting from water level fluctuations, life cycles of the vegetation, and activities of animals like muskrats (Ondatra zibethica). Measures of the patchiness of emergent herbaceous vegetation and open water within a wetland is represented by variable 5 (V5)in the model.

Blackbirds prefer patchy stands of cattails interspersed with areas of open water over dense homogeneous stands of cattails (Robertson 1972). Variable 5 is assumed to have a suitability index of 1.0 when the quantity of open water and emergent vegetation is about even (about 40% to 60%). Robertson (1972) found a nesting density of about 96 nests/ha in herbaceous wetland habitat when patchy vegetation was about 41% of the total wetland area. Wetlands with large areas of emergent vegetation and small areas of open water receive relatively low SI's because of the small quantity of suitable nest sites. Case and Hewitt (1963) described the Inlet Valley Marsh in New York as a small, closed herbaceous wetland with upland trees and shrubs immediately adjacent for nesting and foraging sites. The red-winged blackbird nesting density in this herbaceous wetland was about 33/ha. Variable 5 is assigned an SI of 0.3 when a wetland is completely covered with emergent herbaceous vegetation, as described above.

Conditions where there are small areas of emergent vegetation and large areas of open water also receive a low SI because of the reduced availability of niche spaces. Moulton (1980) found red-winged blackbirds nesting in emergent vegetation along ditch banks that surrounded large areas of open water in rice (Oryza sativa) paddies in northern Minnesota. Nest densities averaged about 2.5 nests/ha of total wetland habitat, presumably because both nests and emergent vegetation were restricted to long, narrow strips of edge.

The territorial behavior of red-winged blackbirds may have restricted the nest density along the ditch banks. An SI of 0.1 is assigned to V5 for wetland habitats with a limited amount of emergent herbaceous cover. The SI's for wetlands with different amounts of emergent herbaceous vegetation are listed below. User's can interpolate between listed values as needed.

V5 = 1.0 if the wetland area contains about an equal mix of emergent herbaceous vegetation and open water.

V5 = 0.3 if the wetland area is covered by a dense stand of emergent herbaceous vegetation.

V5 = 0.1 if the wetland area contains a few patches of emergent herbaceous vegetation and extensive areas of open water.

Condition B wetlands are wetlands that are likely to be dry sometime during the year or that do not have an aquatic insect resource. These wetlands may still provide some habitat for nesting red-winged blackbirds. Blackbirds will tend to use the available emergent vegetation as nest sites and rely on vegetation surrounding the wetland as a foraging substrate. The distance that red-winged blackbirds will fly from wetlands to forage on insects in upland habitats is not known. In this model, only foraging sites within 200 m of wetlands that contain nest sites are assumed to be useful to blackbirds. The quality of a wetland without permanent water or an aquatic insect resource is assumed to be no better than the quality of available foraging sites outside the wetland (V6). Wetlands that only have upland habitats with understory vegetation (such as old fields, pastures, or hay fields) available as foraging substrates are given an SI of 0.1. Wetlands near uplands that have a deciduous midstory or tree canopy as a foraging substrate are assumed to have an SI of 0.4. Red-winged blackbirds nesting in one herbaceous wetland will forage on insects in other, close-by, herbaceous wetlands (Holm 1973). Condition B wetlands situated within 200 m of a condition A herbaceous wetland that has an emergent aquatic insect fauna (Odonates) and undefended foraging areas are given an SI of 0.9.

V6 = 0.1 if the only suitable foraging substrate is an understory layer.

V6 = 0.4 if the suitable foraging substrates include a midstory and/or an overstory layer.

V6 = 0.9 if the suitable foraging area is a condition A wetland.

Food and reproductive components (upland cover types). Upland habitats (Fig. 1; condition C) frequently are less productive than are wetland habitats. The number of young red-winged blackbirds fledged per territory may be as large in upland sites as in some wetland habitats (Dolbeer 1976). The number of young fledged/ha in upland sites, however, frequently is less than 10% of the number fledged/ha in good quality wetland habitat. For example, Robertson (1972) reported 133 young fledged/ha in one wetland study area, while only 5 young fledged/ha in nearby upland sites. The nesting density in the wetland habitat, with patches of emergent, herbaceous vegetation interspersed with patches of open water, was about 10 times higher than in upland habitats.

Robertson found about 100 red-winged blackbird nests/ha in suitable wetland habitat, 2 to 13 nests/ha in upland hay fields, and 0.1 nests/ha in a Christmas tree plantation.

Robertson's (1972) data on the numbers of nests/ha and young fledged/ha suggest that, if the best wetland habitats have an HSI of 1.0, the best upland sites may have an HSI of about 0.1. Graber and Graber (1963) determined that summer populations of red-winged blackbirds (number/40 ha) in Illinois from 1958 to 1959 were 301 birds in herbaceous wetlands (whether condition A or B is unknown), 342 birds in edge shrubs, 204 birds in sweet clover, 158 birds along drainage ditches, 134 birds in mixed hay, 89 birds in red clover (Trifolium pratense), 65 birds in oat (Avena sativa) fields, 64 birds in ungrazed grasslands, 58 birds in alfalfa, 30 birds in wheat (Triticum aestivum), 27 birds in fallow fields, 24 birds in pastureland, 23 birds in shrub-grown areas, 5 birds in corn fields, and 3 birds in soybeans (Glycine max). The observed nest densities would not exceed the values measured by Robertson (1972) for upland habitats even if all of the birds in each of these different habitat types were nesting females.

The type of upland cover available as nest sites for the red-winged blackbird is represented by V7 in the model. Red-winged blackbirds nest in a wide variety of upland sites. For example, blackbirds nested in hay fields and old fields, but not in tilled and fallow fields, in southern Michigan (Albers 1978). Important characteristics of upland nest sites include the presence of dense, tall, herbaceous vegetation, the availability of fence posts and other structures that serve as display perches for males and as observation posts for both males and females, and a proximity to open water (Joyner 1978). Specific information on the preferred proximity of nest sites in upland habitats to open water were not found in the literature.

Variable 7 (V7) describes the availability of dense, sturdy herbaceous vegetation in forbland, grassland, and pasture/hayland upland sites. Variable 7 has a habitat suitability index of 0.1 if the herbaceous vegetation is dense and tall, like sweet clover (Melilotus spp.), mixed hay, alfalfa, and coarse weeds, which provide suitable nest sites and protective cover. Variable 7 has a suitability index of 0.0 if the habitat site has some other surface cover, such as cut or fallow fields, agricultural fields, woodlots, or tilled soils.

V7 = 0.1 if upland habitat provides dense, tall, herbaceous vegetation.

V7 = 0.0 if upland habitat has some other surface cover.

Early nests of red-winged blackbirds in upland sites are more productive than are late nests (Dolbeer 1976). Early nests are placed in robust, dense, old herbaceous growth. Activities that are destructive to this vegetation, such as mowing, heavy grazing pressure, or burning, reduce habitat suitability for red-winged blackbirds. The occurrence of disturbances that might impact nesting success in upland cover types is included as V8 in the model.

V8 = 0.1 if disturbances, such as mowing, heavy grazing, or burning, do not occur to the potential habitat site in most years.

V8 = 0.0 if disturbances occur to the potential habitat site in most years.

HSI determination. Three types of habitat conditions (A, B, and C) are described in Figure 1. Condition A represents a wetland that contains the preferred vegetative structure for nest placement, permanent water that supports a population of emergent aquatic insects that are available as food, the absence of carp, and the interspersion of open water within emergent herbaceous vegetation. The equation combining the SI's for V1 to V5 to estimate an HSI for condition A wetlands is:

$$HSI = (V1 \times V2 \times V3 \times V4 \times V5)$$

Condition B habitats (Fig. 1) are wetlands where the emergent herbaceous vegetation does not have the preferred structure, there is no permanent water, carp are present, or benthic invertebrates are absent. Condition B habitats have a basic SI of 0.1, determined by the 0.1 SI for the unsuitable conditions of V1, V2, V3, or V4. The basic SI of 0.1 can be increased if suitable foraging substrate is available outside the boundary of the wetland. Food sources are considered more limiting if only an understory layer is available than if deciduous midstory and/or overstory layers also are available as foraging surfaces. A condition B habitat may be of highest value to red-winged blackbirds if the birds can readily feed on emergent aquatic insects in a nearby condition A herbaceous wetland habitat. The equation for estimating the HSI for condition B habitats is:

$$HSI = (0.1 \times V6)^{1/2}$$

Condition C habitats are upland sites, like grass, forb, and pasture/hayland cover types. Their HSI's, which will be either 0.1 or 0, are described by the following equation:

$$HSI = (V7 \times V8)^{1/2}$$

The measure of habitat quality represented by the HSI actually reflects an estimate of the quantity of niche space available to the blackbird. Habitats with higher HSI's are assumed to contain more niche space than habitats with lower HSI's. More niche space in a habitat frequently means that more individuals will occur in that habitat.

Application of the Model

Summary of model variables. This model can be applied by interpreting a recent, good quality, aerial photograph of the assessment area and making selected field measurements. The habitat to be evaluated is outlined on the aerial photograph. Each wetland within the assessment area is identified and a 200 m zone drawn around its perimeter. The wetlands within the assessment area are evaluated, on a per ha basis, with field observations and measurements that determine: (1) the type of emergent vegetation present; (2) the probable permanency of the water; (3) the presence or absence of carp; (4) the presence

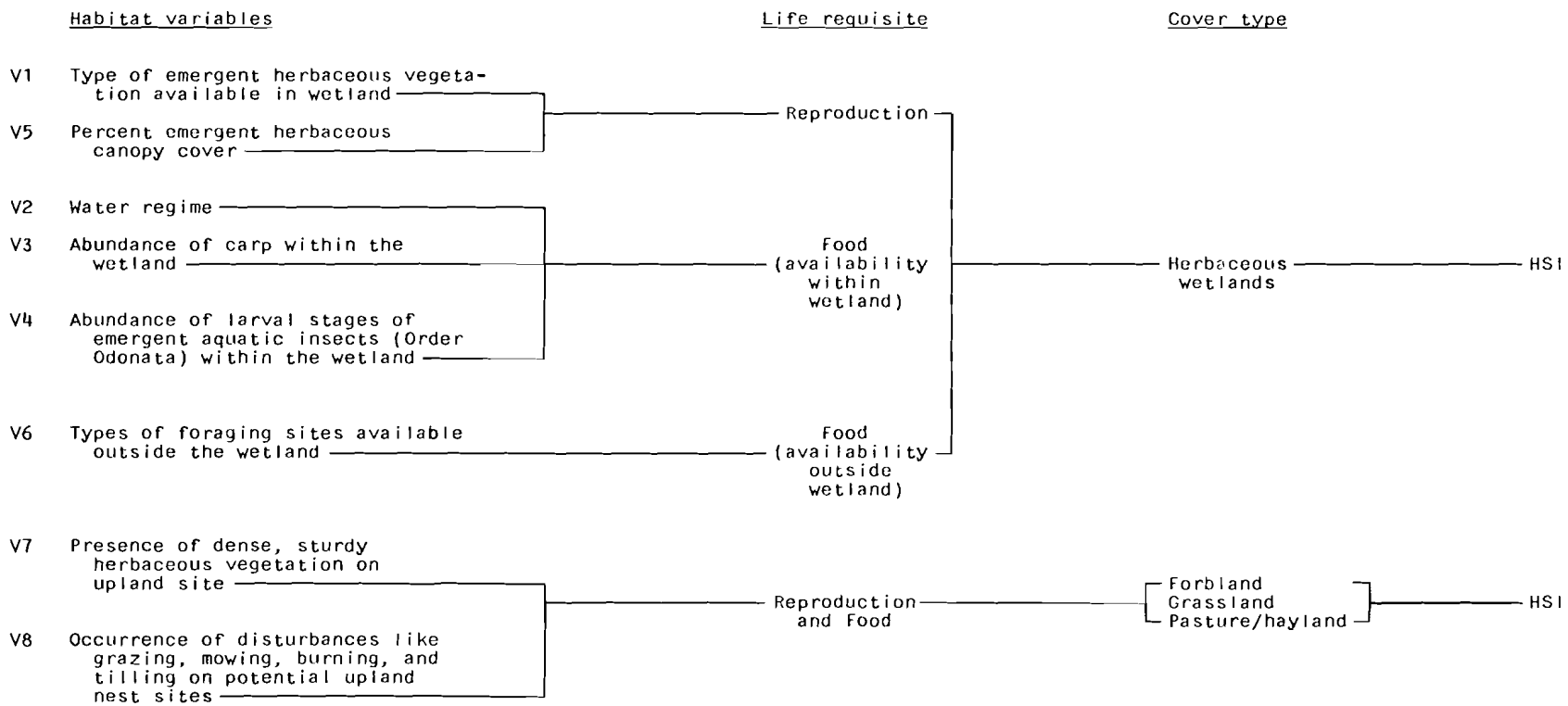

Figure 2. Relationship of habitat variables, life requisites, and cover types in the red-winged blackbird HSI model.

or absence of larval stages of emergent aquatic insects; (5) the mix of open water and emergent herbaceous vegetation; and (6) the nature of the vegetative cover within 200 m surrounding the wetland (Fig. 2). The proportion of open water and emergent herbaceous vegetation within the wetland is estimated from a map made after boating or wading through the wetland. The presence of benthic invertebrates is determined from field sampling. Upland habitats within the assessment area are evaluated by ground truthing to determine cover types and land-use practices. Habitat conditions, like the presence of dense, tall herbaceous cover and the probability that disturbances such as grazing, burning, mowing, and tilling will occur during the March to July nesting season, are noted.

Definitions of variables and suggested field measurement techniques are provided in Figure 3.

Model assumptions. I have assumed that it is possible to synthesize results from many studies conducted in different seasons of the year, different years, and a wide variety of nest sites throughout North America into a model describing the relative quality of breeding habitat for the red-winged blackbird. My basic assumptions about habitat criteria important to red-winged blackbirds are based on descriptive and correlative relationships expressed in the literature. My descriptors of habitat quality will obviously be in error if authors made incorrect judgements or measurements or if I have emphasized the wrong data sets or misinterpreted the meaning of published data.

I have assumed that the quality of some wetland habitats exceeds the quality of the best upland habitats. This assumption was based largely on reports of the numbers of red-winged blackbirds fledged per hectare of wetland and upland habitats. I compiled and analyzed characteristics of wetland habitats that seemed to distinguish habitats where varying numbers of red-winged blackbirds were fledged. I assumed that I could meaningfully bound the size of study areas to be evaluated as nesting habitat as ≥ 0.1 ha for wetland sites and ≥ 1.0 ha for suitable upland sites. I arbitrarily selected distances (200 m) that blackbirds might fly from their nests in wetlands to forage on insects and seeds in surrounding vegetative cover. I assumed that the presence of dense, tall, herbaceous cover reasonably close to water, coupled with a strong probability that the dense cover would remain relatively undisturbed during the breeding season, would adequately indicate the value of upland habitats as nest sites for the red-winged blackbird.

The values for Variables 1 through 8 are estimates. The ecological information available does not seem sufficient to suggest: (1) other pertinent variables; (2) more appropriate values for the present variables; or (3) more definitive interrelationships between the variables. Finally, I have assumed that the multiplicative relationship described in the model is an appropriate summary statement to provide a Habitat Suitability Index that reflects the relative importance of different habitats as nest sites for the red-winged blackbird.

Variable (definition)		Cover type	Suggested technique
V1	Type of emergent herbaceous vegetation available in wetland.	HW	Identify the dominant species of emergent herbaceous vegetation in the wetland. Determine if the dominant species is a broad-leaved monocot.
V2	Water regime.	HW	Determine whether or not water will be retained in the wetland throughout the year in most years; use, if possible, indicators like muskrat houses and fish. Evaluate records describing permanence and level of water in wetland. Determine the classification type of wetland if the wetland has been classified.
V3	Abundance of carp within the wetland.	HW	Determine presence of carp by seining, using local data about presence of carp within wetland or observations to see if water is clear or generally murky, as it is when carp are feeding.

Figure 3. Definitions of variables and suggested measurement techniques.

Variable (definition)	Cover type	Suggested technique
V4 Abundance of larval stages of emergent aquatic insects (Order Odonata) within the wetland.	HW	Collect insect larvae by dragging a sieve net along water bottom near edge of clumps of emergent herbaceous vegetation. Sampling is done for some fixed time period. A second sampling procedure involves kicking up the substratum at the edge of clumps of emergent herbaceous vegetation in front of the mouth of a net in some standardized manner (Hynes 1972:240). The collected invertebrates are sorted and identified by comparison with illustrations in an appropriate manual (like Needham and Needham 1970) to determine the presence of damselfly and dragonfly larvae (Order Odonata).
V5 Percent emergent herbaceous canopy	HW	Determine the mix of open water and emergent herbaceous vegetation within the wetland study area. Estimate the mix from a map prepared after wading, walking, or boating through the wetland or from a map made from a recent, high quality, aerial photograph.

Figure 3. (continued).

Variable (definition)		Cover type	Suggested technique
V6	Types of foraging sites available outside the wetland.	HW	Use map measurer (Hays et al. 1981) to determine if another wetland with an emergent aquatic insect population occurs within 200 m of nest sites within the wetland being evaluated. Map vegetation within 200 m of the wetland and determine, using a dot grid (Hays et al. 1981) or a planimeter, if deciduous midstory and overstory layers comprise at least 10% cover when projected to the ground surface. If midstory and/or overstory do not provide at least 10% cover, and a condition A wetland does not occur within 200 m of the wetland being evaluated assume only the understory layer is available as a foraging substrate.
V7	Presence of dense, sturdy herbaceous vegetation on upland site.	F,G,P/H	Interpret the aerial photograph or a map prepared from the aerial photograph to determine areas of upland herbaceous vegetation. Ground truth to determine types of herbaceous vegetation occurring in the upland within the assessment area and determine if tall, dense, herbaceous cover covers at least 10% of the surface area.

Figure 3. (continued).

Variable (definition)	Cover type	Suggested technique
V8 Occurrence of disturbances like grazing, mowing, burning, and tilling on potential upland nest sites.	F,G,P/H	Ground truth to predict past and future land-use practices (types of disturbances that may impact nesting success).

Figure 3. (concluded).

SOURCES OF OTHER MODELS

Weatherhead and Robertson (1977) identified and quantified some parameters that affected the nesting success of red-winged blackbirds in wetland habitats in Ontario, Canada. They determined that nesting success, as judged by numbers of young fledged per female, was positively correlated with territory quality scores based on nest placement. Nesting success seemed to be related to four parameters: (1) water depth within the wetland; (2) height of nest above the herbaceous wetland floor; (3) relative openness of nesting cover within the wetland; and (4) the identity of the support vegetation holding the nest. Two of these variables are represented in the present model of habitat suitability for the red-winged blackbird: (1) presence or absence of permanent water; and (2) the relative openness of vegetation within flooded herbaceous wetlands. No other models for use in predicting the quality of nesting habitat for red-winged blackbirds were found in the literature.

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A review and synthesis of existing information were used to develop a Habitat Suitability Index (HSI) model for the red-winged blackbird (Agelaius phoeniceus L.). The model consolidates habitat use information into a framework appropriate for field application, and is scaled to produce an index between 0.0 (unsuitable habitat) and 1.0 (optimum habitat). HSI models are designed to be used with Habitat Evaluation Procedures previously developed by the U.S. Fish and Wildlife Service.

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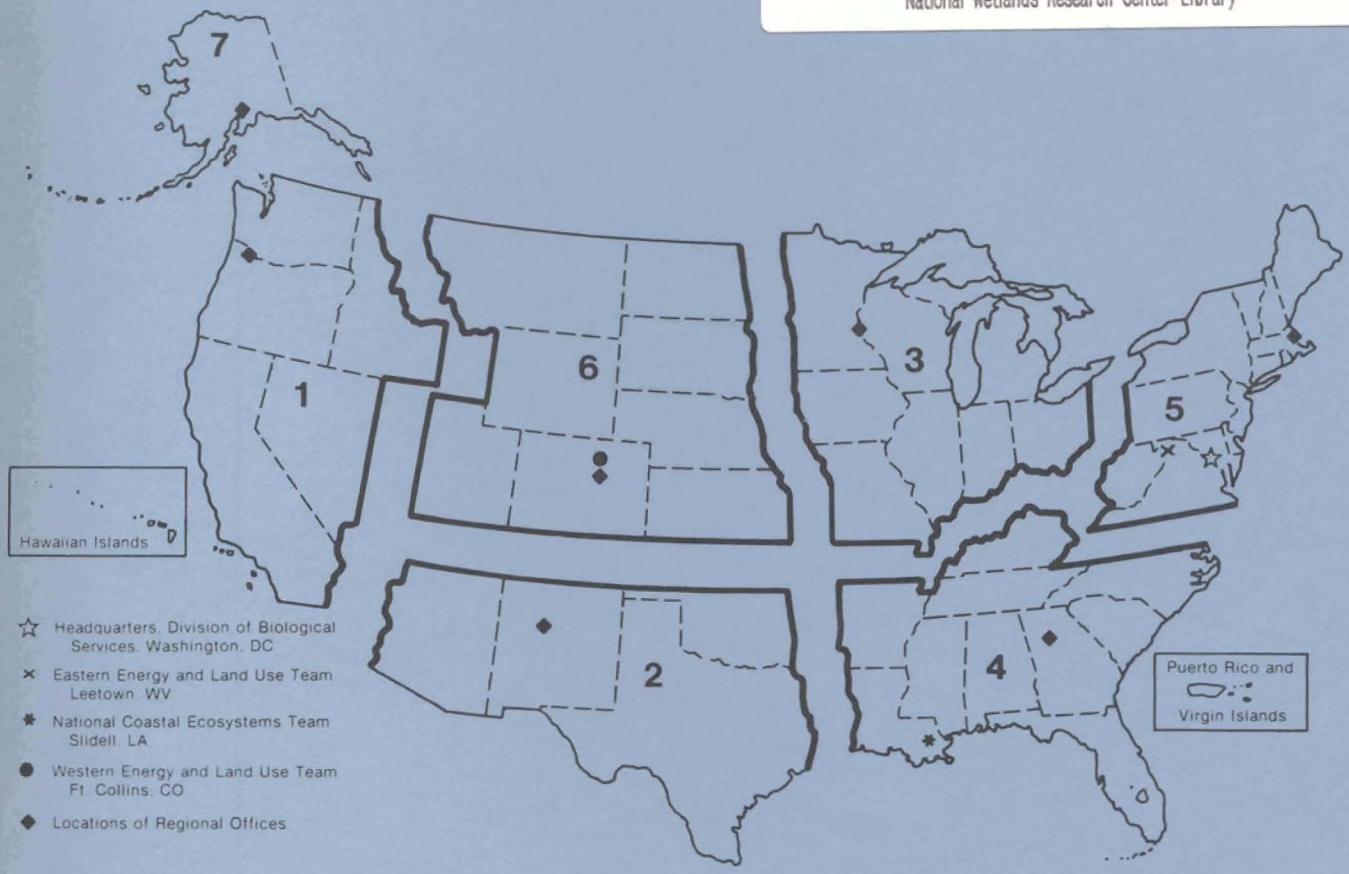

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