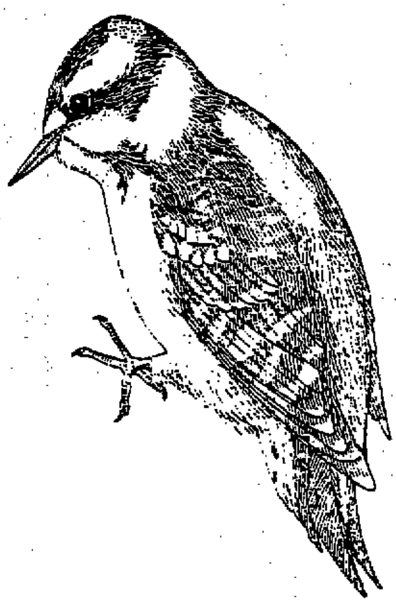
SUMMARY REPORT

TRINITY RIVER DIVISION WILDLIFE IMPACT ASSESSMENT HABITAT EVALUATION PROCEDURES



U.S. DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
REGION 1

DECEMBER 1993

United States Department of the Interior

TAKE PRIDE IN AMERICA

FISH AND WILDLIFE SERVICE
Ecological Services
Sacramento Field Office
2800 Cottage Way, Room E-1803
Sacramento, California 95825-1846

December 1, 1993

Memorandum

To: Project Leader, Trinity River Fishery Resource Office, Weaverville, California (FRO) (Attn: Bill Brock)

From: Acting Field Supervisor, Ecological Services, Sacramento Field Office, Sacramento, California (ES)

Subject: Trinity River Division, Upland Habitat Assessment Habitat Evaluation Procedures (HEP) Project, Final Report

Attached are two copies of our final report concerning the Trinity River Division, Upland Habitat Assessment HEP. This report is provided pursuant to the Work Plan Agreement signed by our offices in 1991.

A memorandum was received from your office dated June 16, 1993, and included comments on our draft report. Those comments we found appropriate were incorporated into our final report. Most comments we found inappropriate for inclusion were discussed between Bill Brock of your staff, and Caroline Wilkinson of my staff, during a telephone call on July 6, 1993. All comments with which our representative staff disagree are addressed in this memorandum and are highlighted in bold type.

Page 1, paragraph 3: **...We may suggest only consideration of omitting Appendix ["C"], the HSI species models, which comprises 173 pages of the report.**

We did not omit this appendix for the final report, since it is an integral part of understanding the HEP process. Without these models, no one reading the report would be able to determine which methods, variables, algebraic equations, etc., were used to complete the HEP.

Page 2, paragraph 2: **We would prefer that an executive summary be added to this report, although it need not exceed two pages.**

We did not include an Executive Summary (summary) in the final report for the following reasons: 1) We believe a summary is not relevant for a technical report; 2) We had no funds to allow us to write such a summary, and; 3) If we did write a summary, it would need to be much longer than two pages in order to include all important information pertinent to understanding the HEP process for this project.

Page 3, paragraph 1: "<u>Without and With the Project</u>" - ...We are a bit confused about how it can be concluded: "...that the Trinity Reservoir area was a very important winter range for deer.", while the pre-project HSI value for this area was poor for deer. May an additional sentence help clarify this apparent inconsistency?

Because the Trinity Reservoir area was a very important winter range for deer does not preclude the pre-project HSI value being poor for deer. This may be due to a number of reasons: 1) The area may have been more important as a foraging range than a wintering range; 2) The black-tailed deer model we used may not have measured the factors relevant to the original assessment of the specific area; 3) The surrounding areas could have been even poorer than the Trinity Reservoir area, suggesting that this area was the best the deer had at the time, and; 4) We believe the variables we measured were indicative of the pre-project values for that particular area, however, perhaps what we assumed was pre-project habitat was not. It is difficult to know this since pre-project conditions occurred 36 years ago. Pre-project habitat variables were determined using best biological knowledge.

Page 3, paragraph 2: "<u>Compensation Analysis, General</u>" - The first full paragraph begins with: "Since more than 14,000 acres of wildlife habitat have been permanently lost, restoration of wildlife to pre-project levels is an unrealistic goal." This statement is not technically correct as suggested by the three Idaho reservoir compensation reports mentioned earlier. What is really limiting our effort here is funding; in Idaho, post-hoc reservoir HEP analysis led to 20,000 acres being proposed for compensation by requiring $15 million dollars, in one example. Purchasing private lands for wildlife management purposes was an important method.

We agree that restoration of wildlife to pre-project levels is an unrealistic goal because of funding. However, it is also an unrealistic goal because we do not know exactly what the pre-project levels were and because of lack of available on-site lands for mitigation.

Page 3, paragraph 4: Page [28] and elsewhere: we are not certain <u>why</u> montane hardwood conifer is compensated for in this plan through montane hardwood and mixed chaparral habitats. If the simple explanation "why" has been omitted, pleased add; if we missed the reason elsewhere, please point this out.

The reason why montane hardwood conifer is compensated for through montane hardwood and mixed chaparral habitats is described on page [10], under #6 for goals and objectives: Montane hardwood conifer, montane hardwood, and mixed chaparral habitats are in Resource Category 3, which is "no net loss of habitat value while minimizing the loss of in-kind habitat value". Therefore, montane hardwood conifer can be replaced with out-of-kind habitats; in this case, montane hardwood and mixed chaparral. If montane hardwood conifer habitat was in Resource Category 2, which is "no net loss of in-kind habitat values", then montane hardwood conifer would need to be replaced in-kind with montane hardwood conifer.

If you have any questions concerning these responses, or would like additional copies of this report, please contact Caroline Wilkinson of my staff at (916) 978-4613, ext. 337.

for Dale A. Pierce

Attachment

cc: (w/number of attachments)
ARD, ES, FWS, Portland, OR (w/out attachment)
Brian Boroski, U.S. Forest Service, Forestry Sciences Lab, Fresno, CA (1)
U.S. Fish and Wildlife Service, Lewiston, CA (2)
Pat McLaughlin, California Department of Fish and Game, Lewiston, CA (1)
Cindy Roberts, U.S. Forest Service, Weaverville, CA (1)

UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE

SUMMARY REPORT

TRINITY RIVER DIVISION
WILDLIFE IMPACT ASSESSMENT
HABITAT EVALUATION PROCEDURES

prepared by

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Division of Ecological Services
Sacramento, California

prepared for

U.S. Fish and Wildlife Service
Trinity River Basin Field Office
Weaverville, California

DECEMBER 1993

Cover illustration was obtained from:

Zeiner, D.C., W.F. Laudenslayer, Jr., K.E. Mayer, and M. White, eds. 1990. California's wildlife, volume II, birds. California statewide wildlife habitat relationships system, state of California, The Resources Agency, Department of Fish and Game, Sacramento, California.

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INTRODUCTION

This report describes the U.S. Fish and Wildlife Service's (Service) detailed assessment of the impact of the Trinity River Division of the Central Valley Project (CVP) on upland resources within the inundation zones of the Trinity (Clair Engle) and Lewiston Reservoirs. It employs the Service's Habitat Evaluation Procedures (HEP) methodology to quantify impacts to wildlife and their habitats and to quantify and evaluate potential mitigation management plans. The HEP addresses the direct effects of Trinity and Lewiston Dams and their respective reservoirs' modifications to a 27-mile reach of the Trinity River and its wildlife habitat environment.

Due to inadequate pre-project wildlife habitat information or population data, full mitigation needs for wildlife losses due to the project are impossible to determine. It is, however, possible to determine the approximate acreage of broadly defined habitat types impacted by using old aerial photography and other information. Therefore, a "post hoc" HEP was used.

BACKGROUND INFORMATION

The Trinity River Division, CVP, was authorized by Congress (P.L. 84-386) in 1955. The authorization called for the development of water storage and conveyance facilities for the transfer of "surplus" Trinity River water to the Sacramento River. The most important of these facilities are the Trinity Dam and Lewiston Dam and their respective reservoirs, Trinity Reservoir and Lewiston Reservoir. Construction by the U.S. Bureau of Reclamation (Reclamation) began in 1956 and was completed in 1960. Storage began in 1960 and ended in 1963. Full operation began in 1964 (VTN Environmental Sciences 1979). Therefore, the authorization and construction of the Trinity River Project (Project) pre-dated the National Environmental Policy Act (NEPA).

Under the Trinity Act of 1984 (P.L. 98-541), which provides for the restoration of fish and wildlife in the Trinity River Basin, Congress found that:

(1) the construction of the Trinity River division of the Central Valley project in California, authorized by the Act of August 12, 1955 (69 Stat. 719), has substantially reduced the streamflow in the Trinity River Basin thereby contributing to damage to pools, spawning gravels, and rearing areas and to a drastic reduction in the anadromous fish populations and a decline in the scenic and recreational qualities of such river system;

(2) the loss of land areas inundated by two reservoirs constructed in connection with such project has contributed to reductions in the populations of deer and other wildlife historically found in the Trinity River Basin;

(3) the Act referred to in paragraph (1) of this section directed the Secretary of the Interior (hereinafter in this Act referred to as the "Secretary") to take appropriate actions to ensure the preservation and propagation of such fish and wildlife and additional authority was conferred on the Secretary under the Act approved September 4, 1980 (94 Stat. 1062), to take certain actions to mitigate the impact on fish and wildlife of the construction and operation of the Trinity River division;

(4) activities other than those related to the project including, but not limited to, inadequate erosion control and fishery harvest management practices, have also had significant adverse effects on fish and wildlife populations in the Trinity River Basin and are of such a nature that the cause of any detrimental impact on such populations cannot be attributed solely to such activities or to the project;

(5) a fish and wildlife management program has been developed by an existing interagency advisory group called the Trinity River Basin Fish and Wildlife Task Force; and

(6) the Secretary requires additional authority to implement a basin-wide fish and wildlife management program in order to achieve the long-term goal of restoring fish and wildlife populations in the Trinity River Basin to a level approximating that which existed immediately before the start of the construction of the Trinity River division.

Sec. 2 (a) Subject to subsection (b), the Secretary shall formulate and implement a fish and wildlife managment program for the Trinity River Basin designed to restore the fish and wildlife populations in such basin to the levels approximating those which existed immediately before the start of the construction referred to in section 1(1) and to maintain such levels. The program shall include the following activities:

(1) The design, construction, operation, and maintenance of facilities to

(A) rehabilitate fish habitats in the Trinity River between Lewiston Dam and Weitchpec,

(B) rehabilitate fish habitats in tributaries of such river below Lewiston Dam and in the south fork of such river, and

(C) modernize and otherwise increase the effectiveness of the Trinity River Fish Hatchery.

(2) The establishment of a procedure to monitor (A) the fish and wildlife stock on a continuing basis, and (B) the effectiveness of the rehabilitation work.

(3) Such other activities as the Secretary determines to be necessary to achieve the long-term goal of the program.

(b)(1) The Secretary shall use the program described in section 1(5) of this Act as a basis for the management program to be formulated under subsection (a) of this section. In formulating and implementing such management program, the Secretary shall be assisted by an advisory group called the Trinity River Basin Fish and Wildlife Task Force established under section 3.

(2) In order to facilitate the implementation of those activities under the management program over which the Secretary does not have jurisdiction, the Secretary shall undertake to enter into a memorandum of agreement with those Federal, State, and local agencies, and the Indian tribe, represented on the Task Force established under section 3 [not included in this report]. The memorandum of agreement should specify those management program activities for which the respective signatories to the agreement are primarily responsible and should contain such commitments and arrangements between and among the signatories as may be necessary or appropriate to ensure the coordinated implementation of the program.

(3) To the extent not provided for under a memorandum of agreement entered into under paragraph (2), the Secretary shall coordinate the activities undertaken under such managment program with the activities of State and local agencies, and the activities of other Federal agencies, which have responsibilities for managing public lands and natural resources within the Trinity River Basin (House of Representatives 1981).

In the early 1970's, several agencies undertook preliminary studies to define the problems related to Project construction, and to recommend possible remedial actions, but no funds were available to execute the actions. In 1974, the Trinity River Basin Fish and Wildlife Task Force (Task Force) was reactivated and expanded. Its responsibilities included obtaining funding and preparing a comprehensive action program to rehabilitate the Trinity River (Trinity River Basin Fish and Wildlife Task Force 1981).

In 1976, Congressman Harold T. Johnson secured Congressional funding from Congress to develop an interim action program, and a long-term management program for the Trinity River Basin. The Task Force was responsible for administering these programs. Two objectives identified were: (1) define and rectify fish and wildlife problems in the Trinity River Basin resulting from construction of the Project; and (2) define and rectify fish and wildlife problems in the Trinity River Basin resulting from other sources (Trinity River Basin Fish and Wildlife Task Force 1981).

Due to funding limitations, the Task Force gave precedence to preparation of a comprehensive management program which listed all activities needed to restore fish and wildlife populations to their pre-project levels, and identified costs and time needed to complete these activities (Trinity River Basin Fish and Wildlife Task Force 1981).

The program was developed to meet five main goals; three relate to fisheries restoration, one to wildlife, and one to protection after completion of restoration. These goals are: (1) use artificial production as compensation for salmon and steelhead spawning and rearing areas that were lost due to obstruction of the Trinity River by the Lewiston Dam; (2) restore full natural salmon and steelhead production in the Trinity River and its tributaries downstream of Lewiston Dam; (3) develop and distribute harvest information and management recommendations compatible with goal #2; (4) provide compensation for deer and other wildlife losses resulting from inundation of land by Trinity and Lewiston Reservoirs; and (5) develop recommendations for regulations to protect the River Basin from future activities (i.e., improper road building and logging) (Trinity River Basin Fish and Wildlife Task Force 1981).

Thirteen action items were identified to meet these five goals; action item #9, "Formulate and Conduct a Wildlife Management Program," is intended to compensate for loss of deer and other wildlife populations through habitat manipulation techniques including controlled burning (Trinity River Basin Fish and Wildlife Task Force 1981). Part of action item #9 includes an Upland Habitat Assessment for which it was decided that a HEP be conducted to quantify impacts to wildlife and their habitats and to determine compensation requirements. Thus, this report is the result of that Upland Habitat Assessment in which we included impacts to riparian and riverine habitats as well.

STUDY AREA

The mainstem Trinity River has its headwaters approximately 20 miles southwest of Mount Shasta in the rugged canyons bordered by the Scott Mountains on the northwest, the Eddy Mountains on the east, and the Salmon-Trinity Alps on the south. The mainstem flows 170 miles west from its origins to the Klamath River at Weitchpec, 43.5 miles upstream from the Pacific Ocean. The South Fork of the Trinity River originates in the Yolla Bolly Mountains and flows northwest to the mainstem near Salyer. The North Fork Trinity River flows south from its headwaters in the Trinity Alps to its confluence with the mainstem near Helena (USFWS 1983).

The Trinity River drains 2,965 square miles. Of this, approximately one-quarter is above the town of Lewiston and approximately one-third is occupied by the South Fork Trinity River watershed. The terrain is predominantly mountainous and covered with forests, with very little farming area. Elevations in the basin range from over 9,000 feet in headwater areas to less than 300 feet at the confluence with the Klamath River (USFWS 1983). Major tributaries of the Trinity River include Coffee Creek and Stuart's Fork (which enter the Trinity River upstream from Lewiston Dam), and Canyon Creek, North Fork Trinity River, New River, and South Fork Trinity River (Hubbell undated).

Trinity Dam is in Trinity County, California, on the Trinity River about 9 miles northeast of the town of Lewiston. The site is in the southern half of section 10T, 34N, R8W, Mount Diablo meridian; it is about 5 miles west of the Trinity-Shasta county line, but all of the reservoir area is in Trinity County within the boundaries of Shasta-Trinity National Forests. Lewiston Reservoir is located just downstream of Trinity Reservoir (Figure 1).

Trinity Dam and Lewiston Dam are components of the Trinity River Division of the CVP. Trinity River water is initially stored in Trinity Reservoir, which has a storage capacity of 2,448,000. Releases from Trinity Dam are re-regulated 7 miles downstream in Lewiston Reservoir, which has a capacity of 14,600 acre-feet. From Lewiston Reservoir, water is diverted via Clear Creek Tunnel, Whiskeytown Lake, and Spring Creek Tunnel to Keswick Reservoir on the Sacramento River (USFWS 1983).

Trinity Reservoir at full pool elevation has a surface area of about 16,500 acres. The reservoir has about 122 miles of shoreline. Lewiston Reservoir serves as the afterbay for regulating the flow releases for power generation from Trinity Reservoir, and as the diversion pool for the Clear Creek tunnel. It has a water surface area of about 600 acres, and 15 miles of shoreline. Shoreline development has been restricted due to physical characteristics (e.g., topography) and operational considerations (Frederiksen *et al.* 1979a).

Livestock grazing, small-grain farming, lumbering, and mining were the major land-use activities in what are now the Trinity Reservoir and Lewiston Reservoir areas
(USFWS 1951).

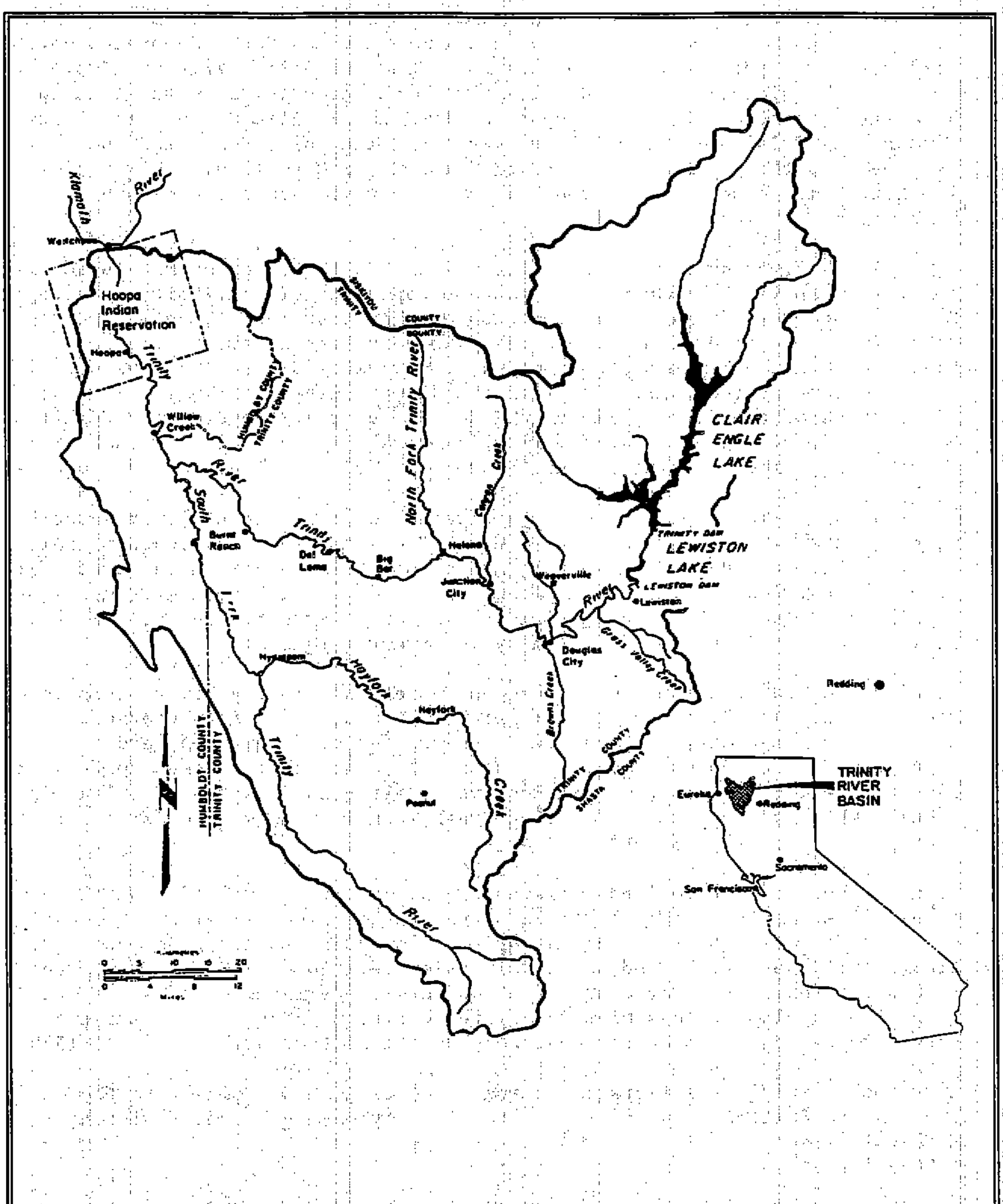

Figure 1. Location map of the Trinity River Basin (post-dam) (Source: Trinity River Basin Fish and Wildlife Task Force 1981).

PROJECT DESCRIPTION

The Trinity River Division of the CVP was developed primarily for the purposes of irrigation and power generation. This multi-purpose facility involved construction of the Trinity and Lewiston Dams, associated tunnels, power plants, and other works. The reservoir areas are within the boundaries of the Shasta-Trinity National Forests. Development of the CVP impacted two U.S. Forest Service administrative stations, required relocation of major portions of the existing road system, created a public recreation area, and caused removal of large quantities of National Forest and private timber (Grace 1960).

The Service in Weaverville, California, is studying the feasibility of compensating for about 14,028 acres of riparian and upland terrestrial habitat that were lost upon completion of the CVP in 1963. An inventory of wildlife cover types was not performed prior to this inundation and, therefore, very little pre-project information exists concerning wildlife. Information dealing with winter range habitat for the Weaverville deer herd was the only data collected prior to and immediately after completion of the Project. Information was also collected on the effects of CVP operations on the riparian corridor from Lewiston downriver to the North Fork Trinity (Wilson *et al.* 1991).

During September 15 through November 18, 1992, a HEP study was conducted at the Project site by the Service. The purpose of the study was to quantify wildlife habitat losses and compensation needed to offset habitat losses. This HEP analysis does not address endangered species issues, although we are providing a summary of listed and proposed threatened and endangered species that may occur in the Project area (Appendix A). If you have any questions or concerns about this summary, they should be directed to Laurie Simons of the Habitat Conservation Division of our office.

ANALYSIS METHODOLOGY

HEP Description

HEP is an impact assessment methodology developed by the Service which can be used to document the quality and quantity of available habitat for selected wildlife species. HEP provides information for two general types of wildlife habitat comparisons: 1) the relative value of different areas at the same point in time; and 2) the relative value of the same areas at future points in time. By combining the two types of comparisons, the impacts of proposed or anticipated land- and water-use changes on wildlife habitat can be quantified. In a similar manner, any compensation needs (in terms of acreage) for the project can also be quantified.

A HEP application is based on the assumption that habitat for selected wildlife species or communities can be described by a model which produces a Habitat Suitability Index (HSI). The HSI, a value from 0.0 to 1.0, is assumed to relate directly to the carrying capacity of the habitat being evaluated. The HSI is multiplied by the area of available habitat to obtain Habitat Units (HUs). Changes in habitat value and quantity are tracked over time at specified time periods known as target years (TYs). Those changes over the life of the project are annualized to yield Average Annual Habitat Units (AAHUs). The differences in AAHUs for various project scenarios permit comparison of alternatives.

The reliability of a HEP application, including the significance of HUs and AAHUs, is directly dependent on the ability of the HEP user(s) to assign a well-defined and accurate HSI to the selected evaluation species or communities. Also, the HEP user(s) must be able to identify and measure (or predict) the area of each distinct cover type that is utilized by fish and wildlife within the project impact area. Both the HSIs and cover type acreages must also be reasonably estimable at various future points in time. The Service has determined that these HEP criteria can be met, or at least reasonably approximated, for the Project; thus HEP was considered to be an appropriate analytical tool.

HEP usually relies on a team approach to sampling and projecting future values. In this study, HEP team members were: Caroline Wilkinson, Service, Sacramento, and Rosemary Gartner, Service, Lewiston. Staff from the Service in Lewiston, the U.S. Forest Service in Weaverville, and the California Department of Fish and Game (Department) in Lewiston were available to answer site-specific biological questions and provide background information on the Project and the site.

A HEP assessment is directly applicable only to those species chosen as evaluation species; however, it generally reflects changes for a habitat as a whole. A list of HSI evaluation species models applied to cover types used in this study is found in Table 1.

Table 1. Habitat Suitability Index (HSI) models applied to cover types for Trinity River HEP analysis.

	COVER TYPES[1]						
EVALUATION SPECIES MODELS	MHA	MHC	CHA	RIP	RIV	WET	CRO
Downy woodpecker	XXX	XXX		XXX			
Blue grouse		XXX					
California ground squirrel							XXX
Black-tailed deer	XXX	XXX	XXX				
California quail	XXX		XXX			XXX	XXX
Bobcat	XXX	XXX	XXX				
Mink				XXX	XXX		
Wood duck				XXX	XXX		
Red-winged blackbird						XXX	

[1] MHA - montane hardwood
MHC - montane hardwood conifer
CHA - chaparral
RIP - montane riparian
RIV - riverine
WET - wet meadow/wetlands
CRO - cropland

HEP Goals and Objectives

The following general goals and objectives were established for the HEP used in this study:

1. Quantify and describe habitat conditions prior to Project construction.

2. Quantify and describe current wildlife habitat conditions.

3. Quantify the impacts of the Project to the inundation zone and area adjacent the reservoirs.

4. Develop mitigation/compensation projects and locate potential management sites within the Trinity River Basin.

5. Develop and evaluate an array of management alternatives designed to improve and/or restore cover types impacted by the Project.

6. Determine the replacement acreage of various habitats necessary to compensate for the impacts of the Project on the terrestrial cover types in the Project area. More specifically, the goal of the HEP analysis is

to provide compensation recommendations that would result in *no net loss of in-kind habitat values* for riparian and wet meadow/wetlands cover types. This is in accordance with the Service's classification of these habitats as Resource Category 2 under the Service's Mitigation Policy (Federal Register 46:15, January 23, 1981). In-kind replacement, as defined in the Mitigation Policy, means providing or managing substitute resources to replace the habitat value of the resources lost, where such substitute resources are physically and biologically the same or closely approximate those lost.

The goal of the HEP analysis is to also provide compensation recommendations that would result in *no net loss of habitat value while minimizing the loss of in-kind habitat value* for montane hardwood, mixed chaparral, montane hardwood conifer, and cropland habitats, in accordance with the Service's classification of this habitat as Resource Category 3 under the Service's Mitigation Policy. If losses are likely to occur, then the Service will recommend ways to immediately rectify them or reduce or eliminate them over time. If losses remain likely to occur, then the Service will recommend that these losses be compensated by replacement of habitat value so that the total loss of habitat value will be eliminated. Montane hardwood conifer (Resource Category 3) will be replaced by montane hardwood and mixed chaparral. Cropland (Resource Category 4) will be replaced by montane hardwood and mixed chaparral also (Table 2).

Cover Types

Wildlife habitats have been divided into three very broad categories: 1) riparian (stream and river corrider); 2) upland terrestrial, and; 3) "other". These can be separated even further. Riparian includes montane riparian, riverine, and wet meadow/wetland habitat; upland includes montane hardwood, montane hardwood conifer, and mixed chaparral; cropland is included in the "other" category (Table 3).

The following paragraphs describe the seven cover types found in the study area, and their importance to wildlife species. A heavy reliance was placed upon the naming conventions found in "A Guide to Wildlife Habitats of California" (Mayer and Laudenslayer 1988). For more information on these cover types, please refer to this Guide.

Montane Riparian (Resource Category 2)

The vegetation found in montane riparian habitat is quite variable and often structurally diverse (Marcot 1979 *in* Mayer and Laudenslayer 1988). It usually occurs as a narrow, dense grove of broadleaved, deciduous trees up to 98 feet (30 meters) tall containing a sparse understory. At high mountain elevations, montane riparian is usually less than 49 feet (15 meters) high containing a more dense understory. Also, at high elevations, montane riparian may not be well developed or may occur in the shrub stage only (Mayer and Laudenslayer 1988).

Table 2. Habitat types, evaluation species, Resource Categories, and mitigation goals for the habitat, cover and land use types found within the Trinity River HEP Project area.

HABITAT TYPE	EVALUATION SPECIES	RESOURCE CATEGORIES	MITIGATION GOALS
Montane riparian	Downy wood-pecker, mink, wood duck	2	No net loss of in-kind habitat value
Riverine	Mink, wood duck	2	No net loss of in-kind habitat value
Wet Meadow	California quail, red-winged black-bird	2	No net loss of in-kind habitat value
Montane hardwood	Downy wood-pecker, black-tailed deer, California quail, bobcat	3	No net loss of habitat value while minimizing loss of in-kind habitat value
Montane hardwood conifer	Downy wood-pecker, blue grouse, black-tailed deer, bobcat	3	No net loss of habitat value while minimizing loss of in-kind habitat value
Chaparral	Black-tailed deer, California quail, bobcat	3	No net loss of habitat value while minimizing loss of in-kind habitat value
Cropland	California ground squirrel, California quail	4	Minimize loss of habitat value

Table 3. Cover types and acreages lost behind the Trinity and Lewiston Dams.

COVER TYPE	ACREAGE
Uplands	
Montane hardwood conifer	2,759.95
Montane hardwood	7,245.86
Mixed chaparral	1,066.46
Riparian	
Montane riparian	68.61
Riverine	1,503.73
Wet meadow/wetlands	311.08
Other	
Urban	38.99
Cropland (agriculture)	1,072.36
Total cover type acreage impacted by the project	14,067.04[1]

[1]The actual acreage obtained by planimetering totalled 15,427.80. This included construction and mine tailings which totalled 1,360.76 acres. This represents about 85 percent of the entire reservoir (about 17,424.00 acres of Trinity Reservoir + 704.49 acres of Lewiston Lake = 18,128.49 acres). We have assumed the discrepancy is due in part to the presence of logging roads, farm buildings, etc. Also, there was room for error in putting the inundation zone on the enlarged maps, due to differences in overlap, distortion due to enlargement, and differences in camera angles. No attempt was made to further refine acreage figures for this study.

The transition between montane riparian and bordering nonriparian vegetation is often abrupt, especially in steep terrain. Montane riparian is found with montane chaparral, montane hardwood, montane hardwood conifer, lodgepole pine (*Pinus contorta*), red fir (*Abies magnifica*) and wet meadow habitats (Mayer and Laudenslayer 1988).

All montane riparian habitats have extremely high values for a wide variety of wildlife species (Thomas 1979, Marcot 1979, Sands 1977 *in* Mayer and Laudenslayer 1988). These areas provide water, thermal cover, migration corridors, nesting, and feeding opportunities. The shape of many riparian zones is especially important, particularly the linear nature of rivers and streams, which maximizes the development of edge, so highly valuable for wildlife (Thomas 1979 *in* Mayer and Laudenslayer 1988). Vegetation species found in the riparian zones along the Trinity River, Trinity County are given in Appendix B.

Riverine (Resource Category 2)

Rivers and streams constitute riverine habitat. Riverine habitat is composed of 1) open water, which is defined as greater than 6.6 feet (2.0 meters) in depth and/or beyond the depth of floating rooted plants, and does not involve substrate; 2) the submerged zone which is between open water and the shore; and 3) the shore, which is seldom flooded and is less than 10 percent canopy cover.

Open water of large rivers provides nesting and escape cover for waterfowl. Also, many bird species hunt in open water, and near-shore waters provide food for waterfowl, herons, etc. Mammals such as the mink (*Mustela vison*) and river otter (*Lutra canadensis*) are also found in riverine habitat (Mayer and Laudenslayer 1988).

Wet Meadow/Wetlands (Resource Category 2)

Wet meadow habitat at all elevations generally has a simple structure which consists of a layer of herbaceous plants. Shrub or tree layers are usually absent or very sparse, but are often important features of the meadow's edge. Wet meadows consist of a great variety of plant species. Several genera are common to wet meadows throughout the State and include *Agrostis*, *Carex*, *Danthonia*, *Juncus*, *Salix* and *Scirpus*. In general, wet meadows are too wet to provide suitable habitat for small mammals during most of the year (Mayer and Laudenslayer 1988).

Fresh emergent wetlands are characterized by erect, rooted herbaceous hydrophytes; dominant vegetation generally consists of perennial monocots to 6.6 feet (2 meters) tall (Cheatham and Haller 1975, Cowardin *et al*. 1979 *in* Mayer and Laudenslayer 1988). Emergent wetlands are regularly flooded so that the roots live in an anaerobic environment (Gosselink and Turner 1978 *in* Mayer and Laudenslayer 1988). Sizes vary from small clumps to large areas.

The upper margins of fresh emergent wetlands support species such as big leaf sedge (*Carex amplifolia*) and baltic rush (*Juncus balticus*), and wetter sites support species such as cattail (*Typha domingensis*) and arrowhead (*Sagittaria* sp.). These wetlands are among the most productive wildlife habitats in California, as they provide cover, food, and water to more than 160 species of birds (U.S. Comptroller General 1979 *in* Mayer and Laudenslayer 1988) and many species of reptiles, amphibians, and mammals.

Montane Hardwood Conifer (Resource Category 3)

Montane hardwood conifer habitat includes both hardwoods and conifers (Anderson *et al*. 1976 *in* Mayer and Laudenslayer 1988) often as a closed forest. To be considered montane hardwood conifer habitat, at least one-third of the trees must be conifer and at least one-third must be broadleaf (Anderson *et al*. 1976 *in* Mayer and Laudenslayer 1988). This habitat often occurs in a mosaic-like pattern with small stands of broad-leaved trees (Sawyer 1980 *in* Mayer and Laudenslayer 1988), and consists of a broad range of mixed, fast growing conifer and hardwood species. Usually, conifers up to 200 feet (65 meters) in height form the upper canopy, and broad-leaved trees 30 to 100 feet (30 meters) in height comprise the lower canopy (Proctor *et al.* 1980, Sawyer 1980 *in* Mayer and Laudenslayer 1988). Little understory is found under the dense, bi-layered canopy of montane hardwood conifer (Mayer and Laudenslayer 1988).

The North facing slopes generally support montane hardwood conifer forests. Common tree species associated with this cover type are ponderosa pine (*Pinus ponderosa*), Douglas-fir (*Pseudotsuga menziesii*), California black oak (*Quercus kelloggii*), tanoak (*Lithocarpus densiflorus*), Pacific madrone (*Arbutus menziesii*), and Oregon white oak (*Quercus garryana*) (Wilson *et al.* 1991). Other specific vegetation species associated with montane hardwood conifer include incense cedar (*Calocedrus decurrens*), greenleaf manzanita (*Arctostaphylos patula*), whiteleaf manzanita (*Arctostaphylos viscida*), wedgeleaf ceanothus (*Ceanothus cuneatus*), lemon ceanothus (*Ceanothus lemmonii*), mountain whitethorn (*Ceanothus cordulatus*), birchleaf mountain mahogany (*Cercocarpus betuloides*), silktassel (*Garrya fremontii*), and bitter cherry (*Prunus emarginata*) (Kie and Menke 1980, Mayer and Laudenslayer 1988)

Montane hardwood conifer habitat is transitional between dense coniferous forests, montane hardwood, mixed chaparral, or open woodlands and savannahs. It provides habitat for a variety of wildlife species: mature forests are valuable to cavity nesting birds, mast crops are an important food source for many birds and mammals, and canopy cover and understory vegetation are variable, which make the habitat suitable for many wildlife species (Mayer and Laudenslayer 1988).

Montane Hardwood (Resource Category 3)

South facing slopes adjacent to the Trinity River support montane hardwood habitat. This habitat contains a pronounced hardwood tree layer, poorly developed shrub stratum, and a sparse herbaceous layer. Knobcone pine (*Pinus attenuata*), Digger pine (*Pinus sabiniana*), Oregon white oak, and coast live oak (*Quercus agrifolia*) are found in abundance on these slopes at lower elevations along the river (Wilson *et al.* 1991). At low and middle elevations, mixed chaparral is found with montane hardwood. Habitats found at middle elevations, often overlapping above and below, are montane hardwood conifer, mixed conifer, and Douglas-fir. At higher elevations, montane hardwood is found near Jeffrey pine (*Pinus jeffreyi*) and montane chaparral (Mayer and Laudenslayer 1988).

Other vegetation species associated with montane hardwood include California black oak, Pacific madrone, knobcone pine, greenleaf manzanita, whiteleaf manzanita, wedgeleaf ceanothus, lemon ceanothus, deerbrush (*Ceanothus integerrimus*), silktassel, and interior live oak (*Quercus wislizenii*). Associated understory includes Oregon grape (*Berberis aquifolium*), wood rose (*Rosa gymnocarpa*), manzanita, and poison oak (*Toxicodendron toxicodendron*) (Kie and Menke 1980, Mayer and Laudenslayer 1988).

Bird and mammal species associated with montane hardwood habitat include scrub jay (*Aphelocoma coerulescens*), Steller's jay (*Cyanocitta stelleri*), acorn woodpecker (*Melanerpes formicivorus*), and western gray squirrel (*Sciurus griseus*) which scatter acorns, and those that use acorns as a major food source such as wild turkey (*Meleagrus gallopavo*), mountain quail (*Oreortyx pictus*), band-tailed pigeon (*Columba fasciata*), and California ground squirrel (*Spermophilus beecheyi*). Black-tailed deer (*Odocoileus hemionus columbianus*) use the foliage for food and cover, and many amphibians and reptiles are found on the forest floor (Mayer and Laudenslayer 1988).

Mixed Chaparral (Resource Category 3)

Mixed chaparral habitat is a structurally homogeneous brushland type containing mainly shrubs with thick, stiff, heavily cutinized evergreen leaves. Shrub height and crown cover vary considerably with age since the last burn, precipitation regime (cismontane vs. transmontane), aspect, and soil type. When it is mature, cismontane mixed chaparral is typically a very dense thicket with greater than 80 percent absolute shrub cover. No wildlife species are restricted to mixed chaparral (Mayer and Laudenslayer 1988).

Specific vegetation species associated with mixed chaparral include chamise (*Adenostoma fasciculatum*), silktassel, birchleaf mountain mahogany, California buckeye (*Aesculus californica*), poison oak, yerba santa (*Eriodictyon californicum*), coffeeberry (*Rhamnus californica*), greenleaf manzanita, whiteleaf manzanita, wedgeleaf ceanothus, lemon ceanothus, deerbrush, California black oak, and Oregon white oak (Mayer and Laudenslayer 1988).

Cropland (Resource Category 4)

Cropland is associated with orchards, irrigated pastures, and wildlife habitats such as montane riparian, mixed chaparral, wetlands, desert, and herbaceous types. Croplands are found on the State's most fertile soils, which historically supported an abundance of wildlife. Croplands have greatly reduced the wildlife richness and diversity of California, however, many species of rodents and birds have adapted to croplands and are controlled by various methods to prevent excessive crop losses (CDFA 1975 *in* Mayer and Laudenslayer 1988).

Some species of waterfowl depend on waste rice and corn that remain in the fields after harvesting (CDFG 1983 *in* Mayer and Laudenslayer 1988). Cultivated crops found before the dams were built included alfalfa, vetch, clover, orchards, and farm gardens (USFWS 1964).

Evaluation Species

Evaluation species used in HEP analyses can be selected based on any one or more of the following criteria: 1) the species occurs or is likely to occur in the project area; 2) the species is representative of a guild or group of species that uses habitat in the project area; 3) a HSI model exists for the species; 4) the variables used in the model measure critical components of the habitat type that will be affected (e.g., percent tree canopy cover) by the project; 5) the species are important in maintaining the "health" and overall function of the cover type; and 6) the species will respond to management actions. The evaluation species chosen in this analysis are: downy woodpecker (*Picoides pubescens*), blue grouse (*Dendragapus obscurus*), California quail (*Callipepla californica*), wood duck (*Aix sponsa*), red-winged blackbird (*Agelaius phoeniceus*) California ground squirrel, bobcat (*Lynx rufus*), mink, and black-tailed deer. Rationale for choosing these nine species and their dependence on the now inundated cover types are discussed in the following paragraphs.

Downy Woodpecker

The downy woodpecker is a common, yearlong resident of montane riparian, montane hardwood and montane hardwood conifer habitats, all used for cover. Loss of riparian habitat and snags has caused population numbers to decrease in recent decades (Grinnell and Miller 1944 *in* Zeiner *et al.* 1990a). The woodpecker excavates a nest cavity in a snag or dead branch 4-50 feet above the ground and at least 9 inches dbh. Abandoned snag and tree cavities are used by many other species of wildlife as well (Zeiner *et al.* 1990a).

The downy woodpecker is an important indicator species of montane hardwood, montane hardwood conifer, and montane riparian habitats, all of which were impacted by construction of the dam.

Blue Grouse

The blue grouse is found in montane hardwood conifer habitat, i.e., in open, medium to mature-aged stands of fir, Douglas-fir, and other conifer habitats, that are interspersed with medium to large openings, and available water. It uses these firs and other conifers with dense foliage for roosting, however, it often does well in second-growth stands following logging (Zeiner *et al.* 1990a). The blue grouse's winter diet consists mainly of conifer needles; its summer diet consists of green leaves, fruit, seeds, flowers, animal matter, and conifer needles (Schroeder 1984). The blue grouse is an important indicator species of montane hardwood conifer habitat.

California Quail

The California quail is found in montane hardwood, mixed chaparral, wet meadow, and cropland habitats. Brush and tall shrubs or trees provide cover for feeding, escape, movement, and roosting. Suitable habitat for the California quail consists of a mosaic of low brushy vegetation with grass and forb openings, a few tall shrubs or trees, and water sources (Zeiner *et al.* 1990a). The California quail is an important upland game bird, and indicator species of montane hardwood, mixed chaparral, wet meadow, and cropland habitats, all of which were impacted by construction of the Project.

Wood Duck

The wood duck is found in montane riparian and slow-moving riverine habitats bordered by deciduous trees such as willows, cottonwoods, and oaks, and emergent vegetation. Reservoirs are less suitable than riverine habitat, especially during the nesting season. The wood duck prefers roosting on quiet waters, sheltered by trees, shrubs, or tall emergent vegetation, and swamps, ponds, lake coves, flooded woodlands, and open water, and it often roosts in large flocks. In midday, it rests onshore, or in water (Zeiner *et al.* 1990a).

The wood duck nests in tree cavities, pileated woodpecker (*Dryocopus pileatus*) nest-cavities, or old, rotted northern flicker (*Colaptes auratus*) cavities (Palmer 1976 *in* Zeiner *et al.* 1990a) of which there appear to be few along the section of the river north of Trinity Dam (Wilson *et al.* 1991). Suitable nest boxes and other artificial structures are also used (Bellrose *et al.* 1964, Bellrose 1976, Griffith and Fendley 1981 *in* Zeiner *et al.* 1990a). For nesting, the wood duck also requires trees bordering quiet aquatic habitat with emergent vegetation. Quiet water providing overhanging wooded vegetation, dense emergent vegetation, small passages of open water, submerged vegetation providing invertebrate food, and perches are ideal habitats for brood-rearing and summer molt (Palmer 1976 *in* Zeiner *et al.* 1990a). During the nonbreeding season, aquatic habitat may be bordered by any tall vegetation, but trees are preferred (Zeiner *et al.* 1990a).

The wood duck is a very shy bird and is most often found in secluded backwaters and pools along the Trinity River (Grinnel and Miller 1944 *in* Wilson *et al.* 1991). Wilson *et al.* (1991) suggests that their abundance and reproductive success is very low in this system. This could be due to predation (i.e., mink and otter), or lack of adequate nest sites. The wood duck is an important indicator species of montane riparian and riverine habitats, both of which were impacted by the Project, however, this riparian species has probably benefited from increased vegetation along the river below Lewiston Dam, as a result of the Trinity and Lewiston Dams.

Red-winged Blackbird

The red-winged blackbird is a common to abundant resident of wetland habitats throughout most of California. Most foraging takes place in cropland, grassland, and wet meadow habitats (Zeiner *et al.* 1990a). In California, it typically roosts in fresh or brackish emergent wetlands of cattails and tules, or in moist, open habitats with thickets of sedges, willows, dense forbs, and grasses. It also uses trees, shrubs, or other low, dense vegetation, usually in moist open habitats. The roost-site is usually over water (Orians 1961 *in* Zeiner *et al.* 1990a). Thus, the red-winged blackbird is an excellent indicator species of wet meadow/wetlands habitat.

California Ground Squirrel

The California ground squirrel uses open and disturbed areas, especially along roadsides, in croplands, and in grazed meadows. Burrows provide cover and are excavated in friable soils, usually near rocky areas or under trees or logs. Suitable areas also include herbaceous sites, and openings in most brush and forest habitats. Enhanced habitat includes friable soils, rocks, scattered trees, logs, and other ground cover (Zeiner *et al.* 1990b). The California ground squirrel is a good indicator species of cropland habitat for this analysis.

Bobcat

The bobcat is a common to uncommon, permanent resident throughout most of California. It uses nearly all habitats and successional stages of montane hardwood, montane hardwood conifer, and mixed chaparral habitats. Optimal habitats are brushy stages of low and mid-elevation conifer, oak, riparian, and pinyon-juniper forests, and all stages of chaparral. The bobcat also uses rocky cavities, hollow logs, snags, stumps, and dense brush for cover (Zeiner *et al.* 1990b). The bobcat is an important furbearer and indicator species of montane hardwood, montane hardwood conifer, and mixed chaparral habitats, again, all of which were significantly impacted by the Project.

Mink

The mink is an uncommon, permanent resident, generally occurring in the northern half of California (Grinnell *et al.* 1937 *in* Zeiner *et al.* 1990b). It is a semi-aquatic animal, inhabiting most aquatic habitats of montane riparian and riverine habitats. It forages along rivers, streams, lakes, ponds, canals, and in marshes, and uses existing cavities and burrows in wetland and riparian vegetation for cover (Zeiner *et al.* 1990b). Mink prefer areas with a dense tree canopy and shallow streams (Burgess and Bider 1980 *in* Wilson *et al.* 1991).

This riparian species has probably benefited from increased vegetation along the river below Lewiston Dam, as a result of the Trinity and Lewiston Dams. The mink is a good indicator species of montane riparian and riverine habitats.

Black-tailed Deer

The black-tailed deer is a common to abundant, yearlong resident or elevational migrant with a widespread distribution throughout most of the state. It occurs in early to intermediate successional stages of most forest, woodland, and brush habitats including montane hardwood, montane hardwood conifer, and mixed chaparral. It prefers a mosaic of various-aged vegetation providing woody cover, meadow and shrubby openings, and available water. Brushy areas and tree thickets are important for escape cover and vegetative cover is critical for thermal regulation in winter and summer (Zeiner *et al.* 1990b). The black-tailed deer is a very important big game species and indicator species of montane hardwood, montane hardwood conifer, and mixed chaparral habitats.

HEP Analysis Procedures

The HSI species models used in this study are published mechanistic models developed by the Service's National Ecology Research Center in Fort Collins, Colorado, and by the Service's Sacramento field office. The term "mechanistic" means that the models define a specific mathematical relationship between measured habitat parameters and their value to the evaluation species. All of the models used apply to habitats and species found within the project reaches. Copies of the models used for this study are found in Appendix C.

A HSI model for a species defines both the habitat variables that are important, by determining the value of the habitat to the species, and the relationships between those variables. Further, the model describes how to measure the habitat variables and how such measurements are to be converted to a HSI. Information used was obtained from published and unpublished literature and from individuals familiar with the species. Numerous assumptions were made in the field and during application of the models (Appendix D). Nine HSI species models were used for this study.

Determination of the Suitability Indices (SIs) needed to calculate each species' HSI was made from data generated by field sampling and aerial photo interpretation. Field sampling was conducted from September 15 through November 18, 1992 by Rosemary Gartner, Caroline Wilkinson, and Christine Willis of the Service. Appendix E lists the species, variable descriptions, cover types, and methods used to gather the variable data.

Before field work could proceed, however, pre-dam acreages were determined using aerial photos. The area of inundation was transferred by tracing the inundation zone from color, aerial photographs (9" X 9", 1:12,000 scale [1"= 1,000'], September 1991) of the Trinity and Lewiston Reservoirs at the post-dam stage, onto a sheet of mylar. This mylar was then placed on top of a mosaic of black and white aerial photographs (9" X 9", 1:12,000 scale, November 1957) of the same area, only at the pre-dam stage. Due to differences in overlap and camera angles, the inundation zone from 1991 had to be adjusted slightly to "fit" the 1957 photos. Subsequently, the 1957 inundation zone was visually transferred to enlarged aerial photos (45" X 45", 1:2,400 scale [1" = 200']). Distortions due to enlargement of the photos, and having to "eyeball" the inundation zone transfer were considered acceptable for the purposes of this project.

After the inundation zone was transferred from the 9" X 9" to the 45" X 45" photos, cover types were delineated by referring to "A Guide to Wildlife Habitats of California" (Mayer and Laudenslayer 1988), topographical maps, and on-site ground-truthing (June 15 and 16, 1992). These cover types were then planimetered to obtain acreage values, i.e., total acreage of each cover type that was inundated by the Project.

Since the Trinity Reservoir and the surrounding area were so large in size, we were able to collect data for the field-sampled variables over only a small portion of the entire area. The methods recommended in each model for gathering data for determination of each SI were generally followed. Also, at each sample site in the field, an 82 foot (25 meter) transect was laid out with a tape marked in feet and inches (tenths). The starting point of the transect was found by throwing a stick or stone in the air and the point where it landed was taken as the beginning of the transect. A random numbers table was used to locate different points along the tape. Five measurements were taken at different points along the tape, at six tape locations at each sample site (for a total of thirty measurements on average for each sample site). The transects formed the baseline from which all variable measurements were made.

Upon completion of the field data collection, the data were summarized and analyzed. Values for each of the measured variables at each sample site were calculated, and an average value for each variable by cover type was calculated. Average values were then used to determine the SIs for the variables in the individual species models. For each species, SIs were combined as described in the model to arrive at an overall study area HSI for that species. All SIs and HSIs were calculated by hand, calculator, or spreadsheets, as appropriate. The equations used to calculate HSIs are contained in each model (Appendix C).

When using HEP, it is necessary to determine HSIs for each evaluation species at selected target years for both with-project and without-project scenarios. Proposed mitigation areas must be treated similarly (with-management is substituted for with-project conditions). Since it is not possible to empirically determine habitat quality and quantity for future years, future HSI values were projected. Please note, however, that for this particular project, they were calculated for the past as well as for the future, since the present is TY36, i.e., baseline occurred 36 years ago in 1956, when Project construction began (per 1992 when this study began). This was accomplished by increasing or decreasing specific baseline SI values for each evaluation species based on probable past and future conditions, and best professional judgement. Predicted habitat changes for past, baseline, and future scenario target years are given in Appendix F. The assumptions used to derive past and future HSIs for with- and without- the project on the impact and compensation areas are given in Appendix G. The life of the project is based upon a 100-year period (USBR 1952).

Separate past, baseline, and future values were developed for each of the previously-described cover types. Weighted mean HSI values were then calculated for each evaluation species for 1) montane riparian and riverine habitats, and 2) mixed chaparral and montane hardwood cover types; these values then were used in the HEP accounting analysis along with cropland and wet meadow/wetland habitat values. All past, baseline, and future HSI values, including weighted means, are given in Appendix G and H, Tables 3, 5, 7, 9, 11, 13, and 15. The weighted mean HSI incorporates the habitat quality estimate and is weighted by the areal extent of the cover type if more than one cover type is used by the species, or by subarea if there is more than one subarea within a single cover type (USFWS 1980). Wet meadow needed to be calculated separately since it is a Resource Category 2 habitat type. Montane riparian and riverine are also Resource Category 2 habitat types, but were weighted since they are so closely related.

The compensation area required for mixed chaparral and montane hardwood was calculated using the equal replacement compensation goal. Equal replacement specifies that AAHU gains for a species can be used to offset the loss of an equal number of AAHUs for any other evaluation species. The compensation areas for wet meadow/wetlands, montane riparian, and riverine was calculated using in-kind replacement compensation goal. In-kind replacement requires AAHU gains for a species be used to offset the loss of in-kind AAHUs for the same evaluation species.

The HEP version 2.1 Accounting Software package was used on an IBM-compatible personal computer to calculate HUs, AAHUs, and sizes of the compensation areas needed to offset project impacts to wildlife (Appendix H, Tables 4, 6, 8, 10, 12, 14, 16, and 17-25). Comparing changes in AAHUs for the study area and the compensation area can be somewhat misleading when viewed on an absolute basis since the sizes of the areas are so different, therefore, it is important to remember that it is the **ratios** of changes in AAHUs that are compared.

RESULTS AND DISCUSSION

Baseline Conditions

Results of the evaluation of baseline habitat conditions are shown in Appendix H. Baseline conditions in the impact area were found to range from very low to high (Appendix H, Table 4):

- Mink (montane riparian, riverine) = average HSI
- Wood duck (montane riparian, riverine) = very low HSI
- Downy woodpecker (montane riparian) = very low HSI
- California quail (wet meadow) = high HSI
- Red-winged blackbird (wet meadow) = high HSI
- Downy woodpecker (montane hardwood, montane hardwood conifer) = low HSI
- Blue grouse (montane hardwood conifer) = very low HSI
- Black-tailed deer (montane hardwood, montane hardwood conifer, mixed chaparral) = low HSI
- California quail (montane hardwood, mixed chaparral) = average HSI
- Bobcat (montane hardwood, montane hardwood conifer, mixed chaparral) = average HSI
- California ground squirrel (cropland) = average HSI
- California quail (cropland) = very low HSI

Existing conditions in the compensation area were found to be very poor to very high under the without management scenario (Appendix H, Table 7), in some cases, declining in suitability over time:

- Mink (montane riparian, riverine) = average HSI
- Wood duck (montane riparian, riverine) = very low HSI
- Downy woodpecker (montane riparian) = low HSI
- California quail (wet meadow) = very high HSI
- Red-winged blackbird (wet meadow) = low HSI
- Downy woodpecker (montane hardwood) = low to very low HSI
- Black-tailed deer (montane hardwood, mixed chaparral) = low to very low HSI
- California quail (montane hardwood, mixed chaparral) = low to very low HSI
- Bobcat (montane hardwood, mixed chaparral) = very high HSI
- California quail (montane hardwood, mixed chaparral) = low HSI

Impact Analysis

General

For with the project scenario (Project Alternative 2 or PA2), conditions in the impact area were assumed to be a value of 0.0 for all cover types by the end of TY1, which constitutes the first year of construction of Trinity and Lewiston Dams (Appendix H, Table 5). Our analysis indicates that the Project adversely impacted 68.61 acres of montane riparian, 1,503.73 acres of riverine, 311.08 acres of wet meadow/wetlands, 1,066.46 acres of mixed chaparral, 7,245.86 acres of montane hardwood, 2,759.95 acres of montane hardwood conifer, and 1,072.36 acres of croplands, for a total of 14,028.05 acres (Table 3). The most significant cover type acreage loss was montane hardwood habitat.

The entire reservoir area was cleared of shrubs and trees up to the elevation of the maximum pool. At maximum (normal high) pool the reservoir inundated about 27.0 miles of the Trinity River, 8.0 miles of Stuart Fork, 6.0 miles of the East Fork of Stuart Fork, 4.0 miles of the East Fork of Trinity River, and 2.0 miles of Swift Creek (CDFG 1956) (Figure 2).

The following is a discussion of with and without project scenarios. We relied on 1951 data because we were unable to locate more recent habitat-related information. According to the Trinity River Basin Fish and Wildlife Task Force (1981), except for black-tailed deer, no data exist on losses of other wildlife habitats and populations. We were also unable to locate any post-1981 data.

Without and With the Project

Trinity Reservoir, Without the project - There were quite a few black bears (*Ursus americanus*) in the mountain regions to the north and west of Trinity Reservoir, however, the annual kill in the reservoir area during the winter was very low, indicating the reservoir did not contain a large population of this species. Black-tailed deer were found over most of the available mountain country during the summer months, but deep snows forced the deer into relatively small areas during the winter months. Numerous migration routes were utilized by the deer in their annual movements from the higher mountains to their wintering grounds in canyons and valleys like those in the reservoir site. Winter densities were estimated at over five times the summer density, indicating that the Trinity Reservoir area was a very important winter range for deer (USFWS 1951).

Populations of upland game species were low in the proposed Trinity Reservoir area. A small amount of hunting probably was done for California and mountain quail, band-tailed pigeons, and mourning doves (*Zenaida macroura*). Blue grouse, tree squirrels, snowshoe hare (*Lepus americanus*) and brush rabbits (*Sylvilagus bachmani*), were found in the reservoir area but were seldom ever hunted (USFWS 1951).

The following animals were believed to have occurred in the reservoir area, at least for brief periods during the year: raccoon (*Procyon lotor*), ring-tailed cat (*Bassariscus astutus*), marten (*Martes americana*), mink, river otter (*Lutra canadensis*), striped skunk (*Mephitis mephitis*), spotted skunk (*Spilogale putorius*), badger (*Taxidea taxus*), gray fox (*Urocyon cinereoargenteus*), and bobcat (USFWS 1951).

The Trinity River Basin, including the reservoir area, was never considered significant waterfowl habitat. It is off the flyways and far-removed from the

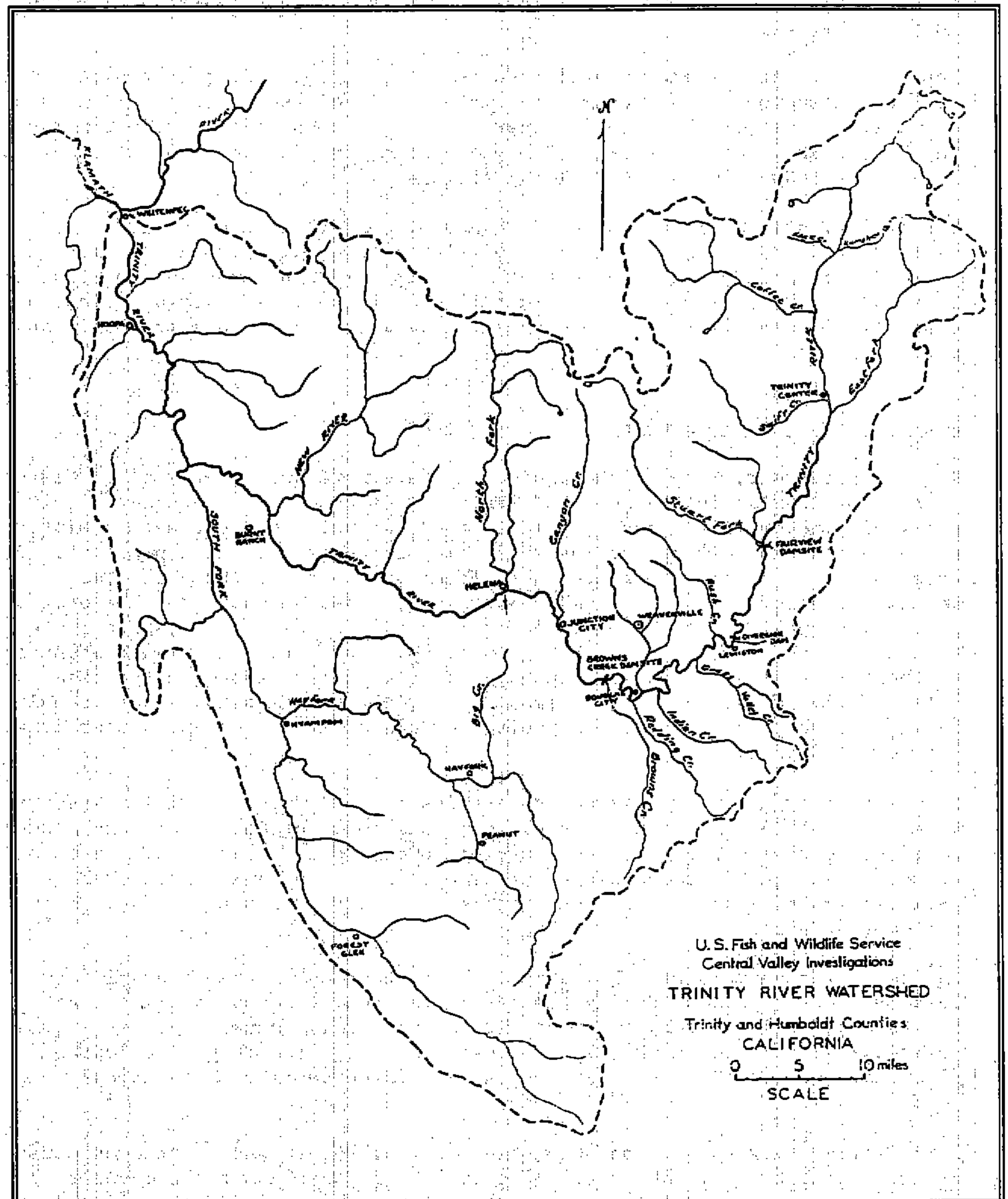

Figure 2. Location map of the Trinity River Basin (pre-dam) (Source: Moffet and Smith 1950).

major Central Valley wintering areas. Further, there is little waterfowl habitat in the rugged canyons of this portion of the Trinity River and its tributaries. Nevertheless, ducks such as mallards (*Anas platyrhynchos*), wood ducks, and common mergansers (*Mergus merganser*) were summer residents. Winter populations, composed of mallards, northern pintails (*Anas acuta*), and common mergansers, were considered to be about equal to adult summer populations in this area. Wood ducks were not present in the winter months. Canada geese (*Branta canadensis*) were seen along the Trinity River on rare occasions (USFWS 1951). The area along the main Trinity River supported a few species of migratory waterfowl which were attracted to the small marshy patches and ponds created by gold dredge tailings. Besides this, there was little habitat suitable for waterfowl (CDFG 1963).

Trinity Reservoir, With the project - Big game habitat was eliminated completely in the reservoir's inundation zone. During the winter of 1962-63, when Trinity Reservoir first filled, deer use increased nearly five times on adjacent dry areas (Dunaway 1964, USFWS *in* VTN Environmental Sciences 1964). This was due mainly to the clearing operations which increased forage production and to removal of livestock (Gordon, pers. comm. *in* VTN Environmental Sciences 1979). Winter deer range was seriously depleted during the first winter by the deer displaced from the reservoir area. The displaced animals crowded in with those deer which normally winter on range around the reservoir and initially exceeded the carrying capacity of the winter range (USFWS 1951). However, it is known that deer will swim the width of the reservoir during spring migration (Boroski 1992).

Although upland game species such as California and mountain quails, band-tailed pigeons, mourning doves, blue grouse, tree squirrels, and snowshoe and brush rabbits continue to occur on lands surrounding the reservoir, annual use of the reservoir area by these animals is believed to be insignificant (USFWS 1951).

With the Project, there is believed to be no suitable habitat available in the reservoir area for the majority of the fur animals that probably occurred on the area previously. However, it is expected that raccoons, minks, and a few otters continue to use the reservoir area. It seems doubtful that the long reservoir shoreline can support a fur animal population as large as that which existed previously along stream banks and pools in the dredged areas, since reservoir operations do not permit the establishment of suitable aquatic vegetation (USFWS 1951, M. Hampton, pers. comm.).

Over the last 10 years, reservoir fluctuation levels have ranged between 0-179 feet (D. Hoertling, pers. comm.). In combination with a comparatively short growing season, very little aquatic vegetation has become established in Trinity Reservoir. This decrease in food had a non-beneficial effect on waterfowl in the area. However, slight increases in dabbling and diving ducks, waders and coots have been noted (VTN Environmental Sciences 1979). Wood ducks and American mergansers may have increased on the area because the average annual maximum pool will occur at the time when these birds nest, thus bringing the water's edge close to available nesting sites in old conifers and oaks. Since this reservoir area is far-removed from the regular migration routes and centers of wintering waterfowl concentrations, probably at no time in the future will there be more than minor use of the area as wintering waterfowl habitat (USFWS 1951).

Trinity Reservoir inundated all of the dredge pond habitat. Fluctuating water levels eliminated wetlands and ponds, which are important to waterfowl. It is possible that the reservoir may be used as a resting place for migrating birds since the upper Trinity Basin is on the western fringe of the Pacific Flyway, however, studies would need to be done to confirm this (CDFG 1963).

Ospreys have increased at least slightly and bald eagles have substantially increased in the reservoir area (P. Detrich, pers. comm.). These species are believed to have increased due to a greater food source and ease in catching fish.

Appendix I lists animal species occurring at Trinity Reservoir and the surrounding area.

Lewiston Reservoir, Without the project - Black bears were uncommon in this area. The center of the local bear population is north and west of the Trinity Reservoir area. Black-tailed deer were summer residents in the reservoir area and the surrounding mountain ridges. The same summering and wintering deer situation existed in this reservoir area as in the Trinity Reservoir area. Deep snows forced the deer out of the high country and concentrations occurred in this reservoir area, especially during the period December though March. The site of the Lewiston Reservoir area was considered to be critical winter range since the winter deer density is about five times greater than the summer density (USFWS 1951).

Some hunting probably took place for California and mountain quail, band-tailed pigeons, and mourning doves. Tree squirrels, black-tailed jack rabbits (*Lepus californicus*), brush rabbits, raccoon, ring-tailed cat, mink, otter, striped and spotted skunks, badger, gray fox, and bobcat also occurred in the reservoir area (USFWS 1951).

Lewiston Reservoir is also on the fringe of the Pacific flyway and far-removed from major Central Valley wintering waterfowl areas. Waterfowl species were the same on Trinity and Lewiston Reservoir areas (USFWS 1951).

Lewiston Reservoir, With the project - Existing big game habitat in the reservoir area was lost. Also, habitat of big game species has been destroyed by inundation. Big game benefits that may have resulted from the possible establishment of a fringe of shrub species around the reservoir are considered negligible with the project (USFWS 1951).

Year-round populations of waterfowl at the Lewiston Reservoir area may have increased if emergent aquatic plants have become established around the reservoir. Nesting habitat may be more abundant, and the aquatic foods should be supporting more waterfowl than occurred pre-dam on the area during the winter months (USFWS 1951). Slight increases in dabbling and diving ducks, waders and coots have been noted (VTN Environmental Sciences 1979).

Lewiston Reservoir inundated all of the dredge pond habitat. It is possible that the reservoir may be used as a resting place for migrating birds. This could have resulted in an increase in the waterfowl population of the area, however, again, a study would need to be done to confirm this assumption (CDFG 1963).

Bald eagles have substantially increased in the reservoir area (P. Detrich, pers. comm.). As with Trinity Reservoir, this species is believed to have increased in the area due to a greater food source and ease in catching fish.

Compensation Analysis

General

The mitigation planning goals for impacts from the reservoirs are to: 1) provide compensation recommendations that would result in *no net loss of in-kind habitat values* for riparian and wet meadow/wetlands habitat types, which means providing or managing substitute resources to replace the habitat value of the resources lost, where such substitute resources are physically and biologically the same or closely approximate those lost, and; 2) to provide compensation recommendations that would result in *no net loss of habitat value while minimizing the loss of in-kind habitat value* for montane hardwood, montane hardwood conifer, mixed chaparral, and cropland habitats, which means that if losses are likely to occur, the Service will recommend ways to immediately rectify them or reduce or eliminate them over time. If losses remain likely to occur, then the Service will recommend that these losses be compensated by replacement of habitat values so that the total loss of habitat values will be eliminated. Montane hardwood conifer will be replaced by montane hardwood and chaparral. Croplands will also be replaced by montane hardwood and chaparral.

Since more than 14,000 acres of wildlife habitat have been permanently lost, restoration of wildlife to pre-project levels is a very difficult goal. Also, few data are available to determine how wildlife species have been affected. The best that can be hoped for is to compensate for any losses by improving the remaining habitat. The primary goal should be to, within reason, compensate for wildlife by carrying out habitat improvement work that will benefit a variety of species (Frederiksen *et al.* 1979b).

Compensation will be met through present and future on-site habitat improvements, and acquisition of off-site lands (USFWS *et al.* 1990). For the compensation analysis, we considered each of the variables in the HSI models used in the HEP to identify those which could potentially be improved so as to increase overall habitat value. Compensation plans for each cover type will be discussed separately; each plan relates to the variables impacted.

The size of the compensation areas needed to offset project impacts is dependent on many factors: baseline habitat values, predicted changes in habitat quantity and quality over time, and the type and extent of mitigation measures proposed. Due to limited available compensation areas, the sites measured for the compensation areas are low in acreage and do not nearly meet the acreages needed to compensate for the habitats lost.

The Future Assumptions section (Appendix G) shows MP3-MP5, which are variations of the MP2. Only MP2 for each cover type, our preferred Management Plan, will be discussed in this compensation analysis section.

Management Plan 2 (MP2)

General

Variables for montane riparian and riverine were measured below Lewiston Dam, where there has been a significant increase in riparian vegetation since construction of the dams. Some of this increase in riparian constitutes a small amount of compensation for the Project under the MP2. Montane hardwood conifer is compensated for in this plan through montane hardwood and mixed chaparral habitats. The MP2 for montane hardwood and mixed chaparral is composed of eight actions: 1) crush and burn every 5 years in a rotational manner to retard manzanita, to stimulate ceanothus sprout growth to the early successional stage, and to retain open areas suitable for growth of forbs, grasses, and other palatable browse (USFWS 1992), and to improve animal access (chaparral); 2) reseed every 5 years (i.e. wedgeleaf ceanothus) (chaparral); 3) place logs and/or brush piles on site to improve small mammal habitat and bobcat cover (montane hardwood); 4) install quail guzzlers (montane hardwood); 5) plant trees (montane hardwood); 6) plant shrubs and vines (montane hardwood); 7) plant forb seeds for herbs (montane hardwood); and 8) create snags by girdling planted trees, to create habitat for nesting, perching, etc. (montane hardwood).

The MP2 for wet meadow/wetlands is composed of six actions: 1) rediverting a gulch back to its naturally flowing course with a culvert so it would naturally flood this valley area. Through this method, yellow star thistle (*Centaurea soltitialis*), which is currently growing there, would die from the inundation of the water; 2) dredge ponds along the Trinity River to provide a permanent water source; 3) provide roosting cover; 4) provide escape cover; 5) plant preferred forb seeds for quail, and; 6) manage the area annually. Croplands are compensated for through montane hardwood and mixed chaparral habitats.

Montane Riparian and Riverine

The amount of montane riparian and riverine habitat lost due to inundation of these habitats behind Trinity and Lewiston Dams was 1,572.34 acres. The amount of acreage needed for compensation (Appendix H, Table 22) is 5,698.60 acres; using this number ensures that all species are compensated for. However, along 40.60 river miles of the Trinity River, from Lewiston Dam to the North Fork of the Trinity River (Figure 1), montane riparian habitat increased after the dams were constructed; it totals about 349.80 acres (planimetered from 1987 aerial photographs). Acreage for riverine along this same reach totals about 249.57 acres (planimetered from 1987 aerial photographs). Montane riparian plus riverine totals 599.37 acres. Therefore, it is our conclusion that 599.37 acres of montane riparian and riverine habitat have already been compensated for, and a total of 5,099.23 acres would still be needed to fully compensate for the impacts to this habitat type (5,698.60 acres minus 599.37 acres equals 5,099.23 acres). The mitigation ratio is about 3.6:1 for montane riparian and riverine (5,698.60 acres lost compared to 1,572.34 acres needed for mitigation). The net change for the plan alternative is -1,173.64 AAHUs and the net change for the management plan is 2.53 AAHUs. Since so many AAHUs were lost, it will take many acres to compensate for this loss. Under this compensation plan, the HSI value for each evaluation species will have increased to 1.0.

The following paragraphs offer an explanation for the increased montane riparian habitat along the Trinity River between Lewiston Dam and the North Fork of the Trinity River, after Trinity and Lewiston Dams were constructed.

The portion of the Trinity River riparian habitat affected most by the management of the Trinity Division is the 40.60 miles of river immediately downstream of Lewiston Dam. Controlled flow releases from Lewiston Dam have attenuated flood peaks and provided higher summer stream flows. This in turn has provided the right conditions for riparian proliferation (USFWS 1991). A comparison of pre- and post-dam riparian habitat reveals a tremendous expansion and encroachment of riparian vegetation between 1960 and 1977 (Evans 1980 *in* Wilson *et al.* 1991). Scattered patches of streamside vegetation and gravel bars were present before project construction, resulting in the riparian corridor being set back from the water's edge. The riparian zone is now characterized as a narrow strip on both sides of the river, usually less than 100 feet (30 meters) wide (Evans 1980 *in* Wilson *et al.* 1991)

Stable flows during May-October, instead of reduced discharge, is thought to be the main factor contributing to the increase in riparian vegetation. The lack of scouring winter and spring flood flows after the dams were constructed is another reason for the encroachment of riparian vegetation (Pelzman 1973 *in* Wilson *et al.* 1991) into the stream channel.

The increase in riparian habitat may have, in turn, increased wildlife abundance and richness in the Basin. Below the dam, riparian vegetation has reached later successional stages because it is seldom subject to the stresses of periodic, scouring flood flows. An adequate assessment of the effects of these changes on wildlife species in these riparian areas has yet to be undertaken (Wilson *et al.* 1991).

Due to limited available areas within the Project area, we were unable to determine a location for a compensation area for montane riparian and riverine habitats.

Wet Meadow/Wetlands

The compensation site is about 110.0 acres and is located next to the Trinity River. One-half of the area is owned by the California Department of Water

Resources, and the other one-half is owned by a private landowner and is for sale. Snipe Gulch, located across the street from this potential compensation area, was diverted from its naturally flowing course by a ditch, which has directed its flow into Grass Valley Creek which then flows into the Trinity River. The main vegetation species growing on the compensation site is yellow star thistle. The area at TY0 was wetter than at present, contained shorter grasses, and was grazed prior to TY36.

Specific management objectives for the wet meadow are: 1) redirect the gulch back to its naturally flowing course with a culvert directly below the gulch so it would naturally flood this valley area. Through this method, the yellow star thistle, which is currently growing there, would die from the inundation of the water. Part of the compensation area would be wet and part would be dry, however, the wet area would only be wet part of the year, and would dry out by the Summer, after the Winter and Spring run-off; 2) dredge ponds along the Trinity River to provide a permanent water source for wildlife; 3) plant trees, shrubs, and vines to provide roosting cover for California quail, with blue elderberry (*Sambucus caerulea*), California black oak (*Quercus kelloggii*), and arroyo willow (*Salix lasiolepis*) (USFWS 1985, K. Fuller, pers. comm., Munz 1968), and provide roosting and nesting habitat for red-winged blackbirds, with cattails (*Typha* sp.), tules (*Scirpus* sp.), California blackberry (*Rhubus vitifolius*), arroyo willow, and sandbar willow (*Salix hindsiana*) (SCS 1980, K. Fuller, pers. comm.); 4) provide escape cover for quail and other wildlife by planting herbs, shrubs, and vines such as wild rose (*Rosa californica*), buck wheat (*Eriogonum* spp.), and blue elderberry (USFWS 1985, K. Fuller, pers. comm.); 5) plant preferred forb seeds for California quail to include red clover (*Trifolium pratense*), miner's lettuce (*Montia perfoliata*), ryegrass (*Lolium* sp.), and some species of pigweed (*Chenopodium* spp.) (USFWS 1985, CDFG 1989a, K. Fuller, pers. comm.); and 6) manage the area annually. Pure live seed would be used to plant the forbs, and container stock with no bare roots would be used to plant the trees and shrubs (K. Fuller, pers. comm.). Cattails and tules would be brought in by tubers. A more complete list of vegetation species to plant can be found in Appendix J.

Under this compensation plan, the HSI for the California quail will have increased back to its baseline value, which is high (.87), and the HSI for the red-winged blackbird will have improved significantly (1.0) (Appendix H, Table 9). The area needed for compensation under the MP2 is 499.21 acres (Appendix H, Table 22). Figure 3 gives the location of the wet meadow site measured for the MP2.

<u>Montane Hardwood Conifer</u>

This cover type was replaced in the HEP accounting analysis by montane hardwood and mixed chaparral cover types. PA1 (without the project) and PA2 (with the project) for the blue grouse, under the cover type montane hardwood conifer, were input into the HEP accounting analysis. Through MP1 (without management) and MP2 (with management) for all cover types, montane hardwood conifer was replaced through the mitigation goal of equal replacement. The preferred management plan (MP2, see description in the following section on

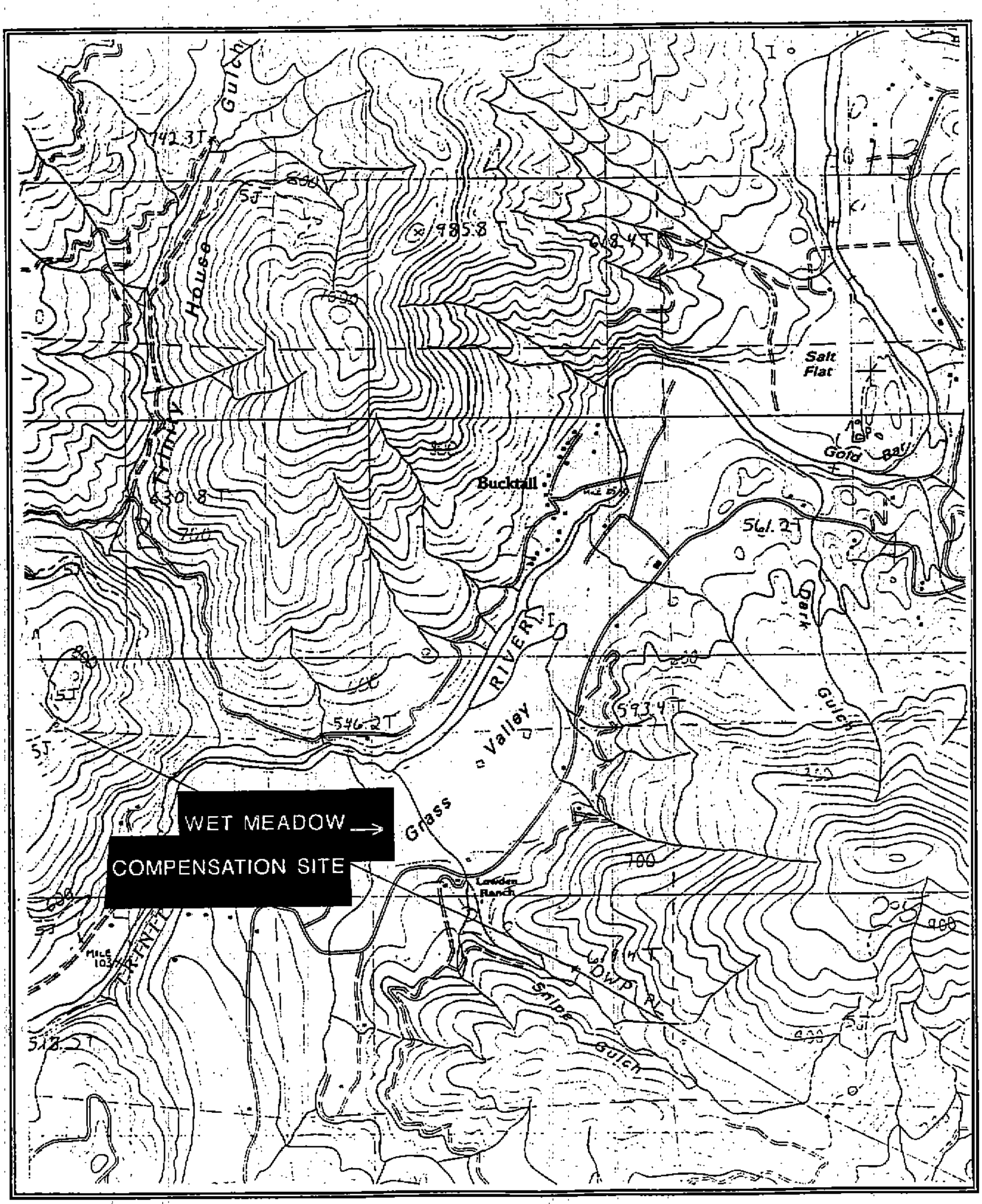

Figure 3. Location of wet meadow compensation site (Source: USGS 1982a).

montane hardwood and mixed chaparral) would provide sufficient gains to meet our equal compensation goal for this cover type.

Montane Hardwood and Mixed Chaparral

The chaparral compensation site is 29.7 acres and is owned by the Bureau of Land Management; the montane hardwood compensation site is 28.8 acres and is owned by the U.S. Forest Service. The chaparral site contains extremely decadent (marked by decline or decay) vegetation (about 25 percent manzanita and 75 percent wedgeleaf ceanothus) (TY36); at TY0, it was assumed to be mature. The montane hardwood site previously had hardwoods growing on it (TY0) (at least in November 1957); it is now simply a grassy area (TY36).

Specific management objectives for mixed chaparral are: 1) crush and burn every 5 years in a rotational manner to retard manzanita, to stimulate ceanothus growth, and to retain open areas suitable for growth of forbs, grasses, and other palatable browse (USFWS 1992), and to improve animal access; and 2) reseed every 5 years (i.e. wedgeleaf ceanothus) (USFWS 1992). Specific management objectives for montane hardwood are: 1) place logs and/or brush piles on site to improve small mammal habitat and bobcat cover; 2) install quail guzzlers to provide a water source; 3) plant trees to provide roosting cover for California quail and other wildlife, and nesting habitat for the downy woodpecker, to include Oregon white oak (*Quercus garryana*), California black oak, and canyon live oak (*Quercus chrysolepis*) (USFWS 1985, K. Fuller, pers. comm.), and to provide browse for black-tailed deer such as wedgeleaf ceanothus, deerbrush, California black oak, and lemon ceanothus (Kie and Menke 1980, CDFG 1989a) (Appendix K); 4) plant herbs, shrubs, and vines such as Oregon grape, chamise, and interior live oak, to provide escape cover for California quail and other wildlife (USFWS 1985, K. Fuller, pers. comm.); 5) plant forb seeds for food for California quail and other wildlife to include red-stem filaree (*Erodium cicutarium*), all species of vetch (*Vicia* spp.), prickly lettuce (*Lactuca scariola*), turkey mullein (*Eremocarpus setigerus*), tumbleweed (*Amaranthus graecizans*), and rough pigweed (*Amaranthus retroflexus*) (USFWS 1985, CDFG 1989a, K. Fuller, pers. comm.); 6) create snags by girdling planted trees, to create habitat for nesting and perching habitat for downy woodpeckers and other birds. Pure live seed (PLS) should be used to plant the forbs, and container stock with no bare roots should be used to plant the shrubs and trees (K. Fuller, pers. comm.). A more complete list of vegetation species to plant can be found in Appendix L.

Figures 4 and 5 give locations of these potential compensation sites.

By TY105, under this compensation plan, all HSI's for the evaluation species in these cover types would be improved, with the exception of the California quail model which decreased its HSI value slightly, and the bobcat model, which stayed the same (1.0) (Appendix H, Table 10). The area needed for compensation under the MP2 is 32,879.63 acres.

The following paragraphs discuss the values of controlled burning on mixed chaparral sites.

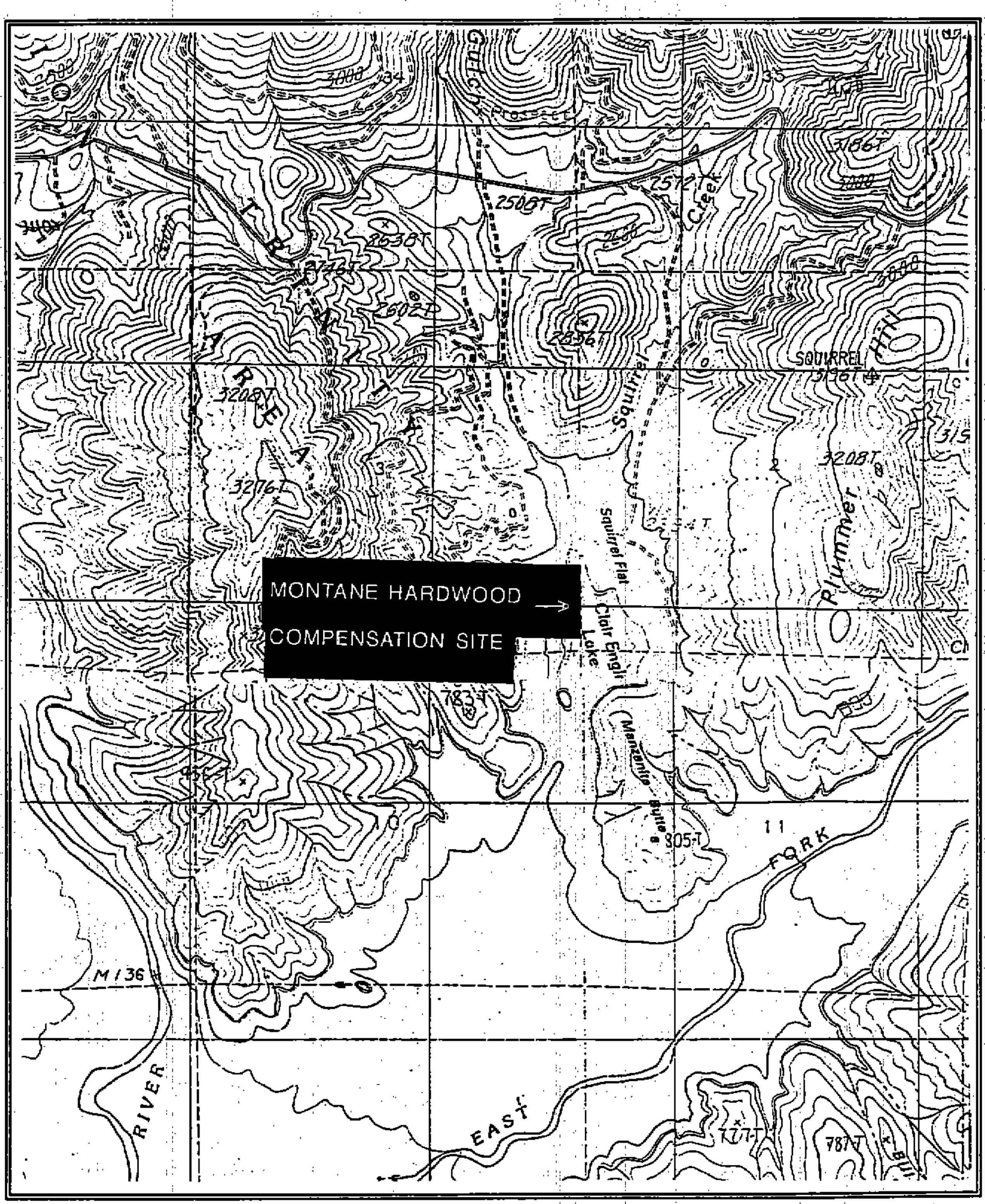

Figure 4. Location of montane hardwood compensation site (Source: USGS 1982b, 1986).

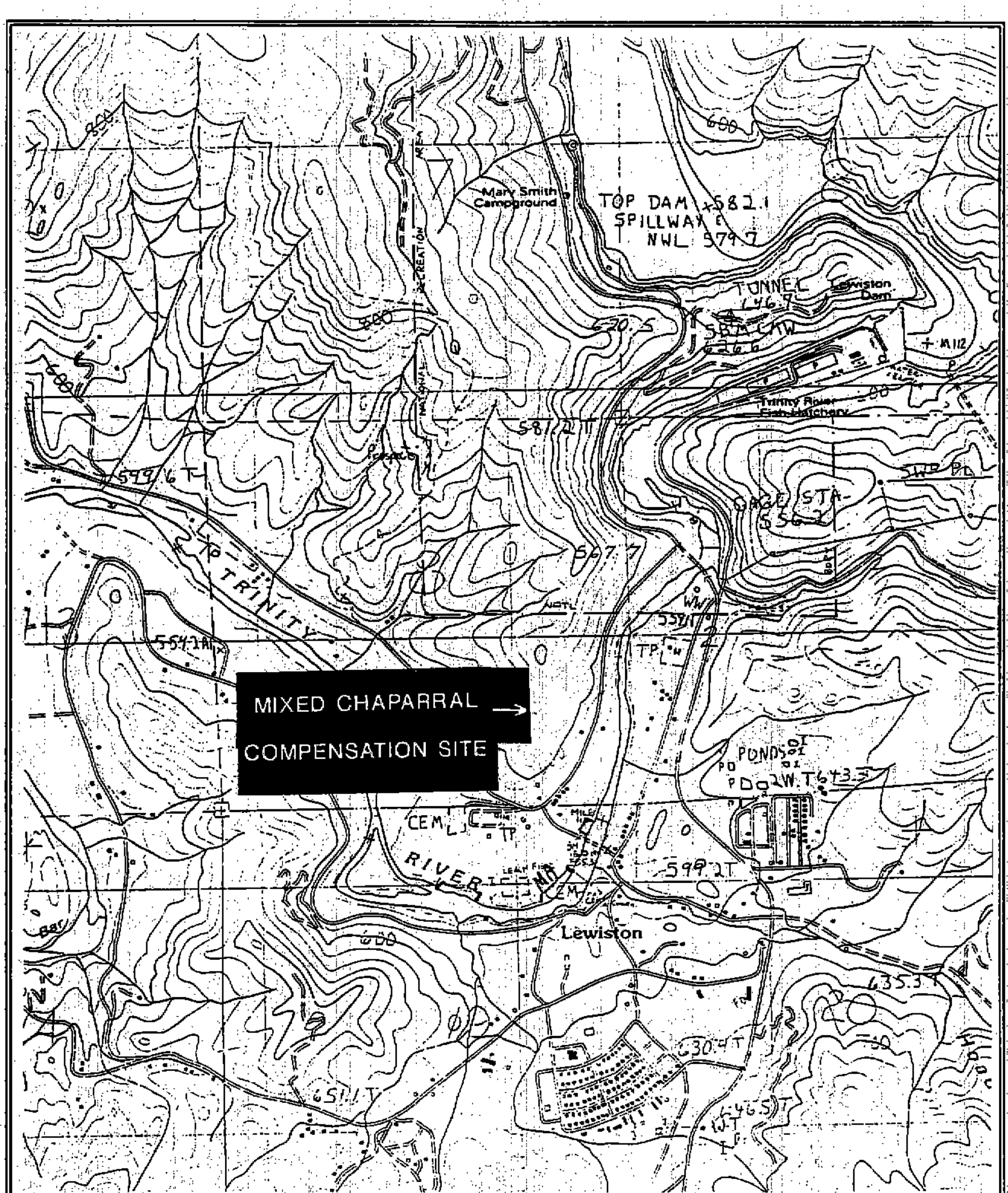

Figure 5. Location map of mixed chaparral compensation site (Source: USGS 1982a).

Controlled burning is an economical method of removing undesirable brush from mixed chaparral habitat. It can be used for removal of plant cover, regeneration of seedlings and sprouts, preparation of seed beds to provide food for wildlife, such as deer, and to provide better access to browse within the mixed chaparral habitat. In some areas, it may be the only treatment necessary if burned at the right time and the proper pre-burn preparations are made (CDFG 1963).

Germination on mixed chaparral sites is greatest during the first wet season after a controlled burn (Went *et al.* 1952; Horton and Kraebel 1955; Patric and Hanes 1964 *in* Barbour and Major 1988). In northern California, chaparral burns are dominated by herbaceous forms for the first 3 years, then forbs give way to grasses during the fourth and fifth years (Cooper 1922; Sampson 1944; Sweeney 1956 *in* Barbour and Major 1988). The increase in flowering and subsequent seed production from herbs insures an abundant seed source for the continuation of these species after the next controlled burn (Barbour and Major 1988).

Jepson (1925 *in* Barbour and Major 1988) and Horton (1950 *in* Barbour and Major 1988) consider chaparral a transition vegetation type which, if not for recurring fire, would eventually be replaced by oak woodland (Barbour and Major 1988). Also, most old, unburned chaparral stands become decadent. In northern California, this may occur within 20-25 years (Sampson 1944 *in* Barbour and Major 1988). Chamise chaparral stands older than 60 years are considered decadent (Hedrick 1951; Hanes 1971 *in* Barbour and Major 1988). Species diversity is low, there is little annual growth, and there is little, if any, herbaceous understory (McPherson and Miller 1969 *in* Barbour and Major 1988).

Deer in the Weaverville herd consume greenleaf and whiteleaf manzanita probably from the lack of other, more nutritious forage (VTN Environmental Sciences 1979, Burton and Monroe 1983). Limited benefits to deer will result from burning pure stands of manzanita; the main benefits of burning in manzanita stands will result in ease of access by deer and possibly by increased grass and forb production (Kie and Menke 1980).

Cropland

PA1 (without the project) and PA2 (with the project) for the California quail and California ground squirrel, were input into the HEP accounting analysis. Through MP1 (without management) and MP2 (with management), cropland was compensated through the California quail under the cover types montane hardwood and mixed chaparral. This cover type, therefore, was compensated by the mitigation goal of equal replacement (Appendix H, Table 10). The amount of compensation needed under the MP2 is 7,420.12 acres (Appendix H, Table 22).

CONCLUSIONS AND RECOMMENDATIONS

Wildlife habitats and numerous wildlife species have been adversely impacted by the construction of the Trinity River Division. Many important game and non-game species have declined. Despite not being mandated by law to fully mitigate for adverse impacts to wildlife resulting from construction of the Trinity River Project, it is nevertheless important to compensate for certain inundated habitats. Securing the proposed budget for this action will ensure that past project-related activities, combined with future Management Plans and continued land management activities, will not lead to further decline in wildlife habitat but contribute to restoration efforts (USFWS 1991).

It is our opinion that the lands in the vicinity of the Trinity and Lewiston Reservoirs generally will not have a high potential for substantial improvement in terms of wildlife habitat quality. Steep slopes around the lake reduce the mitigation potential of much of the land. Areas with poor soils are difficult to improve for the benefit of wildlife, yet highly productive soils will likely continue to be used mainly for timber production.

Cost will also be a prime factor in determining what management actions can be realistically accomplished. With the indication in this analysis of the large size of the area that will need to be managed, it is anticipated that compensation for all wildlife habitat losses would likely be very costly.

The Service recommends that:

1. Loss of habitat be compensated by using Management Plan 2 for all cover types. This is the most comprehensive plan and would insure the greatest improvement of habitat for the evaluation species and other important wildlife found at the Project site.

2. Administration of the controlled burn program on the Project site, as in Management Plan 2, stress planning, funding, maintenance, monitoring, and inter-agency cooperation.

3. Lands be obtained with high habitat development potential for compensation.

4. The impacts of Management Plan 2 on wildlife be assessed by carrying out wildlife inventories both prior to and after habitat manipulation. These inventories should continue for a minimum of five years, or until adequate data are collected to indicate that the goals of the Plan (see MP2) have been accomplished.

LITERATURE CITED

Barbour, M.G. and J. Major, eds. 1988. Terrestrial vegetation of California. University of Davis, California Native Plant Society. Special Publication No. 9. 1,020 pp.

Boroski, B.B. 1992. Deer habitat assessment and evaluation of winter range habitat manipulation projects in the Trinity River Basin and characterization of deer winter range on the eastern side of Trinity Lake. An interim project report on Agreement No. FG1555 between the State of California, the Department of Fish and Game, and the USDA, Pacific Southwest Forest and Range Experiment Station, Fresno, California.

Burton, T.S. and G.S. Monroe. 1983. Weaverville deer herd plan. California Department of Fish and Game, Redding, California. 83 pp.

CDFG (California Department of Fish and Game). 1956. Plan for the protection and maintenance of fish and wildlife resources affected by the Trinity River Division, Central Valley Project. 76 pp.

_____. 1963. Trinity River Diversion, habitat replacement. Redding, California. 12 pp. + appendices.

_____. 1968. CDFG biologist for Trinity County water use survey.

_____. 1989a. Plant list for revegetation projects. Developed by P.L. McLaughlin (California Department of Fish and Game Wildlife Biologist), Lewiston, California.

_____. 1989b. Wildlife habitat relationships database system. System developed by the Pacific Gas and Electric Company for the California Department of Fish and Game, Rancho Cordova, California.

Christensen, L.V. 1986. Neuberg Photography and Printing, Hayfork, California. 96 pp.

Frederiksen, Kamine, and Associates, Inc. 1979a. Proposed Trinity River basin fish and wildlife management program. Draft main report, Sacramento, California. 344 pp.

_____. 1979b. Proposed Trinity River basin fish and wildlife management program. Draft report, Appendix C, Volume 2, Sacramento, California. 46 pp.

Grace, H.D. 1958, revised 1960. Summary Report to the Regional Director, U.S. Bureau of Reclamation, Region II on impact of Trinity River Project on Shasta-Trinity National Forests. USDA, Forest Service, California Region, San Francisco, California. 54 pp.

House of Representatives. 1981. Fish and wildlife restoration in the Trinity River basin. October 21, 1981.

Hubbell, P.M. Undated. A review of investigations relating to the anadromous salmonid resources on the Trinity River Basin, California, draft report. California Department of Fish and Game, Sacramento, California. 92 pp.

Kie, J.G. and J.W. Menke. 1980. Deer response to Trinity River habitat manipulation. A cooperative study, University of California at Davis, U.S. Department of Agriculture, Forest Service, California Department of Fish and Game, Trinity River Basin Fish and Wildlife Task Force. 157 pp.

Mayer, K.E. and W.F. Laudenslayer, Jr., eds. 1988. A guide to wildlife habitats of California. California Department of Forestry, Sacramento, California. 166 pp.

Moffet, J.W. and S.H. Smith. 1950. Biological investigations of the fishery resources of the Trinity River, California. U.S. Fish Wildl. Serv., Special Scientific Report, Fisheries Bulletin No. 12. 71 pp.

Munz, P.A. 1968. California flora and supplement. University of California Press, Berkely, L.A., London. 1,681 pp. + supplement.

Natural Resources Services of Redwood Community Action Agency. 1989. Hamilton site revegetation plan, Grass Valley Creek, Trinity County, California. Prepared for the California Department of Water Resources. Eureka, California. 37 pp.

Schroeder, R.L. 1984. Habitat Suitability Index Models: Blue grouse. U.S. Fish Wildl. Serv. FWS/OBS-82/10.81. 19 pp.

SCS (Soil Conservation Service). 1980. Red-winged blackbird habitat suitability index model, draft. Davis, California. 11 pp.

Trinity River Basin Fish and Wildlife Task Force. 1981. Trinity River basin fish and wildlife management program. 42 pp.

USBR (U.S. Bureau of Reclamation). 1952. Report of the Regional Director, Substantiating Report, Report of the National Park Service, Report of the Fish and Wildlife Service. U.S. Bureau of Reclamation, Trinity River Division Central Valley Project Ultimate Plan. 27 pp., 184 pp., 36 pp., 66 pp.

USDA (U.S. Department of Agriculture). 1992. Vegetation species found in the riparian zones of Trinity County, California. U.S. Forest Service, Big Bar Ranger District, Big Bar, California.

USFWS (U.S. Fish and Wildlife Service). 1951. Preliminary evaluation report on fish and wildlife resources affected by the proposed Trinity River Division, Central Valley Project Ultimate Plan, California. U.S. Fish and Wildlife Service, Trinity River Division Central Valley Project, California, Portland, Oregon. 66 pp.

_____. 1964. Habitat replacement report. U.S. Fish and Wildlife Service, Trinity River Division, Central Project, Portland, Oregon. 14 pp. + appendices.

_____. 1980. Habitat as a basis for environmental assessment 101-102 ESM. U.S. Fish and Wildlife Service, Habitat Evaluation Procedures Manual, Washington, D.C.

_____. 1983. Trinity River Basin fish and wildlife management program. U.S. Fish and Wildlife Service, final environmental impact statement, Sacramento, California. 148 pp.

_____. 1985. California quail habitat suitability index model, Sacramento, California.

_____, USACE (U.S. Army Corps of Engineers), WDW (Washington Department of Wildlife). 1990. Lower Snake River fish and wildlife compensation plan, wildlife habitat compensation goals for the Lower Snake River project, Boise, Idaho. 58 pp. + appendices.

_____. 1991. Trinity River fish and wildlife management program. U.S. Fish and Wildlife Service, wildlife management plan outline for riparian and upland habitat, Weaverville, California.

_____. 1992. Auburn interim wildlife mitigation program, planning aid memorandum. Prepared for the U.S. Bureau of Reclamation, Sacramento, California. 8pp.

USGS (U.S. Geological Survey). 1982a. Lewiston Quadrangle, California, 7.5 minute series topographic map. U.S. Geological Survey, Denver, Colorado.

_____. 1982b. Trinity Center Quadrangle, California, 7.5 minute series topographic map. U.S. Geological Survey, Denver, Colorado.

_____. 1986. Carrville Quadrangle, California, Trinity County, 7.5 minute series topographic map. U.S. Geological Survey, Denver, Colorado.

VTN Environmental Sciences. 1979. Fish and wildlife management options. Final report to U.S. Bureau of Reclamation, Trinity River Basin, Northwestern California.

Wilson, R.A., A.J. Lind, and H. Welsh, Jr. 1991. Trinity River riparian wildlife survey - 1990. Final report of USDA, Forest Service, Pacific Southwest Experiment Station to Wildlife Task Group, Trinity River Restoration Project, Weaverville, California. 97 pp + appendices.

Zeiner, D.C., W. F. Laudenslayer, Jr., K.E. Mayer, and M. White, eds. 1990a. California's Wildlife, Volume II, Birds. California statewide wildlife habitat relationships system, State of California, The Resources Agency, Department of Fish and Game, Sacramento, California. 731 pp.

_____. 1990b. California's Wildlife, Volume III, Mammals. California statewide wildlife habitat relationships system, State of California, The Resources Agency, Department of Fish and Game, Sacramento, California. 407 pp.

PERSONAL COMMUNICATIONS

Detrich, P. 1993. U.S. Fish and Wildlife Service, Ecological Services, Sacramento, California.

Fuller, K. 1993. U.S. Fish and Wildlife Service, Ecological Services, Sacramento, California.

Hampton, M. 1993. U.S. Fish and Wildlife Service, Trinity River Flow Study, Lewiston, California.

Hoertling, D. 1993. U.S. Bureau of Reclamation, Central Valley Project, Shasta Dam Division, Redding, California.

APPENDIX A

LISTED AND PROPOSED ENDANGERED AND THREATENED SPECIES AND CANDIDATE SPECIES THAT MAY OCCUR IN THE AREA OF THE PROPOSED TRINITY RIVER DIVISION PROJECT, UPLAND HABITAT ASSESSMENT, TRINITY COUNTY, CALIFORNIA (1-1-93-SP-247, FEBRUARY 1, 1993)

Listed Species

Fish
winter-run chinook salmon, *Oncorhynchus tshawytscha* (T)

Birds
bald eagle, *Haliaeetus leucocephalus* (E)
northern spotted owl, *Strix occidentalis caurina* (T)

Proposed Species

None

Candidate Species

Fish
green sturgeon, *Acipenser medirostris* (2R)

Amphibians
foothill yellow-legged frog, *Rana boylei* (2)
northern red-legged frog, *Rana aurora aurora* (2)
tailed frog, *Ascaphus truei* (2R)

Reptiles
northwestern pond turtle, *Clemmys marmorata marmorata* (2•)

Birds
northern goshawk, *Accipiter gentilis* (2)

Mammals
California wolverine, *Gulo gulo luteus* (2)
Pacific fisher, *Martes pennanti pacifica* (2)
Pacific western big-eared bat, *Plecotus townsendii townsendii* (2)

Invertebrates
Trinity Alps ground beetle, *Nebria sahlbergii triad* (2)
Siskiyou ground beetle, *Nebria gebleri siskiyouensis* (2R)
Franklin's bumblebee, *Bombus franklini* (2)

Plants
Klamath manzanita, *Arctostaphylos klamathensis* (2)
Pickering's ivesia, *Ivesia pickeringii* (2)
Trinity phacelia, *Phacelia dalesiana* (2)
Howell's alkali grass, *Puccinellia howellii* (1R)
Canyon Creek stonecrop, *Sedum obtusatum* ssp. *paradisum* (2)

(E)--Endangered (T)--Threatened (P)--Proposed (CH)--Critical Habitat
(1)--Category 1: Taxa for which the Fish and Wildlife Service has sufficient biological information to support a proposal to list as endangered or threatened.
(2)--Category 2: Taxa for which existing information indicated may warrant listing, but for which substantial biological information to support a proposed rule is lacking.
(1R)-Recommended for Category 1 status.
(2R)-Recommended for Category 2 status.
(•)--Listing petitioned.
(*)--Possibly extinct.

Note: For questions concerning the threatened winter-run chinook salmon, please contact Jim Lecky, Endangered Species Coordinator, at the National Marine Fisheries Service, Southwest Region, 501 West Ocean Boulevard, Suite 4200, Long Beach, California 90802-4213, or call him at (310) 980-4015.

APPENDIX B

Vegetation species found in the riparian zones, Trinity County, California.

COMMON NAME	BOTANICAL NAME
Arroyo willow	*Salix lasiolepis*
Yellow willow	*Salix lasiandra*
Red willow	*Salix laevigata*
Long leaf willow	*Salix melanopsis* var. *bolanderiana*
Sandbar willow	*Salix hindsiana*
Black cottonwood	*Populus trichocarpa*
Fremont cottonwood	*Populus fremontii*
Oregon white oak	*Quercus garryii*
California black oak	*Quercus kelloggii*
Canyon live oak	*Quercus chrysolepis*
Tanoak	*Lithocarpus densiflorus*
Pacific madrone	*Arbutus menziesii*
Douglas-fir	*Psudasuga menziesii*
Western azalea	*Rhododendron occidentale*
California rose	*Rosa californica*
Raspberry	*Rhubus leucodermis*
California blackberry	*Rhubus vitifolius*
Birchleaf mountain mahogany	*Cercocarpus betuloides*
Serviceberry	*Amelanchier pallida*
California sage	*Artemisia californica*
California fushia	*Zauschneria californica*
Silver lupine	*Lupine albifrons*
Turkey mullein	*Verbascium thapsus*
White sweet clover	*Melilotus albus*
Ridge hedge nettle (Mint)	*Stachys rigida*
Toadflax	*Linaria dalmatica*
Chicory (Blue sailors)	*Cichorium intybus*
Goldenrod	*Solidago californica*
Mountain ash	*Fraxinus dipetala*
Black locust	*Robina pseudo-acacia*
"Tree of Heaven"	*Ailanthus glandulosa*
Vine maple	*Acer circinatum*
Big-leaf maple	*Acer macrophyllum*
Monkshood	*Aconitum columbianum*
Red alder	*Alnus oregana*
White alder	*Alnus rhombifolia*
American dogwood	*Cornus stolonifera*
Pacific dogwood	*Cornus nutallii*
Blue elderberry	*Sambucus caerulea*
Indian rhubarb	*Barmeda peltata*
Umbrella plant	*Peltiphyllum peltatum*
Cow parsnip	*Cicuta douglassii*
California aralia (Elk clover)	*Aralia california*
Mugwort	*Artemesia douglasiana*
Oregon grape	*Berberis aquifolium*
Buckwheat	*Erigonium* sp.
California honeysuckle	*Lonicera interrupta*

COMMON NAME	BOTANICAL NAME
Lady fern	*Athrium felix-femina*
Five-finger fern	*Adiantum pedatum*
Sword fern	*Polystichum munitum*
Common horsetail	*Equisetum arvense*
Rushes	*Juncus* spp.
Bulrushes	*Scirpus* spp.
Cattails	*Typha* spp.
Grasses	*Poaceae* spp.

(Source: Christensen 1986, USDA 1992)

APPENDIX C

HABITAT SUITABILITY INDEX MODELS

Nec (2)

Jiri Scammell Tinling

FWS/OBS-82/10.38
APRIL 1983

HABITAT SUITABILITY INDEX MODELS: DOWNY WOODPECKER

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.

This report should be cited as:

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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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CONTENTS

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We gratefully acknowledge Richard Conner and Lawrence Kilham for their review of this habitat model. Funds for the development of this model were provided by the U.S. Fish and Wildlife Service Regional Office in Portland. Publication costs of this model were partially paid for by the U.S. Army Corps of Engineers. The cover of this document was illustrated by Jennifer Shoemaker. Word processing was provided by Carolyn Gulzow and Dora Ibarra.

DOWNY WOODPECKER (Picoides pubescens)

HABITAT USE INFORMATION

General

Downy woodpeckers (Picoides pubescens) inhabit nearly all of North America where trees are found (Bent 1939). They are rare or absent in arid desert habitats and most common in open woodlands.

Food

The downy woodpecker is primarily an insectivore; 76% of the diet is animal foods, and the remainder is vegetable food (Beal 1911). Beetles, ants, and caterpillars are the major animal foods, and vegetable foods include fruits, seeds, and mast. Downy woodpeckers feed by digging into the bark with the bill, by gleaning along the bark surface, and, infrequently, by flycatching (Jackson 1970).

Downy woodpeckers in Illinois foraged more in the lower height zones of trees than in the tree canopies and foraged more often on live limbs than on dead limbs (Williams 1975). Similarly, downy woodpeckers in Virginia foraged primarily on live wood in pole age and mature forests (Conner 1980). Downy woodpeckers in New York spent 60% of their foraging time in elms (Ulmus spp.) (Kisiel 1972). They foraged most frequently on twigs 2.5 cm (1 inch) or less in diameter, and drilling was the foraging technique used most often. Downy woodpeckers are not strong excavators and do not excavate deeply to reach concentrated food sources, such as carpenter ants (Camponotus spp.) (Conner 1981).

Downy woodpeckers in Virginia foraged in the breeding season in habitats with a mean basal area of 11.3 m^2/ha (49.2 ft^2/acre). Habitats used for foraging during the postbreeding and winter seasons had significantly higher mean basal areas of 21.4 m^2/ha (93.2 ft^2/acre) and 17.2 m^2/ha (74.9 ft^2/acre), respectively. Downy woodpeckers in New Hampshire fed heavily in stands of paper birch (Betula papyrifera) that were infected with a coccid (Xylococchus betulae) (Kilham 1970). The most attractive birches for foraging were those that were crooked or leaning, contained broken branches in their crown, and had defects, such as cankers, old wounds, broken branch stubs, and sapsucker drill holes. Downy woodpeckers invaded an area in Colorado in high numbers during the winter months in response to a severe outbreak of the pine bark beetle (Dendroctonus ponderosae) (Crockett and Hansley 1978). This outbreak of beetles had not resulted in increased breeding densities of the woodpeckers at the time of the study.

Downy woodpeckers foraged more on tree surfaces during summer than in winter (Conner 1979). They increased the amount of time spent in subcambial excavation in winter months, probably in response to the seasonal availability and location of insect prey. Downy woodpeckers appear to broaden all aspects of their foraging behavior in the winter in order to find adequate amounts of food (Conner 1981).

Downy woodpeckers in Ontario extracted gall fly (Eurosta solidaginis) larvae from goldenrod (Solidago canadensis) galls growing near forest edges (Schlichter 1978). Corn stubble fields supported small winter populations of downy woodpeckers in Illinois (Graber et al. 1977).

Water

Information on the water requirements of the downy woodpecker was not located in the literature.

Cover

The cover requirements of the downy woodpecker are similar to their reproductive requirements, which are discussed in the following section.

Reproduction

The downy woodpecker is a primary cavity nester that prefers soft snags for nest sites (Evans and Conner 1979). These woodpeckers nest in both coniferous and deciduous forest stands in the Northwest. Nests in Virginia were common in both edge situations and in dense forests far from openings (Conner and Adkisson 1977). Downy woodpeckers in Oregon occur primarily in deciduous stands of aspen (Populus tremuloides) or riparian cottonwood (Populus spp.) (Thomas et al. 1979). The highest nesting and winter densities in Illinois were in virgin or old lowland forests (Graber et al. 1977).

Downy woodpeckers in Virginia preferred to nest in areas with high stem density, but with lower basal area and lower canopy heights than areas used by the other woodpeckers studied (Conner and Adkisson 1977). They preferred sparsely stocked forests commonly found along ridges (Conner et al. 1975). Preferred nest stands had an average basal area of 10.1 m^2/ha (44 ft^2/acre), 361.8 stems greater than 4 cm (1.6 inches) diameter/ha (894/acre), and canopy heights of 16.3 m (53.5 ft) (Conner and Adkisson 1976). Downy woodpeckers in Tennessee were frequently seen feeding in the understory and apparently selected habitats with an abundance of understory vegetation (Anderson and Shugart 1974).

Downy woodpeckers excavate their own cavity in a branch or stub 2.4 to 15.3 m (8 to 50 ft) above ground, generally in dead or dying wood (Bent 1939). There was a positive correlation between downy woodpecker densities and the number of dead trees in Illinois (Graber et al. 1977). Downy woodpeckers rarely excavate in oaks (Quercus spp.) or hickories (Carya spp.) with living cambium present at the nest site (Conner 1978). They apparently require both sap rot, to soften the outer part of trees, and heart rot, to soften the interior, when hardwoods, and possibly pines, are used for nesting. Downy woodpeckers in Virginia nested mainly in dead snags with advanced stages of fungal heart rot (Conner and Adkisson 1976).

Downy woodpeckers "search image" of an optimal nest site is a live tree with a broken off dead top (Kilham 1974). Suitable nest trees are in short supply in most areas and appear to be a limiting factor in New Hampshire. Downies in Montana appeared to prefer small trees, possibly to avoid the difficulty of excavating through the thick sapwood of large trees (McClelland et al. 1979). The average dbh of nest trees (n = 3) in Montana was 25 cm (10 inches). All 11 nests in an Ontario study were in dead aspen, and the average dbh of four of these nest trees was 26.2 cm (10.3 inches) (Lawrence 1966). Fourteen of 19 nest trees in Virginia were dead, the average dbh of nest trees was 31.8 cm (12.4 inches), and nest trees averaged 8.3 m (27.2 ft) in height (Conner et al. 1975).

Thomas et al. (1979) estimated that downy woodpeckers in Oregon require 7.4 snags, 15.2 cm (6 inches) or more dbh, per ha (3 snags/acre). This estimate is based on a territory size of 4 ha (10 acres), a need for two cavities per year per pair, and the presence of 1 useable snag with a cavity for each 16 snags without a cavity. Evans and Conner (1979) estimated that downies in the Northeast require 9.9 snags, 15 to 25 cm (6 to 10 inches) dbh, per ha (4 snags/acre). Their estimate is based on a territory size of 4 ha (10 acres), a need for four cavity trees per year per pair, and a need for 10 snags for each cavity tree used in order to account for unuseable snags, a reserve of snags, feeding habitat, and a supply of snags for secondary users. Conner (pers. comm.) recommended 12.4 snags/ha (5 snags/acre) for optimal downy woodpecker habitat.

Interspersion

Downy woodpeckers occupy different size territories at different times of the year (Kilham 1974). Fall and winter territories consist of small, defined areas with favorable food supplies and the area near roost holes. Breeding season territories consist of an area as large as 10 to 15 ha (24.7 to 37.1 acres) used to search out nest stubs, and a smaller area around the nest stub itself. Breeding territories of downies in Illinois ranged from 0.5 to 1.2 ha (1.3 to 3.1 acres) (Calef 1953 cited by Graber et al. 1977). Male and female downy woodpeckers retain about the same breeding season territory from year to year, while their larger overall range has more flexible borders (Lawrence 1966).

Downy woodpeckers occupy all portions of their North American breeding range during the winter (Plaza 1978). There is, however, a slight, local southward migration in many areas.

Special Considerations

Conner and Crawford (1974) reported that logging debris in regenerating stands (1-year old) following clear cutting were heavily used by downy woodpeckers as foraging substrate. Timber harvest operations that leave snags and trees with heart rot standing during regeneration cuts and subsequent thinnings will help maintain maximum densities of downy woodpeckers (Conner et al. 1975). Foraging habitat for the downy woodpecker in Virginia would probably be provided by timber rotations of 60 to 80 years (Conner 1980).

HABITAT SUITABILITY INDEX (HSI) MODEL

Model Applicability

Geographic area. This model was developed for the entire range of the downy woodpecker.

Season. This model was developed to evaluate the year-round habitat needs of the downy woodpecker.

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).

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 habitat areas for downy woodpeckers was not found in the literature. However, based on reported territory and range sizes, it is assumed that a minimum of 4 ha (10 acres) of potentially useable habitat must exist or the HSI will equal zero.

Verification level. Previous drafts of this model were reviewed by Richard Conner and Lawrence Kilham and their comments were incorporated into the current draft (Conner, pers. comm.; Kilham, pers. comm.).

Model Description

Overview. This model considers the ability of the habitat to meet the food and reproductive needs of the downy woodpecker 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 food quality through measurements of vegetative conditions. The reproductive component of this model assesses the abundance of suitable snags. The relationship between habitat variables, life requisites, cover types, and the HSI for the downy woodpecker is illustrated in Figure 1.

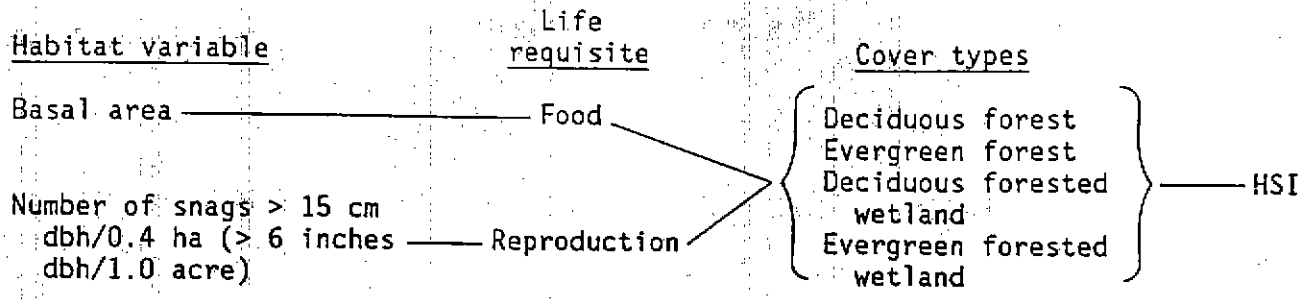

Figure 1. Relationships of habitat variables, life requisites, and cover types in the downy woodpecker model.

The following sections provide a written documentation of the logic and assumptions used to interpret the habitat information for the downy woodpecker 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 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. Food for the downy woodpecker consists of insects found on trees in forested habitats. Downy woodpeckers occupy a wide variety of forested habitats from virgin bottomlands to sparsely stocked stands along ridges. The highest downy woodpecker densities were most often reported in the more open stands with lower basal areas, but it is assumed that all forested habitats have some food value for downies. Optimal conditions are assumed to occur in stands with basal areas between 10 and 20 m^2/ha (43.6 and 87.2 ft^2/acre), and suitabilities will decrease to zero as basal area approaches zero. Stands with basal areas greater than 30 m^2/ha (130.8 ft^2/acre) are assumed to have moderate value for downy woodpeckers.

Reproduction component. Downy woodpeckers nest in cavities in either totally or partially dead small trees. They require snags greater than 15 cm (6 inches) dbh for nest sites. Optimal habitats are assumed to contain 5 or more snags greater than 15 cm dbh/0.4 ha (6 inches dbh/1.0 acre), and habitats without such snags have no suitability.

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.

FWS/OBS-82/10.38
April 1983

HABITAT SUITABILITY INDEX MODELS: DOWNY WOODPECKER

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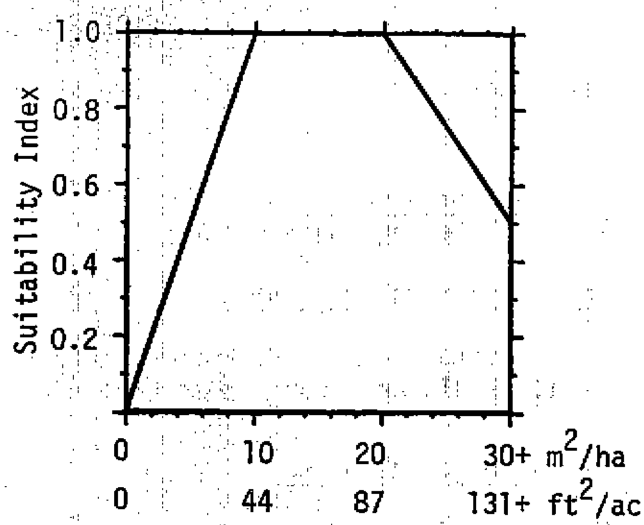
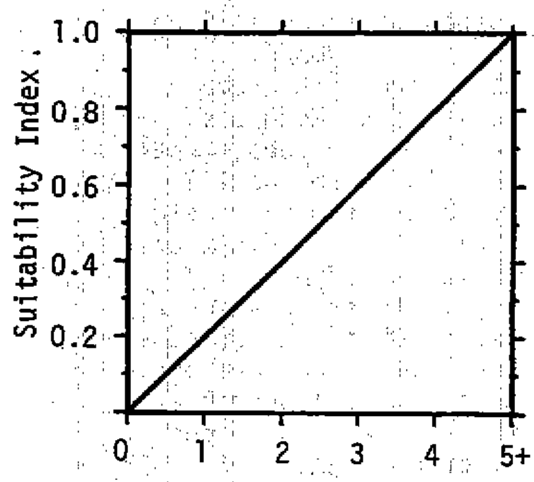
Cover type	Variable		Suitability graph
EF,DF, EFW,DFW	V_1	Basal area.	
EF,DF, EFW,DFW	V_2	Number of snags > 15 cm dbh/0.4 ha (> 6 inches dbh/ 1.0 acre).	

<u>Life requisite values</u>. The life requisite values for the downy woodpecker are presented below.

Life requisite	Cover type	Life requisite value
Food	EF,DF,EFW,DFW	V_1
Reproduction	EF,DF,EFW,DFW	V_2

HSI determination. The HSI for the downy woodpecker is equal to the lowest life requisite 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	Basal area [the area of exposed stems of woody vegetation if cut horizontally at 1.4 m (4.5 ft) height, in m²/ha (ft²/acre)].	EF,DF,EFW,DFW	Bitterlich method
V_2	Number of snags > 15 cm (6 inches) dbh/0.4 ha (1.0 acre) [the number of standing dead trees or partly dead trees, greater than 15 cm (6 inches) diameter at breast height (1.4 m/4.5 ft), 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].	EF,DF,EFW,DFW	Quadrat

Figure 2. Definitions of variables and suggested measurement techniques.

SOURCES OF OTHER MODELS

Conner and Adkisson (1976) have developed a discriminant function model for the downy woodpecker that can be used to separate habitats that possibly provide nesting habitat from those that do not provide nesting habitat. The model assesses basal area, number of stems, and canopy height of trees.

REFERENCES

Anderson, S. H., and H. H. Shugart, Jr. 1974. Habitat selection of breeding birds in an East Tennessee deciduous forest. Ecology 55:828-837.

Beal, F. 1911. Food of the woodpeckers of the United States. U.S. Dept. Agric., Biol. Surv. Bull. 37:1-64.

Bent, A. C. 1939. Life histories of North American woodpeckers. U.S. Natl. Mus. Bull. 174. 334 pp.

Calef, R. T. 1953. Ecological analysis of the flora and vertebrate fauna of Funks Forest Natural Area, McClean County, Illinois. M.S. Thesis, Univ. Ill., Urbana. 85 pp. Cited by Graber et al. 1977.

Conner, R. N. 1978. Snag management for cavity nesting birds. Pages 120-128 in R. M. DeGraaf, tech. coord. Management of southern forests for nongame birds. U.S. Dept. Agric., For. Serv. Gen. Tech. Rep. SE-14. 176 pp.

____________. 1979. Seasonal changes in woodpecker foraging methods: Strategies for winter survival. Pages 95-105 in J. G. Dickson, R. N. Conner, R. R. Fleet, J. C. Kroll, and J. A. Jackson, eds. The role of insectivorous birds in forest ecosystems. Academic Press, NY. 381 pp.

____________. 1980. Foraging habitats of woodpeckers in southwestern Virginia. J. Field Ornithol. 51(2):119-127.

____________. 1981. Seasonal changes in woodpecker foraging patterns. Auk 98(3):562-570.

____________. Personal communication (letter dated 10 November, 1982). U.S. Dept. Agric., For. Serv., Southern For. Exp. Stn., Nacogdoches, TX.

Conner, R. N., and C. S. Adkisson. 1976. Discriminant function analysis: A possible aid in determining the impact of forest management on woodpecker nesting habitat. For. Sci. 22(2):122-127.

____________. 1977. Principal component analysis of woodpecker nesting habitat. Wilson Bull. 89(1):122-129.

Conner, R. N., and H. S. Crawford. 1974. Woodpecker foraging in Appalachian clearcuts. J. For. 72(9):564-566.

Conner, R. N., R. G. Hooper, H. S. Crawford, and H. S. Mosby. 1975. Woodpecker nesting habitat in cut and uncut woodlands in Virginia. J. Wildl. Manage. 39(1):144-150.

Crockett, A. B., and P. L. Hansley. 1978. Apparent response of Picoides woodpeckers to outbreaks of pine bark beetle. Western Birds 9(2):67-70.

Evans, K. E., and R. N. Conner. 1979. Snag management. Pages 215-225 in R. M. DeGraaf, tech. coord. Management of north central and northeastern forests for nongame birds. U.S. Dept. Agric., For. Serv. Gen. Tech. Rep. NC-51. 268 pp.

Graber, J. W., R. R. Graber, and E. L. Kirk. 1977. Illinois birds: Picidae. Ill. Nat. Hist. Surv. Biol. Notes 102:15-21.

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

Jackson, J. A. 1970. Quantitative study of the foraging ecology of downy woodpeckers. Ecology 51:318-323.

Kilham, L. 1970. Feeding behavior of downy woodpeckers. I. Preference for paper birch and sexual differences. Auk 87:544-556.

__________. 1974. Early breeding season behavior of downy woodpeckers. Wilson Bull. 86(4):407-418.

__________. Personal communication (letter dated 18 October, 1982). Box 37, Lyme, New Hampshire.

Kisiel, D. S. 1972. Foraging behavior of Dendrocopos villosus and D. pubescens in eastern New York State. Condor 74(4):393-398.

Lawrence, L. D. 1966. A comparative life-history of four species of woodpeckers. Ornithol. Monogr. 5:1-156.

McClelland, B. R., S. S. Frissell, W. C. Fischer, and C. H. Halvorson. 1979. Habitat management for hole-nesting birds in forests of western larch and Douglas-fir. J. For. 77(8):480-483.

Plaza, P. D. 1978. Distribution of selected North American Picids determined by computer mapping. Am. Birds 32(4):912-922.

Schlichter, L. 1978. Winter predation by black-capped chickadees and downy woodpeckers on inhabitants of the goldenrod ball gall. Can. Field-Nat. 92(1):71-74.

Thomas, J. W., R. G. Anderson, C. Maser, and E. L. Bull. 1979. Snags. Pages 60-77 in J. W. Thomas, ed. Wildlife habitat in managed forests--the Blue Mountains of Oregon and Washington. U.S. Dept. Agric., For. Serv. Agric. Handb. 553. 512 pp.

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

Williams, J. B. 1975. Habitat utilization by four species of woodpeckers in a central Illinois woodland. Am. Midl. Nat. 93:354-367.

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7. Author(s): Richard L. Schroeder			8. Performing Organization Rept. No.
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12. Sponsoring Organization Name and Address: Western Energy and Land Use Team Division of Biological Services Research and Development Fish and Wildlife Service Washington, DC 20240			13. Type of Report & Period Covered 14.
15. Supplementary Notes			

16. Abstract (Limit: 200 words)

A review and synthesis of existing information was used to develop a habitat model for the downy woodpecker (*Picoides pubescens*). 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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b. Identifiers/Open-Ended Terms

Downy woodpecker
Picoides pubescens
Habitat Suitability Indexes (HSI)

c. COSATI Field/Group

18. Availability Statement	19. Security Class (This Report)	21. No. of Pages
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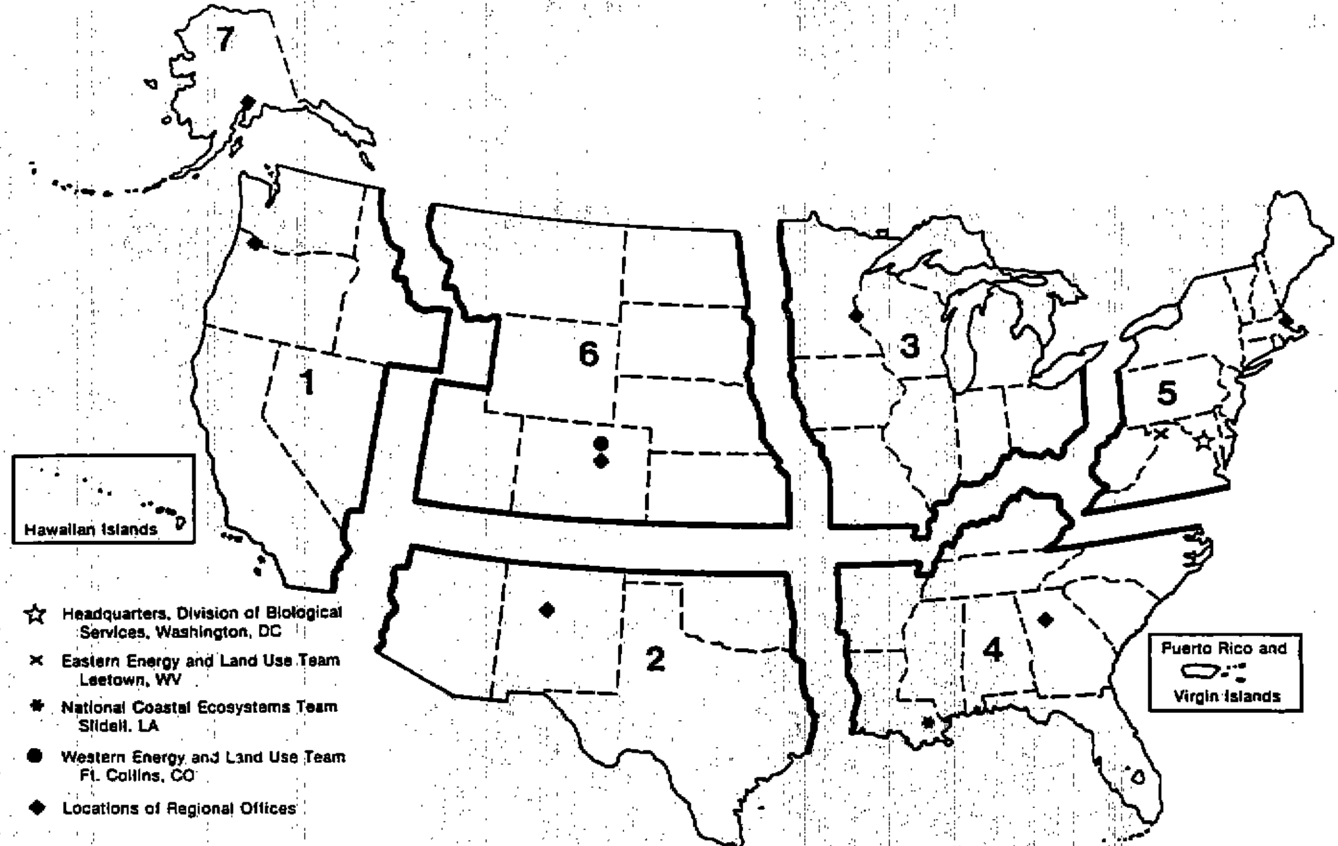

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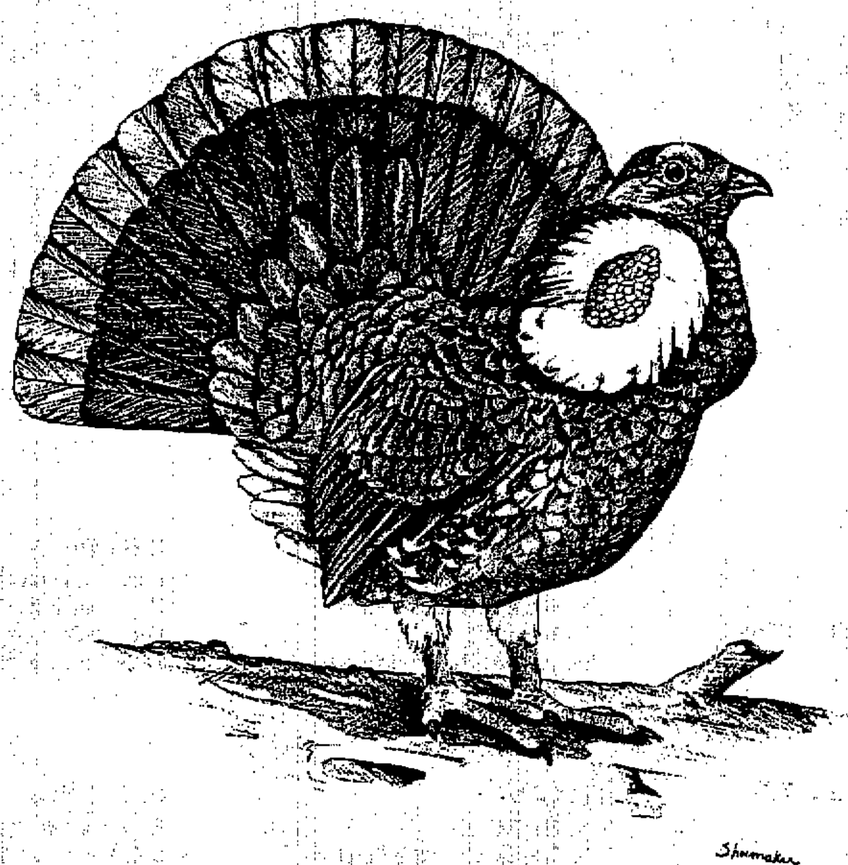
FWS/OBS-82/10.81
AUGUST 1984

HABITAT SUITABILITY INDEX MODELS: BLUE GROUSE



Fish and Wildlife Service

U.S. Department of the Interior

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August 1984

HABITAT SUITABILITY INDEX MODELS: BLUE GROUSE

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PREFACE

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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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BLUE GROUSE (Dendragapus obscurus)

HABITAT USE INFORMATION

General

Blue grouse (Dendragapus obscurus) inhabit coniferous forests in western North America, primarily in open habitats with a mixture of deciduous trees and shrubs (American Ornithologists' Union 1983). They prefer coniferous forest edges and aspen groves (Populus tremuloides) in the breeding season, and coniferous forests in the winter (Aldrich 1963). Blue grouse populations consist of two groups, the sooty grouse group, found along the Pacific coast, and the dusky grouse group, found in the Great Basin and Rocky Mountain areas (American Ornithologists' Union 1983).

Food

The food habits of the blue grouse vary from a simple winter diet consisting primarily of coniferous needles, to a summer diet consisting of a variety of green leaves, fruits, seeds, flowers, animal matter, and conifer needles (Stewart 1944). The yearly diet of blue grouse in Washington and northern Idaho consisted of 98% plant food and 2% animal matter (Beer 1943). Sixty-four percent of the plant material was conifer needles, mostly from firs (Abies spp.) and Douglas-fir (Psuedotsuga menziesii); 17% was berries, primarily from currants (Ribes spp.), serviceberries (Amelanchier spp.), blackberries (Rubus spp.), huckleberries (Vaccinium spp.), and bearberry (Arctostaphylos uva-ursi); and 17% was miscellaneous plant materials. The youngest birds fed almost exclusively on insects, and the availability of an adequate supply of insects is important during the first month of growth of blue grouse chicks.

The major spring and summer food items of blue grouse in British Columbia were conifer needles, broad-leaved vegetation, flowers, fruits, and invertebrates (King and Bendell 1982). Huckleberry was a preferred food in another British Columbia study and provided 60% of the food consumed by juveniles that were 10 days to 6 weeks of age (King 1973). As grouse in Idaho moved from their winter range to lower elevation Douglas-fir forests during May and June, their diet consisted primarily of the flowering parts of various plants (Marshall 1946). These grouse moved to lower elevations along streams during July and August, and their diet shifted to the fruits and leaves of various shrubs. Forest habitats that are in early stages of second growth vegetation provide important summer foods for adults and chicks (Fowle 1960).

The winter diet (from October through April) of blue grouse consists almost entirely of conifer needles (Beer 1943). The winter and spring diet of blue grouse in British Columbia was comprised of the needles, twig tips, and cones of conifers, especially those of mountain hemlock (Tsuga mertensiana), pine (Pinus spp.), and fir (King 1973). The needles and buds of Douglas-fir provided 99% of the winter diet of grouse in Idaho (Marshall 1946). Fall use of conifers by dusky blue grouse in Wyoming (in terms of percent frequency) consisted of lodgepole pine (P. contorta), 39.3%; juniper (Juniperus spp.), 21.4%; limber pine (P. flexilis), 17.9%; Douglas fir and subalpine fir (A. lasiocarpa), 8.9%; and Engelmann spruce (Picea engelmannii), 5.4% (Harju 1974). Zwickel and Bendell (1972) believed that winter food supplies were generally adequate for blue grouse. It appears that spring densities are not determined by winter food supplies, but are related to the quality of the breeding range (Zwickel et al. 1968). Winter habitat preferences of blue grouse are only recently being studied, and it is possible that the quality and quantity of winter habitat may be a limiting factor for blue grouse (Hoffman pers. comm.).

Water

Dusky blue grouse in Colorado occur at elevations between 1,830 and 3,874 m (6,000 and 12,700 ft) in areas where either free water or succulent vegetation is available (Rogers 1968). Blue grouse in Washington and northern Idaho were generally found near a source of water, either open water or succulent vegetation and berries (Beer 1943). Free water is not required if succulent vegetation or fruit is available.

Cover

Blue grouse in Idaho relied almost totally on conifers for escape cover (Marshall 1946). Male blue grouse in British Columbia utilized small conifer thickets, log tangles, and spaces under logs and stumps for rest and concealment during the breeding season (Bendell and Elliott 1967). In the spring, hens concealed themselves under logs, stumps, and small conifers for cover, in locations similar to those used for nest sites. Hens with broods were found more often in more exposed locations, particularly road edges and moist depressions with lush vegetation. Shrubs and forbs supplied most of the cover during the summer months in Colorado, and dusky blue grouse have not been observed in Colorado where shrubs are lacking (Rogers 1968). Blue grouse in Idaho roosted most frequently in dense stands of trees that were 15.2 to 30.5 cm (6 to 12 inches) dbh and 6.1 to 15.3 m (20 to 50 ft) in height (Caswell 1954).

Winter range is provided primarily by montane forests (Bendell and Elliott 1966) and blue grouse spend most of the winter in coniferous trees, until the snow melt allows ground feeding (Hoffman 1956). In Colorado, most blue grouse observed in the winter were found in conifers, with the use of Douglas-fir occurring in greater proportion than its availability (Cade, in prep.). Blue grouse also used spruce-fir and lodgepole pine forests during the winter where Douglas-fir was absent or scarce. Intensively used conifer stands were structurally similar to less used stands, and within all occupied stands blue grouse tended to be found in the largest conifers available. Conifer stands that were not suitable for wintering blue grouse included low density [less than 70 trees/ha (28.4/acre)] stands of small conifers and high density [more than 1,200 trees/ha (486/acre)] stands of mature trees.

Reproduction

Blue grouse in British Columbia preferred very open habitats over very dense habitats during the breeding season (Bendell and Elliott 1966). Very open habitats averaged 15% canopy cover of trees, while very dense habitats were almost totally closed. Forests with 50% tree canopy cover that contained a discontinuous and patchy shrub layer supported the highest densities of male blue grouse in another British Columbia study area (Donaldson and Bergerud 1974). Established territories in Alberta generally had 50% tree canopy cover overall, with trees occurring in clumps and surrounded by openings (Boag 1966). Habitats became less acceptable to territorial males as canopy cover deviated from this condition. In general, blue grouse populations decline rapidly as canopy cover of conifers approaches 75% (Redfield et al. 1970). The density of hooting males in a British Columbia study area declined from 40 to 0 in 8 years, as the vegetation changed from open to dense (Bendell and Elliott 1966). Once occupied, a territory is generally used by a male grouse throughout his lifetime, even if the habitat becomes very dense. However, new adults and yearlings will not occupy dense areas, and show habitat selection for more open areas.

Blue grouse breed throughout their range in Colorado in a variety of forest and mountain shrub vegetation types from the foothills to timberline, and do not appear to be restricted to any specific habitat types within this elevational range (Hoffman 1981). Common features of blue grouse territories in Colorado included: (1) some type of tree cover; (2) shrub thickets; (3) open areas; and (4) openness in the canopy and the understory vegetation. The structural features of the vegetation appear to be more important than species composition in breeding habitat selection. The location and size of male blue grouse territories in Alberta was dependent on the presence of suitable cover and not on the species of trees present (Boag 1966). Blue grouse males established territories in Douglas-fir, aspen, lodgepole pine, and white spruce (_Picea glauca_) forests. Dusky blue grouse in Colorado preferred display sites that were on small, flat, open areas near slopes and dense vegetation (Rogers 1968). The position of male territories in open cover types in British Columbia was influenced by the presence of areas that were higher than the surrounding land (Bendell and Elliott 1967).

Habitats consisting of a logging mosaic of all aged Douglas-fir, with openings of salal (_Gaultheria_ spp.), grass, and rock outcrops, had the highest density of breeding males in a British Columbia study area (Donaldson and Bergerud 1974). Even-aged, closed canopy forests had the lowest grouse densities on this study area. Three habitat components that may be important to males establishing territories are: (1) openings in the tree canopy; (2) openings in the shrub layer; and (3) variation in tree size. Openings in the tree canopy increase visibility for hooting males. However, habitat that is too open increases vulnerability to predators. A partially closed canopy with a patchy shrub layer offers the best combination of protection from weather and predators, while providing good visibility during courtship activities. However, blue grouse in Vancouver, British Columbia occur in areas that have been burned or clearcut, where trees are almost absent, and shrub cover is very low (Zwickel, pers. comm.).

Blue grouse territories in a Montana study area all contained small thickets of conifers, used for nesting and escape cover (Martinka 1972). Territories contained an average of 0.08 ha (0.2 acre) of thickets, with 206 m (677 ft) of edge between the thickets and openings. Thickets present outside of territories were 0.04 ha (0.1 acre) in size, with 85 m (278 ft) of edge, significantly different from thickets occurring within territories. Males preferred younger thickets, generally 20 to 40 years in age, with an average tree dbh of 12.4 cm (4.9 inches). Thickets in territories contained an average of 105 trees greater than 20 cm (8 inches) dbh/0.4 ha (1.0 acre), while nonterritory thickets contained an average of 248 such trees/0.4 ha (1.0 acre). Douglas-fir thickets tended to provide better protection than thickets of ponderosa pine (Pinus ponderosa). A high degree of discrimination between territories and nonterritories was shown when thicket size, amount of edge, and average thicket tree dbh were used in a discriminant function analysis.

Areas used by dusky blue grouse during the spring in Wyoming were frequently in or near aspen or lodgepole stands with adjacent openings (Harju 1974). Trees in grouse use areas averaged 10.5 m (34.5 ft) tall and 17.8 cm (7.0 inches) dbh, compared to averages of 15.4 m (50.5 ft) and 28.9 cm (11.4 inches) in random samples of the total area. Canopy cover of low shrubs and herbaceous cover in grouse use areas averaged 32%. Open areas in blue grouse territories in Montana contained herbaceous cover with scattered shrub cover (Martinka 1972). Small amounts of shrub cover may be useful for resting and escape cover, but areas with dense continuous shrub cover obstruct visibility and are avoided. Breeding blue grouse males in Idaho occupied open vegetation types with 40 to 70% cover of tall shrubs and trees (Stauffer 1983). Breeding areas with about 50% tree cover had more grouse than areas with less trees.

Blue grouse nests in Utah were located on the ground adjacent to or beneath shrubs (Weber et al. 1974). The nests consisted of shallow depressions in the ground, lined with twigs and feathers. Almost all nests were located near the territories of male blue grouse (Weber 1975). Broods in this Utah study area were most often found in mule ears (Wyethia amplexicaulis)-sagebrush (Artemisia spp.) vegetation near trees or tall shrub cover. Broods were not found further than 46 m (150 ft) from woody cover. Broods and hens foraged most often in good concealing cover that was 30.5 to 38.1 cm (12 to 15 inches) tall.

Blue grouse females with broods in Montana used grass-forb areas in early summer, and, as vegetation dried out by late July, broods increased their use of deciduous thickets (Mussehl 1960). In British Columbia, females with broods were mostly found in grassy open habitats in logged areas, particularly in moist meadows bordered by forest (Donaldson and Bergerud 1974). The most important habitat features for females with broods were the presence of an extensive herb layer and proximity to cover. Broods in an Idaho study area occupied areas with greater than 50% cover of herbaceous vegetation that was greater than 50 cm (19.7 inches) in height (Stauffer 1983).

Broods in Colorado and Montana utilized areas where the interspersion of plants of various life forms provided a high degree of cover (Mussehl 1963; Hoffman 1981). Homogeneous grass stands were used very little (Mussehl 1963). Herbaceous cover is very important to chicks in their first 6 weeks of life. The best herbaceous growth for blue grouse broods provides a dense canopy of acceptable height, a mixture of plants of various life forms, and small amounts of bare ground. Herbaceous cover used by broods consistently averaged 17.8 to 20.3 cm (7 to 8 inches) in height and had an average canopy cover of 57% in a drought year and 71.5% in years of normal precipitation. The herbaceous cover contained both grasses and forbs, with grasses slightly more abundant. Bare ground (from 8 to 20%) provided travel lanes for broods. Large areas of herbaceous vegetation may not be needed by broods, because broods were most often found within 46 m (150 ft) of woody cover. The value of woody cover for feeding, resting, and escape increased as the chicks matured.

Dusky grouse brood habitat in Wyoming averaged 59.5% canopy cover of low shrub and herbaceous cover and was dominated by grasses (Harju 1974). A wide variety of plant species was present in brood use areas, and actual species composition was probably not important in brood habitat selection.

Zwickel and Bendell (1972) compared blue grouse densities, population parameters, and habitat characteristics from several areas. They concluded that, although breeding densities of blue grouse varied among the different areas, population parameters, such as death rates, clutch size, and late summer brood size, did not vary. The differences in breeding densities could not be explained by the vegetative structure or plant succession on the different sites, although populations were generally lower in habitats containing dense or very dense conifer cover compared to those with open conifer cover. Populations of grouse were declining on some areas that appeared to be structurally identical to areas that supported very high densities. Habitat features were apparently important primarily in setting broad limits of tolerance in areas within which the blue grouse was found. Actual densities of grouse at a particular time may have been related to the genetic quality of animals in the population.

Interspersion

Blue grouse generally winter on high, fir-covered mountain slopes; in the spring, they migrate down to open brushy habitats to breed, nest, and raise their broods (Weber et al. 1974). In the fall, they reverse this movement and migrate back up to the conifer forests. This autumn migration appears to be a dispersal, as members of a specific breeding population may winter miles apart (Bendell and Elliott 1967). Movements from summer to winter range in Utah were up to 8 km (5 miles) (Weber et al. 1974), while movements in a British Columbia study ranged from 1.6 to 16.1 km (1 to 10 miles), with an average of 5.8 km (3.6 miles) (Bendell and Elliott 1967). Autumn migrations up to 49.9 km (31 miles) were recorded in Washington, although most migrations were less than 16.1 km (10 miles) (Zwickel et al. 1968). A female grouse in another

Washington study moved 62.8 km (39 miles) to winter range, although most grouse movements in this study were less than 16.1 km (10 miles) (Bauer 1962). Breeding populations of blue grouse may contain individuals that move long distances to winter range, as well as individuals that winter directly adjacent to their breeding areas (Cade 1982, in prep.). From July through September, most broods in a Montana study moved 0.8 km (0.5 mile), or less, but later dispersed over a very large winter range (Mussehl 1960).

The density of blue grouse on two 14.6 ha (36 acres) study areas in British Columbia was 1.09 birds/ha (0.44 bird/acre) (Bendell and Elliott 1967). Average male territory size was 0.4 to 0.8 ha (1 to 2 acres) in Utah (Weber et al. 1974). Territory size in densely populated areas in British Columbia ranged from 0.4 to 0.8 ha (1 to 2 acres), while maximum male territory size was an estimated 3.2 ha (8 acres) (Bendell and Elliott 1967). Territories of males in Alberta averaged 0.6 ha (1.5 acres) and did not overlap (Boag 1966). Adult females ranged over areas averaging 17.4 ha (43 acres); these ranges overlapped the ranges of other males and females. Adult females in British Columbia constricted their home ranges from 6 to 2 ha (14.8 to 4.9 acres) and yearlings from 20 to 2 ha (49.4 to 4.9 acres) during the period from early to late spring (Hannon et al. 1982). The average winter home range size of adult blue grouse in Colorado was 3.4 ha (8.4 acres) (Cade, in prep.).

Preferred territories for male blue grouse contained abundant edge between openings and conifer cover (Martinka 1972; Donaldson and Bergerud 1974).

Special Considerations

Nesting and brood rearing habitats of blue grouse are often intensively used for spring and early summer grazing by domestic livestock (Marshall 1946). The types, time, and intensity of grazing can have a significant effect on the structure and species composition of the vegetation during the brood rearing season (Mussehl 1963). Ground cover that was ungrazed provided better brood cover than ground cover that was grazed.

Blue grouse densities in mature coastal forests are low, but populations generally increase quickly following logging or burning (Redfield et al. 1970). This population increase is followed by 10 to 25 years of stability and then a rapid population decline due to increased forest density. This relationship is apparently not true in southeast Alaska, where mature forests contain higher breeding densities than clearcut areas (Zwickel, pers. comm.). Selective logging may be beneficial to blue grouse when it opens the canopy and allows for regeneration in the form of thickets (Martinka 1972). However, existing thickets may be destroyed during road building and log removal operations, and large areas of slash left after logging are not used by blue grouse.

HABITAT SUITABILITY INDEX (HSI) MODEL

Model Applicability

Geographic area. There are two major groups of blue grouse, the sooty (coastal) group and the dusky (interior) group. Sooty grouse tend to occupy denser coniferous areas, while dusky grouse utilize conifers, aspen, and sagebrush-grass areas. It is assumed in this model that these differences are a function of the availability of cover types and are not related to distinct habitat preferences of the two groups of grouse. Inadequate data exist to develop different models for these two groups of the blue grouse. The variables and ranges of suitability in this model were chosen to best accommodate the structural habitat needs of all groups of blue grouse. Therefore, this model is intended for application within the range of all subspecies of the blue grouse.

Season. This model was developed to evaluate the breeding season habitat needs of the blue grouse. Winter habitat requirements of the blue grouse are not well known (Hoffman, pers. comm.), and, therefore, are not included in this model.

Cover types. This model was developed to evaluate habitat quality in Evergreen Forest (EF), Deciduous Forest (DF), Evergreen Tree Savanna (ETS), Deciduous Tree Savanna (DTS), Evergreen Shrubland (ES), Deciduous Shrubland (DS), Evergreen Shrub Savanna (ESS), Deciduous Shrub Savanna (DSS), Grassland (G), Forbland (F), and Pasture and Hayland (P/H) areas (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 occupy an area. Specific information on minimum areas required for blue grouse during the breeding season was not found in the literature.

Verification level. Previous drafts of this model were reviewed by Richard Hoffman, Colorado Division of Wildlife, Fort Collins, CO, and Fred Zwickel, Department of Zoology, University of Alberta, Edmonton. Specific comments from each reviewer were incorporated into the current model. Both reviewers felt that separate HSI models should be developed for the coastal and inland groups of the blue grouse. However, the information available in the literature did not indicate enough specific differences to develop and document distinct HSI models for each blue grouse group. This apparent lack of difference may be due to a lack of knowledge rather than to an actual lack of difference between the habitat requirements of the two groups. Hoffman (pers. comm.) believed that some of the habitat requirements would be the same for the coastal and inland blue grouse groups, especially those related to habitat structure.

The model presented here is not a statement of proven cause and effect relationships. Rather, the model represents hypotheses of the habitat requirements of the blue grouse.

Model Description

Overview. The structural diversity of tree, shrub, and herbaceous vegetation is a major factor influencing blue grouse habitat suitability. Trees, shrubs, and herbaceous growth provide both food and cover for blue grouse during the breeding season, and optimal habitats are assumed to contain a mix of tree, shrub, and herbaceous vegetation. Maximum suitability occurs when trees, used primarily by territorial males, are well interspersed with the more open habitats used primarily by hens and broods. It is assumed that nesting and water needs will be met if food and cover are adequate.

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

Food/cover component. Food and cover for blue grouse are provided in habitats that contain trees, shrubs, and herbaceous vegetation. The structural features of these different types of vegetation are more important than species composition in determining habitat values.

Trees are an important factor in blue grouse breeding habitat, and provide both food and cover. It is assumed that aspen and evergreens may provide suitable tree cover. Various reports indicate that blue grouse prefer habitats with a total tree canopy cover ranging from 20 to 50%. Habitat suitability decreases rapidly as tree canopy closure approaches 75%, and is very low at canopy closures exceeding 75%. Habitats with either no trees or 100% tree canopy closure over the entire area are assumed to have no suitability. The relationship between tree canopy cover and a suitability index for blue grouse is presented in Figure 1.

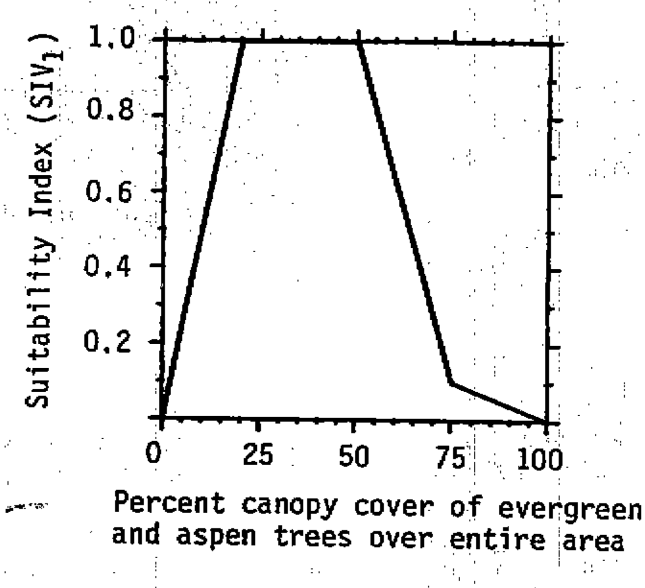

Figure 1. The relationship between the percent canopy cover of evergreen and aspen trees over the entire area and a suitability index for the blue grouse.

Shrubs provide food and cover for blue grouse males, hens, and broods. Overall shrub suitability is assumed to be related to the structure of the shrub component as described by shrub density and height.

Preferred blue grouse habitats contain only a moderately dense shrub cover, and it is assumed in this model that optimum shrub densities occur between 10 and 30% crown cover. Habitats with no shrubs will not be suitable to blue grouse, and habitats with a very dense shrub layer will restrict blue grouse ground movements. It is assumed that habitats with shrub densities exceeding 75% crown cover will not be suitable to blue grouse. The relationship between shrub canopy cover and a suitability index for blue grouse is presented in Figure 2a.

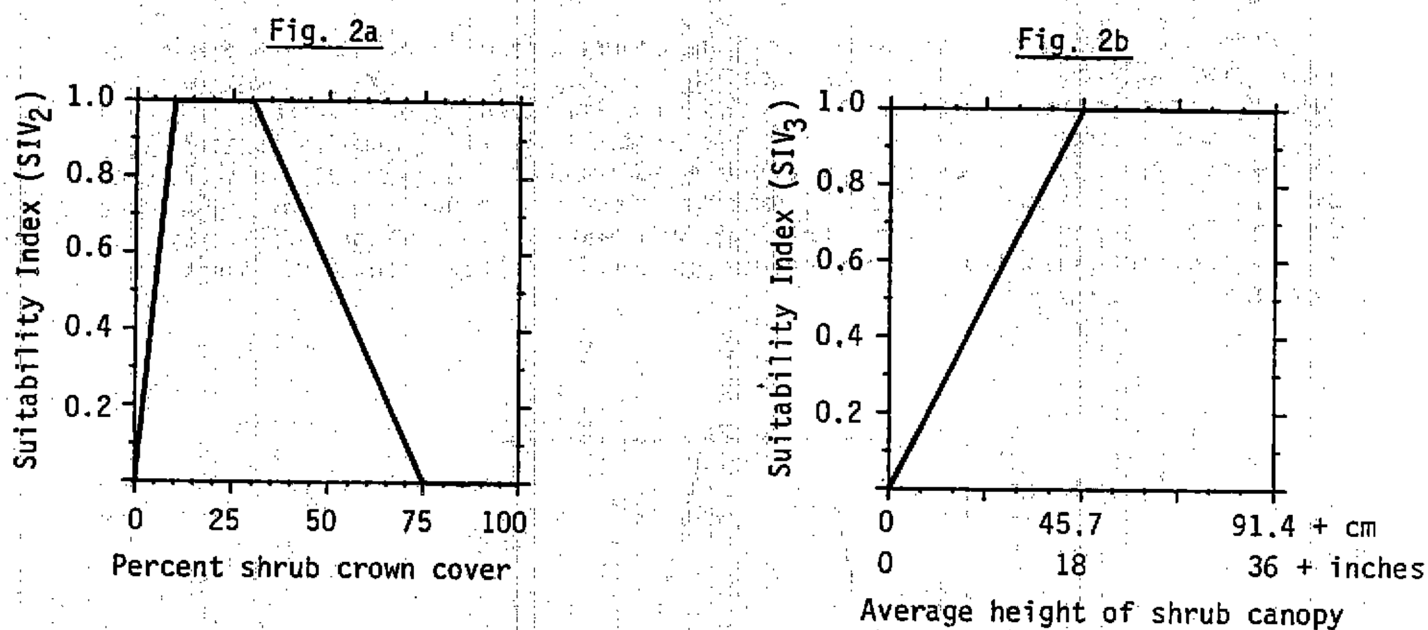

Figure 2. The relationships between habitat variables used to evaluate shrubs and the suitability indices for the variables.

It is assumed that very low growing shrubs will not provide adequate concealing cover for blue grouse. Suitability is assumed to be optimal when average shrub heights exceed 45.7 cm (18 inches), and suitability decreases to zero as shrub heights approach zero. Suitability will not be affected as shrub heights increase above 45.7 cm (18 inches) because tall shrubs may provide useful habitat, similar to small trees. The relationship between shrub height and a suitability index for blue grouse is presented in Figure 2b.

The best blue grouse habitats have shrubs that are both greater than 45.7 cm (18 inches) in height and at densities between 10 and 30% crown cover. Such habitats are assumed to provide ideal shrub cover conditions as well as ample shrub produced foods.

Habitats with shrub heights and/or densities present at levels outside the ranges of optimum described above will not have maximum suitability. In such habitats, it is assumed that the overall suitability of the shrub component will increase as either the height or density suitability values approach optimum levels. For example, a habitat with very low shrub heights and a very sparse canopy cover of shrubs would provide more food and cover for blue grouse if either the height or density of shrubs was increased to a higher suitability level. However, it is assumed that the lower of the two values will have the greatest impact on the final shrub component value. It is further assumed that when shrub height and density are present at the same levels of suitability, the habitat value for the shrub component will also be equal to that level of suitability. This relationship can be expressed mathematically by the following equation:

$$\text{Food/cover component (shrub portion)} = (SIV_2 \times SIV_3)^{1/2}$$

Herbaceous vegetation may provide food, cover, and water, and is especially important to blue grouse females and broods. Suitability of herbaceous vegetation is related to herbaceous canopy cover, height, and diversity. Optimal herbaceous densities are assumed to occur between 40 and 75% canopy cover, and suitability decreases as herbaceous densities approach zero or 100%. Habitats with 100% cover are assumed to provide very low suitability due to the restrictions they cause in grouse movement, while habitats with 0% cover are unsuitable. The relationship between herbaceous canopy cover and a suitability index for blue grouse is presented in Figure 3a.

Optimal herbaceous heights are assumed to occur between 20.3 and 50.8 cm (8 and 20 inches). Habitats with heights less than 20.3 cm (8 inches) will provide lower suitability due to a lack of concealing cover. Suitability will decrease as herbaceous heights approach 152.4 cm (60 inches), and it is assumed that, as herbaceous heights exceed 152.4 cm (60 inches), suitability will not be affected further. The relationship between herbaceous vegetation height and a suitability index for blue grouse is presented in Figure 3b.

Habitats with a high diversity of herbaceous plant species are preferred by blue grouse. Areas with low species diversity may provide some suitability if herbaceous height and density are adequate. The relationship between herbaceous vegetation diversity and a suitability index for blue grouse is presented in Figure 3c.

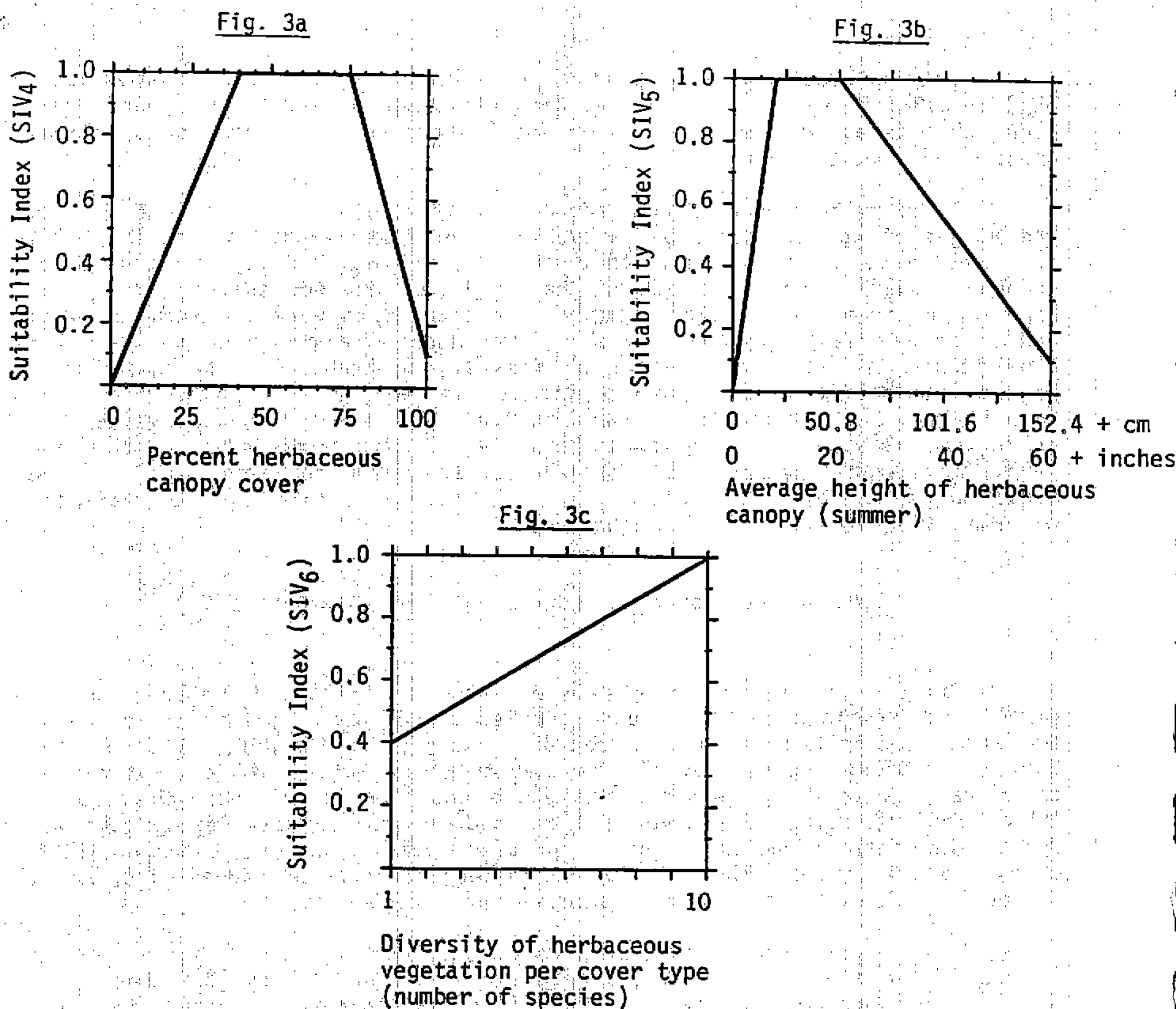

Figure 3. The relationships between habitat variables used to evaluate herbaceous vegetation and the suitability indices for the variables.

The best blue grouse habitats have herbaceous growth that is diverse, between 40 and 75% canopy cover, and between 20.3 and 50.8 cm (8 and 20 inches) in height. Such habitats are assumed to provide the best herbaceous cover conditions as well as ample insect and herbaceous foods.

Habitats with herbaceous height and/or densities present at levels lower than optimum (as described above) will not have maximum suitability. In such habitats, it is assumed that suitability will increase as either the herbaceous height or density suitability values approach optimum levels; however, the lower of the two values will have the greatest influence on the final herbaceous component value. The suitability value for herbaceous diversity directly influences the value given to herbaceous vegetation. Habitats with a given suitability value for herbaceous height and density will have lower overall suitabilities as herbaceous diversity decreases from optimal to low levels. However, habitats with low diversity may have moderate suitability, if herbaceous height and density are adequate, because it is assumed that even areas with a single plant species will be used by blue grouse. This relationship can be expressed mathematically by the following equation:

$$\text{Food/cover component (herbaceous portion)} = (SIV_4 \times SIV_5)^{1/2} \times SIV_6$$

<u>Interspersion component</u>. Maximum blue grouse densities occur in areas where trees are well interspersed with more open habitats. It is assumed that optimal conditions are provided when the distance from herbaceous or shrub cover types to forest or tree savanna cover types is 0.4 km (0.25 mile) or less. Suitability will decrease to zero as this distance approaches 3.2 km (2.0 miles). This relationship is presented graphically in Figure 4.

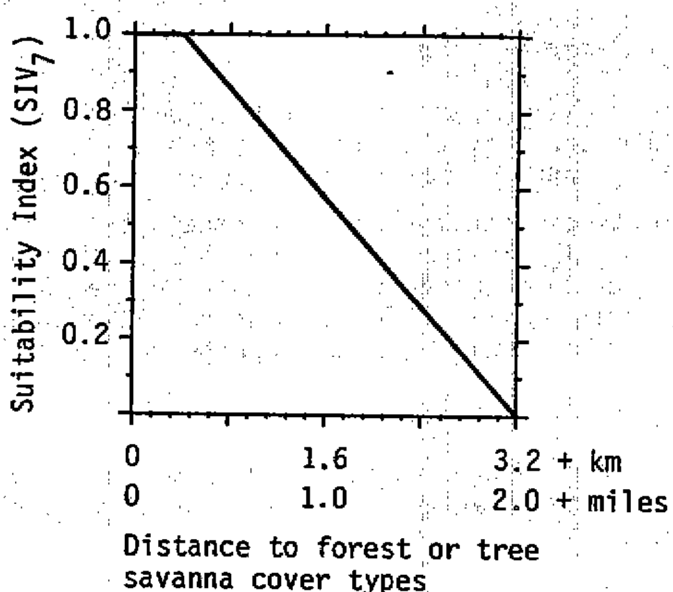

Figure 4. The relationship between the distance from herbaceous or shrub cover types to forest or tree savanna cover types and a suitability index for the blue grouse.

Model Relationships

HSI determination. The overall value for a habitat for blue grouse is a function of the quality of the herbaceous and shrubby vegetation in all cover types, the interspersion of herbaceous and shrub dominated cover types with forest or tree savanna cover types, and the total canopy cover of trees on the area. It is assumed that any of these may act as a limiting factor in determining the HSI.

It is assumed that the lowest value for either herbaceous or shrub growth, modified by the interspersion value, will determine the value of the herbaceous/shrub portion of a cover type for blue grouse. Overall habitat suitability is assumed to be the lower of either the value for percent tree coverage on the entire area or the total value obtained for the herbaceous/shrub portion in all cover types. These assumptions are based on the following logic: (1) All cover types should contain adequate quality of both herbaceous and shrub vegetation. Cover types with either poor herbaceous or poor shrub conditions will provide poor food and cover; (2) The value of the herbaceous and shrub vegetation in cover types without trees (ES,DS,ESS,DSS,G,F,P/H) will be affected by the interspersion of cover types providing trees (EF,DF,ETS,DTS). Interspersion of trees is considered to be adequate in cover types providing trees; and (3) Habitats with too few or too many trees over the entire area will be poor quality, regardless of the condition of the herbaceous and shrub growth.

The HSI is calculated as follows:

1. Determine suitability index (SI) values for each variable in the appropriate cover type by entering the field data into the appropriate SI graph. [Note: For V_1 only, determine one SI value for all cover types used by the blue grouse by multiplying the percent canopy cover of evergreen and aspen trees in each cover type used by the blue grouse by the relative area (see Step 3) of each cover type, summing these products for all cover types, and dividing by 100. Enter this figure into the SI graph for V_1 to determine the SI value for V_1.]

2. Calculate food/cover values for both the shrub and herbaceous portion in each cover type by using the SI values in the appropriate equation.

3. Determine the relative area (%) of each cover type used by blue grouse within the study area, as follows:

$$\text{Relative area (\%) for cover type A} = \frac{\text{Area of cover type A}}{\text{Total area of all cover types used by the blue grouse}} \times 100$$

4. Multiply the lower of either the herbaceous or shrub food/cover value for each cover type by the relative area (%) of that cover type.

5. Sum the values determined in Step 4 for forest and tree savanna cover types (EF, DF, ETS, and DTS).

6. Multiply the values determined in Step 4 for each herbaceous and shrub cover type (ES, DS, ESS, DSS, G, F, and P/H) by the SI value for V_7 for that cover type, and sum these products.

7. Add the sums from Steps 5 and 6, and divide by 100.

8. The HSI is equal to the lower of either the SI value for V_1, or the value from Step 7.

Summary of model variables. Seven habitat variables are used in this model to determine an HSI for the blue grouse. The relationship between habitat variables, life requisites, cover types, and the HSI for the blue grouse is illustrated in Figure 5.

Application of the Model

Application of the blue grouse HSI model requires the measurement of the quality of the herbaceous and shrub vegetation in all cover types. This value is then modified by considering the interspersion of trees with herbaceous and shrub vegetation. The value for tree canopy cover is determined for the entire study area. Overall habitat suitability is limited by either the value of the herbaceous and shrub portion or the value of the tree portion of the model. Refer to the HSI Determination section for further details.

Definitions of variables and suggested measurement techniques (Hays et al. 1981) are provided in Figure 6.

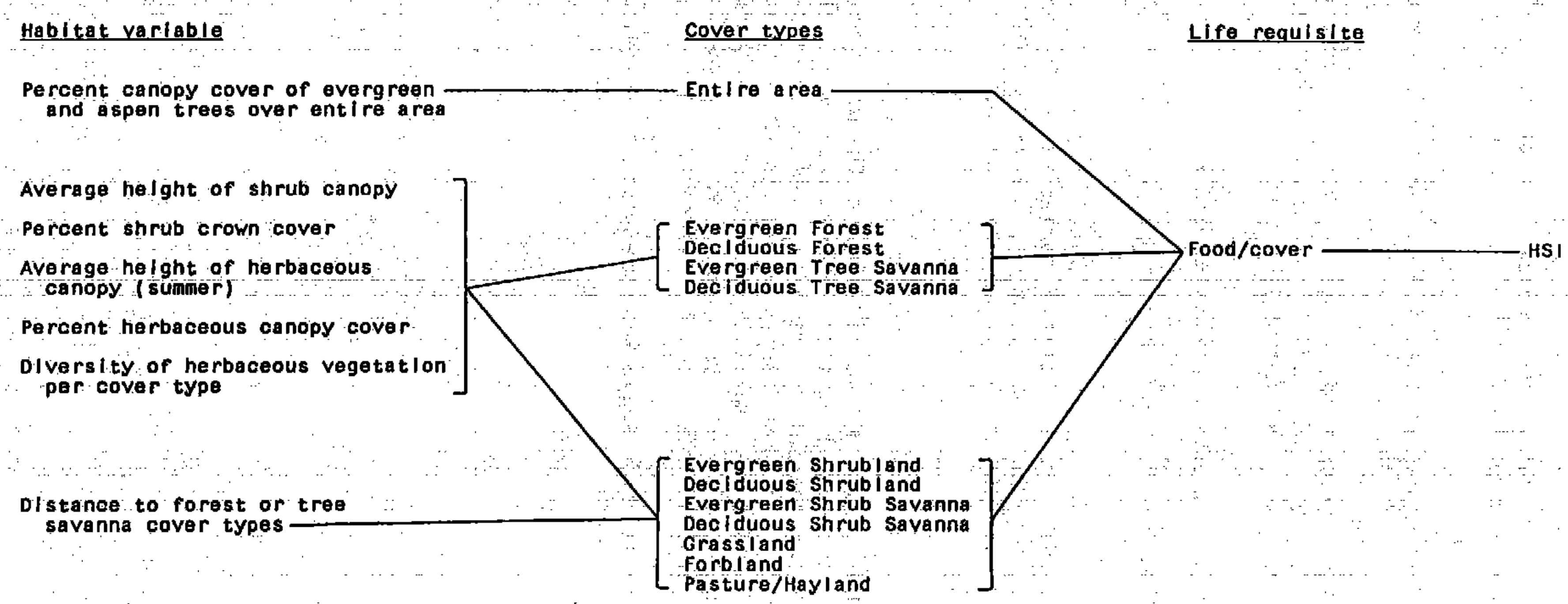

Figure 5. Relationships of habitat variables, life requisites, cover types, and the HSI in the blue grouse model.

Variable (definition)		Cover types	Suggested techniques
V_1	Percent canopy cover of evergreen and aspen trees over entire area [the percent of the ground surface that is shaded by a vertical projection of the canopies of evergreen and aspen woody vegetation taller than 5.0 m (16.4 ft) in height. Determined for the entire area by multiplying the percent canopy cover in each cover type used by the blue grouse by the relative area (see page 13 for definition) of that cover type, and summing these products for all cover types used by the blue grouse.]	Entire study area	Line intercept; remote sensing
V_2	Percent shrub crown cover [the percent of the ground surface that is shaded by a vertical projection of the canopies of woody vegetation ≤ 5.0 m (16.4 ft) tall].	EF,DF,ETS,DTS, ES,DS,ESS,DSS, G,F,P/H	Line intercept, quadrat
V_3	Average height of shrub canopy [the average vertical distance from the ground to the highest point of all woody plants ≤ 5.0 m (16.4 ft) tall].	EF,DF,ETS,DTS, ES,DS,ESS,DSS, G,F,P/H	Line intercept, graduated rod
V_4	Percent herbaceous canopy cover (the percent of the ground surface that is shaded by a vertical projection of all non-woody vegetation).	EF,DF,ETS,DTS, ES,DS,ESS,DSS, G,F,P/H	Line intercept, quadrat

Figure 6. Definitions of variables and suggested measurement techniques.

Variable (definition)		Cover types	Suggested techniques
V_5	Average height of herbaceous canopy (summer) (the average vertical distance from the ground surface to the dominant height stratum of the herbaceous vegetative canopy).	EF,DF,ETS,DTS, ES,DS,ESS,DSS, G,F,P/H	Line intercept, graduated rod
V_6	Diversity of herbaceous vegetation per cover type (the number of plant species comprising 1% or more of the total herbaceous canopy coverage per cover type).	EF,DF,ETS,DTS, ES,DS,ESS,DSS, G,F,P/H	Line intercept, quadrat
V_7	Distance to forest or tree savanna cover types (the distance from random points to the nearest edge of a forest or tree savanna cover type).	ES,DS,ESS,DSS, G,F,P/H	Remote sensing

Figure 6. (concluded)

SOURCES OF OTHER MODELS

Martinka (1972) developed discriminant function models based on vegetative structure in Montana that successfully classified areas into either breeding male territories or nonterritories. Steinhoff (1958) developed a rating scale of grouse abundance in Colorado based on factors such as soils, elevation, and vegetation. These studies classify areas as either being, or not being, blue grouse range, and do not provide quantitative values to distinguish between various quality levels of ranges that are expected to have blue grouse populations.

REFERENCES

Aldrich, J. W. 1963. Geographic orientation of American tetraonidae. J. Wildl. Manage. 27(4):529-545.

American Ornithologists' Union. 1983. Checklist of North American birds. 6th ed. Am. Ornith. Union. 877 pp.

Bauer, R. D. 1962. Ecology of blue grouse on summer range in north-central Washington. M.S. Thesis, Washington State Univ., Pullman. 81 pp.

Beer, J. 1943. Food habits of the blue grouse. J. Wildl. Manage. 7(1):32-44.

Bendell, J. F., and P. W. Elliott. 1966. Habitat selection in blue grouse. Condor 68(5):431-446.

____________. 1967. Behaviour and the regulation of numbers in blue grouse. Can. Wildl. Serv. Rep. Ser. 4. 76 pp.

Boag, D. A. 1966. Population attributes of blue grouse in southwestern Alberta. Can. J. Zool. 44(5):799-814.

Cade, B. S. 1982. Characteristics and habitat preferences of wintering populations of blue grouse. Colo. Div. Wildl., Job Prog. Rep., Fed. Aid Proj. W-37-R-35:215-241.

____________. In prep. Winter habitat preferences and migration patterns of blue grouse in Middle Park, Colorado. M.S. Thesis, Colorado State Univ., Ft. Collins. 85 pp.

Caswell, E. B. 1954. A preliminary study on the life history and ecology of the blue grouse in west-central Idaho. M.S. Thesis, Univ. Idaho, Moscow. 105 pp.

Donaldson, J. L., and A. T. Bergerud. 1974. Behaviour and habitat selection of an insular population of blue grouse. Syesis 7:115-127.

Fowle, C. D. 1960. A study of the blue grouse (Dendragapus obscurus (Say)) on Vancouver Island, British Columbia. Can. J. Zool. 38:701-713.

Hannon, S. J., L. G. Sopuck, and F. C. Zwickel. 1982. Spring movements of female blue grouse: evidence of socially induced delayed breeding in yearlings. Auk 99(4):687-694.

Harju, H. J. 1974. An analysis of some aspects of the ecology of dusky grouse. Ph.D. Thesis, Univ. Wyoming, Laramie. 142 pp.

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

Hoffman, R. S. 1956. Observations on a sooty grouse population at Sage Hen Creek, California. Condor 58(5):321-337.

Hoffman, R. W. 1981. Population dynamics and habitat relationships of blue grouse. Colo. Div. Wildl., Job Final Rep., Fed. Aid Proj. W-37-R-34:103-171.

____________. Personal communication (letters dated 8 March and 10 May, 1983). Colo. Div. Wildl., Wildl. Res. Ctr., Fort Collins, CO 80526.

King, D. G. 1973. Feeding habits of blue grouse in the subalpine. Syesis 6:121-125.

King, R. D., and J. F. Bendell. 1982. Foods selected by blue grouse (Dendragapus obscurus fuliginosus). Can. J. Zool. 60(2):3268-3281.

Marshall, W. H. 1946. Cover preferences, seasonal movements, and food habits of Richardson's grouse and ruffed grouse in southern Idaho. Wilson Bull. 58(1):42-52.

Martinka, R. R. 1972. Structural characteristics of blue grouse territories in southwestern Montana. J. Wildl. Manage. 36(2):498-510.

Mussehl, T. W. 1960. Blue grouse production, movements, and populations in the Bridger Mountains, Montana. J. Wildl. Manage. 24(1):60-68.

____________. 1963. Blue grouse brood cover selection and land-use implications. J. Wildl. Manage. 27(4):547-555.

Redfield, J. A., F. C. Zwickel, and J. F. Bendell. 1970. Effects of fire on numbers of blue grouse. Proc. Tall Timbers Fire Ecol. Conf. 10:63-83.

Rogers, G. E. 1968. The blue grouse in Colorado. Colo. Game, Fish and Parks Tech. Bull. 21. 63 pp.

Stauffer, D. F. 1983. Seasonal habitat relationships of ruffed and blue grouse in southeastern Idaho. Ph.D. Diss., Univ. Idaho, Moscow. 108 pp.

Steinhoff, H. W. 1958. A rating scale for blue grouse range in Colorado. Proc. Soc. Am. For., Wildl. Section. pp. 133-138.

Stewart, R. E. 1944. Food habits of blue grouse. Condor 46:112-120.

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

Weber, D. A. 1975. Blue grouse ecology, habitat requirements, and response to habitat manipulation in north-central Utah. Utah Coop. Wildl. Res. Unit Spec. Rep. 33. 66 pp.

Weber, D., B. Barnes, and J. B. Low. 1974. The blue grouse in northern Utah. Utah Sci. 35(2):43-46.

Zwickel, F. C. Personal communication (letters dated 21 March and 17 May, 1983). Dept. Zoology, Univ. Alberta, Edmonton T6G 2E9.

Zwickel, F. C., and J. F. Bendell. 1972. Blue grouse, habitat, and populations. Proc. Int. Ornithol. Congr. 15:150-169.

Zwickel, F. C., I. O. Buss, and J. H. Brigham. 1968. Autumn movements of blue grouse and their relevance to populations and management. J. Wildl. Manage. 32(3):456-468.

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16. Abstract (Limit: 200 words)

A review of the literature and synthesis of available data are used to develop a habitat suitability model for the blue grouse (Dendragapus obscurus). The model consolidates habitat values into a framework suitable for field application, and is scaled to produce an index value between 0.0 (unsuitable habitat) and 1.0 (optimum habitat) for the breeding habitat of the blue grouse. Habitat Suitability Index models are designed to be used in conjunction with Habitat Evaluation Procedures previously developed by the U.S. Fish and Wildlife Service.

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Habitat suitability

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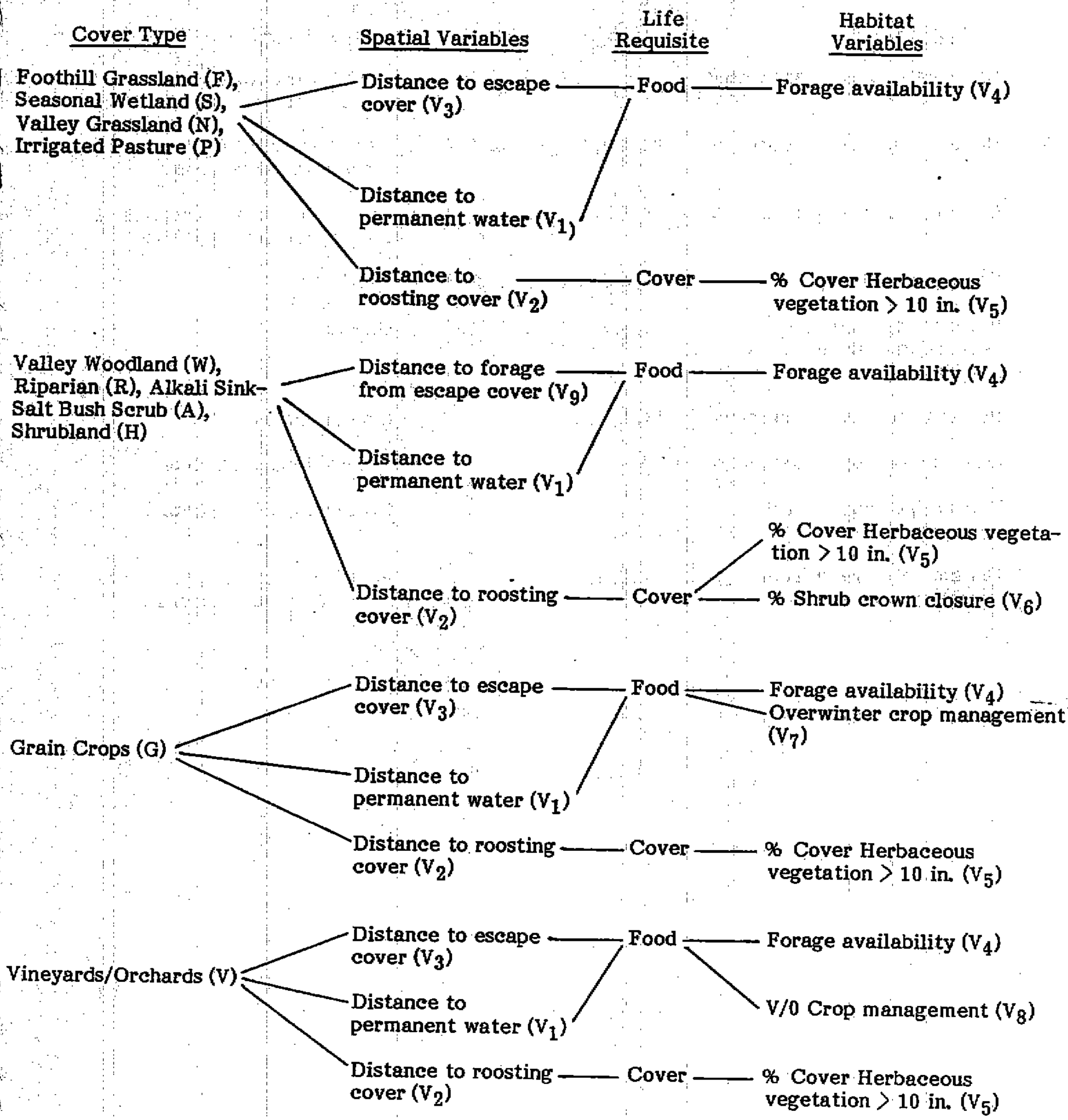
Habitat Suitability Index Model

California Quail

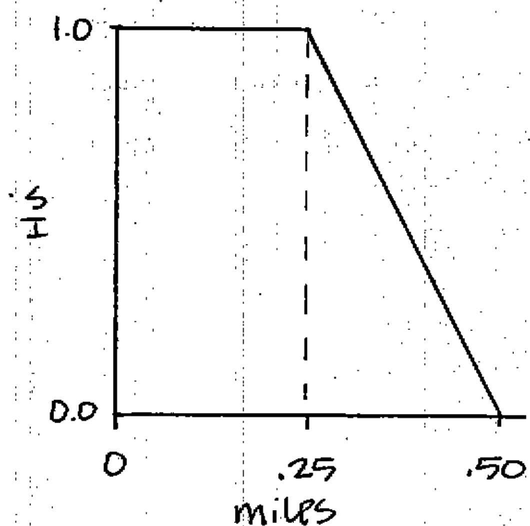
U.S. Fish and Wildlife Service
Division of Ecological Services
Sacramento, California

July 1985


Cover Type
Spatial Variables
Life Requisite
Habitat Variables
Foothill Grassland (F), Seasonal Wetland (S), Valley Grassland (N), Irrigated Pasture (P)
Distance to escape cover (V_3)
Food
Forage availability (V_4)
Distance to permanent water (V_1)
Distance to roosting cover (V_2)
Cover
% Cover Herbaceous vegetation > 10 in. (V_5)
Valley Woodland (W), Riparian (R), Alkali Sink-Salt Bush Scrub (A), Shrubland (H)
Distance to forage from escape cover (V_9)
Food
Forage availability (V_4)
Distance to permanent water (V_1)
Distance to roosting cover (V_2)
Cover
% Cover Herbaceous vegetation > 10 in. (V_5)
% Shrub crown closure (V_6)
Grain Crops (G)
Distance to escape cover (V_3)
Food
Forage availability (V_4)
Overwinter crop management (V_7)
Distance to permanent water (V_1)
Distance to roosting cover (V_2)
Cover
% Cover Herbaceous vegetation > 10 in. (V_5)
Vineyards/Orchards (V)
Distance to escape cover (V_3)
Food
Forage availability (V_4)
V/0 Crop management (V_8)
Distance to permanent water (V_1)
Distance to roosting cover (V_2)
Cover
% Cover Herbaceous vegetation > 10 in. (V_5)

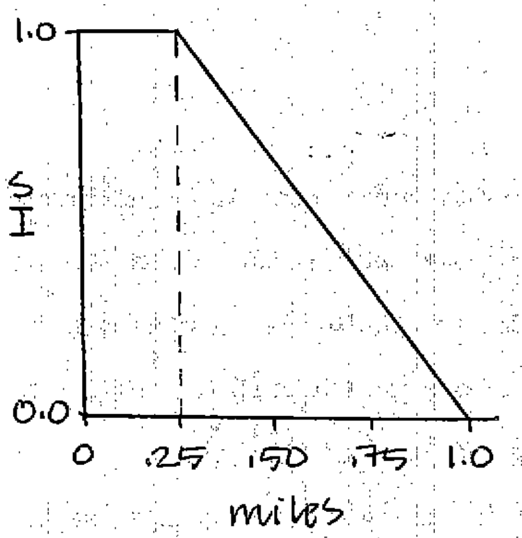
	VARIABLE	HABITAT TYPE	SUGGESTED TECHNIQUE
(V_1)	Distance to permanent water	G,V,F,S,R,A,P,H,N,W	Aerial photo interpretation of random ten acre quadrats
(V_2)	Distance to roosting cover	G,V,F,S,R,A,P,H,N,W	Aerial photo interpretation of random ten acre quadrats
(V_3)	Distance to escape cover	G,V,F,S, A,P,H,N,W	Aerial photo interpretation of random ten acre quadrats
(V_4)	Forage availability	G,V,F,S,R,A,P,H,N,W	Quadrat
(V_5)	Percent cover herbaceous vegetation over 10 inches in height	G,V,F,S,R,A,P,H,N,W	Quadrat
(V_6)	Percent shrub crown closure	R,A,H,W	Line intercept
(V_7)	Overwinter crop management	G	Observation, local data
(V_8)	Vineyard/Orchard Crop management	V	Observation, local data
(V_9)	Distance to forage from escape cover	R,A,H,W	Aerial photo interpretation of random ten acre quadrats

1. Distance to available permanent water (in areas where free drinking water is unavailable (summer and fall), succulent green vegetation may be substituted, if present).



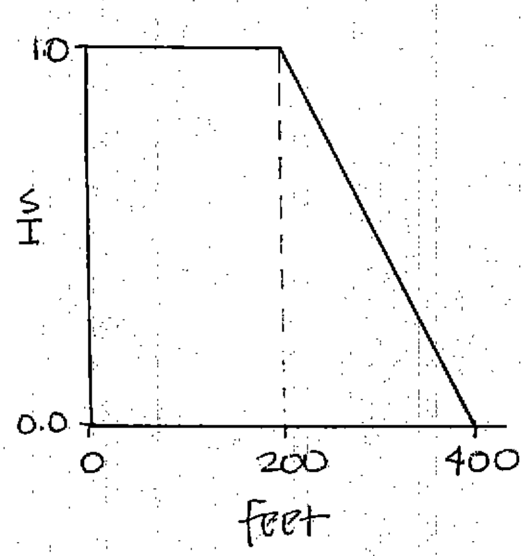
Assumptions: Permanent water must have escape cover within 200 yards to be available to California quail (Leopold, 1977). Broods can travel up to .25 miles to drinking water (Sumner, 1935). Water sources include guzzlers, springs, seeps, water tanks, etc.

2. Distance to roosting cover



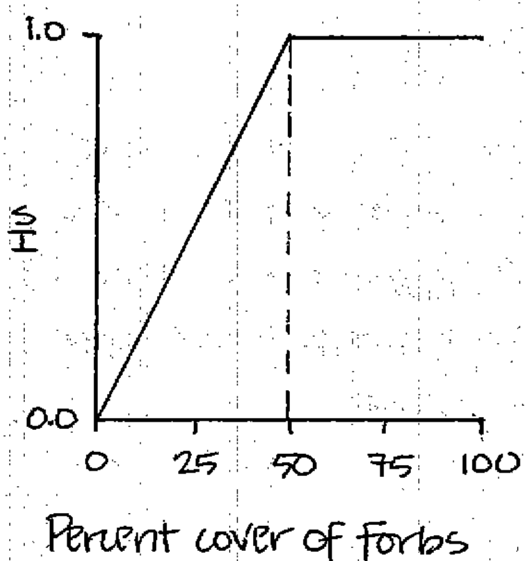
Assumptions: Optimum roost distribution = 1/4 mile or less (Fitzhugh, 1983). One roost every 1/2 mile = good quail habitat (Bauer, 1977). See definition of roosting cover.

3. Distance to escape cover



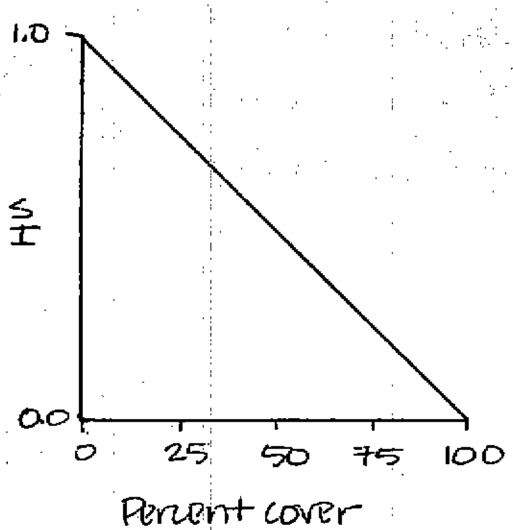
Assumptions: Quail will forage up to 200 feet from escape cover (Bauer 1977). See definition of escape cover.

4. Forage availability



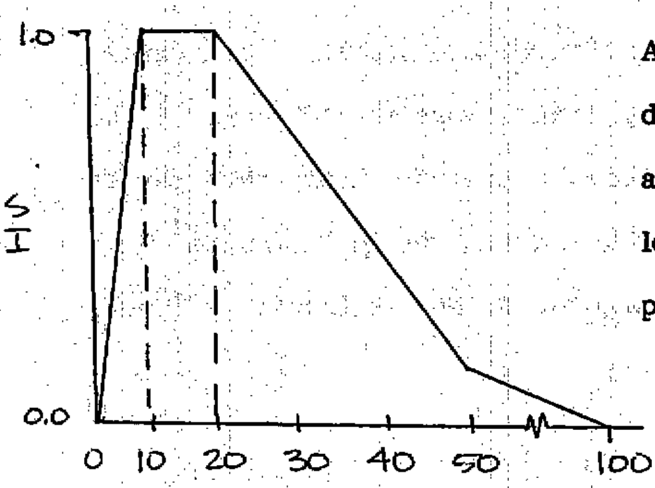
Assumptions: California quail prefer seeds and green leaves of annual forbs (See list of preferred food items). Forbs should comprise approximately 50% cover of the herbaceous vegetation in the study plot to provide optimum forage (estimated from Glading et. al, 1940 & Duncan & Shields, 1966).

5. Percent cover of herbaceous vegetation over ten inches in height



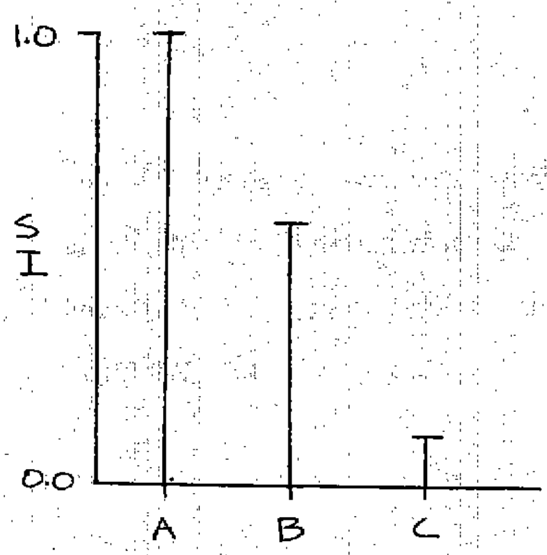
Assumptions: California quail prefer open habitat. Extensive stands of tall, dense herbaceous vegetation are avoided (Leopold, 1977; Crawford, 1978; Fitzhugh, 1983).

6. Percent shrub crown closure



Assumptions: California quail prefer dense, low shrubs covering 10–20% of an area. Units of shrub cover should be at least 10 feet in diameter at their widest point (Fitzhugh, 1983).

7. Overwinter crop management

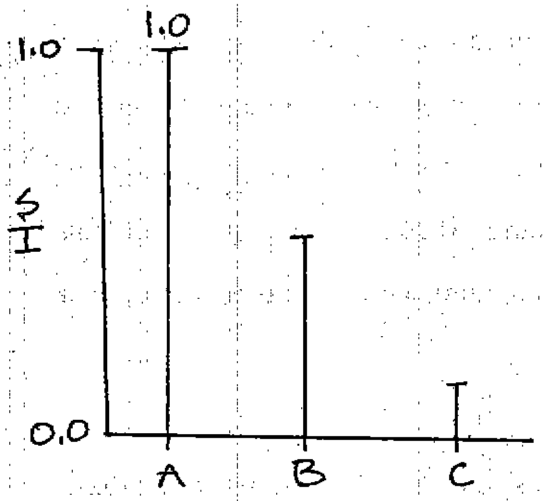


A Crop left unharvested

B Crop harvested, spring plowed

C Crop harvested, fall plowed

8. Vineyard/Orchard Crop Management

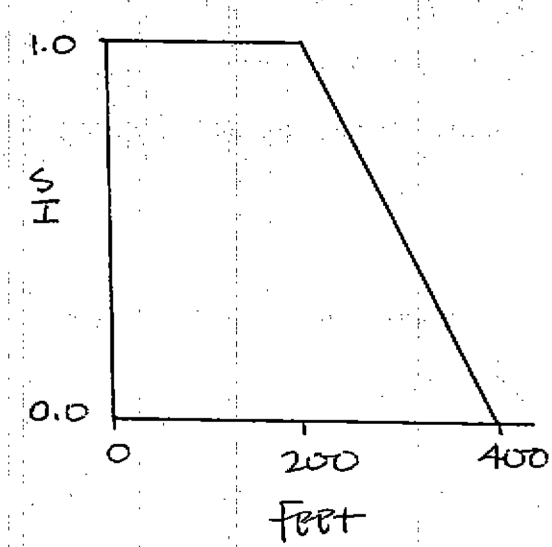


A No herbicide use or no discing/mowing between rows

B Light herbicide use or occasional discing/mowing between rows

C Heavy herbicide use or regular discing/mowing to control herbaceous vegetation between rows

9. Distance to forage from escape cover



Assumption: Suitable forage areas must be within 200 feet of escape cover to be utilized by quail (Bauer 1977).

Additional assumptions:

1. Quail nest in a variety of situations including isolated clumps of dry grass or weeds, dense, tall dry grass, dry grass or weeds growing through fallen, dead brush, rock outcrops, green vegetation in swales or close to streams, in live tarweed or turkey mullein, under shrubs, piles of scrap lumber, rocks, straw piles and in holes in earthen banks (Glading, 1938). For purposes of this model, it is assumed that nesting cover is not limiting and is present if other cover requirements are met.

2. Water quality within the Central Valley is not limiting quail populations. California quail can successfully utilize salt water at Na Cl concentrations of 50% or less. Under conditions of severe drought, saline springs or brackish water could be significant in maintaining quail populations in some locations. (Bartholomew and MacMillen, 1961).

3. Assume a minimum home range of 10 acres (CDFG, 1982). Escape cover should comprise a minimum of 10 percent of the home range or 1 acre, preferrably in clumps of brush 10-20 feet in diameter and spaced 100 to 200 feet apart (Fitzhugh, 1983).

4. This model was constructed for use in plant communities found in the Central Valley of California up to about 500 feet in elevation.

Escape cover - Dense low shrubs, thick vine tangles, high weeds, piles of debri and rocks, brushpiles (Bauer, 1977). Escape cover should cover a minimum of one acre preferrably as clumps of brush and vines 10-20 feet in diameter and 6-8 feet high (Fitzhugh, 1983).

Common escape cover plants (from Bauer, 1977):

- acacia
- Arizona cypress
- blackberry
- blue elderberry
- bush buckwheat
- cactus
- cotoneaster
- deerweed
- encelia
- European beachgrass
- grapevines
- honeysuckle
- juniper
- mesquite
- mulefat
- Oregon grape
- pampas grass
- poison oak
- rabbitbrush
- redberry
- rock gooseberry
- sacaton grass
- sagebrush
- quail brush (saltbrush)
- Scotch broom
- sumac
- tamarix
- toyon
- wild rose
- willow
- desert thorn

Roosting cover – Stiff-twigged, densely foliaged evergreen trees or tall shrubs (> 12 feet) (Bauer, 1977); vine tangles if dense and extending in height above 12 feet (Sumner, 1935); artificial quail roosts (Edminster, 1954). Escape cover must be within 200 yards of roosting cover (derived from Fitzhugh, 1983).

Common roosting cover plants (from Bauer, 1977).

acacia

adelia

Arizona cypress

blue elderberry

citrus trees

holly-leaf cherry

juniper

mesquite

Monterey pine

oak

olive

redberry

Rocky Mountain cedar

Scotch broom

sumac

tamarix

willow

California laurel (Edminster, 1954)

Equations:

a) Equation for food component

Cover Type	Equation	
F,S,P	$(V_1 \times V_3 \times V_4)^{1/3}$	Assumes escape cover, permanent water and forage all critical components of quail habitat. If any variable is zero, the sample site is unsuitable quail habitat
G	$(V_1 \times V_3)^{1/2} \cdot (V_4 \times V_7)^{1/2}$	
V	$(V_1 \times V_3)^{1/2} \cdot (V_4 \times V_8)^{1/2}$	
R,A,L	$(V_9 \times V_1 \times V_4)^{1/3}$	

b) Equation for cover component

Cover Type	Equation	
G,V,F,S,P	$(V_2 \times V_5)^{1/2}$	Assumes roosting and escape cover to be critical components of quail habitat. If either variable is zero, the sample site is unsuitable as quail habitat.
R,A,L	$V_2 \cdot (V_5 \times V_6)^{1/2}$	

Calculating Overall HSI

The HSI value for California quail is equal to the lowest of the values for the food and cover components.

Literature Cited

Bartholomew, G.A. and R.E. MacMillen. 1961. Water economy of the California quail and its use of sea water. Auk 78: 505-514.

Bauer, O. 1977. Improving land for California valley quail. California Department of Fish and Game, Game Manage. Leaflet No. 8. 10pp.

California Department of Fish and Game. 1982. California wildlife and fish habitat relationships system species note. California quail. 2pp.

Crawford, J.A. 1978. Factors affecting California quail populations on the E.E. Wilson Wildlife Area, Oregon. Murrelet 59: 7-13.

Duncan, D.A. 1968. Food of California quail on burned and unburned central California foothill rangeland. California Fish and Game. 54(2): 123-127.

Edminster, F.C. 1954. American game birds of field and forest. Charles Scribner & Sons, N.Y. 490pp.

Fitzhugh, E.L. 1983. How to increase California quail populations. University of California Division of Agric. Sci., Coop. Ext. Leaflet 21325. 4pp.

Glading, B. 1938. Studies on the nesting cycle of the California valley quail in 1937. California Fish and Game 24(4): 318-340

Glading, B., Biswell, H.H. and C.F. Smith. 1940. Studies on the food of the California quail in 1937. J. Wildlife Manage. 4(2): 128-144.

Leopold, A.S. 1977. The California quail. University California Press, Berkeley. 281pp.

Shields, P.W. and D.A. Duncan. 1966. Fall and winter food of California quail in dry years. California Fish and Game 52(4): 275-282.

Sumner, E.L. 1935. A life history study of the California quail, with recommendations for its conservation and management. California Fish and Game 21(3): 167-156 and 21(4): 275-342.

Summer, 1935

LIST OF COMMON CALIFORNIA PLANTS IMPORTANT AS FOOD FOR QUAIL

(Distribution according to Jepson, 1925)

Bur clover (*Medicago hispida*), Fig. 22.
Vetch, all species (*Vicia*), Fig. 23.
Wild clover, all species (*Trifolium*), Fig. 24.
Lupine, small seeded species (*Lupinus*), Fig. 25.
Bird's-foot trefoil and deerweed, all species (*Lotus*), Fig. 26.
Thistles, apparently all species (*Centaurea*, Fig. 27; *Cirsium*; *Silybum*; *Sonchus*, Fig. 28).
Dandelions, all species (*Taraxacum*; *Agoseris*), Fig. 29.
Prickly lettuce (*Lactuca scariola*), Fig. 30.
Tarweeds, all species (*Hemizonia*, Fig. 10, Part I, 31; *Madia*, *Layia*, *Lagophylla*).
Mayweed (*Anthemis cotula*), Fig. 32.
Fuller's teasel (*Dipsacus fullonum*), Fig. 33.
Turkey mullein (*Eremocarpus setigerus*), Fig. 36.
Filaree, all species (*Erodium*), Fig. 35.
Pigweed, all species (*Chenopodium*).
Tumbleweed and rough pigweed (*Amaranthus graecizans*; and *A. retroflexus*) Fig. 34.
Mustards, all species (*Brassica*).
Wild radish (*Raphanus sativus*).
Shepherd's purse (*Capsella bursa-pastoris*), Fig. 37.
Chickweeds, all species (*Cerastium*, Fig. 38; *Stellaria*).
Wild geranium (*Geranium dissectum*), Fig. 39.
Miners' lettuce (*Montia perfoliata*), Fig. 40.
Red maids, all species (*Calandrinia*).
Red sorrel (*Rumex acetosella*), Fig. 41.
Dock, all species (*Rumex*), Figs. 21, 42.
Chess, species with small seeds (*Bromus*), Fig. 43.
Rye grass, all species (*Lolium*), Fig. 44.
Buttercup, all species (*Ranunculus*).
Buckthorn weed or fireweed, all species (*Amsinckia*), Fig. 45.
Pimpernel or Poor Man's Weatherglass (*Anagallis arvensis*), Fig. 46
Plantain, all species (*Plantago*), Fig. 47.
Sumac (*Rhus laurina*).
Poison oak (*Rhus diversiloba*).
Wiregrass and other knot weeds (*Polygonum*), Fig. 48.
Walkgrass and related grasses (*Poa*).
Catchfly and other pinks (*Silene*), Fig. 49.
Gambleweed and other sanicles (*Sanicula*), Fig. 50.
Fescue, all species with small seeds (*Festuca*), Fig. 51.
Gumweed, all species (*Grindelia*), Fig. 52.
Wild buckwheat (*Eriogonum fasciculatum*).

C-61

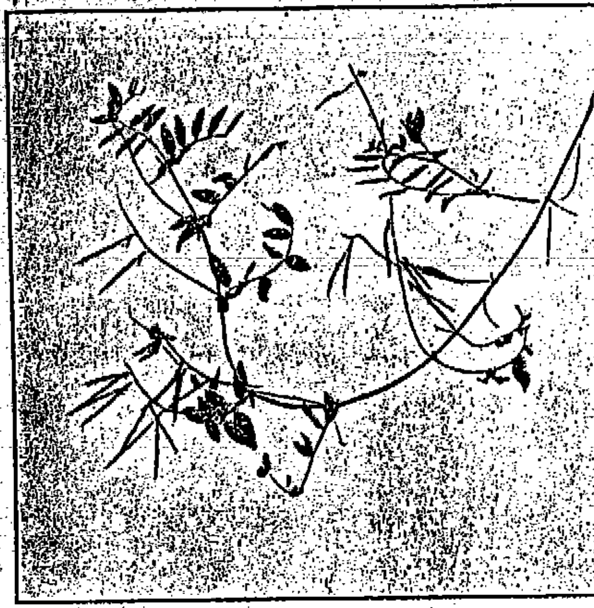


FIG. 23. American vetch (*Vicia americana*). Trailing or climbing, dark green plant with tendrils; coastal southern California, Coast Ranges, Sierra Nevada.

Fig. 25. Lupine (*Lupinus* sp.). One or more species common almost everywhere.

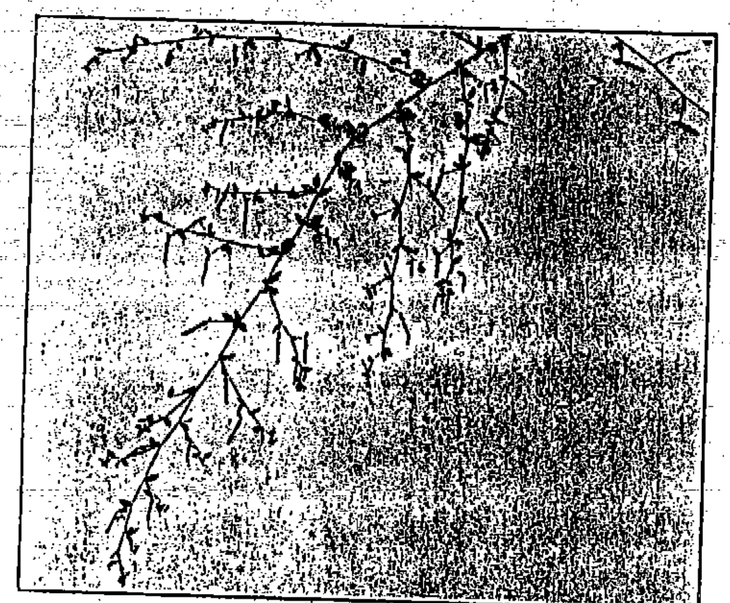


Fig. 26. Bird's-foot Trefoil (*Lotus* sp.). Usually low, inconspicuous, small-flowered; comm[illegible]d w[illegible]istri[illegible]

Fig. 27. Napa Thistle (*Centaurea melitensis*). Flowers yellow; abundant everywhere in agricultural lands and pastured hills.

Fig. 28. Prickly Sow-thistle (*Sonchus asper*). Waste lands in valleys throughout California (left).

Fig. 29. Wild Dandelion (*Agoseris grandiflora*). Flowers yellow; dry slopes or flats throughout California west of the Sierra Nevada (right).

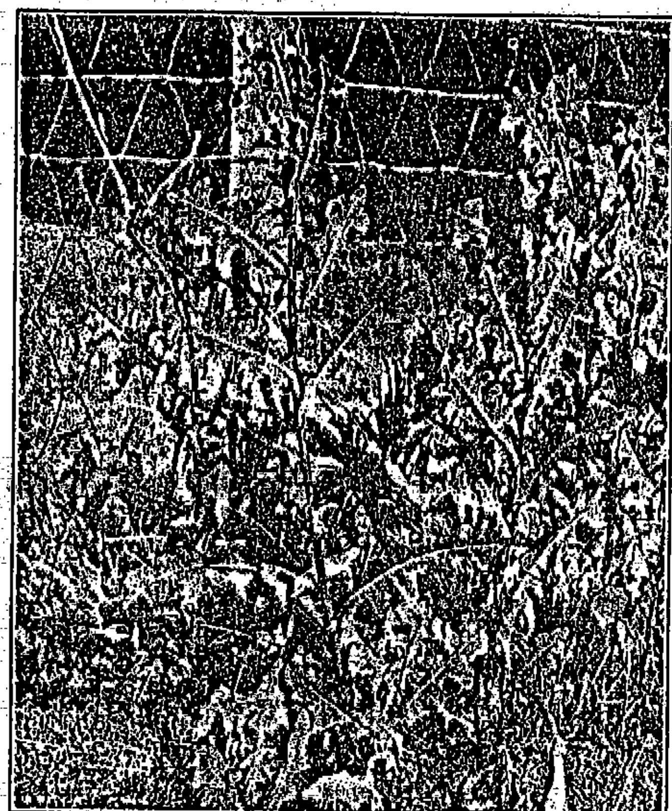


FIG. 30. Prickly Lettuce (*Lactuca scariola*). Santa Clara, San Mateo, Alameda, Humboldt, and Siskiyou counties.

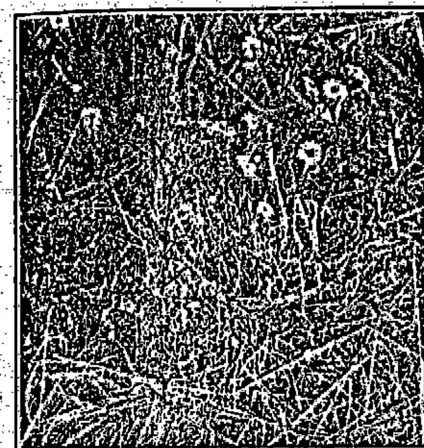


FIG. 31. Tarweed (*Hemizonia* sp.). Flowers white (in *Madia* yellow); plants sticky; common and widely distributed, blooming in late summer.

FIG. 32. Mayweed (*Anthemis cotula*). Strong scented; abundant in pastures and waste lands.

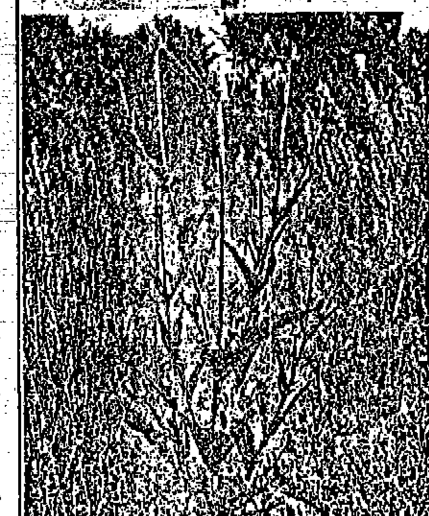


FIG. 33. Fuller's Teasel (*Dipsacus fullonum*). Plant 4-5 feet high; head rigid, prickly; waste lands, especially near the coast.

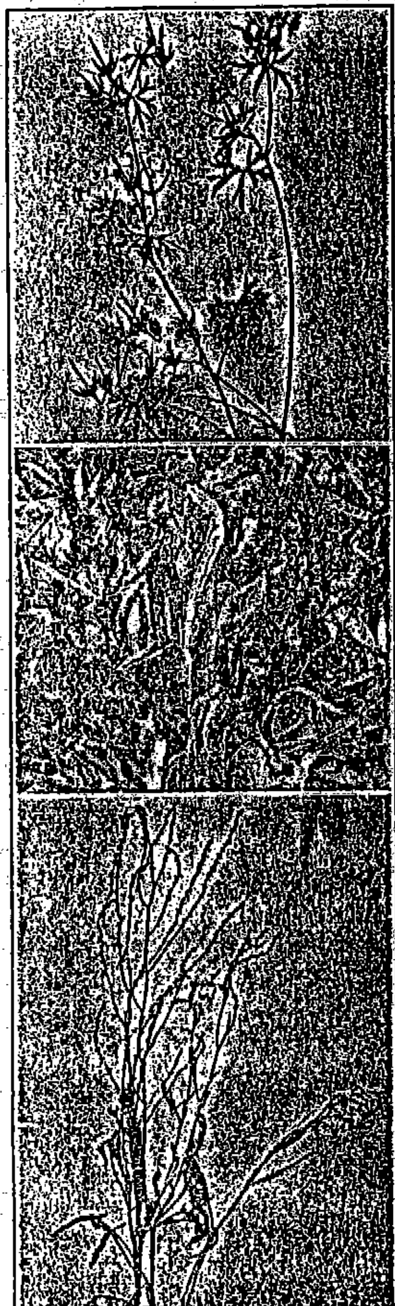


FIG. 39. Wild Geranium (*Geranium dissectum*). Flowers small, rose-purple; stems slender, 7-14 inches high; coast ranges.

FIG. 40. Miners' lettuce (*Montia perfoliata*). Low (4-10 inches), shade-loving; stem leaves forming a rounded disk with stem passing through the center; common everywhere.

FIG. 41. Red Sorrel (*Rumex acetosella*). Reddish-brown when mature; one-half to two feet high; seeds small, reddish-brown, numerous, triangular; throughout California.

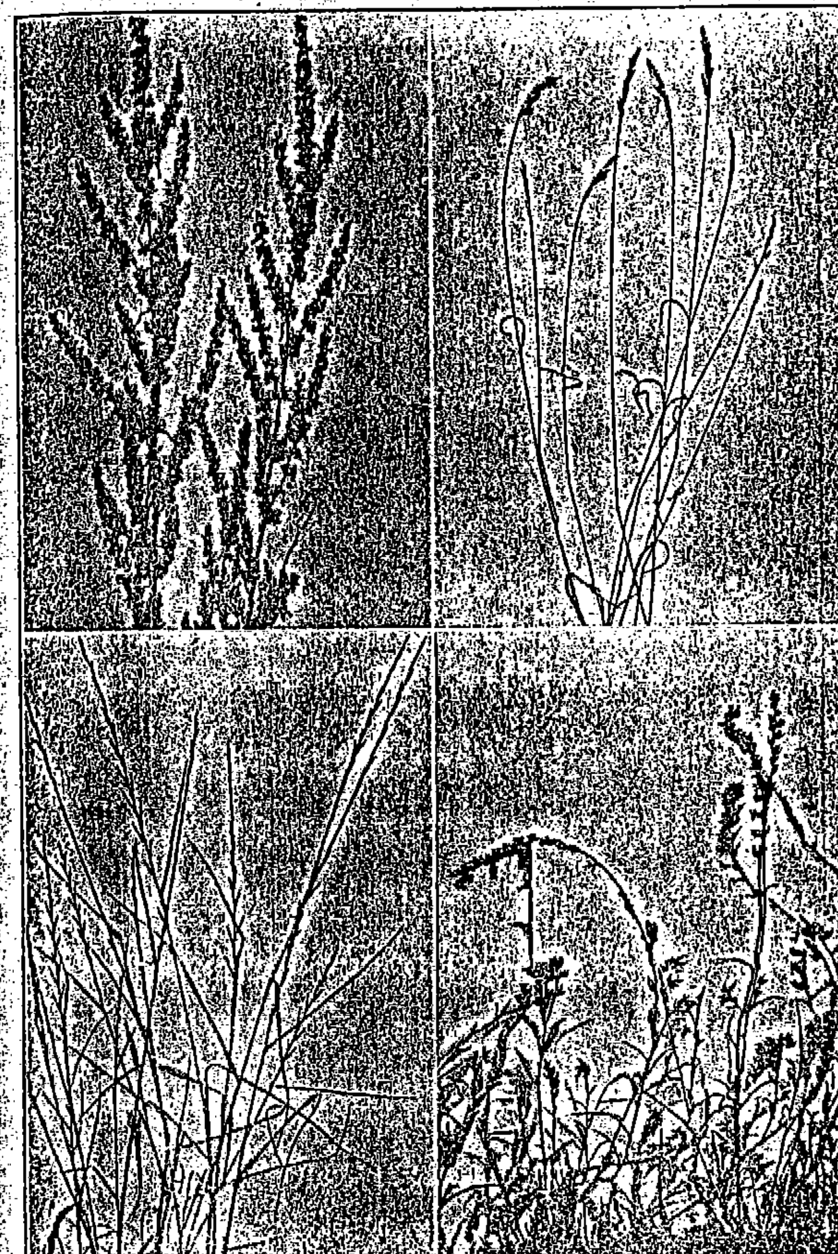


FIG. 42. Curly Dock (*Rumex crispus*). Stem stout (1½-4 feet high); leaves wavy-margined; seeds reddish-brown, numerous, triangular. Common in neglected lands (upper left).
FIG. 43. Soft Cheat (*Bromus hordeaceus*). Abundant grass in fields and waste places (upper right).
FIG. 44. Italian Rye Grass (*Lolium multiflorum*). Common grass in fields and [redacted]te pl[redacted]ower[redacted]
[redacted] Bu[redacted] We[redacted] Fire [redacted] (*Am*[redacted] *dou*[redacted]*a*). [redacted] (1½-4[redacted]
high), densely bristly; flowers orange-yellow. Common in California west of

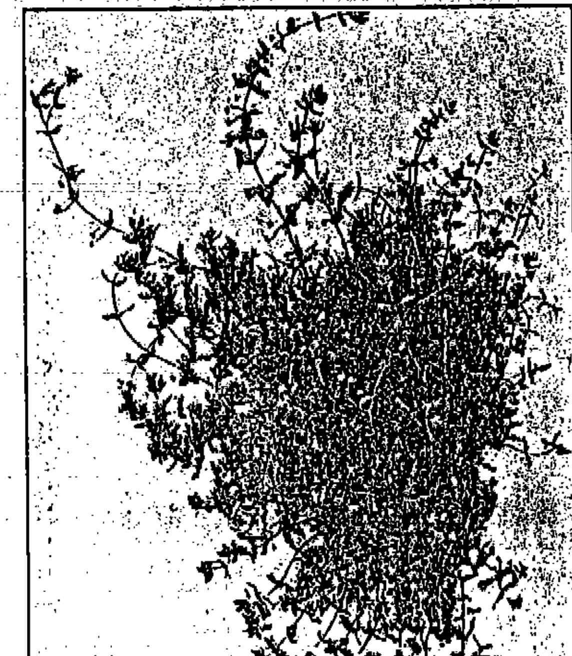


FIG. 46. Pimpernel or Poor Man's Weather-glass (*Anagallis arvensis*). Low, with slender stems lying along the ground; flowers vermilion; common, mostly near the coast.

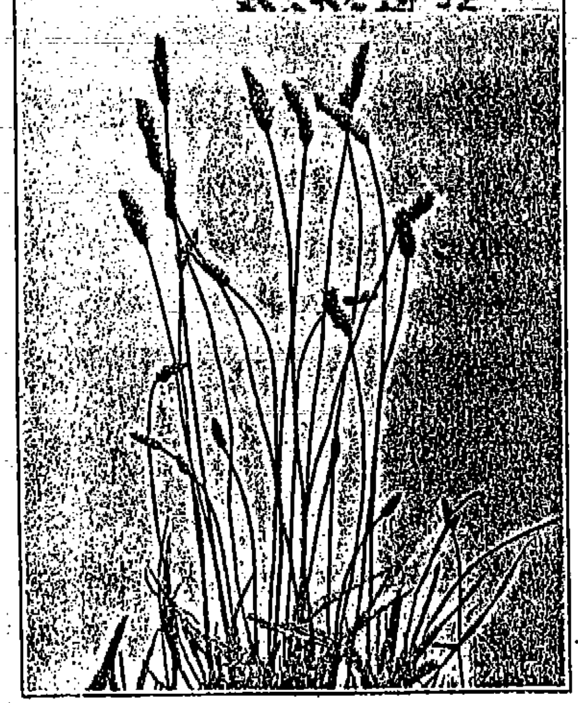


FIG. 47. English Plantain (*Plantago lanceolata*). Moist agricultural lands throughout California.

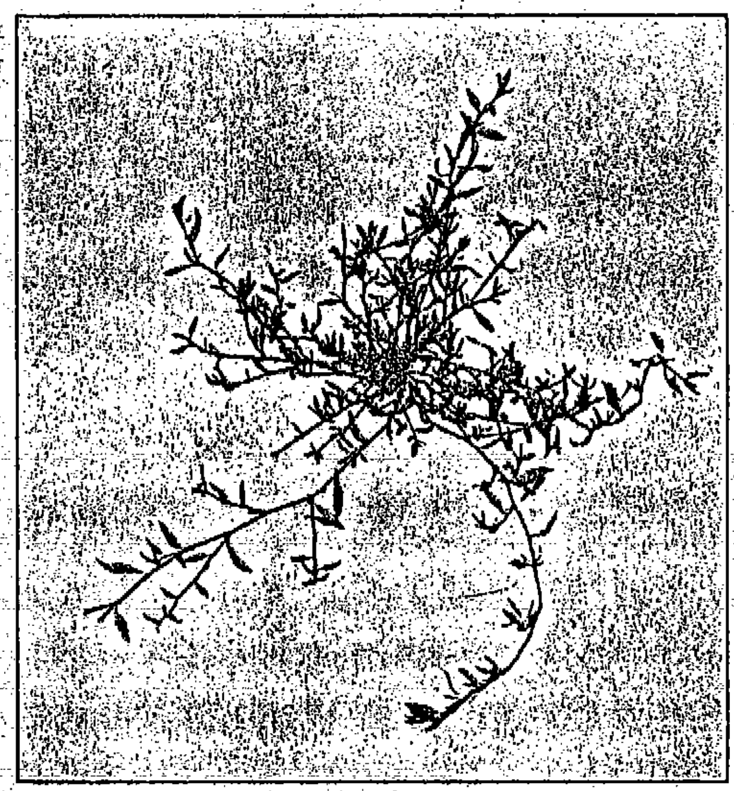


FIG. 48. Wiregrass (*Polygonum aviculare*). Prostrate, with wiry stems; flowers minute, whitish; common in hard, especially beaten soils.

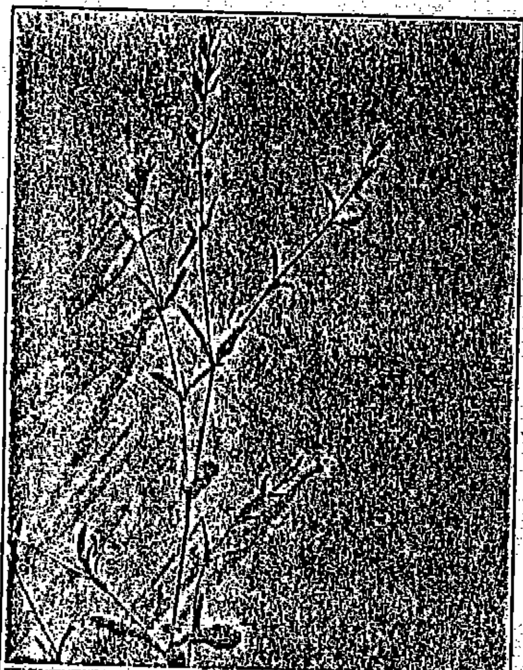


FIG. 49. Windmill Pink (*Silene gallica*). Stem 10–15 inches high; flowers white or flesh color; common in fields and along roadsides.

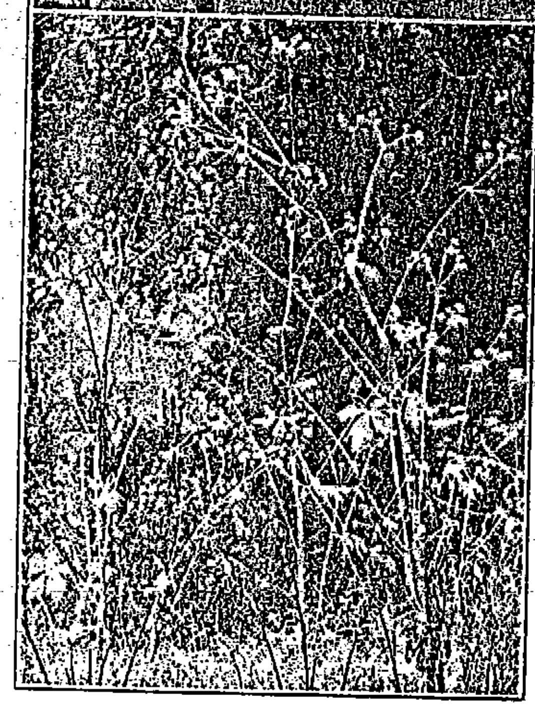


FIG. 50. Gamble Weed (*Santicula menziesii*). Stem 1–3½ feet high; flowers small, yellow; fruits covered with hooked bristles; shady woods in foothills.

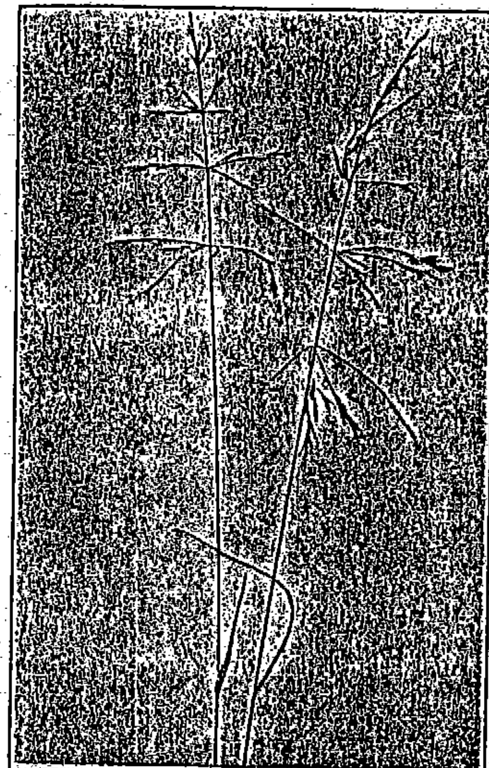
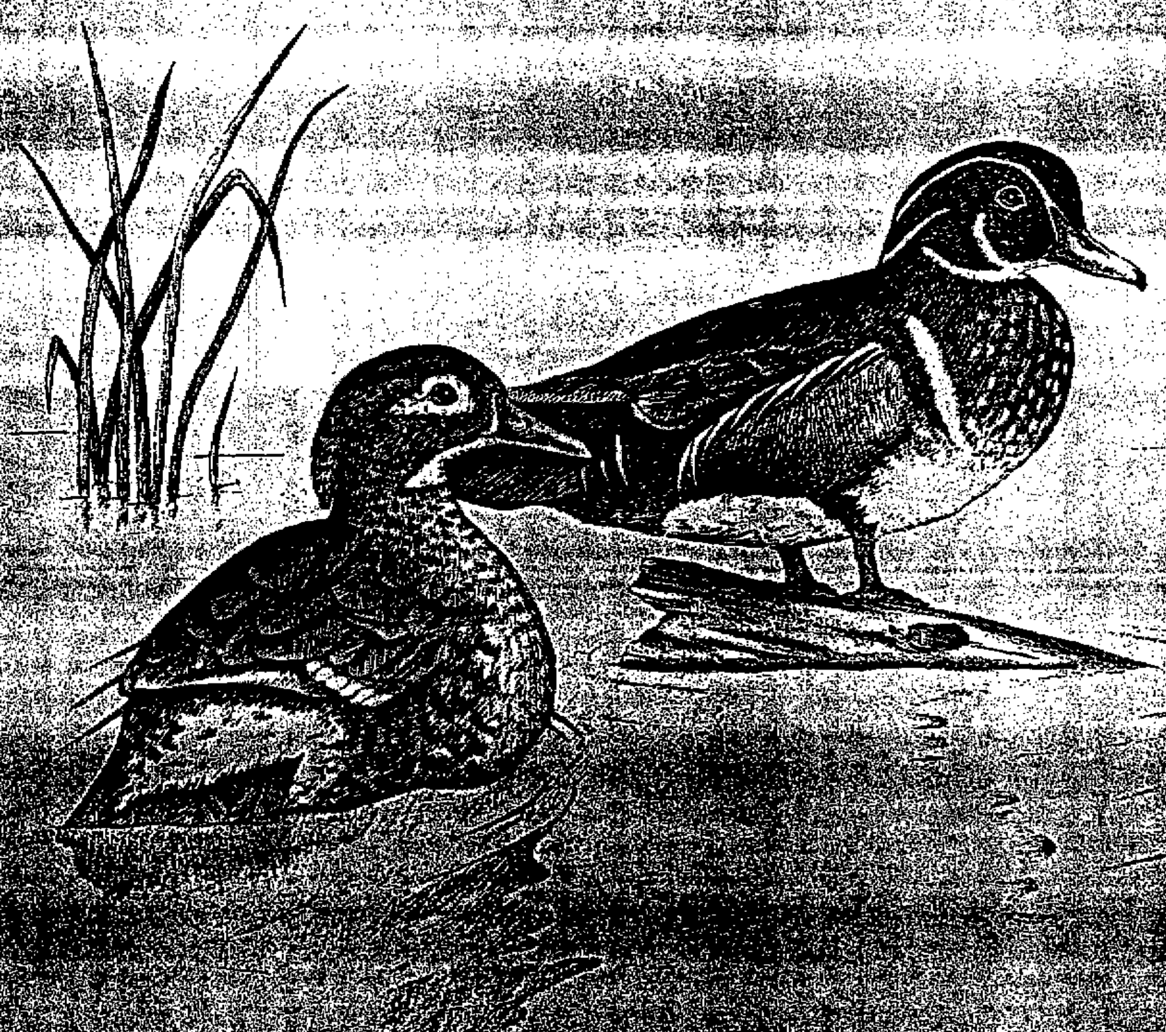


FIG. 51. Fescue (*Festuca* sp.). Tall, slender, grasses with open, spreading heads; nearly everywhere except in desert regions.

FIG. 52. Gumweed (*Grindelia* sp.). Coarse, somewhat woody at base; flower heads gummy, petals yellow; throughout most of California west of the Sierra Nevada.

FWS/OBS-82/10.43
JULY 1983

HABITAT SUITABILITY INDEX MODELS: WOOD DUCK



Fish and Wildlife Service

U.S. Department of the Interior

FWS/OBS-82/10.43
July 1983

HABITAT SUITABILITY INDEX MODELS: WOOD DUCK

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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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CONTENTS

ACKNOWLEDGMENTS

Earlier versions of an HSI model for the wood duck were reviewed by Drs. Leigh Fredrickson, Frank Bellrose, and Frank McGilvrey. Dr. Fredrickson commented on two earlier drafts and his comments were very valuable in helping to describe the relationships between wood ducks and their habitat. The comments and suggestions of all three reviewers have added considerably to the quality and value of this model, and their input is very gratefully acknowledged.

The development of this HSI model was partially funded by the U.S. Army Corps of Engineers through their Waterways Experiment Station in Vicksburg, Mississippi. The participating work unit is Testing of Habitat Evaluation Methods within the Environmental Impact Research Program.

Word processing of this document was provided by Carolyn Gulzow and Dora Ibarra. The cover illustration was drawn by Jennifer Shoemaker.

WOOD DUCK (*Aix sponsa*)

HABITAT USE INFORMATION

General

Wood ducks (*Aix sponsa*) inhabit creeks, rivers, floodplain lakes, swamps, and beaver ponds (Bellrose 1976). The major breeding range of the wood duck is in the eastern United States, from Florida and east Texas north to Maine and North Dakota, and north into the eastern Canadian provinces. A Pacific population breeds from British Columbia south to California and east to Montana. The major wintering range occurs south of Maryland in the Atlantic and Gulf coast States, as well as Arkansas and Tennessee. The majority of the Pacific population winters in the Sacramento Valley. Wood ducks are permanent residents in the southern half of their breeding range.

Food

Wood ducks have been referred to as primarily herbivorous (Landers et al. 1977) although recent studies have indicated that invertebrates make up a significant part of the annual diet (Drobney and Fredrickson 1979). Wood ducks forage on the ground or in water at depths up to 46 cm (18 inches) (McGilvrey 1968). In Missouri, they foraged primarily in flooded timber during spring and fall (Drobney and Fredrickson 1979). The daily foraging radius in the southeastern United States may be as much as 40 to 48 km (25 to 30 mi) (U.S. Forest Service 1971). Food items include mast and fruits, aquatic plants and seeds, insects, and aquatic invertebrates. Acorns and other mast are important fall and winter foods (Landers et al. 1977). When acorns are lacking, other important foods include the seeds of baldcypress (*Taxodium distichum*), hickories (*Carya* spp.), buttonbush (*Cephalanthus occidentalis*), arrowarum (*Peltandra virginica*), and burreed (*Sparganium* spp.) (Bellrose 1976). In South Carolina, McGilvrey (1966) found that greater than 98% of the stomach contents of 108 wood ducks shot by hunters were fruits and seeds of water oak (*Quercus nigra*), pin oak (*Q. palustris*), baldcypress, sweetgum (*Liquidambar styraciflua*), water hickory (*C. aquatica*), and corn (*Zea mays*). Important fall foods of wood ducks in Maine were pondweeds (*Potamogeton* spp.), burreeds, water bulrush (*Scirpus subterminalis*), oaks, and wild rice (*Zizania aquatica*) (Coulter 1957). Wood ducks prefer to forage for mast in areas of shallow water, although they may also forage on the forest floor (Brakhage 1966; Bellrose 1976) and even on tree limbs before the mast has fallen (Brakhage 1966). Important foods during the breeding season include persistent overwintering fruits; corn and other domestic grain; seeds and fruits from bottomland hardwood trees, shrubs, and aquatic herbaceous plants; early spring plants; and invertebrates (McGilvrey 1968).

Female wood ducks have high protein and calcium requirements in the spring and feed heavily on aquatic invertebrates (Landers et al. 1977). They satisfy their protein requirements for egg laying through their diet rather than through internal stores (Drobney 1980). Invertebrates made up about 82% by volume of the diet of wood duck hens in Missouri during the laying period (Drobney 1980). During incubation, when protein requirements were reduced, 58.5% of the diet of the hens was plant foods. Drakes did not exhibit the same pattern of invertebrate use, indicating that hens fed selectively on invertebrates during the egg laying period. The abundance and availability of macroinvertebrates to wood duck hens during the pre-breeding period is critical to successful reproduction (Fredrickson, pers. comm.). Invertebrates made up about one-third of the fall diet of drakes and hens, and the spring diet of drakes (Drobney and Fredrickson 1979).

Ducklings less than 1 week old are dependent on animal foods (primarily insects) and forage in areas where both food and some protective cover are present (Hocutt and Dimmick 1971). The diet of ducklings is similar to that of adults by 6 weeks of age.

Water

No information on dietary water needs of the wood duck was found in the literature. However, water needs are likely satisfied in wetland habitats used by the wood duck. The remainder of this section describes those water characteristics that influence habitat use by wood ducks.

Water depth affects the quantity, variety, and distribution of cover and food, and wood duck needs are generally met between the shoreline and a water depth of 1.8 m (6 ft) (McGilvrey 1968). However, even when wood ducks feed in deeper water, the actual feeding depth is generally restricted to the top 30 cm (12 inches) of water (Fredrickson, pers. comm.). Water is critical in wood duck breeding and brood-rearing habitat from mid-January to late September in the southern United States and from mid-April to late September in the northern portions of the range. Water in most of the breeding habitat should be from 7.5 to 45 cm (3 to 18 inches) deep, still or slow-moving, and sheltered from the wind. Areas with water less than 30 cm (12 inches) deep are especially important in providing invertebrate foods for breeding wood ducks (Drobney and Fredrickson 1979). A water current of 4.8 km/hr (3 mph) has been estimated as the maximum tolerable stream flow for breeding wood ducks, although broods seldom use areas with currents greater than 1.6 km/hr (1 mph) (McGilvrey 1968).

Isolated wetlands much less than 4 ha (10 acres) in size are considered marginal brood rearing habitat (McGilvrey 1968). The more shoreline per unit area of water, the more suitable the habitat, provided the distance between opposite shores is at least 30 m (100 ft).

Cover

Suitable cover for wood ducks may be provided by trees or shrubs overhanging water, flooded woody vegetation, or a combination of these two types (McGilvrey 1968). A ratio of 50 to 75% cover to 25 to 50% open water is preferred in breeding and brood rearing habitat. Adult molting habitat is similar to brood habitat (Palmer 1976), although molting adults make greater use of herbaceous wetlands dominated by cattails and bulrushes (Bellrose, pers. comm.).

An abundance of downed timber provides suitable year-round cover (Webster and McGilvrey 1966). Young trees and mature shrubs with low overhead and lateral growth provide optimal cover for breeding adults (McGilvrey 1968). Ideal shrub cover is provided by shrubs that form a dense canopy about 0.6 m (2 ft) above the water surface. The deciduous forested types used by breeding wood ducks vary throughout their range, although wooded areas that are flooded in early spring are the most suitable nesting habitat. McGilvrey (1968) lists the following as the most important habitats for nesting wood ducks: Southern floodplain forests; red maple (Acer rubrum) swamps; Central floodplain forests; temporarily flooded oak-hickory forests; and Northern bottomland hardwoods. Buttonbush is an important source of cover for wood ducks throughout much of their range (Webster and McGilvrey 1966; McGilvrey 1968).

Winter-persistent emergents that have a life form similar to shrubs, such as cattail (Typha spp.), soft rush (Juncus effusus), bulrush (Scirpus spp.), burreed, purple loosestrife (Lythrum salicaria), and phragmites (Phragmites communis), may satisfy cover requirements where more desirable shrubs and trees are not available (McGilvrey 1968).

Wood duck brood cover is provided by a combination of downfall and woody and herbaceous emergent plants, well interspersed with small, open water channels (Webster and McGilvrey 1966; Palmer 1976). In the Mississippi Alluvial Valley, broods less than 2 weeks old typically use flooded lowland forests in order to satisfy their requirements for invertebrate foods (Fredrickson, pers. comm.). Wood ducks older than 2 weeks of age use habitats dominated by buttonbush. Wood duck broods in Massachusetts preferred areas with dense cover interspersed with small open pools, clumps of buttonbush, and muskrat houses (Grice and Rogers 1965). Buttonbush clumps and muskrat houses provided loafing sites out of the water. Optimal composition in brood habitat consists of 30 to 50% shrubs, 40 to 70% herbaceous emergents, 0 to 10% trees, and 25% open water (McGilvrey 1968). Eight wood duck broods in Florida concentrated their activities in a shrub wetland community with shrub cover greater than 76%, dominated by mature Carolina willow (Salix caroliniana) (Wenner and Marion 1981). Shrubs and/or clumped herbaceous vegetation may provide cover in areas where downed timber is not available (Webster and McGilvrey 1966). South Carolina beaver ponds that provided both shrubby and herbaceous cover received greater use by wood duck broods than ponds dominated by either shrubs or herbaceous vegetation (Hepp and Hair 1977). Shrubs provide cover, security, and loafing sites, while herbaceous vegetation provides cover and habitat for invertebrates that make up a major portion of the diet of ducklings. Emergent herbaceous vegetation that does not provide any early spring cover, especially in pure stands, does not provide much suitable brood cover (Webster and McGilvrey 1966). An abundance of downed trees in shallow water [up to 0.9 m (3 ft) deep] provides excellent brood rearing cover and "...is particularly important for early broods hatching before leaves appear on trees and shrubs and before the appearance of emergent plants" (McGilvrey 1968:11).

Emergent plants used for brood cover vary with latitude but include smartweeds (Polygonum spp.), American lotus (Nelumbo lutea), pickerelweed (Pontederia cordata), bluejoint (Calamagrostis canadensis), arrowheads (Sagittaria spp.), soft rush, spatterdock (Nuphar luteum), arrowarum, and clump sedges (Carex spp.) (McGilvrey 1968). Other important herbaceous plants are water primrose (Jussiaea spp.), reed canarygrass (Phalaris arundinacea), cattail, burreed, swamp loosestrife, and grasses.

Wood duck broods and breeding pairs require loafing sites scattered throughout their habitat for preening and sunning (McGilvrey 1968). The best loafing sites are surrounded by water, have good visibility, and are near escape cover. Loafing sites should be at least 45 by 45 cm (18 by 18 inches) in size and 5 to 15 cm (2 to 6 inches) above water. Optimal habitat contains 10 to 20 loafing sites (muskrat mounds, stumps, logs, small islands, and tussocks) per 0.4 ha (1 acre). Shorelines and points of land that are relatively bare of vegetation are marginal substitutes for more optimal loafing sites. The lack of suitable loafing sites may be a limiting factor in brood use (Beard 1964).

Wood duck broods in South Carolina used small ponds (0.03 to 0.50 ha; 0.07 to 1.2 acres) significantly more often than larger ponds (1.51 to 3.80 ha; 3.7 to 9.4 acres) (Hepp and Hair 1977).

Shrub swamps dominated by buttonbush were preferred as fall roost sites in southern Illinois over flooded forested habitats and open water (Parr et al. 1979). One such roost of 200 ha (494 acres) consisted of 60% buttonbush cover and 40% open water. Another fall roost site was dominated by American lotus, and another one was dominated by water willow (Decodon verticillatus).

Ideal winter habitat consists of a complex of wetlands centered on a permanent wetland (Fredrickson, pers. comm.). Optimum winter habitat includes scrub/shrub wetlands, emergent wetlands, dead timber, and flooded forests.

Reproduction

The distribution of breeding populations of wood ducks is closely related to "... bottomland hardwood forest with trees of sufficient size to contain usable nest cavities and water areas that satisfy food and cover requirements" (McGilvrey 1968:3). Important limiting factors include the availability of suitable nesting cavities (McGilvrey 1968), and the availability of protein foods for pre-breeding females (Fredrickson, pers. comm). Hens are most easily able to satisfy their protein requirements in flooded lowland forests, where flooding dynamics create a highly productive invertebrate food base. In the Mississippi Alluvial Valley, 1 ha (2.47 acres) of properly flooded forest can provide enough protein foods to support 800 wood ducks for 1 day (Fredrickson, pers. comm.). If it is assumed that a hen will use a flooded forest habitat for 60 days during the pre-breeding and nesting periods, then 1 ha (2.47 acres) of properly flooded forest can support about 13 hens (or 5 hens/0.4 ha [1.0 acre]) during the 60-day use period. A ratio of 8 ha (20 acres) of nesting habitat to every 0.4 ha (1 acre) of brood habitat is recommended for maximum production in areas where natural cavities provide the only potential nest sites (McGilvrey 1968). However, this ratio is based on: (1) the presence of at least 1 suitable cavity/2 ha (5 acres); and (2) the carrying capacity of each 0.4 ha (1.0 acre) of brood habitat being sufficient to accommodate broods produced by four nest cavities.

The closer the nest cavity to water, particularly to suitable brood habitat, the better (McGilvrey 1968). Cavities in trees in or near the water are preferred. Most wood duck nests in tree cavities in Massachusetts were located within 183 m (200 yds) of water (Grice and Rogers 1965). Wood ducks nesting in tree cavities in Minnesota selected cavities that were significantly closer to water and to canopy openings than were randomly sampled trees (Gilmer et al. 1978). Nest trees ranged from 0 to 350 m (0 to 383 yds) from water and averaged 80 m (87.5 yds). Twenty-one of 31 nest trees selected by radio-marked hens were within 0.5 km (0.31 mi) of permanent water, while eight nests were farther than 1.0 km (0.62 mi) from permanent water. Artificial nest sites in wooded areas are best located within 0.4 km (0.25 mi) of water, but nest boxes located up to 1.6 km (1 mi) from water may also receive use (Bellrose 1976). Nest boxes placed within 1.4 km (0.86 mi) of brood habitat in a Florida study area received significantly greater use than those placed further away (Wenner and Marion 1981).

Wood ducks generally nest in tree species that have a mature size of at least 35 to 40 cm (14 to 16 inches) dbh and a long life expectancy (Hansen 1966). The minimum-sized tree used for nesting in Minnesota was 28 cm (11 inches) dbh (Gilmer et al. 1978). Overmature and decadent trees usually contain the largest number of suitable cavities (McGilvrey 1968). Conifers (Hansen 1966) and dead trees, other than cypress, rarely provide suitable cavities (McGilvrey 1968). The most suitable cavity trees range from 60 to 90 cm (24 to 36 inches) dbh. Natural cavities used for nesting by wood ducks in Massachusetts ranged from 33.0 to 91.4 cm (13 to 36 inches) dbh, with a mean dbh of 68.6 cm (27 inches) (Grice and Rogers 1965).

Acceptable nest cavities in trees are at least 2 m (6 ft) above ground, have an entrance size of 9 to 30.5 cm (3.5 to 12 inches) in diameter, and a depth of 15 to 120 cm (6 to 48 inches) (McGilvrey 1968). Bellrose (pers. comm.) considered the minimum entrance dimensions to be 7.6 by 10.0 cm (3.0 by 4.0 inches); smaller entrances restrict many wood ducks. Optimal tree cavities, according to McGilvrey (1968) have an entrance size of 10 cm (4 inches) in diameter, a diameter at the bottom of 25 to 27.5 cm (10 to 11 inches), a cavity depth of 60 cm (24 inches), and are 6 to 15 m (20 to 50 ft) above ground. Fredrickson (pers. comm.) suggested that the optimum cavity height of 6 to 15 m, as defined by McGilvrey (1968), is simply where most suitable cavities form in trees rather than an expressed preference by nesting wood ducks. However, Bellrose et al. (1964) found an increasing index of use (i.e., use compared to availability) with increasing cavity height. A suitable cavity must drain well and preferably has its entrance protected from the weather (McGilvrey 1968). Cavity trees in southeastern Missouri were defined as all trees at least 24.1 cm (9.5 inches) dbh that contained at least one cavity with an entrance size of at least 6.4 by 8.9 cm (2.5 by 3.5 inches) (Weier 1966). Suitable cavities were those of adequate dimensions that did not have adverse features, such as water or excessive debris in the cavity or open tops above the cavity. A total of 109 cavity trees were found in three cover types, and 17 were judged to contain suitable cavities for wood ducks, a ratio of 1 suitable cavity to 6.4 cavity trees. A suitable cavity on two study areas in Massachusetts was defined as having a minimum entrance size of 6.4 by 8.9 cm (2.5 by 3.5 inches) and being within 0.8 km (0.5 mi) of water (Grice and Rogers 1965). Results were 1 suitable cavity/5.3 cavity trees (13 suitable out of 69 cavities) on one study area and 1 suitable cavity/4 cavity trees (9 suitable out of 36 cavities) on the second area.

The density of suitable cavities on two Massachusetts study areas was 2.5/2.59 km^2 (1 mi^2) and 0.6/2.59 km^2 (1 mi^2), although the estimates were based on total study area size rather than on timbered area only (Grice and Rogers 1965). The density of suitable cavities in timbered bottomland in Iowa was 1/9.7 ha (24 acres) (Dreis and Hendrickson 1952, cited by Grice and Rogers 1965). In Illinois, suitable cavities were defined as those with an entrance diameter of at least 8.9 cm (3.5 inches) and that were free of water or debris (Bellrose et al. 1964). One suitable cavity/5.3 ha (13 acres) was found in bottomland forests, and 1 suitable cavity/2.0 ha (5 acres) was found in upland woodlots. The density of suitable cavities (defined above) in three timber types in Missouri ranged from 1/1.4 ha (3.4 acres) to 1/4.2 ha (10.3 acres), and averaged 1/2.1 ha (5.2 acres) of forested habitat (Weier 1966). The highest reported density of suitable cavities [defined by an entrance diameter of at least 10 cm (3.9 inches)] was 4/ha (1.6/acre) in mature northern hardwood and mature aspen forests in Minnesota (Gilmer et al. 1978).

Interspersion

The best wood duck habitat is characterized by nest sites in close proximity to brood habitat (McGilvrey 1968). However, wood duck broods in North Carolina moved 2.4 km (1.5 mi) from a nesting pond to a shrub thicket marsh for brood rearing (Hardister et al. 1962). Although most of the movement was along a water course, overland travel of 0.16 km (0.1 mi) was required from the nesting pond to the river used for the major part of the movement. Wood duck hens and broods in Minnesota travelled overland up to 3.9 km (2.4 mi) from nest site to brood habitat (Ball 1973, cited by Gilmer et al. 1978). Wood duck broods in eastcentral Texas moved up to 11.7 km (7.7 mi) to brood habitat from nest sites located in areas without brood habitat, although overall brood survival was only 8% (Ridlehuber 1980). Management of forests for wood duck nesting cavities greater than 0.8 km (0.5 mi) from brood habitat is generally not recommended (McGilvrey 1968). Ball et al. (1975:778) found "... a significant negative linear correlation ... between distance of overland moves completed prior to 2 weeks of age and number of surviving ducklings in broods of radio-marked hens" (21 wood duck hens, 8 mallard [Anas platyrhyncos] hens). Broods that moved less than 0.8 km (0.5 mi) averaged 8.5 ducklings compared to an average of 6.8 ducklings in broods that moved greater distances. The maximum reported brood density is 17 broods on a 5.7 ha (14 acres) impoundment in Maryland (McGilvrey n.d., cited by McGilvrey 1968). In North Carolina, a 16.2 ha (40 acres) brood-rearing area supported a minimum of 27 wood duck broods in 1966 and 17 broods in 1967 (Vance 1968). Also in North Carolina, duckling density averaged about 2.0/0.4 ha (1.0 acre) of suitable brood rearing habitat and ranged from 1.6 to 2.3 ducklings/0.4 ha (1.0 acre) (Baines 1971).

McGilvrey (1969) reported a survival rate of hatched ducklings to flight stage of 53% (9.8 ducklings/brood at hatch; 5.2 ducklings/brood reaching flight stage). Ball et al. (1975) accounted for the loss of total broods, and concluded that wood duck hens successfully raised 41% of the total ducklings hatched.

Wood ducks do not maintain stable home ranges, and both the size and shape of their home ranges are flexible (Bellrose 1976). The total home range utilized by broods in South Carolina varied from 0.77 to 29.6 ha (1.9 to 73.1 acres) (Hepp and Hair 1977). Movements from fall roosts in Illinois ranged up to 10 km (6.2 mi), although most movements were within 2.2 km (1.4 mi) of the roosts (Parr et al. 1979). Areas of activity during the fall ranged from 23.9 to 186.2 ha (59 to 460 acres) and averaged 90.6 ha (224 acres). Most activity of nesting hens in Minnesota was within 1.0 km (0.6 mi) of the nest site, suggesting that a pair may use an area of approximately 3.0 km^2 (1.6 mi^2) (Gilmer et al. 1978).

Special Considerations

In areas where natural cavities are lacking or limiting, artificial nest boxes can be used to increase breeding populations (Bellrose et al. 1964). The most important factors limiting wood duck breeding populations are availability of and competition for suitable cavities, predators (McGilvrey 1968), and food (Fredrickson, pers. comm.). A nest box program that provides predator-proof nesting cavities can minimize the effects of the first two of these factors. In Massachusetts, Grice and Rogers (1965) found strong evidence that natural nest cavities were in short supply and concluded that (p. 87) "... wood ducks can be maintained at a higher level of abundance with [nest boxes] than without them". Other studies have also reported increases in breeding populations due to the use of nest boxes (Bellrose et al. 1964; Jones and Leopold 1967; Strange et al. 1971; Alexander 1977). However, some evidence exists to suggest that an excessive number of nest boxes may be detrimental to wood duck production. In California, a breeding population of wood ducks increased faster than the number of available nest sites (Jones and Leopold 1967). Over the course of the 9-year study, nest sites were gradually increased from 3 to 16 on a 11.3 ha (28 acres) marsh; an increase of breeding pairs from 3 to 35-40 occurred during the same period. At the higher levels of pair density, the population became essentially self-limiting due to intraspecific competition for nest cavities, an increase in nest desertion and dump nesting (i.e., instances in which several hens lay eggs in the same nest site), and a resultant decrease in the production of young per pair. Nest interference is also common on sites with extensive habitat where food is abundant and nest sites are limited (Fredrickson, pers. comm.). However, several researchers have reported that dump-nesting resulted in a greater production of young (Morse and Wight 1969; Clawson et al. 1979; Heusmann et al. 1980). Strader et al. (1978) cautioned that crowded nesting conditions could be detrimental to wood duck production; they observed a wood duck hen call a brood from an adjacent nest box mounted on the same support pole and abandon incubation of her own clutch.

McGilvrey (1968) recommended that nest boxes be placed in clusters of 5 to 10 spaced 15 to 30 m (50 to 100 ft) apart within clusters. Bellrose (1976) recommended that nest boxes be placed in groups of 2 to 4/0.4 ha (1.0 acre). Bellrose et al. (1964) recommended a nest box density of 2 to 3/0.4 ha (1.0 acre) in "high-quality habitat", although criteria to determine high-quality habitat were not presented. This level of nest boxes was recommended for woodlots where nesting in natural cavities was 1 pair/4.0 ha (10 acres). Additional guidelines for nest box placement are available in Bellrose et al. (1964), Bellrose (1976), and McGilvrey (1968). None of these references, however, contain information on a possible saturation level of nest boxes beyond which production would either remain constant or decrease. All of the above references note that nest boxes are effective only if they are predator-proof and regularly maintained.

Clearing of bottomland hardwoods has adversely affected wood duck populations because bottomland hardwood sites provide habitat for nesting, brood rearing, and wintering (Bellrose 1976).

HABITAT SUITABILITY INDEX (HSI) MODELS

Model Applicability

Geographic area. The two HSI models contained here have been developed for application within the breeding and wintering range of the wood duck (Fig. 1).

Season. These HSI models may be used to evaluate breeding (spring and summer) habitat and/or winter (fall and winter) habitat, depending on the residency status of the wood duck in the area to be evaluated.

Cover types. These models may be used to evaluate habitat in the following cover types (terminology follows that of U.S. Fish and Wildlife Service 1981): Deciduous Forest (DF); Deciduous Forested Wetland (DFW); Deciduous Scrub-Shrub Wetland (DSW); Herbaceous Wetland (HW); and Riverine (R). Use of unflooded deciduous forests is restricted to the breeding season model and should not be included when using the winter habitat model; however, flooded lowland deciduous forests should be included as winter habitat. Evaluation of wetlands should be restricted to those with water present during either the nesting/brood-rearing period or during the winter period, depending on the model(s) being used.

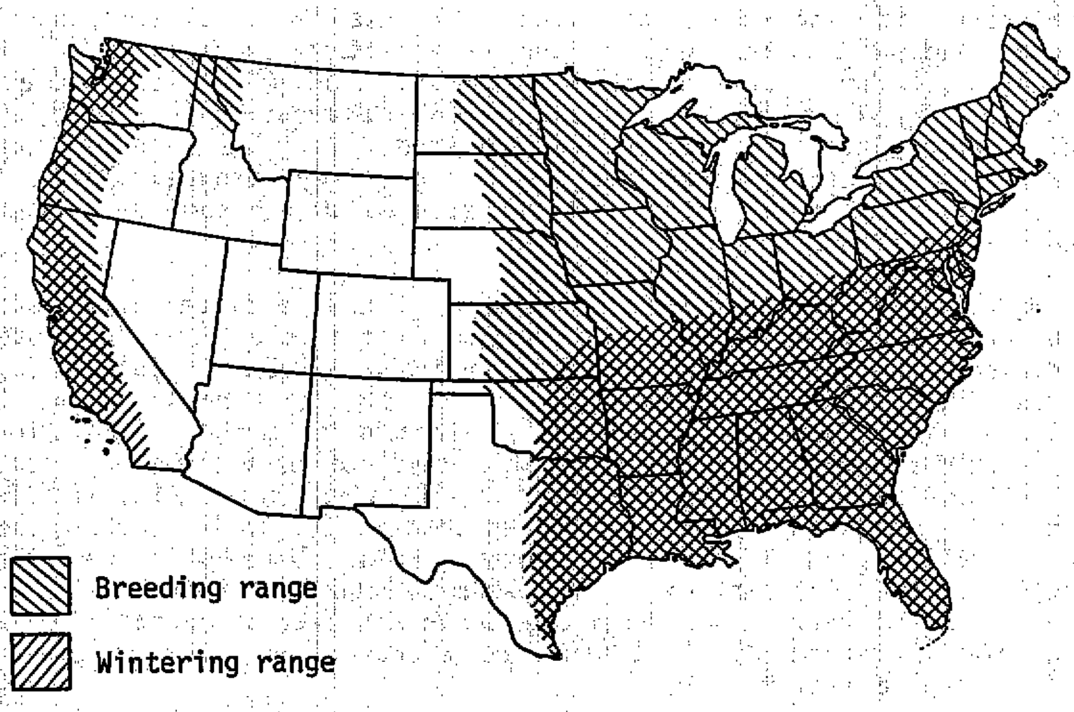


Figure 1. Geographic applicability of the wood duck HSI models within the United States (ranges from Bellrose 1976).

<u>Minimum habitat area</u>. Minimum habitat area is defined as the minimum amount of contiguous habitat that is required before an area will be occupied by a species. The minimum habitat area for broods is estimated to be 4 ha (10 acres) of any of the wetland cover types listed above. Potential brood habitat may exist either as an isolated wetland of at least 4 ha or as smaller wetlands separated by less than 46 m (50 yds) of land where the total area of potential brood habitat equals at least 4 ha. In stream or riverine habitat, small brood units should be within 0.4 km (0.25 mi) of each other. Minimum habitat area for habitat components other than brood habitat is unknown.

<u>Verification level</u>. These models have not been tested against habitats of known quality. Earlier drafts were reviewed by Drs. Leigh Fredrickson, Frank Bellrose, and Frank McGilvrey. Their review comments have been incorporated into the models.

<u>Model Description - Breeding</u>

<u>Overview</u>. The breeding season HSI model for the wood duck considers nesting and brood-rearing needs as critical components of breeding habitat. An HSI value for the breeding season considers the quality, composition, and juxtaposition of nesting and brood rearing resources. Food (vegetable and invertebrate) is considered to be correlated with vegetative cover, and the variable used to evaluate brood cover in this model is assumed to serve as a surrogate measure of food suitability. Factors other than vegetative cover

(e.g., water quality, current, depth, permanence) may affect food suitability for wood ducks, but are not included in this model due to the difficulty of establishing relationships between the variables and a measure of food suitability. This is particularly difficult for highly dynamic variables, such as flooding periodicity. The assumption that food suitability can be estimated by considering vegetative cover only is the major limitation of this model.

The following sections identify important habitat variables, describe suitability levels of the variables, and describe the relationships between variables. The relationship between habitat variables, life requisites, and cover types used in this model and an HSI value for the wood duck during the breeding season is shown in Figure 2.

Nesting component. The quality of nesting habitat is a function of the availability of nesting sites. Potential nesting sites may be either naturally occurring tree cavities or artificial nest sites in the form of nest boxes. However, the presence of natural (including those in live trees and snags) and/or artificial nest cavities does not guarantee an equivalent number of successful nests. The proportion of observed potential nesting sites that are actually suitable for wood duck nesting and the proportion of suitable nesting sites that can be expected to support successful nests are important criteria determining the number of ducklings produced in a specified area.

Grice and Rogers (1965) tallied all cavities on two study areas but defined as suitable those cavities with minimum entrance dimensions of 6.4 by 8.9 cm (2.5 by 3.5 inches) and that were located within 0.8 km (0.5 mi) of water. Only 22 of 105 cavities (20.9%) met the minimum criteria. Weier (1966) tallied all cavities within 0.8 km (0.5 mi) of water that had a minimum entrance dimension of 6.4 by 8.9 cm (2.5 by 3.5 inches), a nesting platform of at least 12.7 by 17.8 cm (5 by 7 inches), and that were located in trees with a minimum dbh of 24 cm (9.5 inches). Suitable cavities met those criteria, did not contain water or debris, and were not open-topped. Seventeen of 109 cavities (15.6%) meeting minimum criteria were classed as suitable. In order to most easily evaluate natural cavities with this model, it is assumed that a cavity is potentially useful if it has a minimum entrance size of 7.6 by 10.0 cm (3.0 by 4.0 inches) (Bellrose, pers. comm.). Based on the information presented above, it is also assumed that only 18% of observed cavities meeting this minimum criterion will actually be suitable for wood duck use. All artificial nest sites are assumed to be suitable if they are predator-proof and cleaned and repaired annually.

The second major criterion determining the number of successful nests on a given area is the proportion of suitable cavities that can be expected to produce successful nests. Bellrose et al. (1964) found that of 631 natural cavities available and structurally suitable (i.e., minimum entrance dimensions as described above and free of water or debris), 235 (37%) were used by wood ducks. Data from numerous studies summarized by Bellrose (1976) indicate that the average use of artificial nest sites is 41% (46,761 house years; 19,108 nests). However, these data for both natural and artificial sites do not take into account whether factors other than the availability of nest sites were limiting the nesting population; for example, poor quality brood-rearing

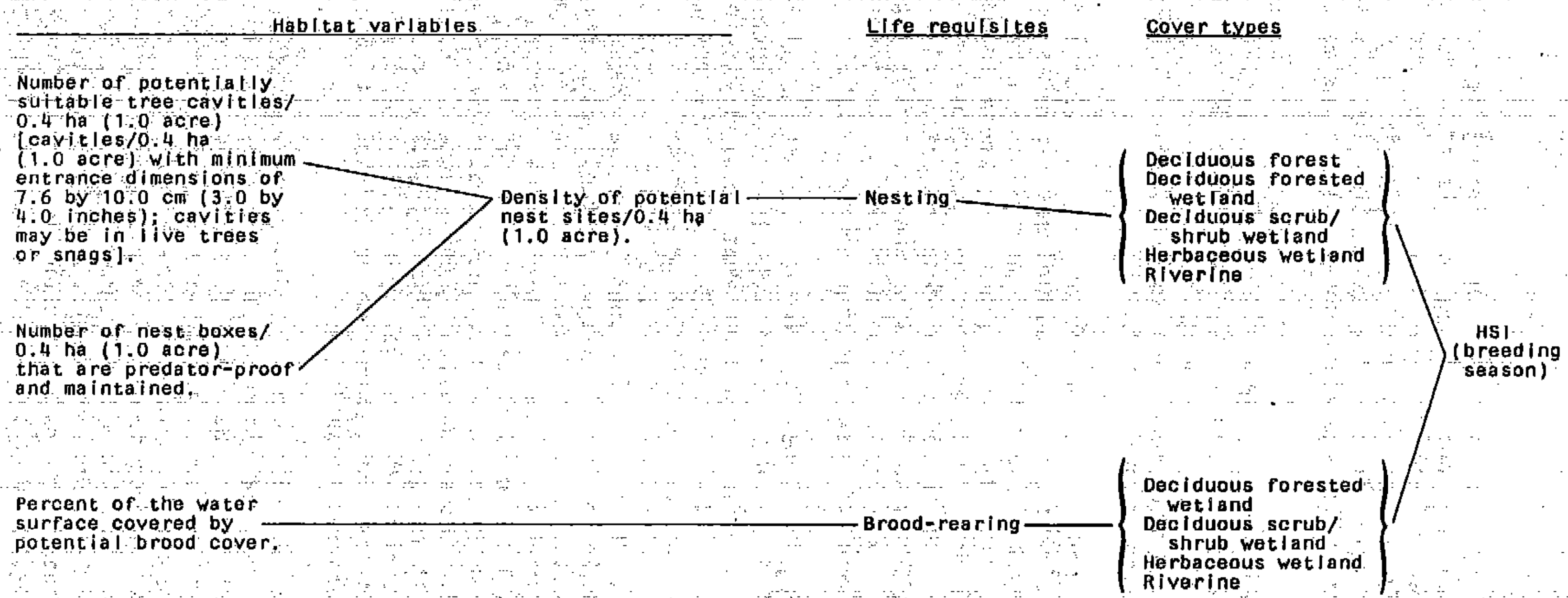


Figure 2. The relationship of habitat variables, life requisites, and cover types to an HSI value for the wood duck during the breeding season.

habitat may have limited recruitment of hens into the breeding population, or poor pre-breeding habitat may have limited the number of hens able to successfully nest. For the purposes of this model, it is assumed that all potential nest sites meeting the minimum criteria defined above may potentially be used.

If it is assumed that all suitable natural and artificial nest sites may potentially be used, then the success rate of the initiated clutches will determine the overall production of young from nest sites. The success rate of nests in natural cavities in Illinois was 49.1% (118 nests, 58 successful) from 1939-1940 and 39.9% (158 nests, 68 successful) from 1958-1961, with the lower success rate due to an increase in predation (Bellrose et al. 1964). However, the highest success rate in natural cavities reported in the literature is 52% (Prince 1965, cited by Bellrose 1976). It is assumed in this model that 52% is the best success rate that can be expected for wood ducks nesting in natural cavities.

Bellrose (1976) summarized the results of a number of studies of artificial nest sites for wood ducks. The average success rate, with individual success rates weighted by the number of nests, was 71.6%. However, the two highest reported success rates for wood ducks nesting in artificial cavities are 95%, based on 341 nests in Arkansas (Brown 1973, cited by Bellrose 1976), and 94%, based on 281 nests in Iowa (Leopold 1966, cited by Bellrose 1976). Based on this information, it is assumed in this model that 95% is the best success rate that can be expected for wood ducks nesting in nest boxes.

Based on the preceding discussion, the number of successful nests that can be expected on a given area can be determined by the following equation:

$$\text{\# of potentially successful nests} = (NT \times P1_T \times P2_T) + (NB \times P1_B \times P2_B) \quad (1)$$

where: NT = the number of tree cavities with a minimum entrance size of 7.6 by 10.0 cm

$P1_T$ = the proportion of observed tree cavities that can be expected to be suitable for nesting by wood ducks

$P2_T$ = the proportion of suitable cavities that can be expected to produce successful nests

NB = the number of available nest boxes

$P1_B$ = the proportion of nest boxes that are actually suitable for nesting by wood ducks

$P2_B$ = the proportion of suitable nest boxes that can be expected to produce successful nests

Substituting the values determined previously for $P1_T$, $P2_T$, $P1_B$, and $P2_B$ yields the following equation:

$$\# \text{ of potential successful nests} = (NT \times .18 \times .52) + (NB \times 1.0 \times .95)$$
$$= (NT \times .09) + (NB \times .95) \quad (2)$$

The maximum reported density of successful nests appears to be about 5 successful nests/0.4 ha (1.0 acre) on a North Carolina study area (Hester n.d., cited by McGilvrey 1968). Although this may not represent a stable maximum density (Bellrose, pers. comm.), it is assumed in this model that 5 successful nests/0.4 ha (1.0 acre) represents the maximum density of successful nests and therefore determines the maximum production of ducklings. Based on equation (2), this maximum density can be achieved with either 55.6 natural cavities/0.4 ha (1.0 acre) or 5.3 nest boxes/0.4 ha (1.0 acre), or by a combination of the two types of nest sites. However, this nest site density does not necessarily need to exist across an entire study area in order to have optimal habitat. The relationship between optimal nesting habitat and optimal brood-rearing habitat is discussed under the Interspersion Component section. Although some evidence exists to suggest that wood duck nesting populations can be so dense that overall production is adversely affected (Jones and Leopold 1967; Strader et al. 1978), such a relationship has not been documented to the point that a decrease in habitat suitability beyond a certain density of nesting sites can be predicted.

Brood-rearing component. The quality of brood-rearing habitat is influenced by cover, water permanence, and wetland characteristics.

Cover for wood duck broods consists of dense cover in shallow wetlands with water present throughout the period of brood occupancy. Cover can be provided by emergent herbaceous vegetation, emergent shrubs and trees with crowns within 1 m (3.3 ft) of the water surface, or woody downfall. Dense cover that is well interspersed with small open water channels provides optimal brood habitat. Optimal brood cover within a wetland is assumed to occur when the proportion of total cover in the wetland ranges from 50 to 75 %. Other factors that influence the suitability of brood habitat include water depth, quality, current, and permanence. All of these factors influence the amount of cover and the macroinvertebrate food base to a certain extent and may be highly dynamic within a wetland. It is assumed in this model that cover conditions are the reflection of the combined influence of these variables. It is assumed, therefore, that the quality of wood duck brood habitat can be evaluated solely on the basis of the amount of cover available in the wetland. A major implication of this assumption is that the abundance and quality of vegetative and invertebrate foods is indicated by the cover conditions described above. This assumed relationship may not be valid in all conditions, especially in flooded lowland forests, where an abundant detrital-based food source may be present in the absence of low, dense cover.

Interspersion component. Nesting and brood-rearing needs can be met by different cover types, and a consideration of the juxtaposition and composition of cover types providing the life requisites is necessary in order to evaluate breeding habitat suitability.

Habitat suitability is influenced by the juxtaposition of nesting and brood-rearing habitat. Optimal juxtaposition of nesting and brood-rearing resources is assumed to exist when cover types providing these life requisites are located within 0.8 km (0.5 mi) of each other. When potential nesting and brood-rearing habitats are separated by more than 3.2 km (2 mi) of upland habitats with no aquatic "travel lanes", it is assumed that the cover types are too far apart to be used by wood ducks or that mortality of ducklings travelling from the nest to brood-rearing habitat will equal 100%.

Habitat suitability is also influenced by the proportion of habitat (composition) providing nesting and brood-rearing resources. In order to determine the optimal composition of nesting and brood-rearing habitat, it is necessary to determine the number of young capable of reaching flight stage per unit area of optimal brood-rearing habitat compared to the number of young produced per unit area of optimal nesting habitat. The maximum reported density of broods is 17 broods on a 5.7 ha (14 acres) impoundment in Maryland, equivalent to 1.2 broods/0.4 ha (1.0 acre) (McGilvrey n.d., cited by McGilvrey 1968). The observed broods on a 54.7 ha (135 acres) area, including the 5.7 ha impoundment, averaged 9.8 ducklings at hatching and 5.2 ducklings reaching flight stage, a survival rate of 53% (McGilvrey 1969). The 5.7 ha impoundment, therefore, supported about 88 ducklings (i.e., 17 broods x 5.2 ducklings/brood) to flight stage, an average of 6.2 ducklings/0.4 ha (1.0 acre) of brood-rearing habitat. This level of production is considered to be the potential of optimal brood-rearing habitat for the purposes of this model.

Optimal nesting habitat was described earlier as capable of producing 5 successful nests/0.4 ha (1.0 acre). If the average clutch size in normal nests is assumed to be 12.2 (Bellrose 1976) and all eggs are assumed to hatch successfully, then 0.4 ha (1.0 acre) of optimum nesting habitat can potentially produce 61 ducklings (i.e., 12.2 ducklings/clutch x 5 clutches/0.4 ha) leaving the nest sites. The highest survival rate of ducklings reported in the literature is 53% (McGilvrey 1969). It is assumed in this model that this is the optimal survival rate of ducklings reaching brood-rearing habitat. If it is further assumed that survival from the nest to brood-rearing habitat equals 100% (i.e., interspersion is optimal), and optimal brood-rearing habitat exists, then an average of 32.3 ducklings (0.53 x 61) will survive to flight stage from the 61 ducklings produced on 0.4 ha (1.0 acre) of optimal nesting habitat. As described above, 0.4 ha (1.0 acre) of optimum brood-rearing habitat can potentially support 6.2 ducklings to flight stage. Therefore, the ratio of optimum brood-rearing habitat to optimum nesting habitat to support maximum wood duck production is approximately 5.2:1 (i.e., 32.3/6.2 = 5.2). The maximum potential production of wood ducks per unit area will occur if optimal nesting and optimal brood-rearing conditions exist on all areas under consideration. Therefore, the optimal composition of wood duck habitat is approximately 19% optimal nesting habitat ([1/5.2] x 100 = 19%) and 100% optimal brood-rearing habitat ([5.2/5.2] x 100 = 100%).

The assumptions involved in determining optimal composition of nesting and brood-rearing resources are summarized below:

1. Optimal nesting habitat will produce 5 successful nests/0.4 ha (1.0 acre).

2. Average clutch size in normal nests (i.e., non-dump nests) is 12.2, and hatching success equals 100%.

3. Survival of ducklings from nests to brood-rearing habitat equals 100%, and survival to flight stage of ducklings reaching brood-rearing habitat equals 53%.

4. Optimal brood-rearing habitat can support 6.2 ducklings/0.4 ha (1.0 acre) to flight stage.

5. Optimal habitat conditions for wood duck production consist of nesting habitat and brood-rearing habitat provided by the same cover types (i.e., all cover types provide both nesting and brood-rearing habitat).

Model Description - Winter

Overview. This winter HSI model for the wood duck considers cover as the key life requisite determining winter habitat suitability. The measurement of vegetative cover within wetlands is assumed to serve as a surrogate measure of winter food suitability. Other factors affect food suitability, but are not included in this model. The assumption that a measure of vegetative cover can be used to evaluate food suitability is a limitation of the model. The assumption may not be valid in some situations, such as when wood ducks are feeding in flooded bottomland forests, where food may be abundant in the absence of low vegetative cover. The relationship between habitat variables, winter cover, cover types, and an HSI for winter habitat of the wood duck is shown in Figure 3.

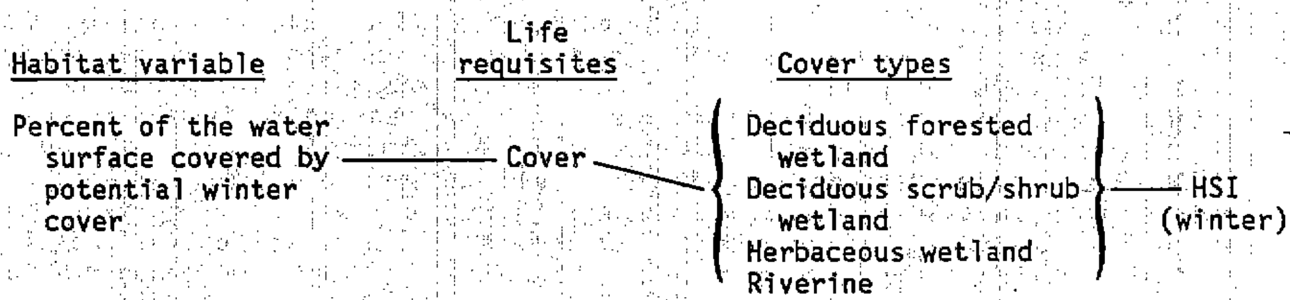
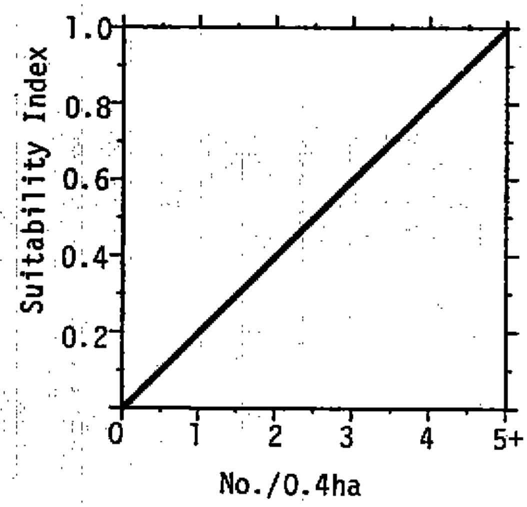
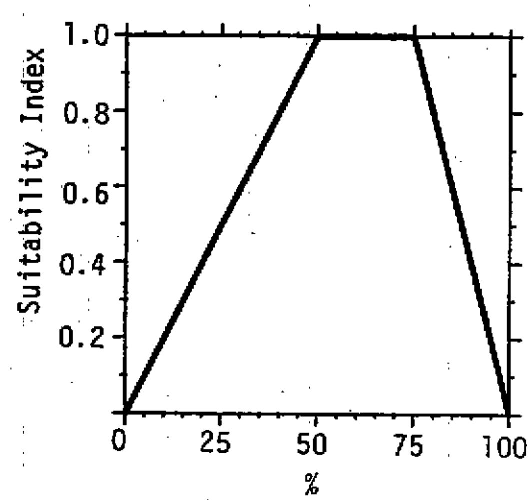


Figure 3. The relationship of habitat variables, life requisites, and cover types to an HSI value for the wood duck during the winter.

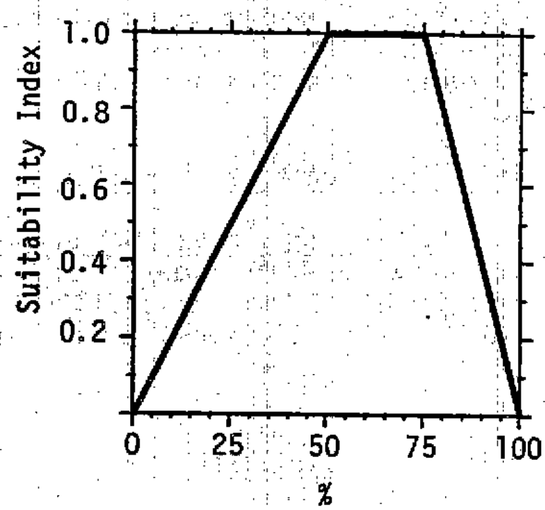
Cover component. It is assumed in this model that winter habitat needs of the wood duck are similar to habitat used during the brood-rearing period (see p. 13). Optimal conditions are assumed to be present if the amount of total cover (woody and/or herbaceous) ranges from 50-75%. Winter-persistent herbaceous plants are the only type of herbaceous vegetation considered in an evaluation of winter habitat. Water depth, quality, current, and permanence are not treated as separate habitat variables for the reasons discussed in the brood-rearing section of the breeding season model. Although acorns and other mast are an important winter food source, wood ducks will use other foods if necessary. It is assumed that food suitability will vary directly with cover suitability, and is not considered as a separate winter life requisite in this model.

Model Relationships - Breeding and Winter

Suitability Index (SI) graphs for habitat variables. This section contains suitability index graphs that illustrate the habitat relationships described earlier. Suitability index graphs for both the breeding HSI model and the winter HSI model are presented in this section.

Cover type	Variable		
DF, DFW, DSW, HW, R	V_3	Density of potential nest sites/0.4 ha (1.0 acre). Determined by the equation: (~~0.10~~ 0.09 x V_1) + (0.95 x V_2) where V_1 = the number of potentially suitable tree cavities/0.4 ha, and V_2 = the number of nest boxes/0.4 ha (see Figure 4 for complete definition of V_1 and V_2).	
DFW, DSW, HW, R	V_4	Percent of the water surface covered by potential brood cover (see Figure 4 for definition).	

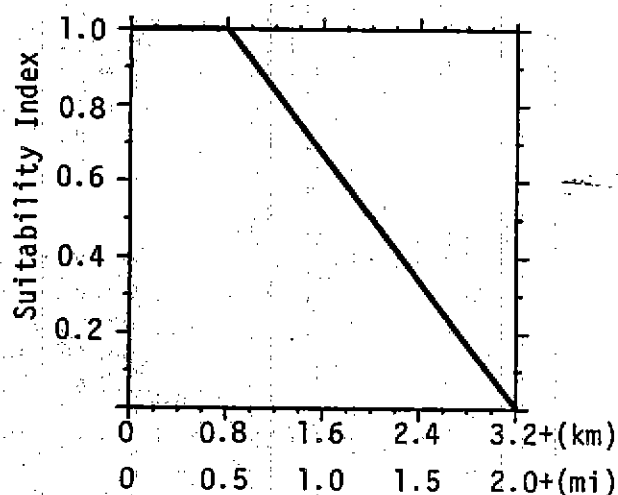
DFW,DSW, HW,R V_5 Percent of the water surface covered by potential winter cover (see Figure 4 for definition).



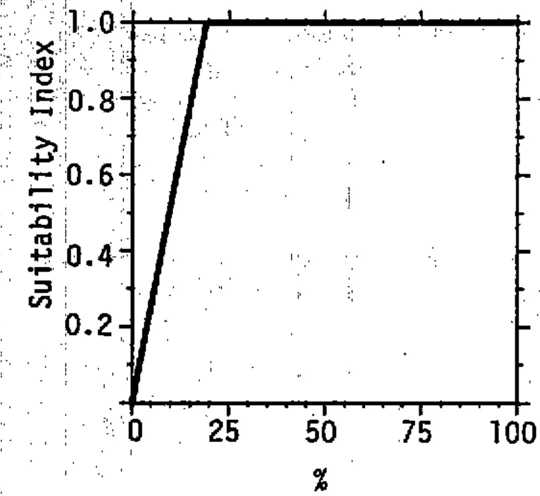
Suitability Index (SI) graphs for interspersion variables. This section contains suitability index graphs that illustrate the relationship between interspersion variables and breeding habitat suitability for the wood duck. The use of these graphs is explained under HSI determination.

Variable

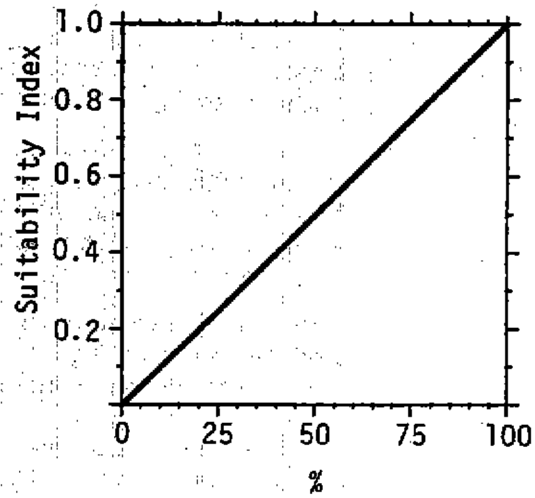
V_6 Distance between cover types.



V_7 Percent of area providing equivalent optimum nesting habitat.



V_8 Percent of area providing equivalent optimum brood-rearing habitat.



<u>Determination of life requisite values</u>. The determination of life requisite suitability indices by cover type with this model involves simple one-variable equations. The nesting value in all cover types equals the SI of V_3. Brood habitat suitability and winter habitat suitability in all cover types except deciduous forest, equals the SI of V_4 and V_5, respectively.

<u>HSI determination - breeding HSI model</u>. It is possible that some cover types will provide nesting habitat but not brood-rearing habitat, or brood habitat but not nesting habitat. In order to adequately evaluate breeding habitat, juxtaposition and composition of resources must be considered. Several steps and calculations are necessary in order to properly incorporate interspersion variables into the HSI determination. They are as follows:

1. Compute the nesting and brood-rearing values for each cover type by collecting field data for each habitat variable, entering this data into the proper suitability index curve, and using the resulting index values in the appropriate life requisite equations. If either nesting or brood-rearing equals zero in all cover types, then the HSI will equal zero and no further calculations are necessary.

2. Determine the relative area (%) of each cover type within the study area as follows:

$$\text{Relative Area (\%) for Cover Type A} = \frac{\text{Area of Cover Type A}}{\text{Total Area of All Cover Types used by the Wood Duck}} \times 100$$

Consider only those cover types used by the wood duck in determining this percentage.

3. Determine which cover types are not providing either nesting or brood-rearing habitat. For each of these cover types, a suitability index for juxtaposition of resources must be computed using V_6. This is accomplished by selecting random points on a map in each cover type missing a life requisite and measuring the distance to the edge of the nearest other cover type that provides that life requisite. Enter each distance measurement into the SI graph for V_6, record the individual interspersion indices, and calculate the average interspersion index for each cover type. If both nesting and brood-rearing habitat are provided within a specific cover type, the interspersion index equals 1.0 for the cover type.

4. Modify the relative area (%) of each cover type missing a life requisite by multiplying the relative area by the average interspersion index for that cover type. This determines the useable relative area (%) of each cover type. For those cover types that provide all life requisites the useable relative area (%) is the same as the relative area (%).

5. To determine the % area in optimum condition for any life requisite, first multiply the useable area (%) for each cover type by the life requisite values for that cover type (from 1 above). Sum the products of this multiplication across all cover types for each life requisite. The sum for each life requisite is the equivalent percent area that provides that life requisite at optimal levels (this is actually an equivalent figure, i.e., 100% of the area at a 0.5 value is equal to 50% of the area at an optimal, 1.0 value).

6. To determine overall life requisite values enter the value determined in Step 5 for nesting into the SI graph for V_7, and the value

determined for brood-rearing into the SI graph for V_8. The resulting index value from V_7 is the overall nesting value, and the index value from V_8 is the overall brood-rearing value.

7. The HSI is equal to the lowest of the overall life requisite values. This single HSI value is considered to represent breeding suitability across the entire area evaluated.

HSI determination - winter HSI model. The winter HSI for the wood duck in a specified cover type equals the winter cover value (i.e., the SI for V_5) determined for that cover type.

HSI determination for year-round use areas. The HSI models presented here are designed to evaluate breeding and winter habitat separately. In those areas where the wood duck is a resident species, it may be desirable to assign one overall HSI to a study area. In order to do so, a weighted (by cover type area) average HSI for winter habitat is determined and compared to the single HSI determined for breeding habitat. Because wood ducks may move between winter habitat and breeding habitat, the HSI in areas of permanent residency should equal the highest of the values determined for breeding and winter habitat suitability.

Application of the Models

Model limitations. These models represent a relatively simple approach to evaluating wood duck habitat suitability during the breeding season and winter. The use of cover estimates as surrogate measures of food suitability is perhaps the most important limitation of this model. Other factors that affect food suitability, such as wetland dynamics, and more direct food measurements are not included in this model because of the lack of adequate literature in these areas. Fredrickson (pers. comm.) indicates that current studies have the potential to address the unknowns in these models and that it should be possible to improve these models in the next few years. However, until such information becomes available, users should be aware of the model's limitations, especially in regards to wetland dynamics. For example, flooded lowland forests potentially provide an abundant source of macroinvertebrates to hens prior to nesting, also to broods during the first few weeks after hatching, and to wintering wood ducks. The quality of this habitat may be high even in the absence of optimum cover conditions as depicted by Variables 4 and 5 in this model. However, means to accurately and directly address the impacts of wetland dynamics on a macroinvertebrate food base are not currently available. The major problem limiting the use of the winter HSI model is that the model does not include an assessment of the importance of wetland complexes to wintering wood ducks (Fredrickson, pers. comm.). Rather, each wetland type is evaluated individually, since the means of evaluating a large variety of arrangements of wetlands is not currently available. Users of this model should use the Habitat Use Information section of this model, as well as local information, to adapt this model to local conditions, if necessary.

Use of model variables. Although these models provide a relatively simple means of evaluating the suitability of wood duck habitat, use of the breeding HSI model requires an estimate of the number of potential nest cavities in trees. Sampling of cavities in live trees is difficult and likely to provide an underestimate. Several options, other than intensive sampling, are available for estimating density of potential nest sites. In areas that are managed for wood ducks with a nest box program, optimum conditions may be provided by artificial sites alone. In cases where there are at least 5.3 nest boxes/0.4 ha (1.0 acre), optimum suitability levels have been reached, and a survey of potential natural nest sites is unnecessary. Alternatively, the potential for cavity production in various cover types can be estimated based on species composition and size classes of trees. McGilvrey (1968) provides a list of desirable tree species for cavity production by geographic region. The minimum dbh of a potential nest tree is 35 cm (14 inches), although the most suitable cavity trees range from 60 to 90 cm (24 to 30 inches) dbh. Intensive sampling of a limited area may provide an adequate estimate of cavity density, or an estimate may be interpolated from available literature (e.g., Dreis and Hendrickson 1952; Bellrose et al. 1964; Weier 1966; Gilmer et al. 1978) or provided by local knowledge.

Definitions of habitat variables and suggested field measurement techniques (Hays et al. 1981) are provided in Figure 4.

SOURCES OF OTHER MODELS

Several other attempts have been made to develop habitat models for the wood duck, including models developed for use with the Habitat Evaluation Procedures in Missouri (Flood et al. 1977; Hallett and Fredrickson 1980; Urich et al. 1983). The Missouri models provide a means of ranking habitat suitability based on habitat characteristics. Flood et al. (1977) includes the wood duck and hooded merganser (*Lophodytes cucullatus*) in a model for waterfowl in bottomland hardwood, upland hardwood, and riverine cover types. The model in Hallett and Fredrickson (1980) is intended for use in both bottomland and upland hardwood cover types and is a refinement of the model in Flood et al. (1977). The model in Urich et al. (1983) is intended for use in bottomland hardwoods and is a modification of the two previous Missouri models. The Missouri models evaluate habitat suitability only in bottomland and/or upland hardwood forests, and do not provide criteria for evaluating the suitability of other wetland types for wood ducks. They are most useful, therefore, where wood duck habitat is provided by upland hardwood forests and forested wetlands. A major difference between the Missouri models and the breeding season HSI model presented here is the method by which interspersion variables are treated. The Missouri models consider the distance between the cover type being evaluated and some critical resource (i.e., timbered habitat or permanent water) as a habitat variable. In our model, we use the distance between a cover type and a missing life requisite (i.e., nesting or brood-rearing habitat) to modify the available habitat area and also use life requisite composition suitability index curves to evaluate the balance of life requisites provided by a given area. A final major difference between the Missouri models and the breeding season HSI model presented here lies in the manner in

Variable (definition)		Cover types	Suggested technique
V_1	Number of potentially suitable tree cavities/ 0.4 ha (1.0 acre) [tree cavities/0.4 ha (1.0 acre) with minimum entrance dimensions of 7.6 by 10.0 cm (3.0 by 4.0 inches); cavities may be in live trees or snags].	DF,DFW,DSW, HW,R	Quadrat
V_2	Number of nest boxes/ 0.4 ha (1.0 acre) (the number of artificial wood duck nest sites/0.4 ha that are predator-proof and maintained).	DF,DFW,DSW, HW,R	Quadrat
V_3	Density of potential nest sites/0.4 ha (1.0 acre) (an estimate of the density of natural and artificial nest sites available to wood ducks. Determined by the following equation: $(0.18 \times V_1) + (0.95 \times V_2)$ where V_1 and V_2 are as defined above).	DF,DFW,DSW, HW,R	----
V_4	Percent of the water surface covered by potential brood cover [an estimate of the proportion of a wetland's water surface area that is covered by shrub cover, overhanging tree crowns within 1 m (3.3 ft) of the water surface, woody downfall, and herbaceous vegetation].	DFW,DSW, HW,R	Remote sensing, ocular estimation, line intercept

Figure 4. Definitions of variables and suggested measurement techniques.

Variable (definition)		Cover types	Suggested technique
V_5	Percent of the water surface covered by potential winter cover (same as for V_4 except that only winter persistent species should be considered in the herbaceous vegetation component).	DFW, DSW HW, R	Remote sensing, ocular estimation, line intercept

Figure 4. (concluded).

which HSI values are determined. The former models result in one HSI value for each cover type, while this model results in one HSI value for the aggregation of cover types used by the wood duck in a given area.

A simple approach to evaluating wood duck breeding habitat along streams was developed by Burbank (1972). This approach is based on tree size and subjective evaluation of general stand conditions. McGilvrey (1968) provides criteria that can be used to develop a habitat model for the wood duck for several geographic areas.

REFERENCES

Alexander, H. L., Jr. 1977. Mallard and wood duck brood survival at Remington Farms, Chestertown, Maryland. Trans. Northeast Fish Wildl. Conf. 34:221-230.

Baines, A. S. 1971. Estimates of the population numbers of juvenile wood ducks (Aix sponsa) on two brood rearing areas. M.S. Thesis, N.C. State Univ., Raleigh. 56 pp.

Ball, I. J., Jr. 1973. Ecology of duck broods in a forested region of north-central Minnesota. Ph.D. Thesis, Univ. Minnesota, St. Paul. 67 pp. Cited by Gilmer et al. 1978.

Beard, E. G. 1964. Duck brood behavior at the Seney National Wildlife Refuge. J. Wildl. Manage. 28(3):492-521.

Bellrose, F. C. 1976. Ducks, geese and swans of North America. Stackpole Books, Harrisburg, PA. 544 pp.

____________. Personal communication (phone conversation record 17 February 1983). Illinois Natural History Survey, Box 599, Havana, IL 62644.

Bellrose, F. C., K. L. Johnson, and T. U. Meyers. 1964. Relative value of natural cavities and nesting houses for wood ducks. J. Wildl. Manage. 28(4):661-676.

Burbank, J. H. 1972. A quick method to assess streamside wood duck breeding habitat. Proc. Southeastern Assoc. Game and Fish Commissioners 26:205-206.

Brakhage, G. K. 1966. Management of mast crops for wood ducks. Pages 75-80 in J. B. Trefethen, ed. Wood duck management and research: a symposium. Wildl. Manage. Inst., Washington, DC.

Brown, B. W. 1973. The Big Lake wood duck: a two-year study of its pre-flight mortality, nest population, growth and migration, 1970-1971. Proc. Southeastern Assoc. Game and Fish Commissioners 26:195-291. Cited by Bellrose 1976.

Clawson, R. L., G. W. Hartman, and L. H. Fredrickson. 1979. Dump nesting in a Missouri wood duck population. J. Wildl. Manage. 43(2):347-353.

Coulter, M. W. 1957. Food of wood ducks in Maine. J. Wildl. Manage. 21(2):235-236.

Dreis, R. E., and G. O. Hendrickson. 1952. Wood duck production from nest boxes and natural cavities on the Lake Odessa area, Iowa, in 1951. Iowa Bird Life 22(2):18-22. Cited by Grice and Rogers 1965.

Drobney, R. D. 1980. Reproductive bioenergetics of wood ducks. Auk 97(3):480-490.

Drobney, R. D., and L. H. Fredrickson. 1979. Food selection by wood ducks in relation to breeding status. J. Wildl. Manage. 43(1):109-120.

Flood, B. S., M. E. Sangster, R. D. Sparrowe, and T. S. Baskett. 1977. A handbook for habitat evaluation procedures. U.S. Dept. Int., Fish Wild. Serv. Resour. Publ. 132. 77 pp.

Fredrickson, L. H. Personal communication (letters dated 24 February 1983 and 11 April 1983). Director, Gaylord Memorial Laboratory, Univ. of Missouri, Puxico, MO 63960.

Gilmer, D. S., I. J. Ball, L. M. Cowardin, J. E. Mathisen, and J. H. Riechmann. 1978. Natural cavities used by wood ducks in north-central Minnesota. J. Wildl. Manage. 42(2):288-298.

Grice, D., and J. P. Rogers. 1965. The wood duck in Massachusetts. Final Rep. Fed. Aid Proj. W-19-R, Mass. Div. Fish Game. 96 pp.

Hallett, D. L., and L. H. Fredrickson. 1980. Wood duck (Aix sponsa). Pages 106-114 in T. S. Baskett, D. A. Darrow, D. L. Hallett, M. J. Armbruster, J. A. Ellis, B. F. Sparrowe, and P. A. Korte (eds.). A handbook for terrestrial habitat evaluation in central Missouri. U.S. Dept. Int., Fish Wildl. Serv. Resour. Publ. 133. 155 pp.

Hansen, H. L. 1966. Silvical characteristics of tree species and decay process as related to cavity production. Pages 65-69 in J. B. Trefethen, ed. Wood duck management and research: a symposium. Wildl. Manage. Inst., Washington, DC.

Hardister, J. P., Jr., F. E. Hester, and T. L. Quay. 1962. Movements of juvenile wood ducks as measured by web-tagging. Proc. Southeastern Assoc. Game and Fish Commissioners 16:70-75.

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

Hepp, G. R., and J. D. Hair. 1977. Wood duck brood mobility and utilization of beaver pond habitats. Proc. Southeastern Assoc. Game and Fish Commissioners 31:216-225.

Heusmann, H. W., R. Bellville, and R. G. Burrell. 1980. Further observations on dump nesting by wood ducks. J. Wildl. Manage. 44(4):908-915.

Hocutt, G. E., and R. W. Dimmick. 1971. Summer food habits of juvenile wood ducks in east Tennessee. J. Wildl. Manage. 35(2):286-292.

Jones, R. E., and A. S. Leopold. 1967. Nesting interference in a dense population of wood ducks. J. Wildl. Manage. 31(2):221-228.

Landers, J. L., T. T. Findley, and A. S. Johnson. 1977. Feeding ecology of wood ducks in South Carolina. J. Wildl. Manage. 41(1):118-127.

Leopold, F. 1966. Experiences with home-grown wood ducks. Pages 113-123 <u>in</u> J. B. Trefethen, ed. Wood duck management and research: a symposium. Wildl. Manage. Inst., Washington, DC. Cited by Bellrose 1976.

McGilvrey, F. B. 1966. Fall food habits of wood ducks from Lake Marion, South Carolina. J. Wildl. Manage. 30(1):193-195.

McGilvrey, F. B. (compiler). 1968. A guide to wood duck production habitat requirements. Bur. of Sport Fish. and Wildl., Resour. Publ. 60. 32 pp.

McGilvrey, F. B. 1969. Survival in wood duck broods. J. Wildl. Manage. 33(1):73-76.

Morse, T. E., and H. M. Wight. 1969. Dump nesting and its effect on production in wood ducks. J. Wildl. Manage. 33(2):284-293.

Palmer, R. S. (ed.). 1976. Handbook of North American birds: Volume 3. Yale Univ. Press, New Haven and London. pp. 252-277.

Parr, D. E., M. D. Scott, and D. D. Kennedy. 1979. Autumn movements and habitat use by wood ducks in southern Illinois. J. Wildl. Manage. 43(1):102-108.

Prince, H. H. 1965. The breeding ecology of wood duck (<u>Aix sponsa</u> L.) and common goldeneye (<u>Bucephala clangula</u> L.) in central New Brunswick. M.S. Thesis, Univ. New Brunswick, Fredericton. 109 pp. Cited by Bellrose 1976.

Ridlehuber, K. T. 1980. Wood duck production and habitat use. Ph.D. Diss., Texas A&M Univ., College Station. 52 pp. (Abstract only, from Diss. Abstr. Int. B Sci. Eng. 41(6):1998.)

Strader, R. W., R. E. Murry, Sr., H. R. Perry, Jr., and R. B. Hamilton. 1978. Hen wood duck calls brood from neighboring nest box. J. Wildl. Manage. 42(4):919-920.

Strange, T. H., E. R. Cunningham, and J. W. Goertz. 1971. Use of nest boxes by wood ducks in Mississippi. J. Wildl. Manage. 35(4):786-793.

Urich, D. L., J. P. Graham, and C. C. Cook (compilers). 1983. A handbook for habitat evaluation in Missouri. Missouri Dept. Conserv., U.S. Soil Conserv. Serv. (Columbia), and U.S. Fish Wildl. Serv. (Columbia). 148 pp.

U.S. Fish and Wildlife Service. 1981. Standards for the development of Habitat Suitability Index models. 103 ESM. U.S. Dept. Int., Fish Wildl. Serv., Div. Ecol. Serv. n.p.

U.S. Forest Service. 1971. Wildlife habitat management handbook. Southern Region. U.S. Dept. Agric., For. Serv. FSH 2609.23 R. n.p.

Vance, J. F., Jr. 1968. A characterization of a brood-rearing area of the wood duck (*Aix sponsa* Linneaus). M.S. Thesis, N.C. State Univ., Raleigh. 51 pp.

Webster, C. G., and F. B. McGilvrey. 1966. Providing brood habitat for wood ducks. Pages 70-75 *in* J. B. Trefethen, ed. Wood duck management and research: a symposium. Wildl. Manage. Inst., Washington, DC.

Weier, R. W. 1966. A survey of wood duck nest sites on Mingo National Wildlife Refuge in southeast Missouri. Pages 91-108 *in* J. B. Trefethen, ed. Wood duck management and research: a symposium. Wildl. Manage. Inst., Washington, DC.

Wenner, K. C., and W. R. Marion. 1981. Wood duck production on a northern Florida phosphate mine. J. Wildl. Manage. 45(4):1037-1042.

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A review and synthesis of existing information were used to develop models for breeding and wintering habitats for the wood duck (Aix sponsa). The models are scaled to produce indices of habitat suitability between 0 (unsuitable habitat) and 1 (optimally suitable habitat). Habitat suitability indices are designed for use with Habitat Evaluation Procedures previously developed by the U.S. Fish and Wildlife Service.

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12.0 RED-WINGED BLACKBIRD

General

The red-winged blackbird (Agelaius phoeniceus) is common resident to Ecoregion 2610; frequenting fresh and brackish-water marshes, grain and mustard fields, riparian areas, and agricultural lands (Peterson 1961; Small 1974).

Food Requirements

Red-winged black birds are opportunistic feeders whose diet depends on spatial and seasonal availability of animal and vegetable materials. During an outbreak of grasshoppers in San Joaquin County, "....flocks were seen at considerable distance from their usual habitat," and they, "....appeared to feed almost wholly in the infested areas..." (Bryant 1912, in Bent 1958, p. 174). From April through September, South Dakota redwing gizzards contained 61% (by vol.) vegetable matter, 25% animal matter, and 14% grit (Mott et al. 1972). Grass seeds were the preferred food item (23%) followed by corn (11%), oats (10%), wheat (7%), and Millet (3%). In California, Beal (1910; in Bent 1958) found redwings annual diet to consist of 86% vegetable and 14% animal matter. Weed seeds (15%) comprised 12 species of noxious weeds. Grains comprised 70% of the annual diet and consisted mostly of, in order of preference, oats (47%), wheat (13%), barley (5.5%), and corn (4%). The food of the "young" in Beal's study was comprised of 99% animal matter. In Wisconsin, gullet samples from nestlings yielded 97.8% animal matter (Snelling 1968).

Water Requirements

No information could be found in the literature regarding requirements for drinking. Although some nesting occurs in upland habitat, most nests are built in marsh vegetation over or near water (Bent 1958; Robertson 1971; Small 1974).

Cover Requirements

The red-winged blackbird is common throughout Ecoregion 2610 in suitable habitat - fresh and brackish water marshes, rivers, streams, lakes, ponds, meadows, and canals that support tule-cattail, margins; upland herbaceous vegetation (Bent 1958; Peterson 1961; Holcomb and Twiest 1968; Small 1974). Prefers a narrow edge of cattails, tall weeds, and blackberry tangles, adjacent to open meadows or fields; not particularly partial to deep water emergent vegetation (Udvardy 1977).

Reproductive Requirements

Nests are usually constructed in wetland vegetation such as cattails (Typha sp.) and Tules (Scirpus sp.). Nests may also be located in trees or shrubs (Bent 1958; Holcomb and Twiest 1968), on the ground (Bent of cit.), or in upland herbaceous vegetation (Holcomb and Twiest 1968; Robertson 1971). Nests suspended over water were more successful than those built in upland cover (Robertson 1972; Weatherhead and Robertson 1977).

Robertson (1971) found redwing nesting densities in Connecticut marshes to be ten times greater than in upland habitat. Predation in marsh habitats was lower than in upland habitats since nests in the former were constructed over water; predation pressure was negatively correlated with the depth of the water beneath the nest.

In Ontario marshes, reproductive success of redwings was negatively correlated with 1) Female breeding density within territories, 2) Nest height, and 3) Nest cover density, (Weatherhead and Robertson 1977). However, the opposite trend was evident for nest height in Ohio (Holcomb and Twiest 1968). This discrepancy appears to be due to differences in vegetation. The Ohio study area included many shrubs and trees of upland habitat, whereas the Ontario study area contained more typical, reedy marsh vegetation. Perhaps, within the marsh vegetation, it would be advantageous to build the nest low, in the dense cover "crown", than at the flimsy proximal end where susceptibility to wind damage might occur. Yet in the shrub and tree cover, over a terrestrial environment, the vegetation will support nests at heights, and within canopies, that will offer better protection from predators.

Special Habitat Requirements

The presence of elevated song perches may affect the selection of territories. In Wisconsin, male redwing territory holders actively defended trees as display perches (Wiens 1965). In the same area, Nero (1956) found that nearly every territory had a tree and some males, located centrally int he marsh, went out of their way to include a perch tree in their territory. Also, artificial perches were quickly utilized by males.

Interspersion Requirements

No requirements could be found in the literature regarding interspersion of habitat types. Redwings prefer the marsh habitat which is optimal for breeding (Robertson 1971). Although upland vegetation may also be utilized for breeding (Robertson 1971; Doibeer 1976), the interspersion of the two habitat types is not required.

Special Considerations

The red-winged blackbird presents both economic benefit and severe losses. Food habits of nestlings in the spring and early summer, 97-99% insects, is of obvious benefit to agriculture. However, fall and winter concentrations in southern states yield extensive crop damage with flocks up to 21 million blackbirds (in general) in Louisiana (Graham 1976). In Tennessee, "Red-wings probably had the least impact on agriculture of all roosting species" (Dolbeer et al 1978; p. 41).

In Ecoregion 2610, red-winged blackbirds primarily consume waste grain; local concentrations may cause economic losses to rice, millo, oats, wheat, barley, sweet corn, chili peppers, almonds, sunflowers, lettuce, and cattle rations in feed lots (Clark 1975).

REFERENCES CITED

Bent, A. C. 1958. Life histories of North America blackbirds, orioles, tanagers, and their allies. U.S. Natl. Mus. Bull. 211.

Clark, D. O. 1975. Vertebrate pest control handbook. Calif. State Dept. of Food and Agri. Div. of Plant Indust., Sacramento.

Dolbeer, R. A. 1976. Reproductive rate and temporal spacing of nesting of red-winged blackbirds in upland habitat. Auk 93(2): 343-355.

______________, P. O. Woronecki, A. R. Stickley, Jr., and S. B. White. 1978. Agricultural impact of a winter population of blackbirds and starlings. Wilson Bull. 90(1): 31-44.

Graham, F. 1976. Blackbirds: A problem that won't fly away. Audubon Magazine.

Holcomb, L. C. and G. Twiest. 1968. Ecological factors affecting nest building in red-winged blackbirds Bird-Banding 39(1): 14-22.

Mott, D. F., R. R. West, J. W. De Grazio, and J. L. Guarino. 1972. Foods of the red-winged blackbird in Brown County, South Dakota. J. Wildl. Manage. 36(3): 983-987.

Nero, R. W. 1956. A behavior study of the red-winged blackbird. II. Territoriality. Wilson Bull. 68(2): 129-150.

Peterson, R. T. 1961. A field guide to western birds. (2nd Ed.) Houghton Mifflin Co. Boston: 309 p.

Robertson, R. J. 1971. Optimal niche space of the red-winged blackbird (Agelaius phoeniceus). I. Nesting success in marsh and upland habitat. Can. J. Zoo. 50(2): 247-263.

Small, A. 1974. The birds of California. Macmillan Publ. Co. Inc. New York 309 p.

Snelling, J. C. 1968. Overlap in feeding habits of red-winged blackbirds and common grackles nesting in cattail marsh. Auk 85(4): 560-585.

Udvardy, M. D. F. U. 1977. The Audubon Society field guide to North American birds - western region. Alfred A. Knopf, N.Y. 856 p.

Weatherhead, P. J. and R. J. Robertson. 1977. Harem size, territory quality, and reproductive success in the red-winged blackbird (Agelaius phoeniceus). Can. J. Zoo. 55(8): 1261-1267.

Weins, J. A. 1965. Behavioral interactions of red-winged blackbirds and common grackles on a common breeding ground. Auk 82(3): 356-374.

ADDITIONAL REFERENCES

Case, N. A. and O. H. Hewitt. 1963. Nesting and productivity of the red-winged blackbird in relation to habitat. Living bird 2:7-20.

Fisher, R. B. 1953. Winter feeding of the red-wing (Agelaius phoeniceus). Auk 70(4): 496-497.

Goddard, S. V. and V. V. Board. 1967. Reproductive success of red-winged blackbirds in north central Oklahoma. Wilson Bull. 79(3):283-289.

Holcomb, L. C. 1971. Nest building and egg laying by red-winged blackbirds in response to artificial manipulations. Auk 88(1): 30-34.

Meanley, B. and J. S. Webb. 1963. Nesting ecology and reproductive rate of the red-winged blackbird in tidal marshes of the upper Chesapeake Bay region. Chesapeake Sci. 4(2): 90-100.

GUIDELINES FOR DETERMINING HABITAT SUITABILITY INDEX (HSI)

Species: Red-winged Blackbird (Agelaius phoeniceus)
Covertypes: Herb-Dominated Wetland and Cropland
Ecoregion: 2610 - The Central Valley of California

HABITAT RELATIONSHIPS

Range Size

Highly variable depending upon suitability of habitat and local crop conditions.

Optimum Habitat Composition

Margins of tule - cattail marshes with elevated song perches. Upland vegetation such as wheat, oats, barley, shrubs, and trees are also utilized but in terms of nesting success, they are less than optimal.

Life Requisite Values

Food - Related to the annual abundance and availability of grain and weed seeds. [V_1]

Water - The availability of permanent water sources is apparently limiting only by its required pressence to support tule - cattail marsh vegetation; redwings' optimum breeding cover.

Cover - No specific winter cover requirements were found in the literature. Presumably, herb-dominated wetland, cropland, and their vegetative associations provide sufficient winter cover.

Reproduction - Related to the habitat type, depth of water beneath nests, height of nests, density of nesting cover, and abundance and availability of insects for nestings. [V_2]

Mechanism to Determine the Habitat Suitability Index (HSI)

The HSI equals the lowest of the Life Requisite Values.

HSI ($\leq$1.0) = ________________

HABITAT EVALUATION CRITERIA

Food - Related primarily to the abundance and availability of grain crops and weedy fields as follows.

Food Value is a function of:

$[V_1]$ The availability of grain and weed seeds within 0.8 km (0.5 mi) of sample site.

(a) Grain and weed seeds abundant and readily available . . . . (0.8 - 1.0 rating)

(b) Grain and weed seeds scattered and not abundant . . . . (0.3 - 0.7 rating)

(c) Grain and weed seeds scarce or not available . . . . (0.0 - 0.2 rating)

Food Value $[V_1]$ = ____________________

Reproduction - Evaluate reproduction primarily by averaging the following criteria.

Reproductive Value is a function of:

$[V_2]$ I. the type of nesting habitat.

(a) Herb-dominated wetland with abundance of cat-tails and tules in shallow (<75 cm) margins with extended perch sites . . . . . (0.8 - 1.0 rating)

(b) Herb-dominated wetland lacking an abundance of cattails and tules, vegetation in deeper water (> 75 cm), or elevated perch sites lacking or nearly so . . . . (0.5 - 0.7 rating)

(c) Upland habitat of grasses (including grains), pasture, shrubs, or trees; cattail or tules in small strips (e.g. irrigation canal) . . . . (0.0 - 0.4 rating)

II. In wetland habitat.

A. Estimated depth of water beneath nests or potential nest sites.

(a) 26 - 50 cm (10.2 - 19.7 in) . . . . (0.8 - 1.0 rating)

(b) 0 - 25 cm (9.8 in) . . . . . (0.5 - 0.7 rating)

(c) 51 - 75 cm (20.1 - 29.5 in) . . . . (0.3 - 0.4 rating)

(d) >75 cm (29.5 in) . . . . (0.0 - 0.2 rating)

B. Density of nest cover over water.

(a) Relatively open . . . . (0.7 - 1.0 rating)

(b) Moderately dense . . . . (0.4 - 0.6 rating)

(c) Relatively dense . . . . (0.0 - 0.3 rating)

C. Height, or potential height of nests.

(a) 0 - 40 cm
(0 - 15.7 in) . . . . (0.8 - 1.0 rating)

(b) 41 - 80 cm
(16.1 - 31.5 in) . . . . (0.4 - 0.7 rating)

(c) >80 cm (31.5 in) . . . . (0.0 - 0.3 rating)

III. In cropland and associated upland vegetation.

A. Height, or potential height of nests.

(a) >121.9 cm (48 in) . . . . (0.8 - 1.0 rating)

(b) 61.0 - 121.9 cm
(24 - 48 in) . . . . (0.5 - 0.7 rating)

(c) <61.0 cm (24 in) . . . . (0.0 - 0.4 rating)

IV. Abundance and availability of insects during the breeding season - spring and early summer.

(a) Abundant . . . . (0.8 - 1.0 rating)

(b) Moderately abundant . . . . (0.3 - 0.7 rating)

(c) Scattered or scarce . . . . (0.0 - 0.2 rating)

Reproductive Value [V_2] equals . . .

IN HERB-DOMINATED WETLAND . . .

$$V_2 = (I + IIA + IIB + IIC + IV) \div 5$$

V_2 = ______________________

IN CROPLAND AND ASSOCIATED UPLAND VEGETATION . . .

$$V_2 = (I + III + 4) \div 3$$

V_2 = ______________

If the sample site is in or near areas where both types occur AND breeding takes place in both, average all applicable parameters.

Other Considerations

In addition to those parameters identified as being important to the red-winged blackbird, there may still be other pertinent evaluation criteria obvious only at an on-site inspection. All criteria identified as being unique to a specific site must be incorporated (and documented) into the appropriate life requisite category as each situation dictates, and considered when determining the HSI.

If any criteria listed are not applicable in a particular situation, do not use in determining the life requisite value or the HSI.

14.0 CALIFORNIA GROUND SQUIRREL

General

The California ground squirrel (Spermophilus beecheyi), sometimes referred to as the beechey ground squirrel, is common throughout much of Ecoregion 2610. Its range extends south from south-central Washington to northern Baja California, through western Oregon and California (Burt and Grossenheider 1964; Ingles 1965; MacClintock 1970; Orr 1971).

This ground squirrel occupies a variety of open habitats in the Central Valley. It can be found in most agricultural land, grassland, plains, small meadows, open rocky places, and on slopes with scattered trees; it avoids areas with dense stands of brush, trees, tall grasses, or herbaceous annual vegetation.

Food Requirements

The diet of the California ground squirrel varies seasonally and includes green herbage, seeds, nuts, bulbs, acorns, agricultural row crops, orchard crops, grains and pasture (Martin et al. 1961). On the San Joaquin Experimental Range, Schitoskey and Woodmansee (1978) found nonlegume forbs to be the most prevalent forage plants in the ground squirrel's annual diet. Over a fifteen month sampling period, the percent composition of dietary elements are as follows:

Nonlegume Forbs	46.4%	Grasses	16.0%
Legumes	19.0%	Miscellaneous	1.5%
Woody Vegetation	17.1%		

Within the San Joaquin Experimental Range, Filaree (Erodium spp.) is the most important nonlegume forb (Fitch 1948; Schitoskey and Woodmansee 1978); comprising 50.2 percent of the nonlegume forbs used and 23.3 percent of the annual diet (Schitoskey and Woodmansee 1978). Filaree forms the bulk of the diet, on the Experimental Range, through winter and spring (Fitch 1948). For detailed diet and seasonal shifts, the reader is referred to: Evans and Holdenried (1943); Fitch (1948); Schitoskey and Woodmansee (1978).

Although only a small proportion of the diet, California ground squirrels have been observed to occasionally seek animal food (Fitch 1948). Linsdale (1946) and Fitch (1948) both report active predation upon grasshoppers and small birds caught in squirrel traps. Linsdale described a tendency of ground squirrels to colonize near chicken enclosures and frequently raid both chicken feed and eggs. Fitch (1948) additionally reports the following predatory observations: eggs of gopher snakes, quail, killdeer and mourning doves; young cottontails removed from their nests; pocket gophers; kangaroo rats; and other ground squirrels killed by accident, poison, or disease.

Many authors agree that the California ground squirrel's habitat has greatly expanded with the introduction of agriculture to Ecoregion 2610. Some of the new food items added to this squirrel's diet are as follows: grain (all types); fruits and nuts including almonds, apples, apricots, peaches, pistachios, prunes, oranges, tomatoes and walnuts; seedlings of certain vegetables and field crops such as sugar beets and cotton; bark of young orchard trees (Clark 1975). Tomich (1962) reports an agricultural setting, in the Sacramento Valley, in which the California ground squirrel thrives as: typically large farms of barley, grain hay, milo maize, tomatoes, sugar beets and dry beans; irrigated pasture, stubble, and grassland grazed by sheep and beef cattle; fallow land and field borders of weedy annual vegetation. Additionally, permanent burrow systems develop in uncultivated fenceline margins providing "...a choice of crops on either side of a fence, as well as of a variety of wild annual weeds along the fenceline or fallow land" (Tomich 1962, p. 215).

Winter hibernation is common to most ground squirrels; the frequency and timing of which varies according to geographical variations of environmental conditions (Linsdale 1946; Fitch 1948). Fat storage and food caches enables ground squirrels to remain below the surface through most, if not all, of the wet and cold season. Therefore, food requirements for winter are actually more closely related to food availability in the fall.

Water Requirements

Of the literature reviewed, very little addressed the issue of moisture requirements or acquisition by the California ground squirrel. However, from studies of grassland populations in southern California, it is believed that the moderate minimum water requirement of 1.2 percent body weight per day is satisfied by a seasonal shift of diet (Baudinette 1974). Fitch (1948, p. 541) suggests that "...the succelence available in tarweed [*Madia* spp.] may be a vital factor in providing them with the necessary amount of moisture," in the dry season.

Estivation (summer dormancy), on stored body fat, occurs in many California ground squirrels. There is a greater tendency for adults, particularly females, to estivate than for young squirrels (Evans and Holdenried 1943; Fitch 1948). This relieves water stress in estivating individuals and reduces intraspecific competition for water sources (i.e., succulent vegetation) among the nondormant segment of the population.

Besides the introduction of new succelent food items into the ground squirrels diet, agriculture provides free water by summer irrigation of even the driest parts of the Central Valley. According to Grinnell and Dixon (1918, in Linsdale 1946) ground squirrels will travel up to a quarter of a mile for water where surface water is available; however, populations still thrive where it is not. Linsdale (1946) further reports observations of free water sources used by ground squirrels as follows: streams and creeks; fog, dew and rain water condensed on broad leaf vegetation; and watering troughs.

Cover Requirements

In Ecoregion 2610, California ground squirrels occupy a variety of habitats, principally characterized as open areas. These include: agricultural pasture and grain fields (Tomich 1962; Burt and Grossenheider 1964; Orr 1971; Clark 1975), orchards (Ingles 1965; Clark 1975), and field crops (Clark 1975); slopes, with scattered trees, and rocky places (Burt and Grossenheider 1964;

MacClintock 1970; Clark 1975); plains and small meadows (MacClintock 1970); open grassland (Evans and Holdenriod 1943); suitable open areas in riparian forest (Roberts et al. 1977).

Surface cover requirements of these ground squirrels appear to be not what vegetation is present, but more or less what vegetation is not present. Escape, reproduction, resting, shelter, and foraging cover is provided almost exclusively by extensive communal burrow systems, with many entrances and simple, singular emergency burrows. Almost all activities are carried on within 137.2 m (150 yds) from the burrow complex (Evans and Holdenried 1943; Fitch 1948; MacClintock 1970; Clark 1975) thus permitting quick access to one of the system's entrances or to an outlying emergency borrow. Therefore, surface cover preferences seem to be for open areas with conspicuously short vegetation; which extends the visibility range for predator detection. California ground squirrels avoid tall, dense vegetation such as heavy brush or dense stands of trees (Evans and Holdenried 1943; Burt and Grossenheider 1964; Clark 1975) and even dense stands of tall grasses and herbaceous annual vegetation (Evans and Holdenried 1943; Linsdale 1946; Tomich 1962).

Owings et al. (1977) observed that California ground squirrels often use promontories (logs, mounds, stones, etc.) when assuming alert postures. In another study, Owings and Borchert (1975) found a partial correlation ($r=0.62$) between promontory and burrow location; which probably offset visual obstruction by the tall grasses present in the area. According to Linsdale (1946), large boulders, mounds, trees, stumps, and fence posts serve ground squirrels as basking and lookout areas. Rocky outcrops and trees also served to anchor and protect burrow systems.

Agricultural land use and grazing have greatly increased suitable habitat for California ground squirrels by reducing excess cover and introducing new food items (Linsdale 1946; Orr 1971). Grazing, in particular, improves ground squirrel habitat by reducing excessive growth (Evans and Holdenried 1943; Linsdale 1946). Tomich (1962) found a large colony in an area of sparse, low cover. However, vegetation of barley and mustard grew to heights between five and seven feet the following year and all but eliminated ground squirrels in that area. Tomich further suggested that excessive rainfall is the most adverse environmental factor affecting these squirrels. Dry years provide adequate seed production and reduces cover which, with the addition of squirrel and cattle grazing, maintains open ground.

Interspersion Requirements

No specific interspersion requirements could be found in the literature. Limited interspersion appears to be tolerated by ground squirrels, so long as the physiognomy of the land is relatively open. Interspersion of scattered trees, bushes and/or inanimate objects (boulders, stumps, fence posts, etc.) may actually be perferred for use as basking and/or lookout perches; particularly where grasses and forbs are several feet tall.

Reproductive Requirements

In Ecoregion 2610, the ground squirrel primarily breeds during the first half of the year (Clark 1975). In northern California, the breeding season runs from February through April (Evans and Holdenried 1943).

No specific requirements were found in the literature.

Special Habitat Requirements

No special habitat requirements were found in the literature.

Special Considerations

Many authors report on the agricultural pest status of the California ground squirrel. All of the crop types listed in the "food requirements" section above are damaged to some extent by ground squirrels.

This common ground squirrel is associated with several human diseases. On this subject, Clark (1975) summarizes:

> Ground squirrels are frequently named as causal agents in human cases of sylvatic (bubonic) plague in California. Circumstantial evidence points to ground squirrels as the host to plague-infected fleas in over half the reported human plague cases in California in the last 40 years. Ground squirrels are not the "reservoir" hosts of the disease; apparently wild mice (and their fleas) are the reservoir hosts from which the disease periodically spreads to other rodents. Records of the incidence of plague in wild mouse and squirrel populations show some areas of the state to be "high risk" areas, while the disease is rare in other areas. Ground squirrels are themselves susceptible to plague, and insecticides have been used as a preventive measure in some recreation areas to kill the fleas, with the result that both human and squirrel populations were protected from the disease. Ground squirrels are also associated with the spread of Rocky Mountain spotted fever, rat bite fever, tularemia, Chagas' disease, adiospiromycosis and encephalomycarditis.

It has long been felt that ground squirrel foraging is in direct competition with cattle grazing on rangeland (Fitch 1948; Clark 1975). However, a recent controversy has emerged on this subject. Schitoskey and Woodmansee (1978) studied the California ground squirrel's diet and energy requirements, at the San Joaquin Experimental Range (where previous cattle-squirrel relationships have been studied) and concluded that 1) the diets of cattle and ground squirrels were generally dissimilar and 2) ground squirrel consumption of the net above ground plant production was only a small amount. Further research is apparently needed to develop a final conclusion.

REFERENCES CITED

Baudinette, R. V. 1974. The physiology of chronic water deprivation in the California ground squirrel (Spermophilus beecheyi): relevance to natural populations. J. Zoo, Lond. 173:159-171.

Burt, W. H. and R. P. Grossenheider. 1964. A field guide to the mammals. 2nd Ed. Peterson Field Guide Series. Houghton Mifflin Co., Boston. 284 p.

Clark, D. O. 1975. Vertebrate control handbook. Calif. Dept. of Food and Agric., Div. of Plant Industry. Sacramento.

Evans, F. C. and R. Holdenried. 1943. A population study of the beechey ground squirrel in central California. J. Mamm. 24:231-260.

Fitch, H. S. 1948. Ecology of the California ground squirrel on grazing lands. Amer. Mid. Nat. 39(3):513-596.

Ingles, L. G. 1965. Mammals of the Pacific States. Stanford Univ. Press, Calif. 258 p.

Linsdale, J. M. 1946. The California ground squirrel. Univ. Calif. Press, Berkeley. 475 p.

MacClintock, D. 1970. Squirrels of North America. Van Nostrand Reinhold Co., N.Y. 184 p.

Martin, A. C., H. S. Zim, and A. L. Nelson. 1961. American wildlife and plants - a guide to wildlife food habits. Dover Publ., Inc. N.Y. 500 p.

Orr, R. T. 1971. Mammals of North America. Double Day & Co., Inc. N.Y. 250 p.

Owings, D. H. and M. Borchert. 1975. Correlates of burrow location in beechey ground squirrels. Great Basin Nat. 35:402-404.

__________, __________, and R. Virginia. 1977. The behavior of California ground squirrels. Anim. Behav. 25:221-230.

Roberts, W. G., J. G. Howe, and J. Major. 1977. A survey of riparian Forest Flora and Fauna in California, pp. 3-19. In: Sands, A. (Ed.). Riparian Forests in California. Inst. of Ecol. No. 15. Univ. Calif., Davis. 122 p.

Schitosikey, F. and S. R. Woodmansee. 1978. Energy requirements and diet of the California ground squirrel. J. Wildl. Manage. 42(2):373-382.

Tomich, P. Q. 1962. The annual cycle of the California ground squirrel, Citellus beecheyi. Univ. Calif. Publ. in Zoo. 65(3):213-282.

ADDITIONAL REFERENCES

Glading, B. 1938. Studies of the nesting cycle of the California valley quail in 1937. Calif. Fish and Game. 24:318-340.

Grinnell, J. and J. Dixon. 1918. Natural history of the ground squirrels of California. Monthly Bull. State Comm. Hort. 1:597-708.

Howard, W. E., K. A. Wagnon, and J. R. Bentley. 1959. Competition between ground squirrels and cattle for range forage. J. Range Manage. 12:110-115.

GUIDELINES FOR DETERMINING HABITAT SUITABILITY INDEX (HSI)

Species: California Ground Squirrel (*Spermophilus beecheyi*; Formerly Beechey Ground Squirrel)

Cover Types: Grassland; Agricultural Field and Row Crops; Deciduous Treeland (Orchards)

Ecoregion: 2610 - The Central Valley of California

HABITAT RELATIONSHIPS

Range Size

Almost all activities take place within 137.2 m (150 yds.) from the ground squirrel's burrow system; or about 5.9 ha (14.3 ac.) in extent. However, some movements to 1,097 m (1,200 yds) have been detected (Evans and Holdenried 1943). The home range may be permanently maintained or shifted to a new area, depending upon annual shifts in environmental conditions. Young of the year have the greatest tendency to establish adult ranges in new territory; always in areas of lower squirrel density.

Optimum Habitat Composition

Linsdale (1946; p. 450) concluded that a favored living place for ground squirrels, in the grassland community of the Hastings Natural History Reservation (Monterey County), has "...scattered trees, scattered bushes, sparse low grass, dry, loose soil, an area which slopes toward the sun, moderate sunshine, dryness, few carnivores, moderate heat, moderate humidity, light wind, protective obstacles, light, burrows, and other squirrels." Tomich (1962) reports on agricultural setting, in the Sacramento Valley, in which the California ground squirrel thrives as: typically large farms of barley, grain hay, milo maize, tomatoes, sugar beets and dry beans; irrigated pasture, stubble, and grassland grazed by sheep and beef cattle; fallow land and field borders of weedy annual vegetation.

Life Requisite Values

Food - Related to the abundance, availability and diversity of green herbage, seeds, nuts, bulbs, acorns and many agricultural row crops, orchard crops, grains and pasture. [V_1]

Water - The absence of free water is not limiting to California ground squirrels as feeding patterns are shifted towards greater succulence during dry parts of the year and adult squirrels estivate ("summer sleep") in their borrows, thus escaping the dry conditions. However, where free water is available, ground squirrels will exceed their normal home range to drink. [V_2]

Cover - Related primarily to the physiognomy of the sample site and the presence of burrows. Prefered sample sites include an open character with sparse, low vegetation of grasses and weedy annual forbs. Due to summer estivation and winter hibernation, above ground activity of squirrels may be difficult to detect during some months; particularly August-September and December-January, respectively. Hence, the presence of burrows indicate present use of the area by these squirrels. Even abandoned burrows may be recolonized as environmental conditions change; either on the sample site or in adjacent areas (i.e., dispersement of young-of-the-year). [V_3]

Interspersion - Habitat interspersion, or the lack thereof, is not limiting to the California ground squirrel, so long as the "open" character of the area is maintained. However, ground squirrels prefer a pseudointerspersion of scattered inanimate objects (e.g., fence posts, stumps, mounds, rocks, etc.), bushes, and trees for use as basking and "lookout" promontories. [V_4]

Mechanism to Determine the Habitat Suitability Index (HSI)

The HSI equals the mean of the above Life Requisite Values.

HSI ($\leq$1.0) = ______________

HABITAT EVALUATION CRITERIA

Food - Related to the abundance, availability, and diversity of green herbage, seeds, nuts, bulbs, and agricultural row crops, orchard crops, grains, and pasture. In natural areas, nonlegume herbs form the bulk of the ground squirrels diet, particularly tarweed (*Madia* spp.) and filaree (*Erodium* spp.). Acorns, when present, form an important winter food as they are cached during fall months. During sample site inspections, optimal diversity is difficult to assess because it includes seasonal changes in the annual vegetation. However, the optimum includes dominance by nonlegume forbs followed by equal abundance of grasses, legumes and in some areas, woody vegetation.

Food Value is a function of:

[V_1] The abundance, availability, and diversity of suitable food types within 137.2 m (150 yds.) from the sample site.

(a) Suitable food types abundant, readily available, and diverse with nonlegume forbs dominant; within 137.2 m (150 yds.) from sample site . . . . (0.8 - 1.0 rating)

(b) Suitable food types scattered, less abundant (medium density), less available (concentrated from 68.6 - 137.2 m or 75 - 150 yds.), or less diverse (nonlegume forbs less than dominant) . . . . (0.4 - 0.7 rating)

(c) Suitable food types scarce, not available within 137.2 m (150 yds) or of monotypic diversity . . . . (0.0 - 3.0 rating)

Food Value [V_1] = ____________________

Water - Related to the availability of free water. Since the lack of free water is not limiting to ground squirrels, low ratings do not apply. However, the presence of free water does improve the habitat suitability of the area and increases the HSI of the sample site.

Water Value is a function of:

[V_2] The availability of free water within 402 m (0.25 mi) from the sample site.

(a) Free water available within 137.2 m (150 yds) . . . . (0.8 - 1.0 rating)

(b) Free water available between 137.2 m (150 yds) and 402 m (0.25 mi) . . . . (0.6 - 0.7 rating)

(c) Free water not available within 402 m (0.25 mi) . . . . DO NOT USE AS A LIFE REQUISITE VALUE IN THE HSI FORMULA BELOW.

Water Value [V_2] = ____________________

Cover - Related not to what vegetation is present, but more or less to what vegetation is not present; i.e., the "open" character of the land. California ground squirrels prefer surface cover which is "open" with conspicuously short vegetation which extends the visibility range for predator detection. Also related to the presence of burrows, active or abandoned, which provides for the rearing of young, hibernation and estivation, food caches, escape cover, and shelter from the elements.

Cover Value is a function of:

[V_3] The presence of burrows and the "openness" of the area within 137.2 m (150 yds) from the sample site.

(a) Grasses and forbs less than 0.3 m (1 ft.) tall, scattered (low density), and burrows abundant . . . . (0.8 - 1.0 rating)

(b) Grasses and forbs between 0.3 - 0.6 m (1-2 ft.) tall, of medium density, runways present, and/or burrows present but scattered . . . . (0.4 - 0.7 rating)

(c) Grasses and forbs taller than 0.6 m (2 ft.), dense, lacking runways, and/or burrows scarce or unavailable . . . . . . (0.0 - 0.3 rating)

Cover Value [V_3] = ________________

Interspersion - Related to the absence of interspersion between grassland, agricultural land, open rangeland, or any other open areas with dense shrubs and trees. Ground squirrels prefer open areas with scattered trees, bushes, or inanimate objects (e.g., fence posts, stumps, mounds, rocks, etc.) for use as basking and "lookout" promontories.

Interspersion Value is a function of:

[V_4] The "open" character of the area within 137.2 m (150 yds) from the sample site and the presence of promontories.

(a) Sample site conspicuously open with well scattered, equally spaced promontories . . . . (0.8 - 1.0 rating)

(b) Sample site conspicuously open with scattered inanimate promontories and small, moderately dense clumps of trees or bushes . . . . (0.5 - 0.7 rating)

(c) Sample site moderately open with moderate interspersion of trees and shrubs . . . . (0.3 - 0.4 rating)

(d) Sample site partially open with open grassy areas well interspersed with dense stands of trees and shrubs or area predominantly trees and shrubs . . . . . (0.0 - 0.2 rating)

Interspersion Value [V_4] = ______________

Habitat Suitability Index (HSI) Determination

For sample sites with free water available within 402 m (0.25 mi):

$$HSI\ (\leq 1.0) = [V_1 + V_2 + V_3 + V_4] \div 4$$

HSI = ________________

For sample sites without free water available within 402 m (0.25 mi):

$$HSI\ (\leq 1.0) = [V_1 + V_3 + V_4] \div 3$$

HSI = ________________

Other Considerations

In addition to those inventory characteristics identified as being important for the California ground squirrel, there may still be other pertinent evaluation criteria obvious only at an on-site inspection. All criteria identified as being unique to a specific site must be incorporated (and documented) into the appropriate life requisite category as each situation dictates and considered when determining the HSI.

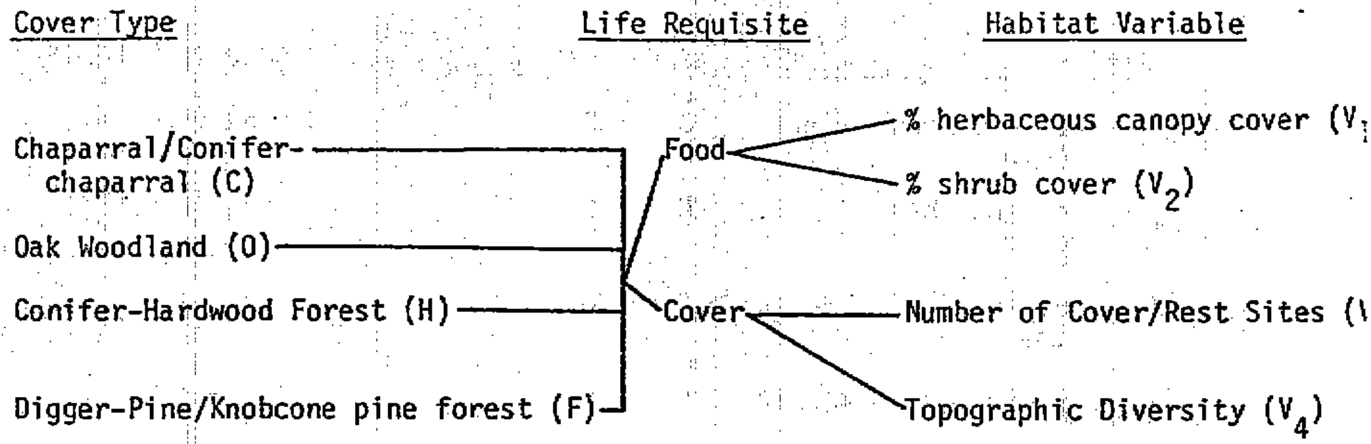
If any criteria listed are not applicable in a particular situation, do not use in determining the life requisite value or the HSI.

④

DRAFT HABITAT SUITABILITY INDEX (HSI) MODEL FOR THE BOBCAT (Lynx rufus)

U.S. Fish and Wildlife Service
Division of Ecological Services
Sacramento, California

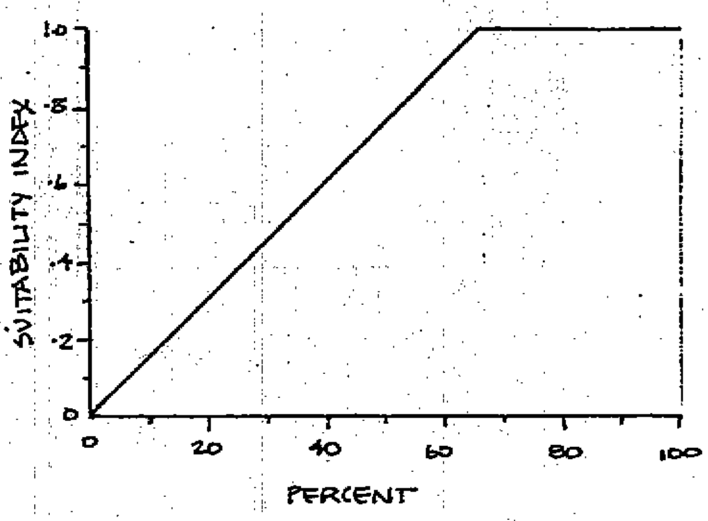
September 1984



Cover Type
Life Requisite
Habitat Variable
Chaparral/Conifer-chaparral (C)
Oak Woodland (O)
Conifer-Hardwood Forest (H)
Digger-Pine/Knobcone pine forest (F)
Food
Cover
% herbaceous canopy cover
% shrub cover (V_2)
Number of Cover/Rest Sites
Topographic Diversity (V_4)

VARIABLE		COVER TYPES	SUGGESTED TECHNIQUE
(V_1)	Percent herbaceous cover	C,F,H,O	Line intercept
(V_2)	Percent shrub cover	C,F,H,O	Line intercept
(V_3)	Number of cover/rest sites	C,F,H,O	Estimate
(V_4)	Topographic diversity	C,F,H,O	Estimate
(V_5)	Percent of area in optimum cover	C,F,H,O	Calculation
(V_6)	Percent of area in optimum food	C,F,H,O	Calculation

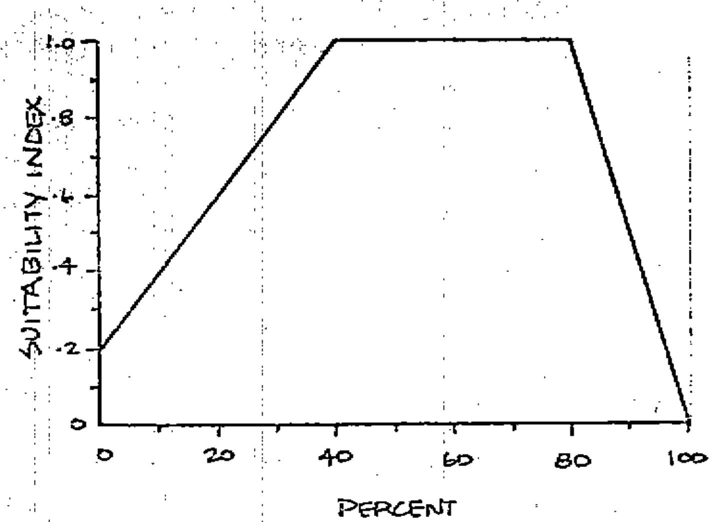
Variable 1. Percent herbaceous cover



Assumes: 1) 66% cover provided optimum habitat for rodents/lagomorphs.

2) 100% cover will not interfere with bobcats ability to find prey

Variable 2. Percent shrub cover



Assumes: 1) 0% is marginally suitable for stalking prey and is not particularly valuable for prey species, but that 40% or 80% begins to limit the ability of bobcats to capture prey.

2) 25% - 100% cover is optimal for prey species, but that 40% to 80% begins to limit the ability of bobcats to capture prey.

3) 40% cover to 80% cover is optimum for stalking and capturing prey.

Variable 3. Number of cover/rest sites

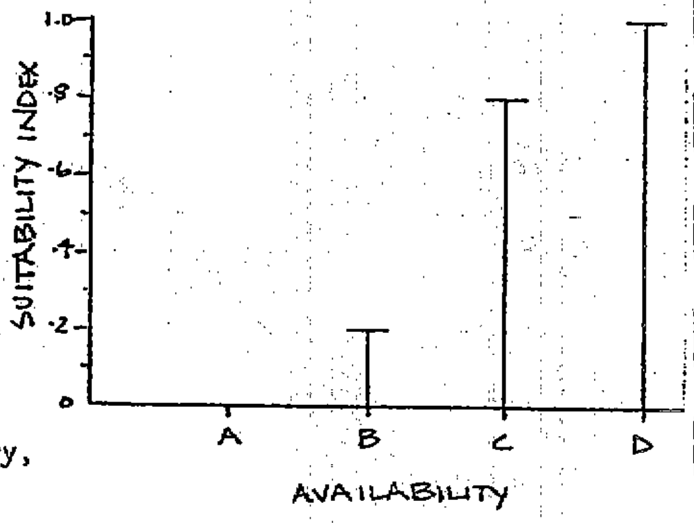
A) No cover available

B) Very few cover sites in area.

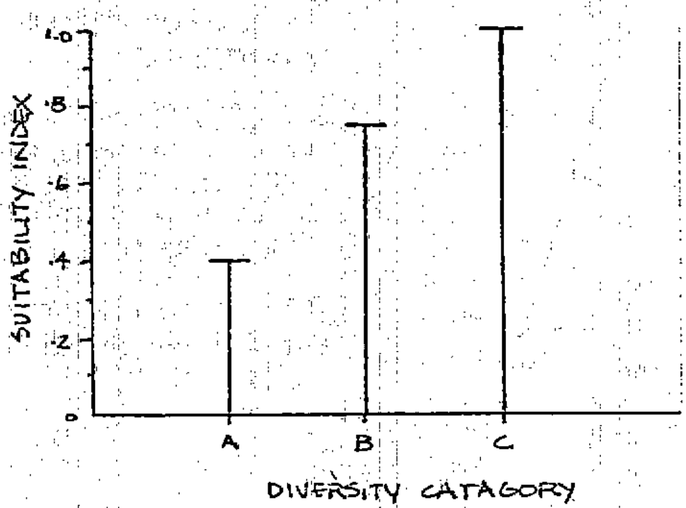
C) Moderate number of suitable cover sites in area.

D) Cover sites abundant and dispersed through area.

Cover sites include hollow logs, rock outcrops, dense thickets or shrub understory, natural crevices and caves.



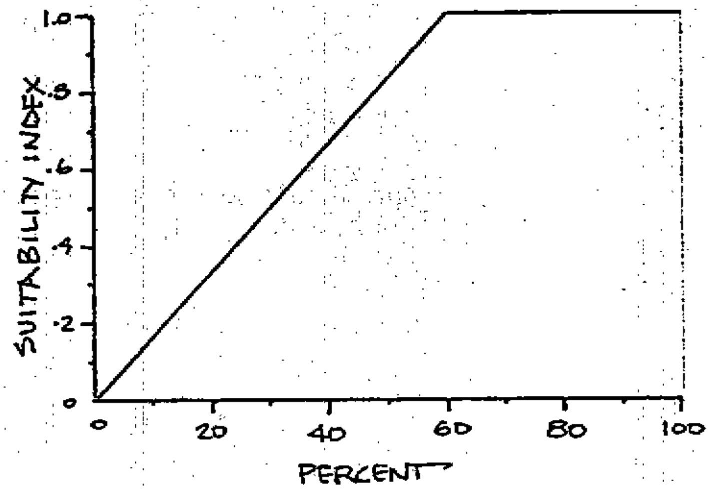
Variable 4. Topographic diversity



Assumes: 1) Bobcats prefer rocky or broken terrain (Baily, 1972)

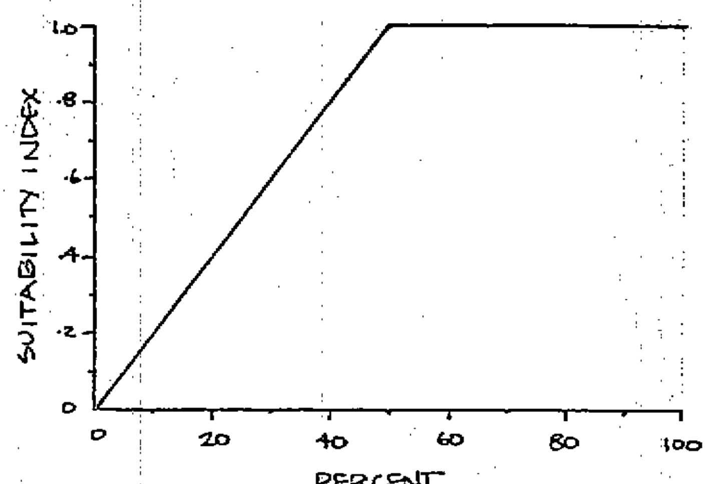
Variable 5. Percent of area in optimum cover

Assumes: 1) 60% or greater of area in optimum cover is optimal.



Variable 6. Percent of area in optimum food

Assumes: 1) 50% or greater of area in optimum food is optimal



Equations to Calculate Suitability Indices

I. Food

A. $\frac{V_1 + V_2}{2}$

Applicable to cover types: C, F, H, O

II. Cover

A. $\frac{V_3 + V_4}{2}$

Applicable to cover types: C, F, H, O

Assumptions Used in Applying the Bobcat Model

V_3 - Availability of cover areas.

Cover sites were assumed abundant and dispsersed throughout the study area; SI = 1.0.

V_4 - Topographic diversity.

The terrain in the study area was assumed to be adequately diverse, rocky, and broken; SI = 1.0.

General Assumptions

Food

A. Cover to allow bobcats to stalk/ambush prey is important (McCord, 1974; Baily, 1972; Rollings, 1945.

B. Prey density positively influences quality of habitat for bobcats (Zezulak and Schwab, 1980; Rollings, 1945; USFWS, 1983; Baily, 1972; Zezulak, 1980).

C. Bobcats presumably feed on rodents and lagomorphs in the study area (Nussbuum and Moser, 1975; Young, 1958; Baily, 1972).

D. Majority of bobcat prey species are associated with grass/forb and brush successional stages (USFS, 1979).

Cover

A. Bobcats seem to prefer broken or rocky terrain (Baily, 1972).

B. Bobcats require rest shelters (Rollings, 1945; Zezulak, 1980).

Reproduction

A. If cover requirements are met, reproduction will not be limiting.

Water

A. Water will not be limiting in study area in view of proximity of lake to all points within the study area and the mobility of the bobcat.

Literature Cited

Baily, T.N. 1972. The elusive bobcat. Nat. History 81(9):42-49.

McCord, C.M. 1974. Selection of winter habitat by bobcats (*Lynx rufus*) on the Quabbin Reservation, Massachusetts. J. Mammel. 55(2):428-437.

Nussbaum, R.A. and C. Maser. 1975. Food habits of the bobcat, *Lynx rufus*, in the Coast and Cascade Ranges of western Oregon in relation to present management policies. Northwest Sci., 49(4): 261-266.

Rollings, C.T. 1975. Habits, foods and parasites of the bobcat in Minnesota. J. Wildlife Mgmt., 9:131-145.

U.S. Fish and Wildlife Service. 1983. Behavior and population dynamics of bobcats in Oaklahoma. Research Information Bulletin No. 83-49. 1 p.

U.S. Forest Service. 1979. California wildlife/habitat relationships program. North Coast/Cascades zone. Vol. III Mammal narratives. Six Rivers National Forest.

Young, S.P. 1958. The bobcat of North America. Stackpole Book Co., and Wildlife Mgmt. Inst., Washington, D.C. 193 pp.

Zezulak, D.S. 1980. Northwestern California bobcat study. Calif. Dept. Fish and Game. Project E-E-2, Job IV-1.6, Contract S-873. 34 pp.

Zezulak, D.S. and R.G. Schwab. 1980. Bobcat biology in a Mohave Desert community. Calif. Dept. Fish and Game and U.S. Bureau of Land Management. Project W-54-R-12, Job IV-4, Contract No. CA-060-CT8-76.

Other References

Ahlborn, G. 1982. California Wildlife and Fish Habitat Relationships System species note. Bobcat (*Lynx rufus*).

Baily, T.N. 1974. Social organization in a bobcat population. J. Wildl. Mgmt. 38(3):435-446.

Ingles, L.G. 1979. Mammals of the Pacific states, Stanford University Press, Stanford, California. 506 pp.

Lembeck, M. undated. Bobcat study, San Diego County, California. Calif. Dept. Fish and Game. Project E-W-2, study IV, Job 1.7.

U.S. Forest Service. 1979.

MLong:5/18/84/rlm
revised 10/19/84
MLONG:O

FWS/OBS-82/10.61
OCTOBER 1983

HABITAT SUITABILITY INDEX MODELS: MINK

Fish and Wildlife Service

U.S. Department of the Interior

FWS/OBS-82/10.61
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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:

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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CONTENTS

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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, fresh 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 (Wise et al. 1981; Linn and Birks 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). 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 and rodents) (Chanin pers. comm.). If prey in any one 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, ranging in length from 7 to 12 cm (2.7 to 4.7 inches) were the major group of prey fish. Larger fish, represented by salmonids, 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 (Anseriformes), and grebes (Podicipediformes) comprising 70%, 11%, and 5%, respectively, 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 principle 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). 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 may comprise up to 50% of the mink's diet even in areas where aquatic prey are abundant. Muskrats have been reported to be an important part of the mink's diet throughout its range (Hamilton 1940). Sealander (1943) reported that muskrats were a major component of the winter diet of mink in southern Michigan. 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. 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.

Water

The majority of mink activity in Quebec was within 3 m (9.8 ft) of the edges of streams (Burgess 1978). All of the mink observations in a Michigan study were within 30.4 m (100 ft) of the water's edge (Marshall 1936). The majority of mink den sites recorded in a British study were within 10 m (32.8 ft) of the water's edge (Birks and Linn 1982). Mink den sites in Minnesota were within 69.9 m (200 ft) of open water (Schladweiler and Storm 1969). Den sites in Idaho were 5 to 100 m (16.4 to 328 ft) from water, and mink were never observed further than 200 m (656 ft) 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 and Sweden are most commonly associated with brushy or wooded cover adjacent to aquatic habitats (Marshall 1936; Gerell 1970). 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 (656 ft) 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 provide suitable cover for mink (Linn pers. comm.). Grasses, even if very tall, do not provide adequate year-round cover for the species. However, harvest data in Louisiana suggests 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). Virtually all mink locations recorded in a North Dakota study were within 20 m (66 ft) of emergent vegetation (Eagle pers. comm.). Evaluating duckling mortality in North Dakota, Talent et al. (1983) found that predation by mink typically occurred on semipermanent wetlands. Based on a lower rate of predation and less mink sign associated with seasonal wetlands, it was 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). 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 (3.38 ft) 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.

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 (767.5 ft) (Eberhardt and Sargeant 1977). The mean distance between dens used for two or more consecutive days in Sweden was 544 m (1784.3 ft) (Gerell 1970). The mean inter-den distance recorded in England was 492.2 m (1614.9 ft) (Birks and Linn 1982). Movements of male mink to new den sites tended to be greater than those recorded for females of the species. New mink dens in Wisconsin were usually within 90 m (295 ft) of the previous den site (Schladweiler and Storm 1969). The majority of inter-den 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. 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 northcentral 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 (984 ft) 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 temporal 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 were 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-long food supply in the intertidal 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 (19.3 acres), while the home range of a female within a sparsely vegetated, heavily grazed area was 20.1 ha (50.2 acres). Female mink home ranges in Michigan did not exceed 8 ha (20 acres) (Marshall 1936). Mink in Idaho were believed to be able to sustain themselves in a 1 to 2 km (0.6 to 1.2 miles) section of stream length (Melquist et al. 1981). Mink population densities along the coast of Vancouver Island ranged from 1.5 to more than 3 animals/km (1.5 to 3/0.6 mi) 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 (1 to 1.5 mi^2) and typically included numerous wetlands (Eagle pers. comm.). Female mink have the smallest and most well defined home range, 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 in close proximity to 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.

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 habitat in the following cover types (terminology follows that of U.S. Fish and Wildlife Service 1981): Evergreen Forested Wetland (EFW); Deciduous Forested Wetland (DFW); Evergreen Scrub-shrub Wetland (ESW); Deciduous Scrub-shrub Wetland (DSW); Herbaceous Wetland (HW); Riverine (R); and Lacustrine (L).

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 have been reviewed by Dr. Johnny Birks, University of Durham, Durham, Great Britain; Dr. Paul Chanin, University of Exeter, Devon, Great Britain; Mr. Thomas Eagle, University of Minnesota, Minneapolis, MN; Mr. John Hunt, Maine Department of Inland Fisheries and Wildlife, Augusta, ME; Mr. Noel Kinler, Louisiana Department of Wildlife and Fisheries, New Iberia, LA; Mr. Ian Linn, University of Exeter, Hatherly Laboratories, Exeter, Great Britain; Mr. Greg Linscombe, Louisiana Department of Wildlife and Fisheries, New Iberia, LA; Mr. John Major, Maine Cooperative Wildlife Research Unit, University of Maine, Orono, ME; and 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, riverine, or lacustrine cover types if sufficient vegetation or cover is present to support an adequate prey base. Although not totally restricted to wetland or wetland-associated habitats, the mink is dependent on aquatic organisms as a food source for a large portion of the year. Transient use of upland habitats 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 vegetative cover must be interspersed with, or adjacent to, relatively permanent surface water to provide the maximum potential as mink habitat. It is assumed, in this model, that quality food 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 habitat 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 cover: (1) identification of variables used in the model; (2) definition and justification of the suitability levels of each variable; and (3) description of the assumed relationships between variables.

Figure 1 illustrates the relationships of habitat variables, life requisites, and cover types for the mink.

Food component. Mink are not totally dependent on aquatic or wetland-associated prey species. However, these species form the largest portion of the annual diet. It is assumed that surface water must be present for a minimum of nine months of the year to provide optimum foraging habitat for mink. Habitats with less permanent surface water are assumed to be less suitable mink habitat. Wetland habitats consisting only of saturated soils, or lacking surface water, are assumed to be of no value as year-round mink habitat.

Several reviewers of this model have commented that eutrophic lakes have greater potential productivity than do oligotrophic lakes. Due to a more diverse and abundant aquatic prey base eutrophic lakes may be capable of supporting larger populations of mink. The primary productivity of a lake is dependent 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, have high concentrations of plant nutrients (e.g., nitrogen, phosphorus), have high organic content, and littoral zone vegetation is generally abundant. 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 potential food production and a lake's ability to provide abundant aquatic prey for mink may vary based on the lake's physical and chemical structure.

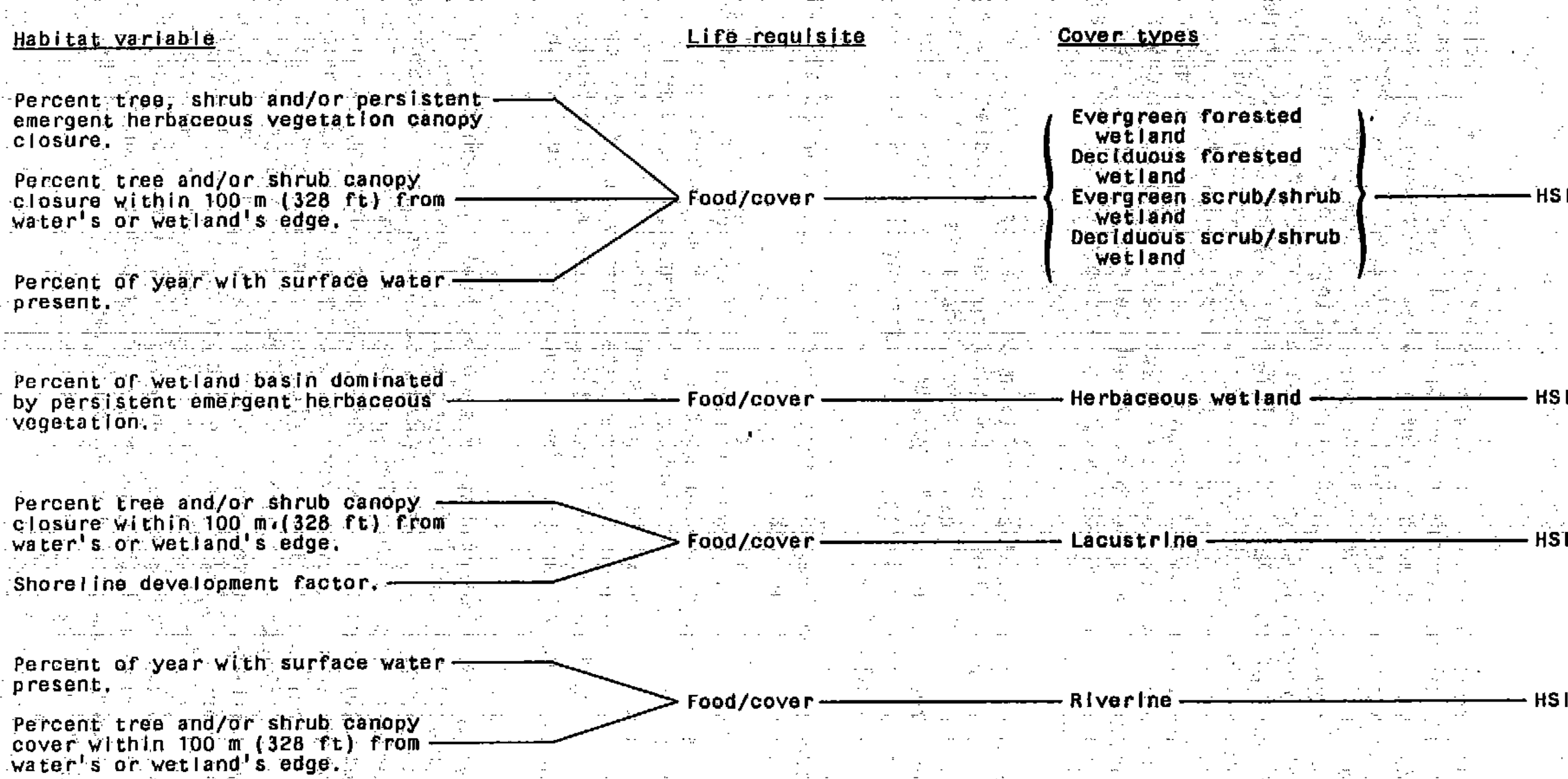


Figure 1. Relationships of habitat variables, life requisites, and cover types in the mink HSI model.

Small terrestrial mammals become a more important component of the diet during the fall and winter months. Sufficient terrestrial 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.

Cover component. Although mink will occasionally use upland habitats, they are most often found in close association with wetland cover types and the vegetative communities immediately adjacent to streams, rivers, and lakes. Dense woody cover provided by trees and/or shrubs provides the mink with potential den sites, escape cover, and foraging cover. Persistent herbaceous cover may also provide mink with sufficient cover for foraging and shelter. It is assumed that terrestrial herbaceous vegetation by itself will not provide sufficient cover for the mink during winter.

Suitable mink habitat within forested or scrub/shrub wetlands is assumed to be a function of the total canopy closure of shrubs, trees, and persistent emergent herbaceous vegetation within the wetland basin. Optimum conditions for cover, denning, and foraging are assumed to occur when the canopy closure of woody and persistent herbaceous vegetation exceeds 75%. Forested or scrub/shrub wetlands with lower vegetative canopy closures are assumed to be less suitable mink habitat. Woody vegetation within 100 m (328 ft) of a wetland's edge is assumed to also influence the potential quality of mink habitat. However, the degree to which vegetative quality in a 100 m (323 ft) band surrounding a forested or scrub/shrub wetland influences the potential habitat quality for mink is dependent on the wetland basins' size. 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 do not utilize, nor are they influenced by the quality of adjacent upland habitats. In large forested or shrub wetlands potential habitat quality for mink is assumed to be a function only of the amount of woody and persistent herbaceous vegetation and the percent of the year with surface water present. Within small, or linear, forested, scrub/shrub wetland basins potential habitat quality is assumed to be a function of the canopy closure of woody and persistent herbaceous vegetation in the wetland basin, the percent of the year with surface water present, and the canopy closure of woody vegetation in a 100 m (328 ft) band adjacent to the wetland basin. For the purposes of this model, large wetland basins are assumed to be 405 ha (1,000 acres) or larger in size. 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 habitat classifications.

Suitable cover for mink in herbaceous wetlands is assumed to be a function of the amount of the wetland basin supporting persistent emergent herbaceous vegetation (e.g., cattails and rushes) and, to a lesser extent, the amount of woody cover immediately adjacent to the herbaceous wetland. Optimum cover conditions for mink in herbaceous wetlands are assumed to occur when the wetland basin consists of 50 to 75% persistent emergent herbaceous vegetation. Herbaceous wetlands with greater than 75% canopy cover of persistent emergent vegetation are assumed to provide lower prey diversity and have slightly less potential in meeting the year-round food requirements of mink. Less than 50% persistent emergent vegetation is assumed to be indicative of less suitable mink habitat. Wetlands totally devoid of persistent emergent vegetation are assumed to have minimum value as year-round mink habitat. The cover value for mink in herbaceous wetlands may be improved if woody vegetation is present within 100 m (328 ft) of the wetland's edge. However, the presence of persistent emergent vegetation is assumed to be the major characteristic defining potential mink habitat in herbaceous wetlands and has been weighted to reflect this assumption. As in the case of forested and shrub wetlands, the presence of surface water within herbaceous wetlands has a direct influence on the habitat potential for mink. Wetlands with surface water present for three months or less are assumed to be unsuitable habitat, while wetlands with surface water present nine months, or longer, are assumed to be indicative of optimum conditions.

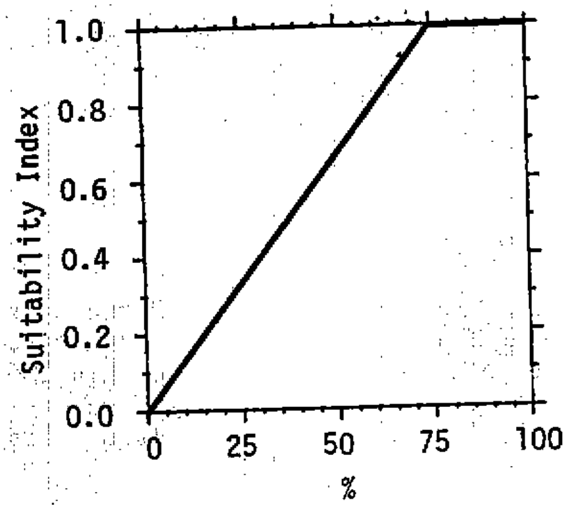
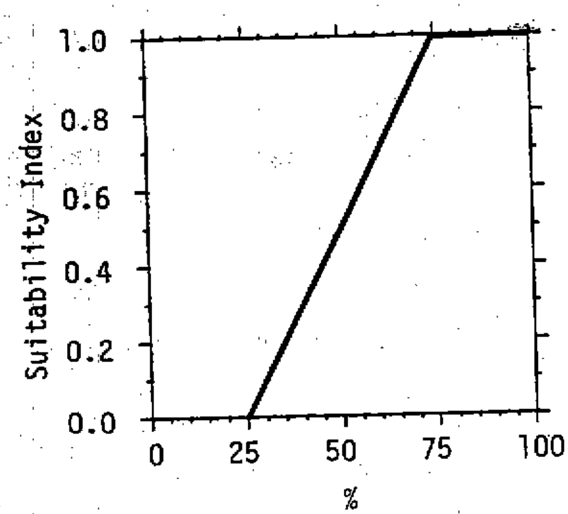
The quality of cover for mink in lacustrine habitats is assumed to be a function of the percent tree and/or shrub canopy closure within 100 m (328 ft) of the water's edge and the shape of the lake basin. A canopy closure of 75% or more of woody vegetation is assumed to characterize optimum vegetative cover. Cover quality is assumed to decrease as the density of woody vegetation decreases. However, because mink will utilize burrows, rock crevices and other forms of temporary shelter, the complete absence of woody vegetation is assumed to not totally limit an area's potential as mink habitat. Greater shoreline development (e.g., complexity) is assumed to reflect more suitable habitat conditions for the mink and its major aquatic prey species. Lakes with irregular and diverse shorelines are assumed to provide higher quality mink habitat than lakes with straight shores or lakes that are roughly circular in shape. The presence of peninsulas, islands, or inlets increases the shoreline edge and is assumed to provide more suitable access and foraging sites for the mink.

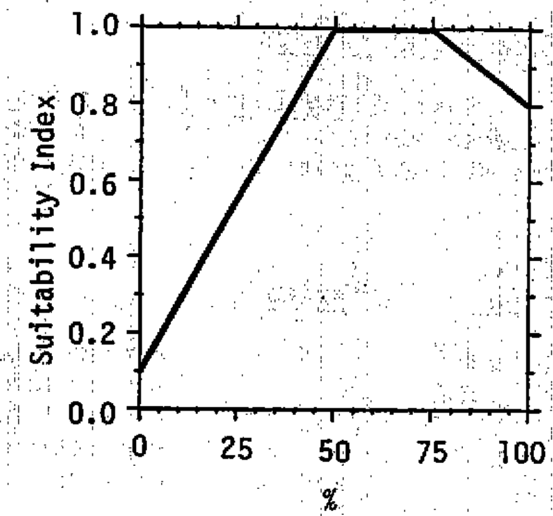
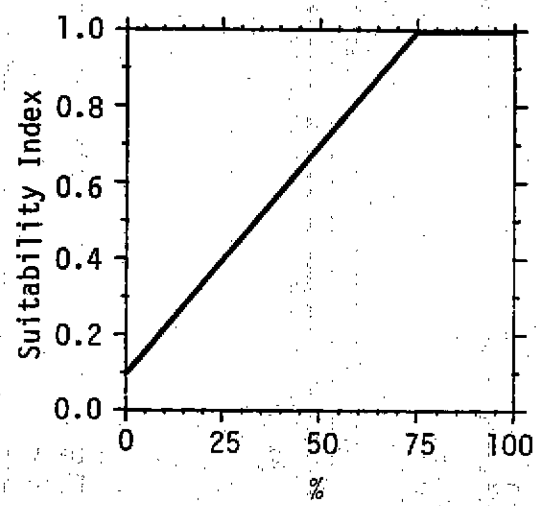
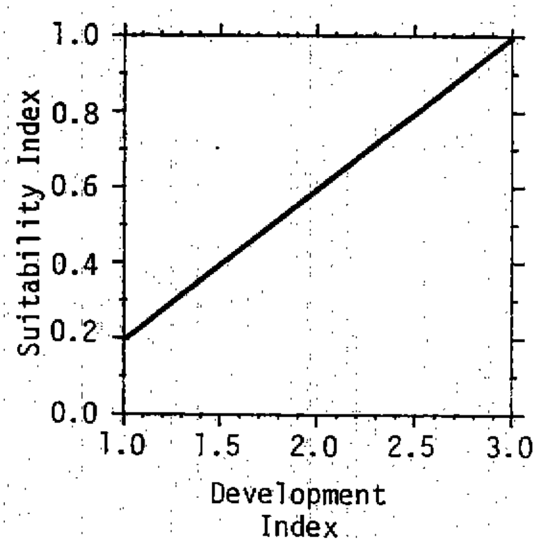
Within riverine cover types, suitable cover for mink is assumed to be related to the density of woody vegetation (trees and/or shrubs) within 100 m (328 ft) of the water's edge. Optimum conditions are assumed to exist when the canopy closure equals or exceeds 75%. Lower cover quality is characterized by less dense stands of woody vegetation adjacent to the river or stream channel. While optimum cover conditions are assumed to occur in riverine habitats bordered by trees and/or shrubs, the complete absence of woody vegetation is assumed to not totally limit the cover value. Minimum cover potential is assumed to exist in habitats devoid of woody vegetation based on the mink's use of other forms of shelter (e.g., rock crevices, animal burrows).

The vegetative cover values in all cover types used by mink are modified by the relative permanence of surface water, as discussed in the <u>Food component</u> section of this model. Even though the vegetative characteristics of a cover type may be of optimum value, it is assumed that mink habitat will not be present if surface water is not available. To provide optimum mink habitat, surface water must be present for a minimum of 9 months of the year.

Model Relationships

Suitability Index (SI) graphs for habitat variables. The relationships between various conditions of habitat variables and habitat suitability for the mink are graphically represented in this section.

Cover type	Variable		
EFW,DFW, ESW,DSW	V_1	Percent tree, shrub, and/or persistent emergent herbaceous vegetation canopy closure.	
EFW,DFW, ESW,DSW, HW,R,L	V_2	Percent of year with surface water present.	

HW	V_3	Percent of wetland basin dominated by persistent emergent herbaceous vegetation.	
EFW,DFW, DSW,ESW, HW,R,L	V_4	Percent tree and/or shrub canopy closure within 100 m (328 ft) of water's or wetland's edge.	
L	V_5	Shoreline development factor.	

Equations. In order to obtain life requisite values for the mink, 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 a food/cover value are presented by cover type in Figure 2.

Life requisite	Cover type	Equations
Food/cover	EFW, DFW, ESW, DSW [< 405 ha (1,000 acres) in size]	$V_2\left(\frac{V_1 + V_4}{2}\right)$
Food/cover	EFW, DFW, ESW, DSW [≥ 405 ha (1,000 acres) in size]	$(V_1 \times V_2)^{1/2}$
Food/cover	HW	$V_2\left(\frac{4V_3 + V_4}{5}\right)$
Food/cover	L	$(V_4 \times V_5)^{1/2}$
Food/cover	R	$(V_2^2 \times V_4)^{1/3}$

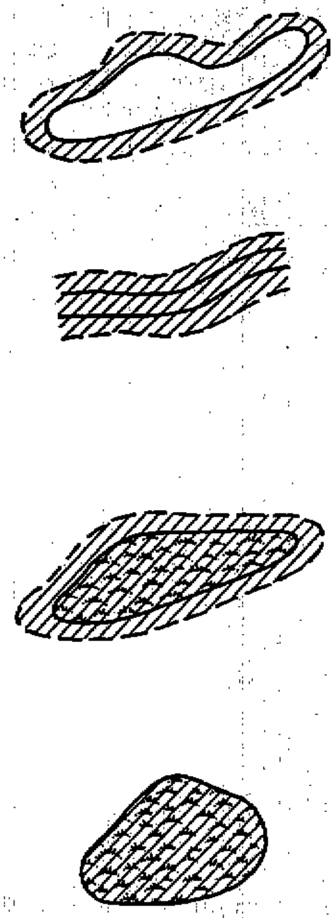
Figure 2. Equations for determining life requisite values by cover type for the mink.

HSI determination. Because food/cover was the only life requisite considered in this model, the HSI equals the food/cover value determined for a specific cover type.

Application of the Model

Potential mink habitat must contain a relatively permanent source of surface water. Because of the mink's use of upland habitats for denning and foraging, optimum mink habitat must also contain suitable cover adjacent to the water body or wetland. Therefore, the application of this model and the determination of habitat units is based on an evaluation of the quality of the wetland, lacustrine, or riverine cover type and a 100 m (328 ft) band of habitat surrounding the aquatic portion of the habitat. Figure 3 illustrates the relationship of cover types to the suggested evaluation area.

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 (herbaceous wetlands, forested wetlands, or 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) or larger in size HSI determined for area contained only within cover type.

Figure 3. Guidelines for determining the area to be evaluated for mink habitat suitability under various cover type conditions.

Definitions of variables and suggested field measurement techniques (Hays et al. 1981) are provided in Figure 4.

Variable (definition)		Cover types	Suggested technique
V_1	Percent tree, shrub, and/or persistent emergent herbaceous canopy closure [the percent of the ground surface that is shaded by a vertical projection of the canopies of all woody vegetation and herbaceous vegetation which normally remains standing after the growing season (e.g., cattails and/or bulrushes)].	EFW,DFW,ESW, DSW	Line intercept, remote sensing
V_2	Percent of the year with surface water present (the proportion of the year in which wetland cover types have surface water present).	EFW,DFW,ESW, DSW,HW,R,L	Remote sensing, local data
V_3	Percent of wetland basin dominated by persistent emergent vegetation [e.g., the proportion of a wetland that supports emergent herbaceous vegetation which normally remains standing after the growing season (e.g., cattails and/or bulrushes)].	HW	Remote sensing
V_4	Percent tree and/or canopy closure within 100 m (328 ft) of the water's or wetland's edge [the percent of the ground surface within 100 m (328 ft) of the water's edge, or edge of a wetland, that is shaded by a vertical projection of the canopies of all woody vegetation].	EFW,DFW,ESW, DSW,HW,R,L	Remote sensing, line intercept

Figure 4. Definitions of variables and suggested measurement techniques.

Variable (definition)	Cover types	Suggested technique
V_5 Shoreline development factor (a ratio relating the relative edge of a water body to its area. To obtain a value for shoreline development, measure the length of the shoreline and the area of the water body. The ratio of shoreline to area is compared to that for a circle having the same area as the water body, using the following formula: $$DI = \frac{l}{2\sqrt{A\pi}}$$ where: DI = diversity index; l = length of shoreline; A = area of water body. A circle would have a value equal to 1.0. The greater the deviation from a circular shape, the greater the DI value will be).	L	Remote sensing, topographic map. Dot grid, planimeter.

Figure 4. (concluded).

SOURCES OF OTHER MODELS

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

REFERENCES

Birks, J. Personal communication (letter dated 16 August 1983). University of Durham Science Laboratories, Durham, Great Britain.

Birks, J. D. S., and I. J. Linn. 1982. Studies of home range of the feral mink, (*Mustela vison*). Symp. Zoo. Soc. Lond. 49:231-257.

Burgess, S. A. 1978. Aspects of mink (Mustela vison) ecology in the Southern Laurentains of Quebec. M.S. Thesis, MacDonald College of McGill Univ. Montreal, Quebec. 112 pp.

Chanin, P. R. F. Personal communication (letter dated 5 August 1983). University of Exeter, Devon, Great Britain.

Chanin, P. R. F., and I. Linn. 1980. The diet of the feral mink (Mustela vison) in southwest Britain. J. Zool., Lond., 192:205-223.

Croxton, L. W. 1960. Southeastern mink management studies. Alaska Dept. Fish and Game. Pittman-Robertson Proj. Rep. Annu. Rep. of Prog. 1959/60:366-371.

Davis, W. B. 1960. Mammals of Texas. Texas Fish and Oyster Comm. Bull. 41.

Dunstone, N. 1978. The fishing strategy of the mink (Mustela vison); time-budgeting of hunting effort? Behaviour 67(3-4):157-177.

Dunstone, N., and R. J. O'Connor. 1979. Optimal foraging in an amphibious mammal. I. The aqualung effect. Anim. Behav. 27(4):1182-1194.

Eagle, T. C. Personal communication (letter dated 24 March 1983). University of Minnesota, Minneapolis.

Eberhardt, R. T. 1973. Some aspects of mink-waterfowl relationships on prairie wetlands. Prairie Nat. 5(2):17-19.

Eberhardt, R. T., and A. B. Sargeant. 1977. Mink predation on prairie marshes during the waterfowl breeding season. Pages 33-43 in R. L. Phillips and C. Jonkel, eds. Proc. 1975 Predator Symp., Montana For. and Conserv. Exp. Stn., Univ. Montana, Missoula.

Errington, P. L. 1943. An analysis of mink predation upon muskrats in north-central United States. Iowa Agric. Exp. Stn. Res. Bull. 320:797-924.

__________. 1954. The special responsiveness of minks to epizootics in muskrat populations. Ecol. Monogr. 24:377-393.

__________. 1961. Muskrats and marsh management. Stackpole Co., Harrisburg, PA. 183 pp.

Gerell, R. 1967. Food selection in relation to habitat in mink (Mustela vison Schreber) in Sweden. Oikos 18(2):233-246.

__________. 1969. Activity patterns of the mink Mustela vison Schreber in southern Sweden. Oikos 20(2):451-460.

__________. 1970. Home ranges and movements of the mink Mustela vison Schreber in southern Sweden. Oikos 21(2):160-173.

Hamilton, W. J. 1940. The summer food of minks and raccoons on the Montezuma Marsh, New York. J. Wildl. Manage. 4(1):80-84.

Harbo, S. J. 1958. An investigation of mink in interior and southeastern Alaska. M.S. Thesis, Univ. Alaska, Fairbanks. 108 pp. (Cited by Pendleton 1982).

Hatler, D. F. 1976. The coastal mink on Vancouver Island, British Columbia. Ph.D. Diss. Univ. British Columbia, Vancouver.

Hays, R. L., C. S. Summers, and W. Seitz. 1981. Estimating wildlife habitat variables. U.S. Dept. Int., Fish Wildl. Serv. FWS/OBS-81/47. 173 pp.

Korschgen, L. J. 1958. December food habits of mink in Missouri. J. Mammal. 39(4):521-527.

Linn, I. J. Personal communication (letter dated 3 August 1983). University of Exeter, Hatherly Laboratories, Exeter, Great Britain.

Linn, I., and J. H. F. Stevenson. 1980. Feral mink in Devon. Nature in Devon 1:7-27.

Linn, I. J., and J. D. S. Birks. 1981. Observations on the home ranges of feral American mink (Mustela vison) in Devon, England as revealed by radio-tracking. Pages 1088-1102 in J. A. Chapman and D. Pursley, eds. Worldwide Furbearer Conf. Proc., Vol. I, Aug. 3-11, Frostberg, MD.

Linscombe, G., N. Kinler, and R. J. Aulerich. 1982. Mink Mustela vision. Pages 629-643 in J. A. Chapman and G. A. Feldhamer, eds. Wild mammals of North America: Biology, Management, and Economics. Johns Hopkins Univ. Press, Baltimore, MD. 1,147 pp.

Linscobme, G., and N. Kinler. Personal communication (letter dated 17 August 1983). Louisiana Department of Wildlife and Fisheries, Route 4, Box 78, New Iberia, LA.

Lowery, G. N., Jr. 1974. The mammals of Louisiana and its adjacent waters. Louisiana State Univ. Press, Baton Rouge, LA. 565 pp.

Marshall, W. H. 1936. A study of the winter activities of the mink. J. Mammal. 17(4):382-392.

McDonnell, J. A., and F. F. Gilbert. 1981. The responses of muskrats (Ondatra zibethicus) to water level fluctuations at Luther Marsh, Ontario. Pages 1027-1040 in J. A. Chapman and D. Pursley, eds. Worldwide Furbearer Conf. Proc., Vol. I, Aug. 3-11, Frostberg, MD.

Melquist, W. E., J. S. Whitman, and M. G. Hornocker. 1981. Resource partitioning and coexistence of sympatric mink and river otter populations. Pages 187-220 in J. A. Chapman and D. Pursley, eds., Worldwide Furbearer Conf. Proc., Vol. I, Aug. 3-11, 1980, Frostberg, MD.

Mitchell, J. L. 1961. Mink movements and populations on a Montana river. J. Wildl. Manage. 25(1):48-54.

Nichols, J. D., and R. H. Chabreck. 1981. Comparative fur harvests of swamp and marsh wetlands in southern Louisiana. Pages 273-387 in J. A. Chapman and D. Pursley, eds. Worldwide Furbearer Conf. Proc., Vol. I, Aug. 3-11, Frostberg, MD.

Northcott, T. H., N. F. Payne, and E. Mercer. 1974. Dispersal of mink in insular Newfoundland. J. Mammal. 55(1):243-248.

Pendleton, G. W. 1982. A selected annotated bibliography of mink behavior and ecology. S. Dak. Coop. Wildl. Res. Unit, Brookings. Tech. Bull. 3.

Sargeant, A. B., G. A. Swanson, and H. A. Doty. 1973. Selective predation by mink, Mustela vison, on waterfowl. Am. Midl. Nat. 89(1):208-214.

Schladweiler, J. L., and G. L. Storm. 1969. Den-use by mink. J. Wildl. Manage. 33(4):1025-1026.

Sealander, J. A. 1943. Winter food habits of mink in southern Michigan. J. Wildl. Manage. 7(4):411-417.

St. Amant, L. S. 1959. Louisiana wildlife inventory and management plan. Louisiana Wildl. Fish. Comm. New Orleans, LA. (cited by Nichols and Chabreck 1982).

Talent, L. G., R. L. Jarvis, and G. L. Krapu. 1983. Survival of mallard broods in south-central North Dakota. Condor 85:74-78.

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

Waller, D. W. 1962. Feeding behavior of minks at some Iowa marshes. M.S. Thesis, Iowa State Univ., Ames. 90 pp.

Wilson, K. A. 1954. The role of mink and otter as muskrat predators in northeastern North Carolina. J. Wildl. Manage. 18(2):199-207.

Wise, M. H., I. J. Linn, and C. R. Kennedy. 1981. A comparison of the feeding biology of mink (Mustela vison) and otter (Lutra lutra). J. Zool., Lond. 195:181-213.

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Habitat preferences of the mink (Mustela vison) are described in this publication, which is one in a series of Habitat Suitability Index (HSI) models. A review and synthesis of the literature is followed by development of a model of the habitat requirements of the mink within inland wetland areas throughout its range. HSI's 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 MODEL

BLACK-TAILED DEER (<u>Odocoileus hemionus</u>)

U.S. Fish and Wildlife Service

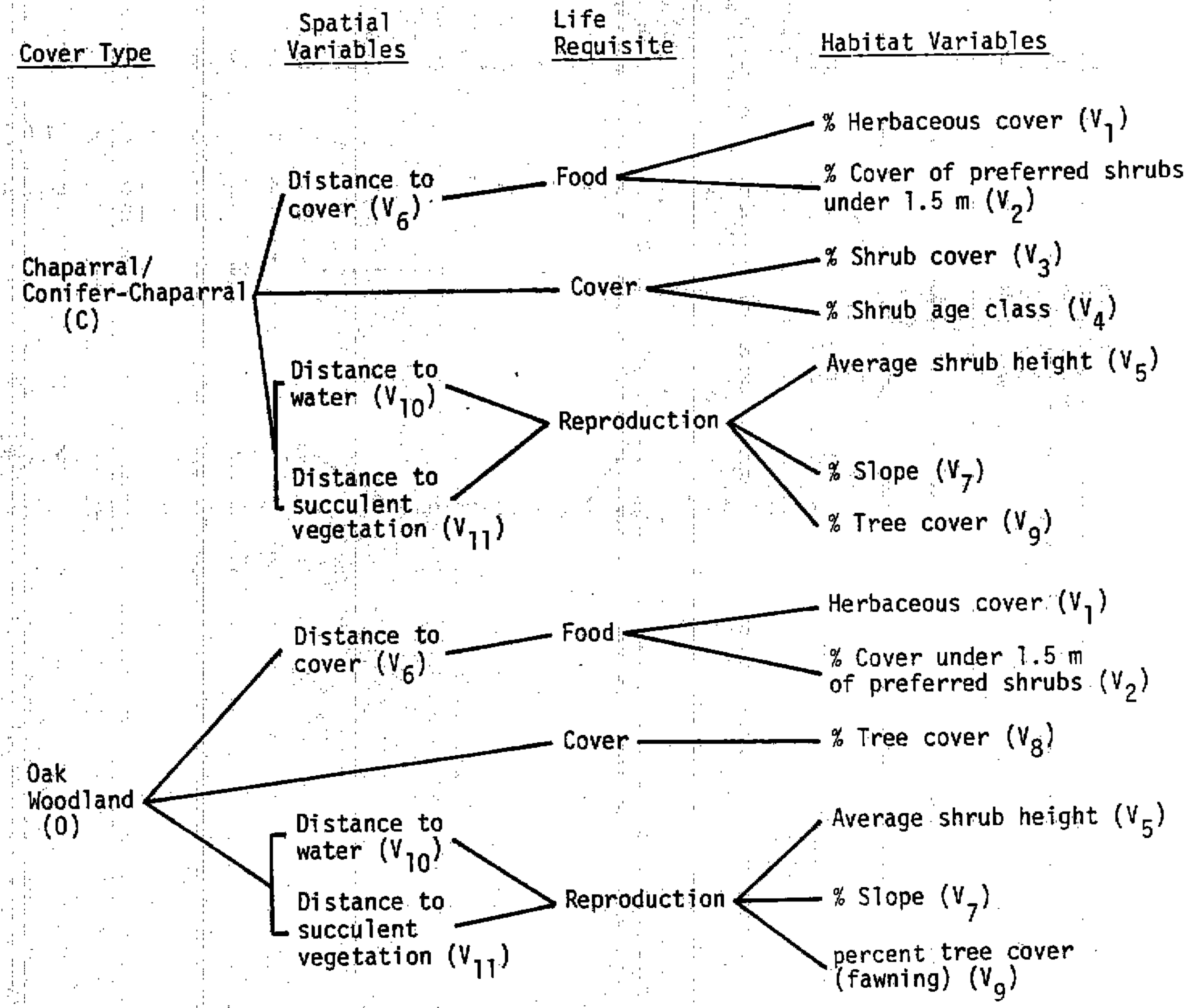
Division of Ecological Services

Sacramento, California

September 1984

ʼ 36

VARIABLE		COVER TYPE	SUGGESTED TECHNIQUE
(V_1)	Percent herbaceous cover	C,O,H,F	Quadrat
(V_2)	Percent cover of preferred shrubs under 1.5 m	C,O,H,F	Line intercept
(V_3)	Percent shrub cover	C,F	Line intercept
(V_4)	Shrub age class	C,F	Estimate
(V_5)	Average shrub height	C,O,H,F	Graduated rod
(V_6)	Distance to cover	C,O,H,F	Measuring tape, split image rangefinder, aerial photos
(V_7)	Percent slope	C,O,H,F	Calculation
(V_8)	Percent tree cover	O,H,F	Line intercept, Lindsey sighting level
(V_9)	Percent tree cover	C,O,H,F	Line intercept
(V_{10})	Distance to water	C,O,H,F	Measuring tape, split image rangefinder
(V_{11})	Distance to succulent vegetation	C,O,H,F	Measuring tape, split image rangefinder
(V_{12})	Percent of area in optimum food	C,O,H,F	Calculation
(V_{13})	Percent of area in optimum cover	C,H,O,F	Calculation
(V_{14})	Percent of area in optimum fawning	C,H,O,F	Calculation



Cover Type
Spatial Variables
Life Requisite
Habitat Variables
Chaparral/ Conifer-Chaparral (C)
Distance to cover (V_6)
Food
% Herbaceous cover (V_1)
% Cover of preferred shrubs under 1.5 m (V_2)
Cover
% Shrub cover (V_3)
% Shrub age class (V_4)
Distance to water (V_{10})
Distance to succulent vegetation (V_{11})
Reproduction
Average shrub height (V_5)
% Slope (V_7)
% Tree cover (V_9)
Oak Woodland (O)
Distance to cover (V_6)
Food
Herbaceous cover (V_1)
% Cover under 1.5 m of preferred shrubs (V_2)
Cover
% Tree cover (V_8)
Distance to water (V_{10})
Distance to succulent vegetation (V_{11})
Reproduction
Average shrub height (V_5)
% Slope (V_7)
percent tree cover (fawning) (V_9)

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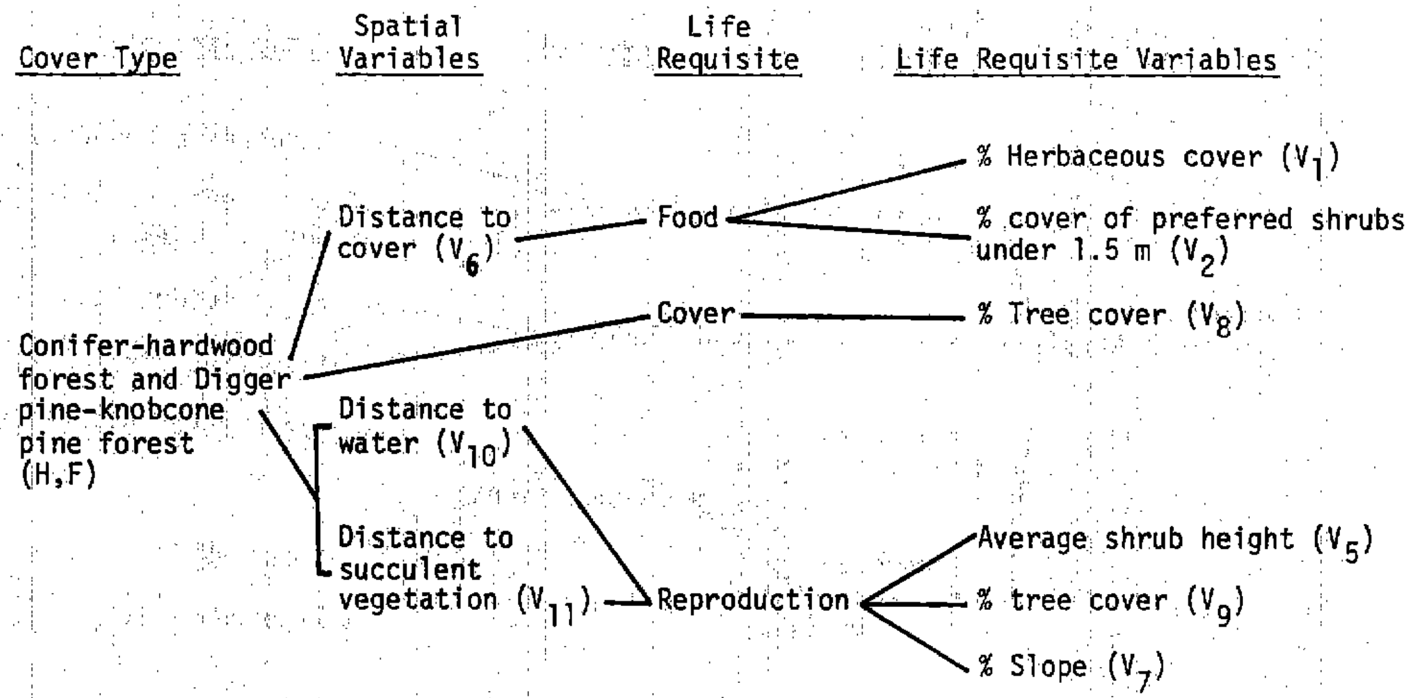
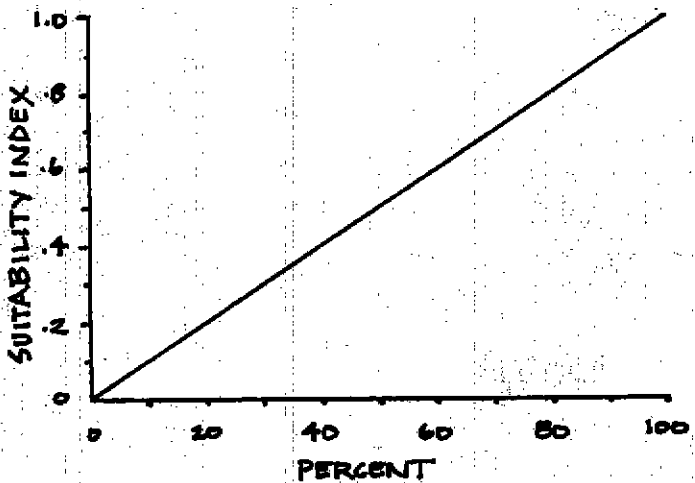
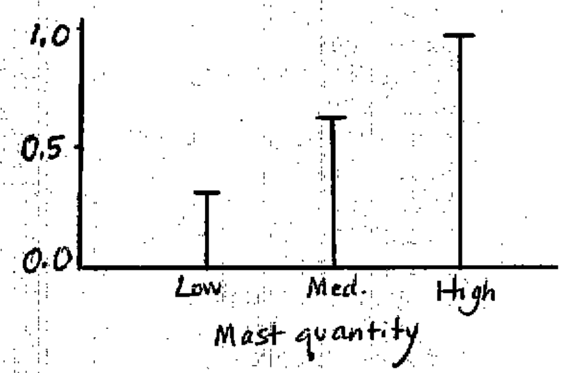

Cover Type
Spatial Variables
Life Requisite
Life Requisite Variables
Distance to cover (V6)
Food
% Herbaceous cover (V1)
% cover of preferred shrubs under 1.5 m (V2)
Cover
% Tree cover (V8)
Conifer-hardwood forest and Digger pine-knobcone pine forest (H,F)
Distance to water (V10)
Distance to succulent vegetation (V11)
Reproduction
Average shrub height (V5)
% tree cover (V9)
% Slope (V7)

Variable 1. Percent herbaceous cover



Assumes: 1) Amount of food available to deer increases as herbaceous cover increases.

OR

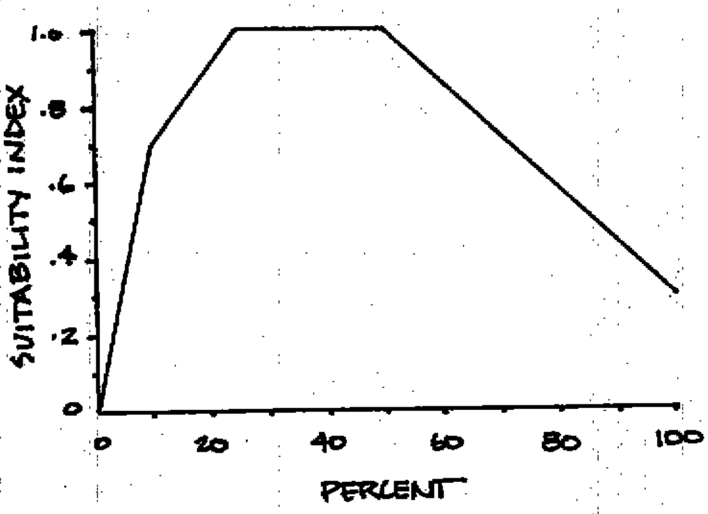


Variable 2. Percent cover of preferred shrubs under 1.5 m

Assumes: 1) That extensive tracts of mature brush do not provide optimal habitat.

Graph adapted from Shimamoto and Sirola, ed. (1981).

List of preferred shrubs follows.

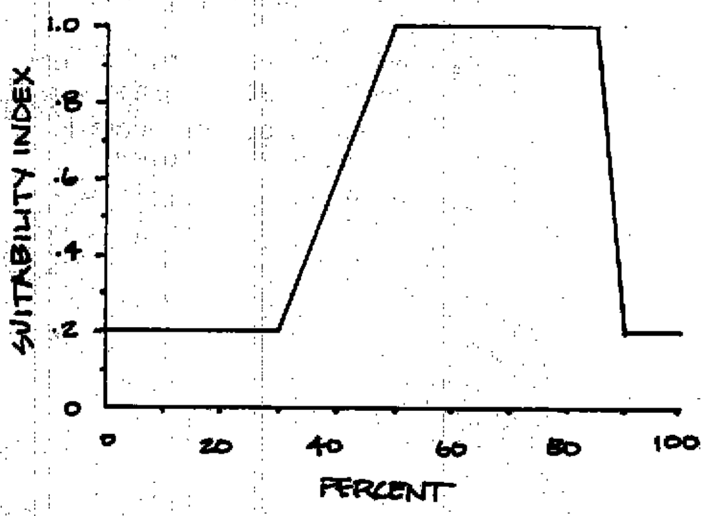


List of preferred browse shrub species

Wedgeleaf ceanothus	(*Ceanothus cuneatus*)
Lemmon'sceanothus	(*C. lemmonii*)
Tobacco brush	(*C. velutinus*)
Snow bush	(*C. cordulatus*)
Squaw carpet	(*C. prostratus*)
Deer brush	(*C. intergerrimus*)
Mountain mahogany	(*Cercocarpus betuloides*)
Snowberry	(*Symphoricarpos mollis*)
Western service berry	(*Amelanchier alnifolia*)
Black oak	(*Quercus kelloggii*)
Scrub oak	(*Q. dumosa*)
Brewer's oak	(*Q. garryana* var. *breweri*)
Oregon white oak	(*Q. garryana*)
Canyon live oak	(*Q. chrysolepis*)
Interior live oak	(*Q. wislizenii*)
Styrax, storax	(*Styrax officinalis* var. *californica*)

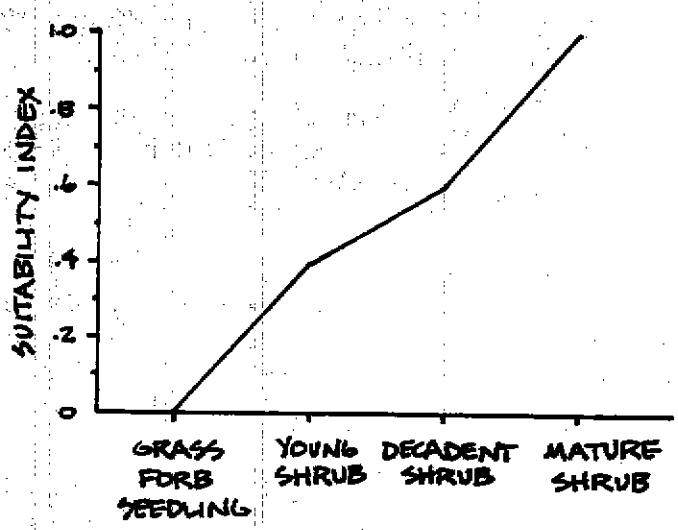
List compiled from: Kie and Menke, 1980; Leach and Hiehle, 1957; Smith, et al., 1984).

Variable 3. Percent shrub cover



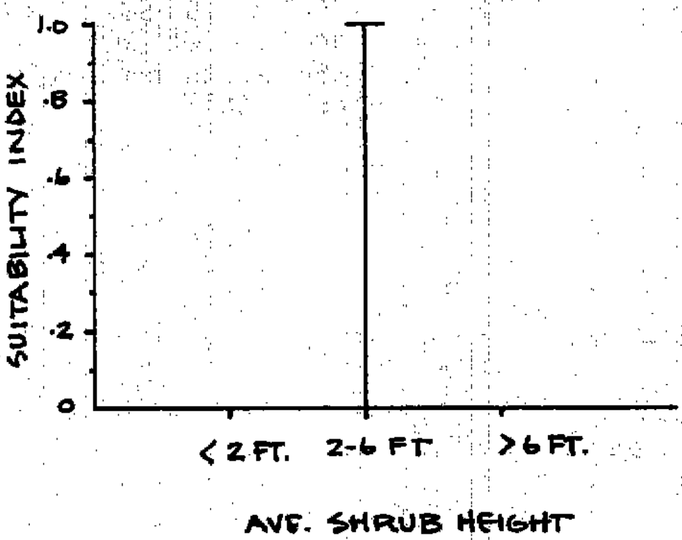
Assumes: 1) Shrub canopy closure of 50-85% is optimal for cover 30-50% & 85-90% is moderate, and 30% or 90% is low. (Shimamoto and Airola, ed., 1981).

Variable 4. Shrub age class



Assumes: 1) Quality of cover is dependent on the density of the vegetation. Decadent shrub becomes at least partially impenetrable.

Variable 5. Average shrub height

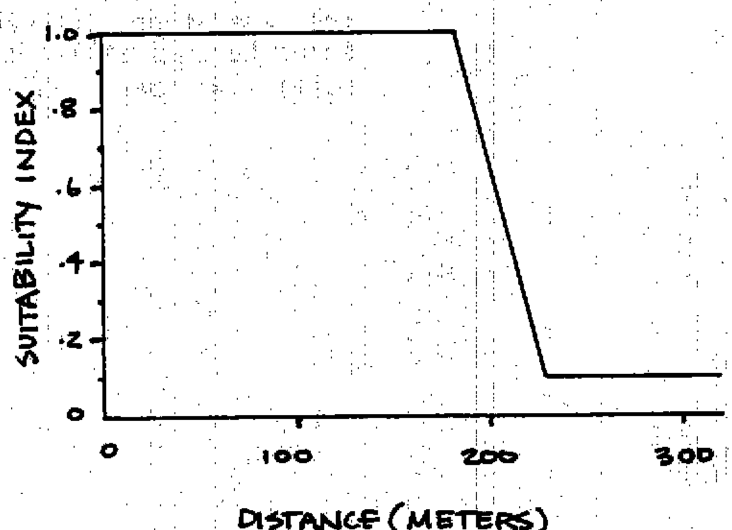


Assumes:

1) Average shrub height between 2 and 6 feet is optimal for reproductive cover (Black et al., 1976).

2) Average shrub height less than 2 feet or greater than 6 feet does not provide the necessary cover (Black, et. al., 1976).

Variable 6. Distance to cover



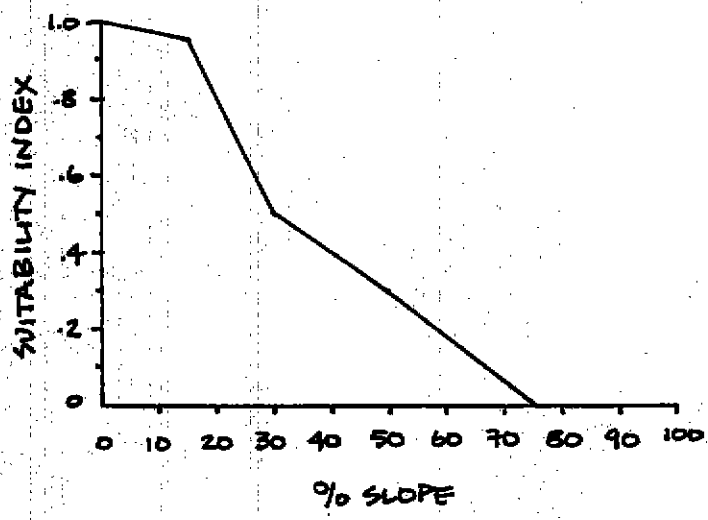
Assumes:

1) Assumes deer use is greater within 183 m cover and is low more than 229 m from cover (Lemos and Hines, 1974; Black et. al., 1976).

2) Assumes cover is at least 300 feet in width. (USFWS undated).

Variable 7. Percent slope

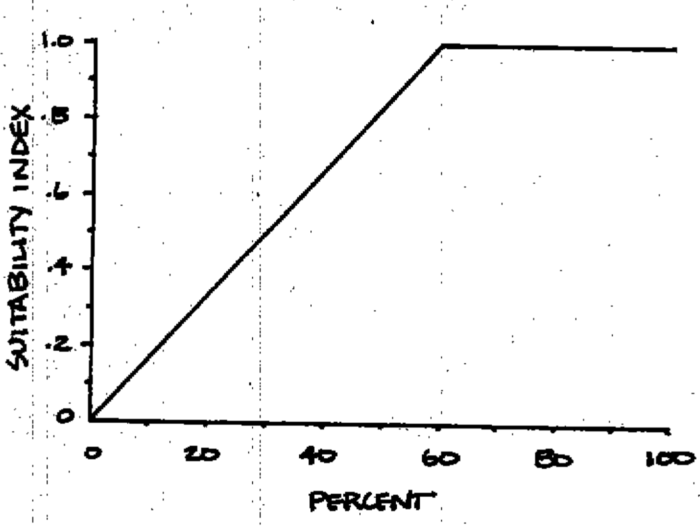
Assumes: 1) Fawning takes place on slopes of less than 15 percent (Black, et al., 1976)



Variable 8. Percent tree cover and shrub cover over 5 feet in height

Assumes: 1) 60% canopy closure is optimal thermal cover (Black et al., 1976).

2) Thermal cover for deer, on summer and spring-fall range, as trees or shrubs, coniferous or deciduous, at least 1.5m (5 ft) tall (Black et al., 1976).



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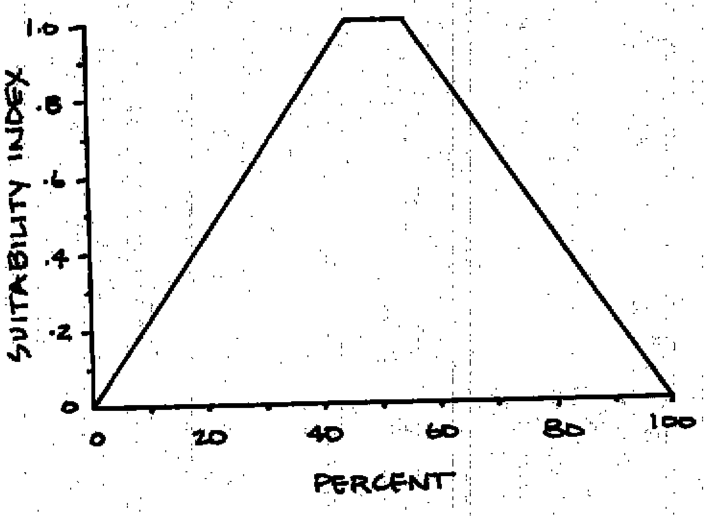
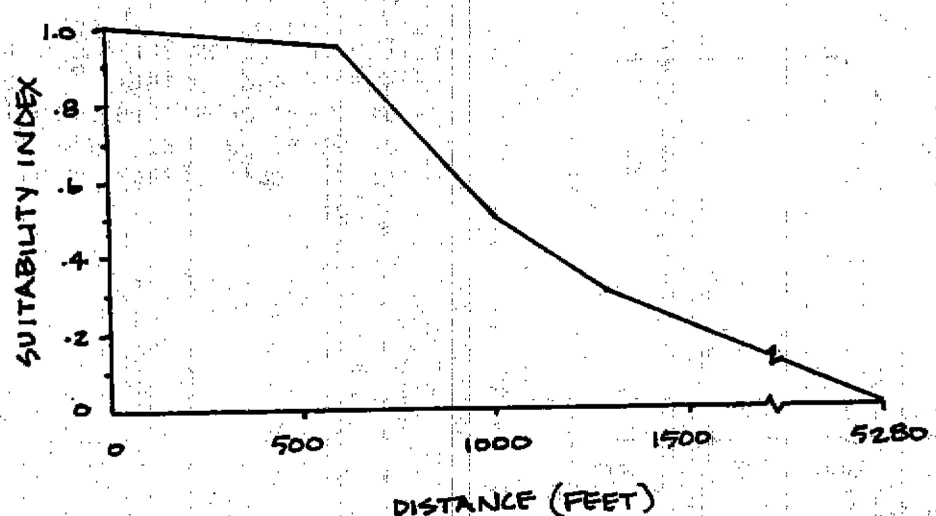
Variable 9. Percent tree cover

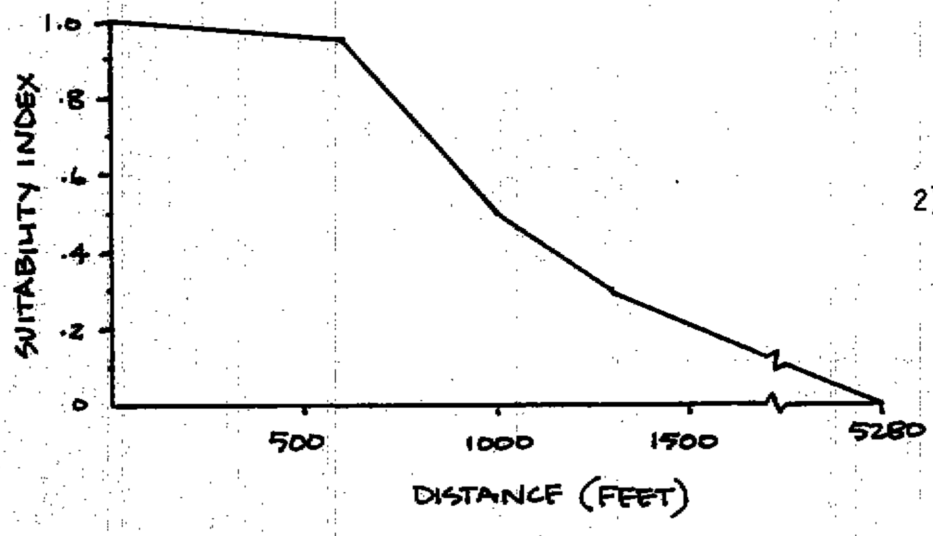
Assumes: 1) 50% canopy closure is optimal for fawning habitat (Black et al., 1976).



Variable 10. Distance to water



Variable 11. Distance to succulent vegetation



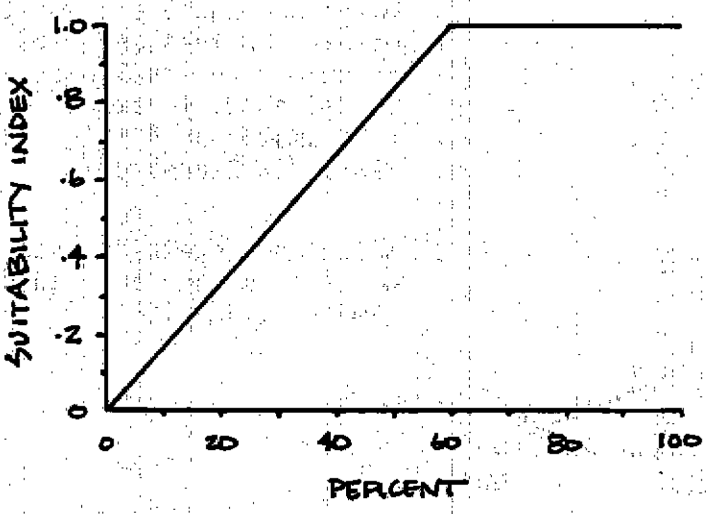
Assumes. 1) Optimal fawning habitat has water and succulent vegetation within 600 feet and water and succulent vegetation beyond .25 miles will not be used. (Shimamoto and Airola, ed., 1981; USFWS undated).

2) Succulent vegetation has to be at least one acre in size (Smith et al., 1984).

Variable 12. Percent of area in optimum food

Assumes: 1) 60 percent of area providing food is optimal (Black et al., 197

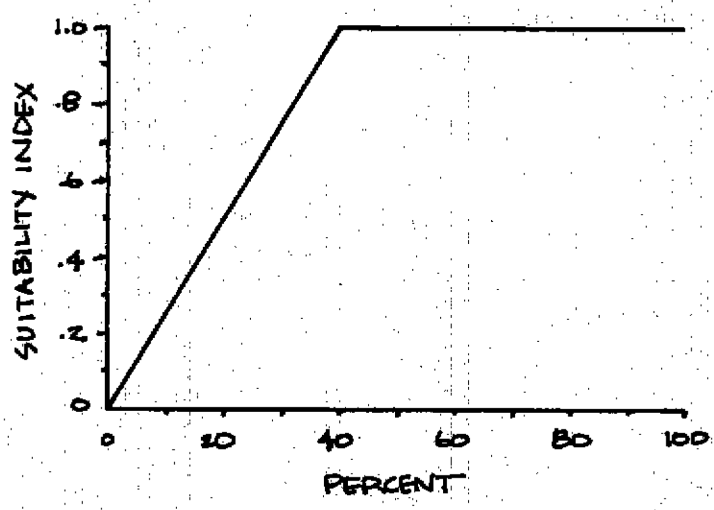
2) Food-producing and cover areas can overlap.



Variable 13. Percent of area in optimum cover

Assumes: 1) 40 percent of area providing cover is optimal (Black et al., 1976).

2) Cover areas can overlap food-producing areas.



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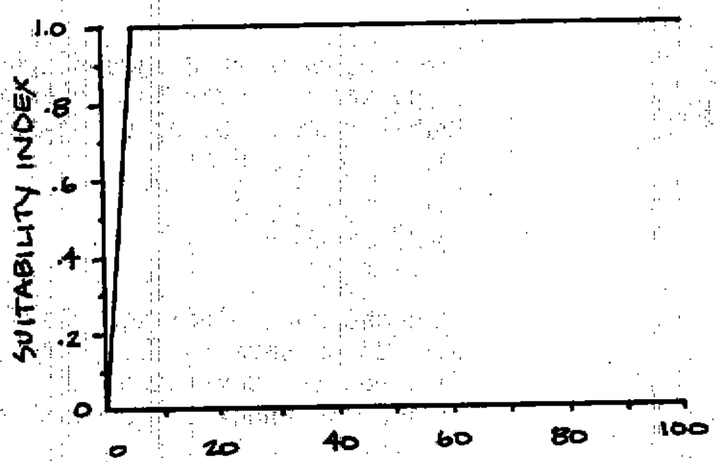
Variable 14. Percent of area in optimum fawning



Assumes: 1) Optimal habitat is comprised of at least 5% areas suitable for fawning (Black et al., 1976).

2) Fawning areas may overlap forage and cover areas.

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Equations Used to Calculate Suitability Indices

I. Chaparral

A. Food (F_C)

$$\frac{(2\,V_2) + V_1}{3} \cdot V_6 = F_C$$

Assumes preferred shrubs are more important to deer on a year round basis than herbaceous vegetation.

B. Cover (C_C)

$$(V_3 \cdot V_4 \cdot V_8)^{1/3} = C_C$$

Assumes that older age class of shrubs may compensate for low canopy closure but not the reverse of this. If shrub age class index is zero, than C_C should be zero.

C. Reproduction R_C

minimum (V_5, V_7, V_9) x minimum (V_{10}, V_{11}) = R_C

Assumes the two life requisite variables are not compensatory - minimum value is limiting.

II. Oak Woodland

A. Food (F_0)

$$\frac{(2\,V_2) + V_1}{3} \cdot V_6 = F_0$$

Assumes the two life requisite variables are not compensatory - minimum value is limiting.

B. Cover (C_0)

$$V_8 = C_0$$

Assumes percent canopy cover and size of dominant trees are compensatory.

C. Reproduction (R_0)

Minimum (V_5, V_7, V_9) x minimum (V_{10}, V_{11}) = R_0

Assumes V_5, V_9 are not compensatory - minimum value is limiting factor.

P4

III. Confier Hardwood Forest & Digger Pine/ Knobcone Pine Forest

A. Food (F_{HF})

$$\frac{(2\ V_2) + V_1}{3} \cdot V_6 = F_{HF}$$

B. Cover (C_{HF})

V_8 = CHF

Assumes total canopy cover is more important than percent conifer composition of cover. Percent conifer composition relates mostly to thermal cover which may not be too critical in Shasta Lake area.

C. Reproduction (R_{HF})

Minimum (V_5, V_7, V_9) x mimimum (V_{10}, V_{11}) = R_{HF}

ACO

Calculating Overall HSI

1. Calculate percent of study area providing each life requisite.

$$LR\% = \sum_{i=1}^{n} (RA_i) \times (SI_i) \times 100$$

Where: LR% = percent of study area supplying the life requisite (i.e. food, cover, or reproduction).

RA_i - relative area of cover type i

$$\text{relative area} = \frac{\text{area of cover type i}}{\text{area of all cover types used by deer}}$$

n - the number of cover types that provide the life requisite.

SI_i - the suitability index for the specified life requisite in cover type i.

2. Derive overall life requisite suitability index.

Using the graphs for variables 12, 13, and 14 determine the SI corresponding to each LR% calculated in step 1.

3. Determine overall HSI.

Compare the SI values for each life requisite (determine in step 2). The minimum value will be the overall HSI for black-tailed deer on the study area.

Assumptions Used in Applying the Black-tailed Deer Model

V_2 - Percent cover of preferred shrubs.

It was assumed that foliage over 5 feet cannot be utilized by deer. Although not supported by the literature, the following species were added to the list of preferred shrubs: deer brush, brewer's oak, canyon live oak, interior live oak, scrub oak, and styrax. Green leaf and white leaf manzanitas were removed (HEP team meeting, June 1984).

V_6 - Distance to cover.

It was assumed that cover was not limiting within the study area; SI = 1.0.

V_7 - Percent slope

Using data for existing and future shoreline miles and lake surface acres, a 30% slope was calculated for the study area.

V_{10} - Distance to water.

It was assumed that water for deer was not limiting, since the study area only included a 200 foot band; SI = 1.0.

V_{11} - Distance to succulent vegetation.

This variable was too difficult to measure. It was assumed that the SI = 0.1 for the study area since very little succulent vegetation was felt to be present.

Literature Cited

Black, H., R.J. Scherzinger, and J.W. Thomas. 1976. Relationships of Rocky Mountain elk and Rocky Mountain mule deer in the Blue Mountains of Oregon and Washington. In: J.M. Peek (chairman) and S.R. Hieb (ed.). Proceedings of the elk-logging-roads symposium. Moscow, Idaho. December 16-17, 1975. For., Wildl., and Range Expt. Stat., Univ. Idaho, Moscow.

Kie, J.G. and J.W. Menke. 1980. Deer response to Trinity River habitat manipulation. A cooperative study. Univ. of Calif. Davis, U.S.D.A. Forest Service, California Department of Fish and Game, and Trinity River Basin Fish and Wildlife Task Force. 158 pp.

Leach, H.R. and J.L. Hiehle. 1957. Food habits of the Tehama deer herd. Calif. Fish and Game, 43(3):161-178.

Lemos, J.C. and W.W. Hines. 1974. Oregon wildlife research: Western Oregon big game habitat studies. Oreg. Wildl. Commiss. Project W-70-R-4 Subproject G, Study I, Job 5. 36 pp.

Ross, M. June 1982. Deer habitat evaluation process, Intermountain Sagebrush Province, Modoc National Forest. U.S. Forest Service. 8 pp.

Salwasser, H., S.A. Holl, and M. Ross, ed. June 1982. Deer habitats in California: deer ecology and habitat relationships models for inventory, planning, and management. U.S. Forest Service, Pacific Southwest Region. 40 pp.

Shimamoto, K. and D. Airola, ed. January 1981. Fish and wildlife habitat capability models and special habitat criteria for northeast zone national forests. U.S. Forest Service. 260 pp.

Smith, D. D. Smith, and T. Brumley. 1984. Personal communication with California Fish and Game and U.S. Forest Service.

U.S. Fish and Wildlife Service. Undated. Draft habitat suitability index model for the black-tailed deer. Western Energy and Land Use Team, Ft. Collins, Colo. 21 pp.

APPENDIX D

Various assumptions made for the Trinity River Division HEP Project.

General

1) HEP was a suitable methodology for quantifying project impacts to wildlife.

2) Only the impacts from flooding of wildlife and their habitats were analyzed.

Study Area

1) Pre-dam - The study area was assumed to be the Trinity River, where it is estimated that the river flowed in what is now the Trinity and Lewiston Reservoirs, and all tributaries of the river in this vicinity including Stuart Fork, East Fork of Stuart Fork, East Fork of the Trinity River, and Swift Creek.

2) Post-dam - The study area was assumed to be the existing Trinity and Lewiston Reservoirs to maximum pool.

Cover Types

1) Pre-dam - The cover types were based upon existing cover types and pre-dam aerial photos to determine location, quantity, and type of each cover type previously found in the reservoir areas.

2) Post-dam - The area of the now-existing reservoirs available for use as wildlife habitat was assumed to be the acreage of the gross pool in each reservoir.

Evaluation Species Selection

1) Nine evaluation species were chosen. We felt that less would not represent the cover types sufficiently, and more would result in more information than could practically be collected and incorporated into the report.

2) The species selected are good representatives of the habitat quality per each cover type, and the changes in habitat quality related to each evaluation species.

3) Species of both political and ecological importance were chosen.

4) The species selected are sufficient to gauge the extent of impacts from the Project.

5) No federally or state threatened or endangered species were chosen, since Federal and State laws may prohibit acceptance of habitat losses for these species.

Models

1) Only HSI species models that exist were selected, as there was no time to build new species models.

See the individual models for assumptions regarding their design and application. Also, there were modifications made to two of the species models:

1) Black-tailed deer - For V1, we included a graph for mast quantity (see model). For V2, we used the list in Appendix K. We did not use V11 because there was no succulent vegetation in the particular sample sites we selected.

2) Wood duck - V3 (which includes V1 and V2 for the calculation) was modified to include only the number of potentially suitable tree cavities/0.4 ha, therefore, we did not use V2 (the number of nest boxes/0.4 ha) (see model).

Field Data Collection

1) The methods used to select sample sites were sufficiently random for the purposes of this study.

2) An average of 6 transects per sample site, taking 5 samples per transect, was adequate for quantifying habitat variables.

3) A shrub was defined as any woody, non-prostrate vegetation less than or equal to 16.4 ft (5 m) tall. A tree was defined to be any woody vegetation greater than 16.4 ft tall.

4) Ferns were counted as herbaceous material, not shrubs.

5) When measuring variables, the biologists made a point of staying away from all roads, so the line transects would not cross over them.

6) A random numbers table provided a sufficient randomization of transect locations.

7) Cover type sites evaluated as impact areas were chosen to represent pre-dam habitat values.

8) An oral history of the area by a member of the U.S. Forest Service provided some background as to what the Project site looked like pre-dam.

9) Only reasonably accessible areas were considered in selection of sample sites.

10) Only cover types within proximity to the reservoir were measured.

11) Data were gathered from September 15 through November 18. Therefore, although we did not measure the variables in the Spring, we made assumptions for certain variables as to what we thought they would look like at that time of year.

__Data Analysis__

1) For the <u>without-project</u> scenario, it was assumed that changes in wildlife habitat quality between target years 0 and 105 would be linear.

2) For the <u>with-project</u> scenario, it was assumed that habitat quality in all habitat types was zero by target year 1 in the reservoir areas. It was further assumed that this change in quality would remain unchanged between target years 5 and 105.

3) It was assumed that cover types found in the study area would be the same cover types found in the compensation areas.

4) It was assumed that compensation on the Project lands to date has been insignificant.

5) For the <u>without-management</u> scenario, it was assumed that habitat quality (in terms of HSIs for the evaluation species) was the same in the compensation area as in the project area for the entire period of analysis. Changes in cover types due to succession were assumed to occur in a similar way and at the same rate as in the project area.

6) For the <u>with-management</u> scenario (MP2), habitat quality on the compensation area was assumed to change by a percentage of the baseline HSI for each evaluation species that would occur in the area. The change in the habitat quality was assumed to take place linearly between target years 36 and 105. The maximum HSI value was 1.0 for mink (montane riparian, riverine), wood duck (montane riparian, riverine), downy woodpecker (montane riparian), red-winged blackbird (wet meadow), downy woodpecker (montane hardwood), and bobcat (montane hardwood, mixed chaparral).

7) Future land use/vegetation patterns were assumed to be as follows:

A) <u>Future Without the Project</u>

1. Land use changes were assumed to be insignificant.

2. The oak component of the montane hardwood conifer cover type would be reduced as the stands grew older.

3. Mixed chaparral habitat would eventually become montane hardwood if not burned.

APPENDIX D (continued)

4. The acreages of the cover types would change due to plant succession.

B) <u>Future With the Project</u>

1. Land ownership patterns around the reservoir would be similar to existing land use patterns.

APPENDIX E

Table 1. Evaluation species, variable description, cover types per variable, and methods used to obtain the variables found in each HSI species model.

EVALUATION SPECIES	VARIABLE DESCRIPTION	COVER TYPE	METHOD USED
Downy woodpecker	**V1** - Basal area	Montane riparian, montane hardwood, montane hardwood conifer (for both variables)	**Field**
	V2 - Number of snags >6 in dbh/ac		**Field**
Blue grouse	**V1** - Percent canopy cover of trees over the entire area	Montane hardwood conifer (for all variables)	**Field**
	V2 - Percent shrub crown cover		**Field**
	V3 - Average height of shrub canopy cover		**Field**
	V4 - Percent herbaceous canopy cover		**Field**
	V5 - Average height of herbaceous canopy cover		**Field**
	V6 - Diversity of herbaceous vegetation per cover type		**Field**
	V7 - Distance to forest or tree savanna cover types		**Topo maps**
California ground squirrel	**V1** - The abundance, availability, and diversity of suitable food types within 150 yds from the sample site	Cropland (for all variables)	**Field**
	V2 - The availability of free water within 0.25 mi from the sample site		**Field**
	V3 - The presence of burrows and the "openness' of the area within 150 yds from the sample site		**Field**
	V4 - The "open" character of the area within 150 yds from the sample site and the presence of promontories		**Field**

Table 1 continued.

EVALUATION SPECIES	VARIABLE DESCRIPTION	COVER TYPE	METHOD USED
Black-tailed deer	**V1** - Percent herbaceous cover (modified)	Chaparral, montane hardwood, montane hardwood conifer	Field
	V2 - Percent cover of preferred shrubs under 4.9 m (modified)	Chaparral, montane hardwood, montane hardwood conifer	Field
	V3 - Percent shrub cover	Chaparral	Field
	V4 - Shrub age class	Chaparral	Field
	V5 - Average shrub height	Chaparral, montane hardwood, montane hardwood conifer (same for the rest of the variables)	Field
	V6 - Distance to cover		Field
	V7 - Percent slope		Field
	V8 - Percent tree cover (optimal thermal cover)		Field
	V9 - Percent tree cover (optimal fawning habitat)		Field
	V10 - Distance to water		Topo maps
California quail	**V1** - Distance to available permanent water	Chaparral, wet meadow, montane hardwood	Topo maps
	V2 - Distance to roosting cover	Chaparral, wet meadow, montane hardwood	Field
	V3 - Distance to escape cover	Wet meadow	Field
	V4 - Forage availability	Chaparral, wet meadow, montane hardwood	Field
	V5 - Percent cover of herbaceous vegetation	Chaparral, wet meadow, montane hardwood	Field
	V6 - Percent shrub crown closure	Chaparral, montane hardwood	Field
	V7 - Overwinter crop management	Cropland	Personal communication with landowner
	V9 - Distance to forage from escape cover	Chaparral, montane hardwood	Field

Table 1 continued.

EVALUATION SPECIES	VARIABLE DESCRIPTION	COVER TYPE	METHOD USED
Bobcat	**V1** - Percent herbaceous cover	Chaparral, montane hardwood, montane hardwood conifer (for all variables)	Field
	V2 - Percent shrub cover		Field
	V3 - Number of cover/rest sites		Field
	V4 - Topographic diversity		Field
	V5 - Percent of area in optimum cover		Field
	V6 - Percent of area in optimum food		Field
Mink	**V1** - Percent tree, shrub, and/or persistent emergent herbaceous vegetation canopy closure	Montane riparian	Field
	V2 - Percent of year with surface water present	Montane riparian, riverine	Field
	V4 - Percent tree and/or shrub canopy closure within 328 ft of water's or wetland's edge	Montane riparian, riverine	Field
Wood duck	**V3** - Density of potential nest sites/1 ac (modified)	Montane riparian, riverine (for all variables)	Field
	V1 - Number of potentially suitable tree cavities/1 ac		Field
	V4 - Percent of the water surface covered by potential brood cover		Field
	V5 - Percent of the water surface covered by potential winter cover		
Red-winged blackbird	**V1** - The availability of grain and weed seeds within 0.5 mi of the sample site	Wet meadow (for all variables)	Field
	V2(I) - The type of nesting habitat		Field
	V2(II)A - Estimated depth of water beneath nests or potential nest sites		Field
	V2(II)B - Density of nest cover over water		Field
	V2(II)C - Height, or potential height, of nests		Field
	V2(IV) - Abundance and availability of insects during the breeding season (spring and early summer)		Field

APPENDIX F

Predicted habitat changes for past, baseline, and future scenario target years for the Trinity River Division HEP Project.

SCENARIO/COVER TYPE/TARGET YEAR	ACTION(S)
<u>Future Without the Project</u>	
(PA1)	
RIPARIAN/RIVERINE, WET MEADOW/WETLANDS, MONTANE HARDWOOD, MONTANE HARDWOOD CONIFER, MIXED CHAPARRAL, CROPLAND	
Target Year 0	No actions - conditions on study area are what they were 36 years ago (TY36 = present conditions)
Target Years 1, 5, 105	TY0 conditions persist, plant succession proceeds, and land use continues more or less as present in the study area, through on-going dynamic processes that are self-maintaining.
<u>Future With the Project</u>	
(PA2)	
RIPARIAN/RIVERINE, WET MEADOW/WETLANDS, MONTANE HARDWOOD, MONTANE HARDWOOD CONIFER, MIXED CHAPARRAL, CROPLAND	
Target Year 0	No actions - conditions on study area are what they were 36 years ago (TY36 = present conditions)
Target Year 1	Construction begins.
Target Year 5	Construction activities are completed and storage begins.
Target Year 105	End of period of analysis.

<u>Future Without Management</u>

(MP1)

RIPARIAN/RIVERINE, WET MEADOW, MONTANE HARDWOOD, CHAPARRAL, CROPLAND

Target Year 0	No actions - conditions on compensation areas are what they were 36 years ago (TY36 = present conditions)
Target Year 1, 36, 105	TY0 conditions persist, land use continues more or less as present on the compensation areas.

<u>Future With Management</u>

(MP2)

RIPARIAN/RIVERINE

Target Year 0	No actions - conditions on compensation areas are what they were 36 years ago (TY36 = present conditions)
Target Year 1	Construction begins.
Target Year 36, 105	These cover types have begun to mitigate by themselves, therefore, no direct management actions are implemented, however, they will need to be compensated for (riparian).

WET MEADOW/WETLANDS

Target Year 0	No actions - conditions on compensation areas are what they were 36 years ago (TY36 = present conditions)
Target Year 1	Construction begins.
Target Year 36	Management actions will begin by TY37.
Target Year 37, 39, 105	By TY37, Snipe Gulch will be redirected to flow into the compensation area; ponds will be dredged; and trees, shrubs, vines, forbs, tules, and cattails will be planted. By TY39,

all vegetation will have begun to grow and provide forage and escape, nesting, and roosting cover wildlife. By TY105, the area will have been managed annually; all planted vegetation will be at their full cover and forage potential.

MONTANE HARDWOOD, MIXED CHAPARRAL, CROPLAND

Target Year 0	No actions - conditions on compensation areas are what they were 36 years ago (TY36 = present conditions)
Target Year 1	Construction begins.
Target Year 36	Management actions will begin by TY41.
Target Years 41, 46, 56, 105	By TY41, the chaparral site will have been crushed, burned and reseeded (this will be done every 5 years); forbs and shrubs will have begun to grow and provide food and cover. The montane hardwood site will have had logs and/or brush piles placed on site; quail guzzlers installed; and trees, shrubs, vines, and forbs planted. All vegetation will have begun to grow and provide food and cover. By TY46, in the montane hardwood site, trees will become sexually mature, and shrubs and forbs will provide more food and cover for wildlife. By TY56, in the montane hardwood site, trees, shrubs, and forbs will become mature for wildlife, and some trees will be girdled to provide snags for downy woodpeckers. By TY105 (end of period of analysis), in the montane hardwood site, all planted vegetation will be mature for wildlife, and the chaparral site will have been crushed, burned and reseeded every 5 years to provide maximum benefits to wildlife.

Future With Management

(MP3)

WET MEADOW/WETLANDS

Target Year 0	No actions - conditions on compensation areas are what they were 36 years ago (TY36 - present conditions)
Target Year 1	Construction begins.
Target Year 36	Management actions will begin by TY37.
Target Year 37, 39, 105	By TY37, Snipe Gulch will be redirected to flow into the compensation area; ponds will be dredged; and trees, shrubs, vines, forbs, tules, and cattails will be planted. By TY39, all vegetation will have begun to grow to provide forage, and escape, nesting, and roosting cover for wildlife. By TY105, the area will have been managed annually; all planted vegetation will be at their full potential in providing forage and cover.

MONTANE HARDWOOD, MIXED CHAPARRAL

Target Year 0	No actions - conditions on compensation areas are what they were 36 years ago (TY36 - present conditions)
Target Year 1	Construction begins.
Target Year 36	Management actions will begin by TY46.
Target Years 46, 56, 105	By TY46, the chaparral site will have been crushed, burned, and reseeded (this will be done every 10 years). Forbs and shrubs will have begun to grow to provide food and cover. Manzanita, wedgeleaf ceanothus and forbs will be mature. The montane hardwood site will have had logs and/or brush piles placed on site; quail guzzlers installed; and trees planted. The trees will be sexually mature by this time. By TY56, in the montane hardwood site, the trees will be valuable for wildlife and some will be girdled to provide snags for the downy woodpecker. By TY105, trees will be mature for

wildlife in the montane hardwood site, and the chaparral site will have been crushed, burned and reseeded every 10 years to provide maximum benefits to wildlife.

Future With Management

(MP4)

WET MEADOW/WETLANDS

Target Year 0	No actions - conditions on compensation areas are what they were 36 years ago (TY36 = present conditions)
Target Year 1	Construction begins.
Target Year 36	Management actions will begin by TY37.
Target Year 37, 39, 105	By TY37, Snipe Gulch will be redirected to flow into the compensation area; ponds will be dredged; shrubs, vines, forbs, tules, and cattails will be planted. By TY39, all vegetation will have begun to grow and provide forage and escape, nesting, and roosting cover wildlife. By TY105, there will have been no management. Roosting and nesting habitat will be available for red-winged blackbirds, but without management, herbaceous vegetation will be too dense for California quail.

MONTANE HARDWOOD,
MONTANE HARDWOOD,
MIXED CHAPARRAL

Target Year 0	No actions - conditions on compensation areas are what they were 36 years ago (TY36 = present conditions)
Target Year 1	Construction begins.
Target Year 36	Management actions will begin by TY41.
Target Years 41, 46, 105	By TY41, the chaparral site will have been crushed and burned (this will be done every 5 years). Forbs and shrubs will have begun to

grow and provide food and cover. The montane hardwood site will have been burned to remove dense herbaceous growth; and trees, shrubs and vines will have been planted. By TY46, in the montane hardwood site, the trees will be sexually mature, and shrubs and vines mature enough to provide food and escape cover. By TY105, the trees will be mature for wildlife in the montane hardwood site, and the chaparral site will have been crushed and burned every 5 years to provide benefits to wildlife. With no reseeding, however, the area will not have revegetated to its maximum potential.

Future With Management

(MP5)

WET MEADOW/WETLANDS

Target Year 0	No actions - conditions on compensation areas are what they were 36 years ago (TY36 = present conditions)
Target Year 1	Construction begins.
Target Year 36	Management actions will begin by TY37.
Target Year 37, 39, 105	By TY37, Snipe Gulch will be redirected to flow into the compensation area; ponds will be dredged; forbs and herbs will be planted. By TY39, all vegetation will be mature. By TY105, there will have been no management. Without management, herbaceous vegetation will be too dense for Caifornia quail.

MONTANE HARDWOOD, MIXED CHAPARRAL

Target Year 0	No actions - conditions on compensation areas are what they were 36 years ago (TY36 = present conditions)
Target Year 1	Construction begins.
Target Year 36	Management actions will begin by TY41.

Target Years 41, 105

By TY41, the chaparral site will have been crushed and burned (this will be done every 5 years). Forbs and shrubs will become mature. The montane hardwood site will have been burned to remove dense herbaceous growth; logs and/or brush piles will have been placed on site; forbs will have been planted. By TY105, the chaparral site will have been crushed and burned every 5 years to provide benefits to wildlife, but with no reseeding, the area will not have revegetated to its maximum potential. The montane hardwood site will contain brush piles and/or logs, and mature forbs, but nothing else.

APPENDIX G

HSI's calculated from past, baseline, and future assumptions.

MONTANE RIPARIAN AND RIVERINE
ASSUMPTIONS
PA1 - FUTURE WITHOUT THE PROJECT

<u>General</u>

1. Variables for riverine habitat were measured at sites above Trinity Reservoir; montane riparian variables were measured along tributaries of the river: Swift Creek and Stuart Fork.

<u>Mink HSI Model</u>
Montane Riparian

TY0 - V1 0.5 HSI = 0.75
V2 1.0
V3 0.1
V4 0.5
TY1 - no change from TY0
TY5 - no change from TY0
TY105 - no change from TY0

<u>Weighted HSI for both cover types, all target years</u> = 0.75

Riverine

TY0 - V1 1.0 HSI = 0.8
V2 0.6
TY1 - no change from TY0
TY5 - no change from TY0
TY105 - no change from TY0

<u>Wood Duck HSI Model</u>
Montane Riparian

TY0 - V3 0.01 HSI = 0.1
V4 0.15
V5 0.1
TY1 - no change from TY0
TY5 - no change from TY0
TY105 - no change from TY0

<u>Weighted HSI for both cover types, all target years</u> = 0.19

Appendix G (continued)

MONTANE RIPARIAN AND RIVERINE
ASSUMPTIONS
PA1 - FUTURE WITHOUT THE PROJECT (continued)

Riverine

TY0 - V3 0.01 HSI = 0.19
V4 0.005
V5 0.005
TY1 - no change from TY0
TY5 - no change from TY0
TY105 - no change from TY0

Appendix G (continued)

MONTANE RIPARIAN AND RIVERINE
ASSUMPTIONS
PA2 - FUTURE WITH THE PROJECT

General

1. No habitat exists in the reservoirs.

Downy Woodpecker HSI Model
Montane Riparian

TY0 - V1 0.3 HSI = 0.3
V2 1.0
TY1 - V1 0.0
V2 0.0
TY5 - no change from TY1
TY105 - no change from TY5

Mink HSI Model
Montane Riparian

TY0 - no change from PA1, TY0
TY1 - V1 0.0
V2 0.0
V3 0.0
V4 0.0
TY5 - no change from TY1
TY105 - no change from TY5

Riverine

TY0 - no change from PA1, TY0
TY1 - V1 0.0
V2 0.0 HSI = 0.0
V3 0.0
V4 0.0
TY5 - no change from TY1
TY105 - no change from TY5

Weighted HSI for both cover types, target years 5 and 105 = 0.0

Wood Duck HSI Model
Montane Riparian

TY0 - no change from PA1, TY0
TY1 - V3 0.0 HSI = 0.0
V4 0.0
V5 0.0

Appendix G (continued)

MONTANE RIPARIAN AND RIVERINE
ASSUMPTIONS
PA2 - FUTURE WITH THE PROJECT (continued)

TY5 - no change from TY1
TY105 - no change from TY5

Weighted HSI for both cover types, target years 5 and 105 = 0.0

Riverine

TY0 - no change from PA1, TY0
TY1 - V3 0.0 HSI = 0.0
V4 0.0
V5 0.0
TY5 - no change from TY1
TY105 - no change from TY5

Downy Woodpecker HSI Model
Montane Riparian

TY0 - no change from PA1, TY0
TY1 - V1 0.0 HSI = 0.0
V2 0.0
TY5 - no change from TY1
TY105 - no change from TY5

MONTANE RIPARIAN AND RIVERINE ASSUMPTIONS MP1 - FUTURE WITHOUT MANAGEMENT

General

1. The same values found for PA1 were given to MP1.

Mink HSI Model

Montane Riparian

TY0 - no change from PA1, TY0
TY1 - no change from PA1, TY1
TY36 - no change from PA1, TY5
TY105 - no change from PA1, TY105

Riverine

TY0 - no change from PA1, TY0
TY1 - no change from PA1, TY1
TY36 - no change from PA1, TY5
TY105 - no change from PA1, TY105

Wood Duck HSI Model

Montane Riparian

TY0 - no change from PA1, TY0
TY1 - no change from PA1, TY1
TY36 - no change from PA1, TY5
TY105 - no change from PA1, TY105

Riverine

TY0 - no change from PA1, TY0
TY1 - no change from PA1, TY1
TY36 - no change from PA1, TY5
TY105 - no change from PA1, TY105

Downy Woodpecker HSI Model

Montane Riparian

TY0 - no change from PA1, TY0
TY1 - no change from PA1, TY1
TY36 - no change from PA1, TY5
TY105 - no change from PA1, TY105

Appendix G (continued)

MONTANE RIPARIAN AND RIVERINE ASSUMPTIONS MP2 - FUTURE WITH MANAGEMENT

General

1. Variables for montane riparian and riverine were measured downstream of Lewiston Dam, where there has been a significant increase in riparian vegetation since the construction of the dams.

Mink HSI Model

Montane Riparian

TY0 - no change from PA1 & MP1, TY0
TY1 - no change from PA1 & MP1, TY1
TY36 - V1 1.0 HSI = 1.0
V2 1.0
V4 1.0
TY105 - no change from TY36

Riverine

TY0 - no change from PA1 & MP1, TY0
TY1 - no change from PA1 & MP1, TY1
TY36 - V2 1.0 HSI = 1.0
V4 1.0
TY105 - no change from PA1, TY36

Wood Duck HSI Model

Montane Riparian

TY0 - no change from PA1 & MP1, TY0
TY1 - no change from PA1 & MP1, TY1
TY36 - V3 0.9 HSI = 1.0
V4 0.4
V5 0.38
TY105 - no change from PA1, TY36

Riverine

TY0 - no change from PA1 & MP1, TY0
TY1 - no change from PA1 & MP1, TY1
TY36 - V3 0.9 HSI = 1.0
V4 0.4
V5 0.38
TY105 - no change from PA1, TY36

MONTANE RIPARIAN AND RIVERINE
ASSUMPTIONS
MP2 - FUTURE WITH MANAGEMENT (continued)

Downy Woodpecker HSI Model
Montane Riparian

TY0 - no change from PA1 & MP1, TY0
TY1 - no change from PA1 & MP1, TY1
TY36 - V1 1.0 HSI = 1.0
V2 1.0
TY105 - no change from PA1, TY36

WET MEADOW
ASSUMPTIONS
PA1 - FUTURE WITHOUT THE PROJECT

General

1. The site is 311.08 acres, located at the Norwegian Ranch, southwest of Trinity Center.

California Quail HSI Model

TY0 - baseline HSI = 0.55
V1 1.0
V2 1.0
V3 0.95
V4 1.0
V5 0.3
TY1 - no change from baseline
TY5 - no change from baseline
TY105 - no change from baseline

Red-winged Blackbird HSI Model

TY0 - baseline HSI = 0.8
V1 1.0
V2(I) 1.0
V2(II)A 0.6
V2(II)B 0.5
V2(II)C 0.9
V2(IV) 1.0
V2 0.8
TY1 - no change from baseline
TY5 - no change from baseline
TY105 - no change from baseline

WET MEADOW
ASSUMPTIONS
PA2 - FUTURE WITH THE PROJECT

General

1. No habitat exists in the reservoirs.

California Quail HSI Model

TY0 - HSI value equivalent to PA1
TY1 - V1 0.0 HSI = 0.0
V2 0.0
V3 0.0
V4 0.0
V5 0.0
TY5 - No change from TY1
TY105 - no change from TY5

Red-winged Blackbird HSI Model

TY0 - HSI value equivalent to PA1
TY1 - V1 0.0 HSI = 0.0
V2(I) 0.0
V2(II)A 0.0
V2(II)B 0.0
V2(II)C 0.0
V2(IV) 0.0
V2 0.0
TY5 - No change from TY1
TY105 - no change from TY5

WET MEADOW
ASSUMPTIONS
MP1 - FUTURE WITHOUT MANAGEMENT

General

1. The site is 110.0 acres (Figure 3), and is located next to the Trinity River.
2. One-half of the area is owned by the Department of Water Resources, and the other one-half is owned by a private landowner and is for sale.
3. The main species growing here is yellow star thistle.
4. The area at TY0 was wetter than it is at present, had shorter grasses, and was grazed prior to TY36.

California Quail HSI Model

TY0 - baseline HSI = 0.87
V1 1.0 (< .25 mi)
V2 1.0 (< .25 mi)
V3 1.0 (< 200 ft.)
V4 1.0 (> 50%)
V5 0.75 (20%)
TY1 - no change from baseline
TY36 - V1 1.0 (no change from baseline) HSI = 0.35
- V2 1.0 (no change from baseline)
- V3 1.0 (no change from baseline)
- V4 1.0 (no change from baseline)
- V5 0.125 (90.4%)
TY105 - no change from TY36

Red-winged Blackbird HSI Model

TY0 - V1 0.9 HSI = 0.54
V2(I) 0.4
V2(II)A 0.6
V2(II)B 0.4
V2(II)C 0.8
V2(IV) 0.5
V2 0.54
TY1 - no change from baseline
TY36 - V1 0.9 (no change) HSI = 0.16
- V2(I) 0.2 (no change)
- V2(II)A 0.0 (no change)
- V2(II)B 0.0 (no change)
- V2(II)C 0.12 (no change)
- V2(IV) 0.5 (no change)
- V2 0.164
TY105 - no change from TY36

Appendix G (continued)

WET MEADOW
ASSUMPTIONS
MP2 - FUTURE WITH MANAGEMENT

General

1. The wet meadow is located next to the Trinity River. Snipe Gulch, which is located across the street from the potential compensation area, was diverted from its naturally flowing course by a ditch, which has directed its flow into Grass Valley Creek which then flows into the Trinity River. We would like to redirect the gulch back to its naturally flowing course with a culvert directly below the gulch so it would naturally flood this valley area. Through this method, the yellow star thistle, which is currently growing there, would die from the inundation of the water.
2. Dredge ponds along the Trinity River to provide a permanent water source.
3. Plant trees, shrubs, and vines to provide roosting cover for California quail, and roosting and nesting habitat for red-winged blackbirds.
4. Plant herbs, shrubs and vines to provide escape cover for California quail and other wildlife.
5. Plant preferred forbs for seeds for California quail food.
6. Manage the area annually.

California Quail HSI Model

TY0 - no change from MP1, TY0
TY1 - no change from MP1, TY1
TY36 - no change from MP1, TY36

TY37 -	V1	1.0	HSI = 1.0
	V2	1.0	
	V3	1.0	
	V4	0.0	
	V5	1.0	
TY39 -	V1	no change from TY37	HSI = 0.87
	V2	no change from TY37	
	V3	no change from TY37	
	V4	1.0 (50%-100%)	
	V5	.75 (25%)	

TY105 - no change from TY39

WET MEADOW
ASSUMPTIONS
MP2 - FUTURE WITH MANAGEMENT (continued)

Red-winged Blackbird Model

```
TY0 - no change from MP1, TY0
TY1 - no change from MP1, TY1
TY36 - no change from MP1, TY36
TY37 - V1        1.0        HSI = 0.2
       V2(I)     0.0
       V2(II)A   1.0
       V2(II)B   0.0
       V2(II)C   0.0
       V2(IV)    0.0
       V2        0.2
TY39 - V1        no change from TY37   HSI = 1.0
       V2(I)     1.0
       V2(II)A   no change from TY37
       V2(II)B   1.0
       V2(II)C   1.0
       V2(IV)    1.0
       V2        1.0
TY105 - no change from TY39
```

Appendix G (continued)

WET MEADOW
ASSUMPTIONS
MP3 - FUTURE WITH MANAGEMENT

General

1. The wet meadow is located next to the Trinity River. Snipe Gulch, which is located across the street from the potential compensation area, was diverted from its naturally flowing course by a ditch, which has directed its flow into Grass Valley Creek which then flows into the Trinity River. We would like to redirect the gulch back to its naturally flowing course with a culvert directly below the gulch so it would naturally flood this valley area. Through this method, the yellow star thistle, which is currently growing there, would die from the inundation of the water.
2. Dredge ponds along the Trinity River to provide a permanent water source.
3. Plant trees, shrubs, and vines to provide roosting cover for California quail, and trees and shrubs to provide roosting and nesting habitat for red-winged blackbirds.
4. Plant preferred forbs for seeds for California quail food.
5. Provide annual management.

California Quail HSI Model

TY0 - no change from MP1 & MP2, TY0
TY1 - no change from MP1 & MP2, TY1
TY36 - no change from MP1 & MP2, TY36
TY37 - V1 1.0 HSI = 1.0
V2 1.0
V3 1.0
V4 0.0
V5 1.0
TY39 - V1 no change from TY37 HSI = 0.87
V2 no change from TY37
V3 no change from TY37
V4 1.0 (50%-100%)
V5 0.75 (25%)
TY105 - no change from TY39

Red-winged Blackbird HSI Model

TY0 - no change from MP1 & MP2, TY0
TY1 - no change from MP1 & MP2, TY1
TY36 - no change from MP1 & MP2, TY36
TY37 - no change from MP1 & MP2, TY37
TY39 - no change from MP1 & MP2, TY39
TY105 - no change from MP1 & MP2, TY105

Appendix G (continued)

WET MEADOW
ASSUMPTIONS
MP4 - FUTURE WITH MANAGEMENT

General

1. The wet meadow is located next to the Trinity River. Snipe Gulch, which is located across the street from the potential compensation area, was diverted from its naturally flowing course by a ditch, which has directed its flow into Grass Valley Creek which then flows into the Trinity River. We would like to redirect the gulch back to its naturally flowing course with a culvert directly below the gulch so it would naturally flood this valley area. Through this method, the yellow star thistle, which is currently growing there, would die from the inundation of the water.
2. Dredge ponds along the Trinity River to provide a permanent water source.
3. Plant shrubs and vines to provide escape cover for California quail and other wildlife.
4. Plant preferred forbs for seeds for California quail food.
5. Provide no annual management.

California Quail HSI Model

TY0 - no change from MP1, MP2, & MP3, TY0
TY1 - no change from MP1, MP2, & MP3, TY1
TY36 - no change from MP1, MP2, & MP3, TY36
TY37 - no change from MP1, MP2, & MP3, TY37
TY39 - no change from MP1, MP2, & MP3, TY39

TY105 -	V1	1.0	no change from TY39	HSI = 0.0
	V2	1.0	no change from TY39	
	V3	1.0	no change from TY39	
	V4	1.0	no change from TY39	
	V5	0.0	(100%)	

Red-winged Blackbird HSI Model

TY0 - no change from MP1, MP2 & MP3, TY0
TY1 - no change from MP1, MP2 & MP3, TY1
TY36 - no change from MP1, MP2 & MP3, TY36
TY37 - no change from MP1, MP2 & MP3, TY37
TY39 - no change from MP1, MP2 & MP3, TY39
TY105 - no change from MP1, MP2 & MP3, TY105

Appendix G (continued)

WET MEADOW
ASSUMPTIONS
MP5 - FUTURE WITH MANAGEMENT

General

1. The wet meadow is located next to the Trinity River. Snipe Gulch, which is located across the street from the potential compensation area, was diverted from its naturally flowing course by a ditch, which has directed its flow into Grass Valley Creek which then flows into the Trinity River. We would like to redirect the gulch back to its naturally flowing course with a culvert directly below the gulch so it would naturally flood this valley area. Through this method, the yellow star thistle, which is currently growing there, would die from the inundation of the water.
2. Dredge ponds along the Trinity River to provide a permanent water source.
3. Plant preferred forbs for seeds for California quail food.
4. Plant herbs to provide escape cover for California quail and other wildlife.
5. Provide no annual management.

California Quail HSI Model

TY0 - no change from MP1, MP2, MP3 & MP4, TY0
TY1 - no change from MP1, MP2, MP3 & MP4, TY1
TY36 - no change from MP1, MP2, MP3 & MP4, TY36
TY37 - no change from MP1, MP2, MP3 & MP4, TY37
TY39 - no change from MP1, MP2, MP3 & MP4, TY39
TY105 - no change from MP4, TY105

Red-winged Blackbird HSI Model

TY0 - no change from MP1 & MP2, TY0
TY1 - no change from MP1 & MP2, TY1
TY36 - no change from MP1 & MP2, TY36
TY37 - no change from MP1 & MP2, TY37
TY39 - no change from MP1 & MP2, TY39
TY105 - no change from MP1 & MP2, TY105

MIXED CHAPARRAL, MONTANE HARDWOOD, MONTANE HARDWOOD CONIFER ASSUMPTIONS PA1 - FUTURE WITHOUT THE PROJECT

General

1. The variables for these habitat types were measured at various locations around the reservoirs.

Black-tailed Deer HSI Model

Chaparral

TY0 -	V1	0.1	HSI = 0.6
	V2	1.0	
	V3	1.0	
	V4	1.0	
	V5	1.0	
	V6	1.0	
	V7	1.0	
	V8	0.2	
	V9	0.3	
	V10	1.0	

TY1 - no change from TY0
TY5 - no change from TY0
TY105 - no change from TY0

Montane Hardwood

TY0 -	V1	1.0	HSI = 0.6
	V2	0.05	
	V5	1.0	
	V6	0.1	
	V7	1.0	
	V8	0.95	
	V9	1.0	
	V10	1.0	

TY1 - no change from TY0
TY5 - no change from TY0
TY105- no change from TY0

MIXED CHAPARRAL, MONTANE HARDWOOD, MONTANE HARDWOOD CONIFER
ASSUMPTIONS
PA1 - FUTURE WITHOUT THE PROJECT (continued)

Montane Hardwood Conifer

TY0 - V1 0.1 HSI = 0.6
V2 0.3
V5 1.0
V6 1.0
V7 0.95
V8 1.0
V9 0.3
V10 1.0
TY1 - no change from TY0
TY5 - no change from TY0
TY105 - no change from TY0

Weighted mean HSI from all three cover types for deer = 0.60

Bobcat HSI Model

Chaparral

TY0 - V1 0.2 HSI = 0.75
V2 1.0
V3 1.0
V4 0.81
TY1 - no change from TY0
TY5 - no change from TY0
TY105 - no change from TY0

Montane Hardwood

TY0 - V1 0.45 HSI = 0.75
V2 0.3
V3 0.17
V4 0.4
TY1 - no change from TY0
TY5 - no change from TY0
TY105 - no change from TY0

Montane Hardwood Conifer

TY0 - V1 0.15 HSI = 0.75
V2 0.6
V3 0.93
V4 0.44
TY1 - no change from TY0
TY5 - no change from TY0

MIXED CHAPARRAL, MONTANE HARDWOOD, MONTANE HARDWOOD CONIFER ASSUMPTIONS
PA1 - FUTURE WITHOUT THE PROJECT (continued)

TY105 - no change from TY0

Weighted mean HSI for all three cover types for the bobcat = 0.75

California Quail HSI Model
Chaparral

TY0 - V1 1.0 HSI = 0.21
V2 1.0
V4 0.3
V5 0.9
V6 0.05
V9 1.0
TY1 - no change from TY0
TY5 - no change from TY0
TY105 - no change from TY0

Montane Hardwood

TY0 - V1 1.0 HSI = 0.83
V2 1.0
V4 0.6
V5 0.85
V6 0.8
V9 1.0
TY1 - no change from TY0
TY5 - no change from TY0
TY105 - no change from TY0

Weighted mean HSI for both cover types for the quail = 0.75

Downy Woodpecker HSI Model
Montane Hardwood

TY0 - V1 1.0 HSI = 0.6
V2 0.6
TY1 - no change from TY0
TY5 - no change from TY0
TY105 - no change from TY0

MIXED CHAPARRAL, MONTANE HARDWOOD, MONTANE HARDWOOD CONIFER
ASSUMPTIONS
PA1 - FUTURE WITHOUT THE PROJECT (continued)

Montane Hardwood Conifer

TY0 - V1 0.5 HSI = 0.5
V2 1.0
TY1 - no change from TY0
TY5 - no change from TY0
TY105 - no change from TY0

Weighted mean HSI for both cover types for the woodpecker = 0.57

Blue Grouse HSI Model
Montane Hardwood Conifer

TY0 - V1 0.05 HSI = 0.075
V2 1.0
V3 0.2
V4 0.225
V5 0.1
V6 0.5
V7 1.0
TY1 - no change from TY0
TY5 - no change from TY0
TY105 - no change from TY0

Appendix G (continued)

MIXED CHAPARRAL, MONTANE HARDWOOD, MONTANE HARDWOOD CONIFER
ASSUMPTIONS
PA2 - FUTURE WITH THE PROJECT

General

1. No habitat exists in the reservoirs.

Black-tailed Deer HSI Model
Chaparral

TY0 - no change from PA1, all target years
TY1 - V1 0.0 HSI = 0.0
V2 0.0
V3 0.0
V4 0.0
V5 0.0
V6 0.0
V7 0.0
V8 0.0
V9 0.0
V10 0.0
TY5 - no change from TY1
TY105 - no change from TY5

Montane Hardwood

TY0 - no change from PA1, all target years
TY1 - V1 0.0 HSI = 0.0
V2 0.0
V5 0.0
V6 0.0
V7 0.0
V8 0.0
V9 0.0
V10 0.0
TY5 - no change from TY1
TY105- no change from TY5

Montane Hardwood Conifer

TY0 - no change from PA1, all target years

MIXED CHAPARRAL, MONTANE HARDWOOD, MONTANE HARDWOOD CONIFER
ASSUMPTIONS
PA2 - FUTURE WITH THE PROJECT (continued)

TY1 - V1 0.0 HSI = 0.0
V2 0.0
V5 0.0
V6 0.0
V7 0.0
V8 0.0
V9 0.0
V10 0.0
TY5 - no change from TY1
TY105- no change from TY5

Weighted mean HSI for all three cover types for target years 5 and 105 for deer = 0

Bobcat HSI Model

Chaparral

TY0 - no change from PA1, all target years
TY1 - V1 0.0 HSI = 0.0
V2 0.0
V3 0.0
V4 0.0
TY5 - no change from TY1
TY105 - no change from TY5

Montane Hardwood

TY0 - no change from PA1, all target years
TY1 - V1 0.0 HSI = 0.0
V2 0.0
V3 0.0
V4 0.0
TY5 - no change from TY1
TY105 - no change from TY5

Montane Hardwood Conifer

TY0 - no change from PA1, all target years
TY1 - V1 0.0 HSI = 0.0
V2 0.0
V3 0.0
V4 0.0

MIXED CHAPARRAL, MONTANE HARDWOOD, MONTANE HARDWOOD CONIFER ASSUMPTIONS
PA2 - FUTURE WITH THE PROJECT (continued)

TY5 - no change from TY1
TY105 - no change from TY5

Weighted mean HSI for all three cover types for target years 5 and 105 for the bobcat = 0

California Quail HSI Model
Chaparral

TY0 - no change from PA1, all target years
TY1 - V1 0.0 HSI = 0.0
V2 0.0
V4 0.0
V5 0.0
V6 0.0
V9 0.0
TY5 - no change from TY1
TY105 - no change from TY5

Montane Hardwood

TY0 - no change from PA1, all target years
TY1 - V1 0.0 HSI = 0.0
V2 0.0
V4 0.0
V5 0.0
V6 0.0
V9 0.0
TY5 - no change from TY1
TY105 - no change from TY5

Weighted mean HSI for both cover types for target years 5 and 105 for the quail = 0.0

Downy Woodpecker
Montane Hardwood

TY0 - no change from PA1, all target years
TY1 - V1 0.0 HSI = 0.0
V2 0.0
TY5 - no change from TY1
TY105 - no change from TY5

MIXED CHAPARRAL, MONTANE HARDWOOD, MONTANE HARDWOOD CONIFER
ASSUMPTIONS
PA2 - FUTURE WITH THE PROJECT (continued)

Montane Hardwood Conifer

TY0 - no change from PA1, all target years
TY1 - V1 0.0 HSI = 0.0
V2 0.0
TY5 - no change from TY1
TY105 - no change from TY5

<u>Weighted mean HSI for both cover types for target years for the woodpecker</u> = 0.0

<u>Blue Grouse</u>
Montane Hardwood Conifer

TY0 - no change from PA1, all target years
TY1 - V1 0.0 HSI = 0.0
V2 0.0
V3 0.0
V4 0.0
V5 0.0
V6 0.0
V7 0.0
TY5 - no change from TY1
TY105 - no change from TY5

Appendix G (continued)

MIXED CHAPARRAL, MONTANE HARDWOOD, MONTANE HARDWOOD CONIFER ASSUMPTIONS
MP1 - FUTURE WITHOUT MANAGEMENT

General

1. The mixed chaparral compensation site is 29.7 acres (Figure 5); the montane hardwood compensation site is 28.8 acres (Figure 4).
2. The chaparral site contains extremely decadent vegetation and supports about 75 percent wedgeleaf ceanothus and 25 percent manzanita. The montane hardwood site previously supported hardwoods (TY0) (at least in November 1957); it is now simply a grassy area (TY36).
3. The chaparral is decadent at present (TY36); at TY0, it was assumed to be mature.

Black-tailed Deer HSI Model
Chaparral

TY0 -	V1	0.1	(12.98%)	HSI = 0.6
	V2	1.0	(38.69%)	
	V3	1.0	(65.66%)	
	V4	1.0	(mature)	
	V5	1.0	(2-6 ft.)	
	V6	1.0	(within 183 m)	
	V7	0.45	(45%)	
	V8	0.1	(5%)	
	V9	0.1	(5%)	
	V10	0.4		

TY1 - no change from TY0
TY5 - no change from TY0

TY36 -	V1	0.5	HSI = 0.0
	V2	0.225	
	V3	1.0	
	V4	0.6	
	V5	0.0	
	V6	1.0	
	V7	0.45	
	V8	0.15	
	V9	0.2	
	V10	0.4	

TY105 - no change from TY36

MIXED CHAPARRAL, MONTANE HARDWOOD, MONTANE HARDWOOD CONIFER ASSUMPTIONS
MP1 - FUTURE WITHOUT MANAGEMENT (continued)

Montane hardwood

TY0 -	V1	0.9	(90%)	HSI = 0.6
	V2	0.05	(3.80%)	
	V5	1.0	(2-6 ft.)	
	V6	0.1	(>183 m)	
	V7	1.0		
	V8	0.7	(40%)	
	V9	0.9	(40%)	
	V10	0.5		
TY1 - no change from TY0				
TY5 -	V1	0.9	no change from TY0	HSI = 0.2
	V2	0.05	no change from TY0	
	V5	1.0	no change from TY0	
	V6	0.1	no change from TY0	
	V7	1.0	no change from TY0	
	V8	0.0	(0%)	
	V9	0.0	(0%)	
	V10	0.5	no change from TY0	
TY36 -	V1	0.95		HSI = 0.0
	V2	0.0		
	V5	0.0		
	V6	0.1		
	V7	1.0		
	V8	0.0		
	V9	0.0		
	V10	0.5		
TY105 - no change from TY36				

Weighted mean HSI's for both cover types for deer are:

TY0	0.6
TY1	0.6
TY5	0.2
TY36	0.0
TY105	0.0

Bobcat HSI Model

Chaparral

TY0 -	V1	0.2	(12.98%)	HSI = 1.0
	V2	1.0	(65.66%)	
	V3	1.0	(abundant and dispersed)	
	V4	0.8		

MIXED CHAPARRAL, MONTANE HARDWOOD, MONTANE HARDWOOD CONIFER ASSUMPTIONS
MP1 - FUTURE WITHOUT MANAGEMENT (continued)

TY1 - no change from TY0
TY5 - no change from TY0
TY36 - V1 0.775 HSI = 1.0
V2 1.0
V3 1.0
V4 1.0
TY105 - no change from TY36

Montane Hardwood

TY0 - V1 1.0 (90%) HSI = 1.0
V2 0.6 (20%)
V3 0.8 (c)
V4 0.4 (a)
TY1 - no change from TY0
TY5 - V1 1.0 HSI = 1.0
V2 0.6
V3 0.2
V4 0.4
TY36 - V1 1.0 HSI = 1.0
V2 0.0
V3 0.0
V4 0.4
TY105 - no change from TY36

Weighted mean HSI's for both cover types for bobcat are:
TY0 1.0
TY1 1.0
TY5 1.0
TY36 1.0
TY105 1.0

California Quail HSI Model
Chaparral

TY0 - V1 1.0 (< .25 mi) HSI = .24
V2 1.0 (< .25 mi)
V4 0.3 (12.98%)
V5 0.6 (40%)
V6 0.1 (65.66%)
V9 1.0
TY1 - no change from TY0
TY5 - no change from TY0

MIXED CHAPARRAL, MONTANE HARDWOOD, MONTANE HARDWOOD CONIFER
ASSUMPTIONS
MP1 - FUTURE WITHOUT MANAGEMENT (continued)

TY36 - V1 1.0 HSI = 0.32
V2 1.0
V4 1.0
V5 0.8
V6 0.125
V9 1.0
TY105 - no change from TY36

Montane Hardwood

TY0 - V1 0.5 HSI= = 0.63
V2 1.0 (< .25 mi)
V4 1.0 (90%)
V5 0.6 (45%)
V6 1.0 (20%)
V9 0.5
TY1 - no change from TY0
TY5 - no change from TY0
TY36 - V1 0.5 HSI = 0.0
V2 1.0
V4 1.0
V5 0.525
V6 0.0
V9 0.5
TY105 - no change from TY36

Weighted mean HSI's for both cover types for the quail are:

TY0	0.43
TY1	0.43
TY5	0.43
TY36	0.16
TY105	0.16

Downy Woodpecker HSI Model
Montane Hardwood

TY0 - V1 1.0 (81.8%) HSI = 0.6
V2 0.6 (3.1%)
TY1 - no change from TY0
TY5 - V1 0.0 HSI = 0.0
V2 0.0
TY36 - no change from TY5
TY105 - no change from TY36

MIXED CHAPARRAL, MONTANE HARDWOOD, MONTANE HARDWOOD CONIFER
ASSUMPTIONS
MP1 - FUTURE WITHOUT MANAGEMENT (continued)

Blue Grouse HSI Model

Our assumption is that the blue grouse often does well in second-growth stands following logging. Therefore, we decided to mitigate for montane hardwood conifer by compensating for it with mixed chaparral and montane hardwood cover types. For this reason, the blue grouse HSI model is not included in this "future without management" plan.

MIXED CHAPARRAL, MONTANE HARDWOOD, MONTANE HARDWOOD CONIFER ASSUMPTIONS MP2 - FUTURE WITH MANAGEMENT

General

1. Crush and burn every 5 years in a rotational manner to retard manzanita, to stimulate ceanothus growth, and to retain open areas suitable for growth of forbs, grasses, and other palatable browse (USFWS 1992), and to improve animal access (chaparral).
2. Reseed every 5 years (USFWS 1992) (i.e. wedgeleaf ceanothus) (chaparral).
3. Place logs and/or brush piles on site to improve small mammal habitat and bobcat cover (montane hardwood).
4. Install quail guzzlers to provide a water source (montane hardwood).
5. Plant trees to provide roosting cover for California quail and other wildlife, nesting habitat for downy woodpeckers, and browse for black-tailed deer (montane hardwood).
6. Plant shrubs and vines to provide escape cover for California quail and other wildlife (montane hardwood).
7. Plant forb seeds for food for California quail and other wildlife (montane hardwood).
8. Create snags by girdling planted trees, to create nesting and perching habitat for downy woodpeckers and other birds (montane hardwood).

Black-tailed Deer HSI Model
Chaparral

TY0 - no change from MP1, TY0
TY1 - no change from MP1, TY1
TY5 - no change from MP1, TY5
TY36 - no change from MP1, TY36

TY41 -	V1	0.4	(40%)	HSI = 0.55
	V2	1.0	(50%)	
	V3	0.6	(40%)	
	V4	1.0	(mature shrub)	
	V5	1.0	(2-6 ft.)	
	V6	1.0	no change from TY36	
	V7	0.45	no change from TY36	
	V8	0.15	no change from TY36	
	V9	0.2	no change from TY36	
	V10	0.4	no change from TY36	

TY46 - no change from TY41
TY56 - no change from TY46
TY105 - no change from TY46

MIXED CHAPARRAL, MONTANE HARDWOOD, MONTANE HARDWOOD CONIFER
ASSUMPTIONS
MP2 - FUTURE WITH MANAGEMENT (continued)

Montane hardwood

TY0 - no change from MP1, TY0
TY1 - no change from MP1, TY1
TY5 - no change from MP1, TY1
TY36 - no change from MP1, TY1
TY41 - no change from TY36

TY46 -	V1	0.9	(90%)	HSI = 0.9
	V2	1.0	(40%)	
	V5	0.0	(> 6 ft.)	
	V6	1.0	(≤ 183 m)	
	V7	1.0	no change from TY41	
	V8	1.0	(60%)	
	V9	0.9	(60%)	
	V10	0.5	no change from TY41	

TY56 - no change from TY46

TY105 -	V1	0.9	no change from TY56	HSI = 0.9
	V2	1.0	(50%)	
	V5	0.0	no change from TY56	
	V6	1.0	no change from TY56	
	V7	1.0	no change from TY56	
	V8	1.0	(80%)	
	V9	0.5	(80%)	
	V10	0.5	no change from TY56	

Weighted mean HSI's for both cover types for deer are:

TY0	0.6
TY1	0.6
TY5	0.2
TY36	0.0
TY41	0.55
TY46	0.72
TY56	0.72
TY105	0.72

Bobcat HSI Model
Chaparral

TY0 - no change from MP1, TY0
TY1 - no change from MP1, TY1
TY5 - no change from MP1, TY1
TY36 - no change from MP1, TY36

MIXED CHAPARRAL, MONTANE HARDWOOD, MONTANE HARDWOOD CONIFER
ASSUMPTIONS
MP2 - FUTURE WITH MANAGEMENT (continued)

TY41 - V1 0.6 (40%) HSI = 1.0
V2 1.0 (40%)
V3 1.0 (d)
V4 1.0 no change from TY36
TY46 - no change from TY41
TY56 - no change from TY46
TY105 - no change from TY56

Montane Hardwood

TY0 - no change from MP1, TY0
TY1 - no change from MP1, TY1
TY5 - no change from MP1, TY5
TY36 - no change from MP1, TY36
TY41 - no change from TY36
TY46 - V1 1.0 (90%) HSI = 1.0
V2 1.0 (70%)
V3 0.8 (c)
V4 0.4 no change from TY41
TY56 - no change from TY46
TY105 - no change from TY56

Weighted mean HSI's for both cover types for bobcat are:

TY0	1.0
TY1	1.0
TY5	1.0
TY36	1.0
TY46	1.0
TY56	1.0
TY105	1.0

California Quail HSI Model

Chaparral

TY0 - no change from MP1, TY0
TY1 - no change from MP1, TY1
TY5 - no change from MP1, TY5
TY36 - no change from MP1, TY36

MIXED CHAPARRAL, MONTANE HARDWOOD, MONTANE HARDWOOD CONIFER
ASSUMPTIONS
MP2 - FUTURE WITH MANAGEMENT (continued)

TY41 -	V1	1.0	no change from TY36	HSI = 0.6
	V2	1.0	no change from TY36	
	V4	0.8	(40%)	
	V5	0.9	(15%)	
	V6	0.4	(40%)	
	V9	1.0	no change from TY36	

TY46 - no change from TY41
TY56 - no change from TY46
TY105 - no change from TY56

Montane Hardwood

TY0 - no change from MP1, TY0
TY1 - no change from MP1, TY1
TY5 - no change from MP1, TY1
TY41 - no change from MP1, TY36

TY46 -	V1	1.0	(≤ .25 mi)	HSI = 0.14
	V2	1.0	(≤ .25 mi)	
	V4	1.0	(90%)	
	V5	0.2	(75%)	
	V6	0.1	(70%)	
	V9	1.0	(< 200 ft.)	
TY56 -	V1	1.0	no change from TY46	HSI = 0.10
	V2	1.0	no change from TY46	
	V4	1.0	no change from TY46	
	V5	0.1	(90%)	
	V6	0.1	(75%)	
	V9	1.0	no change from TY46	

TY105 - no change from TY56

<u>Weighted mean HSI's for both cover types for the quail are</u>:

TY0	0.43
TY1	0.43
TY5	0.43
TY36	0.16
TY41	0.30
TY46	0.37
TY56	0.35
TY105	0.35

MIXED CHAPARRAL, MONTANE HARDWOOD, MONTANE HARDWOOD CONIFER
ASSUMPTIONS
MP2 - FUTURE WITH MANAGEMENT (continued)

Downy Woodpecker HSI Model
Montane Hardwood

TY0 - no change from MP1, TY0
TY1 - no change from MP1, TY1
TY5 - no change from MP1, TY5
TY36 - no change from MP1, TY36
TY41 - no change from TY36
TY46 - no change from TY41

TY56 -	V1	1.0	(50 ft^2/acre)	HSI = 1.0
	V2	1.0	(5+)	
TY105 -	V1	1.0	(75 ft^2/acre)	HSI = 1.0
	V2	no change from TY56		

Appendix G (continued)

MIXED CHAPARRAL, MONTANE HARDWOOD, MONTANE HARDWOOD CONIFER
ASSUMPTIONS
MP3 - FUTURE WITH MANAGEMENT

General

1. Crush and burn every 10 years in a rotational manner to retard manzanita, stimulate ceanothus growth, retain open areas suitable for growth of forbs, grasses, and other palatable browse, and to improve animal access (chaparral).
2. Reseed every 10 years (i.e. wedgeleaf ceanothus) (chaparral).
3. Place logs and/or brush piles on site to improve small mammal habitat and bobcat cover (montane hardwood).
4. Install quail guzzlers to provide a water source (montane hardwood).
5. Plant trees to provide roosting cover for California quail and other wildlife, and nesting habitat for the downy woodpecker and other birds (montane hardwood).
6. Create snags by girdling planted trees, to create habitat for nesting, perching, etc. (montane hardwood).

Black-tailed Deer HSI Model
Chaparral

TY0 - no change from MP1 & MP2, TY0
TY1 - no change from MP1 & MP2, TY1
TY5 - no change from MP1 & MP2, TY5
TY36 - no change from MP1 & MP2, TY36
TY46 - V1 0.4 (40%) HSI = 0.7
V2 1.0 (50%)
V3 0.6 (40%)
V4 1.0 (mature shrub)
V5 1.0 (2-6 ft.)
V6 1.0 no change from TY36
V7 0.45 no change from TY36
V8 0.15 no change from TY36
V9 0.2 no change from TY36
V10 0.4 no change from TY36
TY56 - no change from TY46
TY105 - no change from TY56

Montane hardwood

TY0 - no change from MP1 & MP2, TY0
TY1 - no change from MP1 & MP2, TY1
TY5 - no change from MP1 & MP2, TY1
TY36 - no change from MP1 & MP2, TY1
TY46 - no change from TY41

MIXED CHAPARRAL, MONTANE HARDWOOD, MONTANE HARDWOOD CONIFER
ASSUMPTIONS
MP3 - FUTURE WITH MANAGEMENT (continued)

```
TY56 - V1   0.95  no change from TY46        HSI = 0.7
       V2   0.0   no change from TY46
       V5   0.0   no change from TY46
       V6   0.1   no change from TY46
       V7   1.0   no change from TY46
       V8   1.0   (75%)
       V9   0.5   (75%)
       V10  0.5   no change from TY41
TY105 - V1   0.95  no change from TY56       HSI = 0.7
        V2   0.0   no change from TY56
        V5   0.0   no change from TY56
        V6   0.1   no change from TY56
        V7   1.0   no change from TY56
        V8   1.0   (80%)
        V9   0.5   (80%)
        V10  0.5   no change from TY56
```

<u>Weighted mean HSI's for both cover types for deer are</u>:

TY0	0.6
TY1	0.6
TY5	0.2
TY36	0.0
TY46	0.7
TY56	0.7
TY105	0.7

<u>Bobcat HSI Model</u>
Chaparral

```
TY0 - no change from MP1 & MP2, TY0
TY1 - no change from MP1 & MP2, TY1
TY5 - no change from MP1 & MP2, TY1
TY36 - no change from MP1 & MP2, TY36
TY46 - V1   0.6   (40%)                 HSI = 1.0
       V2   1.0   (60%)
       V3   1.0   no change from TY36
       V4   1.0   no change from TY36
TY56 - no change from TY46
TY105 - no change from TY56
```

MIXED CHAPARRAL, MONTANE HARDWOOD, MONTANE HARDWOOD CONIFER ASSUMPTIONS
MP3 - FUTURE WITH MANAGEMENT (continued)

Montane Hardwood

TY0 - no change from MP1 & MP2, TY0
TY1 - no change from MP1 & MP2, TY1
TY5 - no change from MP1 & MP2, TY5
TY36 - no change from MP1 & MP2, TY36
TY46 - no change from TY36

TY56 -	V1	1.0	(80%)	HSI = 1.0
	V2	0.0	no change from TY46	
	V3	0.8	(c)	
	V4	0.4	no change from TY46	

TY105 - no change from TY56

Weighted mean HSI's for both cover types for bobcat are:

TY0	1.0
TY1	1.0
TY5	1.0
TY36	1.0
TY46	1.0
TY56	1.0
TY105	1.0

California Quail HSI Model

Chaparral

TY0 - no change from MP1 & MP2, TY0
TY1 - no change from MP1 & MP2, TY1
TY5 - no change from MP1 & MP2, TY5
TY36 - no change from MP1 & MP2, TY36

TY46 -	V1	1.0	no change from TY36	HSI = .28
	V2	1.0	no change from TY36	
	V4	1.0	no change from TY36	
	V5	0.8	(20%)	
	V6	0.1	(60%)	
	V9	1.0	no change from TY36	

TY56 - no change from TY46
TY105 - no change from TY56

MIXED CHAPARRAL, MONTANE HARDWOOD, MONTANE HARDWOOD CONIFER ASSUMPTIONS
MP3 - FUTURE WITH MANAGEMENT (continued)

Montane Hardwood

TY0 - no change from MP1 & MP2, TY0
TY1 - no change from MP1 & MP2, TY1
TY5 - no change from MP1 & MP2, TY5
TY36 - no change from MP1 & MP2, TY36
TY46 - no change from TY36

TY56 -	V1	1.0		HSI = 0.0
	V2	1.0	no change from TY46	
	V4	1.0	(≥ 50%)	
	V5	0.6	(45%)	
	V6	0.0		
	V9	1.0	(≤ 200 ft.)	
TY105 -	V1	1.0	no change from TY56	HSI = 0.0
	V2	1.0	no change from TY56	
	V4	1.0	no change from TY56	
	V5	0.2	(75%)	
	V6	0.0	no change from TY56	
	V9	1.0	no change from TY56	

Weighted mean HSI's for both cover types for the quail are:

TY0	0.43
TY1	0.43
TY5	0.43
TY36	0.16
TY46	0.14
TY56	0.14
TY105	0.14

Downy Woodpecker HSI model
Montane Hardwood

TY0 - no change from MP1 & MP2, TY0
TY1 - no change from MP1 & MP2, TY1
TY5 - no change from MP1 & MP2 TY5
TY36 - no change from MP1 & MP2, TY36
TY46 - no change from TY41

TY56 -	V1	1.0	(50 ft^2/acre)	HSI = 1.0
	V2	1.0	(5+)	
TY105 -	V1	1.0	(75 ft^2/acre)	HSI = 1.0
	V2	no change from TY56		

MIXED CHAPARRAL, MONTANE HARDWOOD, MONTANE HARDWOOD CONIFER
ASSUMPTIONS
MP4 - FUTURE WITH MANAGEMENT

General

1. Crush and burn every 5 years in a rotational manner to retard manzanita, stimulate ceanothus growth, retain open areas suitable for growth of forbs, grasses, and other palatable browse (USFWS 1992), and to improve animal access (chaparral).
2. Do a low to moderate burn to remove herbs >10 in. high (montane hardwood).
3. Plant trees to provide roosting cover for California quail and other wildlife, and nesting habitat for the downy woodpecker and other birds (montane hardwood).
4. Plant shrubs and vines to provide escape cover for California quail and other wildlife (montane hardwood).

Black-tailed Deer HSI Model
Chaparral

TY0 - no change from MP1, MP2 & MP3, TY0
TY1 - no change from MP1, MP2 & MP3, TY1
TY5 - no change from MP1, MP2 & MP3, TY5
TY36 - no change from MP1, MP2 & MP3, TY36

TY41 -	V1	0.4	(40%)	HSI = 1.0
	V2	1.0	(50%)	
	V3	0.6	(40%)	
	V4	1.0	(mature shrub)	
	V5	1.0	(2-6 ft.)	
	V6	1.0	no change from TY36	
	V7	0.45	no change from TY36	
	V8	0.15	no change from TY36	
	V9	0.2	no change from TY36	
	V10	0.4	no change from TY36	

TY46 - no change from TY41
TY105 - no change from TY46

Montane hardwood

TY0 - no change from MP1, MP2 & MP3, TY0
TY1 - no change from MP1, MP2 & MP3, TY1
TY5 - no change from MP1, MP2 & MP3, TY1
TY36 - no change from MP1, MP2 & MP3, TY1

MIXED CHAPARRAL, MONTANE HARDWOOD, MONTANE HARDWOOD CONIFER
ASSUMPTIONS
MP4 - FUTURE WITH MANAGEMENT (continued)

TY41 -	V1	0.9	(90%)	HSI = 1.0
	V2	1.0	(30%)	
	V5	1.0	(2-6 ft.)	
	V6	1.0	(≤ 183 m)	
	V7	1.0	no change from TY36	
	V8	0.7	(40%)	
	V9	0.9	(40%)	
	V10	0.5	no change from TY36	
TY46 -	V1	0.9	no change from TY41	HSI = 0.9
	V2	1.0	(40%)	
	V5	0.0	(> 6 ft.)	
	V6	1.0	no change from TY41	
	V7	1.0	no change from TY41	
	V8	1.0	(60%)	
	V9	0.9	(60%)	
	V10	0.5	no change from TY41	
TY105 -	V1	0.9	no change from TY46	HSI = 0.9
	V2	1.0	(50%)	
	V5	0.0	no change from TY46	
	V6	1.0	no change from TY46	
	V7	1.0	no change from TY46	
	V8	1.0	no change from TY46	
	V9	0.5	no change from TY46	
	V10	0.5	no change from TY46	

<u>Weighted mean HSI's for both cover types for deer are</u>:

TY0	0.6
TY1	0.6
TY5	0.2
TY36	0.0
TY41	1.0
TY46	0.95
TY105	0.95

<u>Bobcat HSI Model</u>
Chaparral

TY0 - no change from MP1, MP2 & MP3, TY0
TY1 - no change from MP1, MP2 & MP3, TY1
TY5 - no change from MP1, MP2 & MP3, TY1
TY36 - no change from MP1, MP2 & MP3, TY36

MIXED CHAPARRAL, MONTANE HARDWOOD, MONTANE HARDWOOD CONIFER ASSUMPTIONS
MP4 - FUTURE WITH MANAGEMENT (continued)

TY41 - V1 0.6 (40%) HSI = 1.0
V2 1.0 (40%)
V3 1.0 no change from TY36
V4 1.0 no change from TY36
TY46 - no change from TY46
TY105 - no change from TY56

Montane Hardwood

TY0 - no change from MP1, MP2 & MP3, TY0
TY1 - no change from MP1, MP2 & MP3, TY1
TY5 - no change from MP1, MP2 & MP3, TY5
TY36 - no change from MP1, MP2 & MP3, TY36
TY41 - V1 1.0 (90%) HSI = 1.0
V2 1.0 (50%)
V3 1.0 no change from TY36
V4 1.0 no change from TY36
TY46 - V1 1.0 no change from TY41 HSI = 1.0
V2 1.0 (70%)
V3 1.0 no change from TY41
V4 1.0 no change from TY41
TY105 - V1 1.0 no change from TY46
V2 1.0 (75%)
V3 1.0 no change from TY46
V4 1.0 no change from TY46

<u>Weighted mean HSI's for both cover types for bobcat are</u>:

TY0	1.0
TY1	1.0
TY5	1.0
TY36	1.0
TY46	1.0
TY56	1.0
TY105	1.0

<u>**California Quail HSI Model**</u>
Chaparral

TY0 - no change from MP1, MP2 & MP3, TY0
TY1 - no change from MP1, MP2 & MP3, TY1
TY5 - no change from MP1, MP2 & MP3, TY5
TY36 - no change from MP1, MP2 & MP3, TY36

MIXED CHAPARRAL, MONTANE HARDWOOD, MONTANE HARDWOOD CONIFER
ASSUMPTIONS
MP4 - FUTURE WITH MANAGEMENT (continued)

TY41 - V1 1.0 no change from TY36 HSI = 0.6
V2 1.0 no change from TY36
V4 0.8 (40%)
V5 0.9 (15%)
V6 0.4 (40%)
V9 1.0 no change from TY36
TY46 - no change from TY41
TY105 - no change from TY46

Montane Hardwood

TY0 - no change from MP1, MP2 & MP3, TY0
TY1 - no change from MP1, MP2 & MP3, TY1
TY5 - no change from MP1, MP2 & MP3, TY5
TY36 - no change from MP1, MP2 & MP3, TY36
TY41 - V1 0.5 no change from TY36 HSI = 0.22
V2 1.0 no change from TY36
V4 1.0 (≥ 50%)
V5 0.5 (50%)
V6 0.1 (50%)
V9 1.0 (< 200 ft.)
TY46 - V1 0.5 no change from TY41 HSI = 0.14
V2 1.0 no change from TY41
V4 1.0 no change from TY41
V5 0.2 (75%)
V6 0.1 (70%)
V9 1.0 no change from TY41
TY105 - V1 0.5 no change from TY46 HSI = 0.1
V2 1.0 no change from TY46
V4 1.0 no change from TY46
V5 0.1 (90%)
V6 0.1 (75%)
V9 1.0 no change from TY46

<u>Weighted mean HSI's for both cover types for the quail are</u>:

TY0	0.43
TY1	0.43
TY5	0.43
TY36	0.16
TY41	0.41
TY46	0.37
TY105	0.37

MIXED CHAPARRAL, MONTANE HARDWOOD, MONTANE HARDWOOD CONIFER
ASSUMPTIONS
MP4 - FUTURE WITH MANAGEMENT (continued)

Downy Woodpecker HSI Model
Montane Hardwood

TY0 - no change from MP1, MP2 & MP3, TY0
TY1 - no change from MP1, MP2 & MP3, TY1
TY5 - no change from MP1, MP2 & MP3 TY5
TY36 - no change from MP1, MP2 & MP3, TY36
TY41 - V1 1.0 (50 ft^2/acre) HSI = 0.0
V2 0.0 no change from TY36
TY46 - V1 1.0 (75 ft^2/acre) HSI = 0.0
V2 0..0
TY105 - V1 1.0 (90 ft^2/acre) HSI = 0.6
V2 0.6 (~3 snags/acre)

Appendix G (continued)

MIXED CHAPARRAL, MONTANE HARDWOOD, MONTANE HARDWOOD CONIFER
ASSUMPTIONS
MP5 - FUTURE WITH MANAGEMENT

General

1. Crush and burn every 5 years in a rotational manner to retard manzanita, stimulate ceanothus growth, retain open areas suitable for growth of forbs, grasses, and other palatable browse (USFWS 1992), and to improve animal access (chaparral).
2. Install guzzlers for quail (montane hardwood).
3. Do a low to moderate burn to remove herbs $\geq$ 10 in. (montane hardwood).
4. Place logs and/or brush piles on site to improve small mammal habitat (montane hardwood).
5. Plant forb seeds for food for California quail and other widlife (montane hardwood).

Black-tailed Deer HSI Model
Chaparral

TY0 - no change from MP1, MP2, MP3 & MP4, TY0
TY1 - no change from MP1, MP2, MP3 & MP4, TY1
TY5 - no change from MP1, MP2, MP3 & MP4, TY5
TY36 - no change from MP1, MP2, MP3 & MP4, TY36

TY41 -	V1	0.4	(40%)	HSI = 0.55
	V2	1.0	(50%)	
	V3	0.6	(40%)	
	V4	1.0	(mature shrub)	
	V5	1.0	(2-6 ft.)	
	V6	1.0	no change from TY36	
	V7	0.45	no change from TY36	
	V8	0.15	no change from TY36	
	V9	0.2	no change from TY36	
	V10	0.4	no change from TY36	

TY105 - no change from TY41

Montane hardwood

TY0 - no change from MP1, MP2, MP3 & MP4, TY0
TY1 - no change from MP1, MP2, MP3 & MP4, TY1
TY5 - no change from MP1, MP2, MP3 & MP4, TY1
TY36 - no change from MP1, MP2, MP3 & MP4, TY1

MIXED CHAPARRAL, MONTANE HARDWOOD, MONTANE HARDWOOD CONIFER
ASSUMPTIONS
MP5 - FUTURE WITH MANAGEMENT (continued)

TY41 - V1 0.9 (90%) HSI = 0.55
V2 0.0 no change from TY36
V5 0.0 no change from TY36
V6 0.1 no change from TY36
V7 1.0 no change from TY36
V8 0.0 no change from TY36
V9 0.0 no change from TY36
V10 0.5 no change from TY36
TY105 - V1 0.9 no change from TY41

<u>Weighted mean HSI's for both cover types for deer are</u>:

TY0	0.6
TY1	0.6
TY5	0.2
TY36	0.0
TY41	0.55
TY105	0.55

<u>Bobcat HSI Model</u>
Chaparral

TY0 - no change from MP1, MP2, MP3 & MP4, TY0
TY1 - no change from MP1, MP2 & MP3, TY1
TY5 - no change from MP1, MP2 & MP3, TY1
TY36 - no change from MP1, MP2 & MP3, TY36
TY41 - V1 0.6 (40%) HSI = 1.0
V2 1.0 (40%)
V3 1.0 no change from TY36
V4 1.0 no change from TY36
TY46 - no change from TY41
TY105 - no change from TY56

Montane Hardwood

TY0 - no change from MP1, MP2 & MP3, TY0
TY1 - no change from MP1, MP2 & MP3, TY1
TY5 - no change from MP1, MP2 & MP3, TY5
TY36 - no change from MP1, MP2 & MP3, TY36
TY41 - V1 1.0 (90%) HSI = 1.0
V2 0.0 no change from TY36
V3 0.8 (c)
V4 0.4 (a)
TY105 - V1 1.0 no change from TY41

MIXED CHAPARRAL, MONTANE HARDWOOD, MONTANE HARDWOOD CONIFER ASSUMPTIONS
MP5 - FUTURE WITH MANAGEMENT (continued)

Weighted mean HSI's for both cover types for bobcat are:

TY0	1.0
TY1	1.0
TY5	1.0
TY36	1.0
TY46	1.0
TY56	1.0
TY105	1.0

California Quail HSI Model

Chaparral

TY0 - no change from MP1, MP2 & MP3, TY0
TY1 - no change from MP1, MP2 & MP3, TY1
TY5 - no change from MP1, MP2 & MP3, TY5
TY36 - no change from MP1, MP2 & MP3, TY36

TY41 -	V1	1.0	(≤ .25 mi)	HSI = 0.6
	V2	1.0	no change from TY36	
	V4	0.8	(40%)	
	V5	0.9	(15%)	
	V6	0.4	(40%)	
	V9	1.0	(≤ 200 ft)	

TY105 - no change from TY41

Montane Hardwood

TY0 - no change from MP1, MP2 & MP3, TY0
TY1 - no change from MP1, MP2 & MP3, TY1
TY5 - no change from MP1, MP2 & MP3, TY5
TY36 - no change from MP1, MP2 & MP3, TY36

TY41 -	V1	1.0		HSI = 0.0
	V2	1.0	(≤ .25 mi)	
	V4	1.0	(90%)	
	V5	0.5	(50%)	
	V6	0.0		
	V9	1.0	(≤ 200 ft.)	
TY105 -	V1	1.0	no change from TY41	HSI = 0.0
	V2	1.0	no change from TY41	
	V4	1.0	no change from TY41	
	V5	0.2	(75%)	
	V6	0.0	no change from TY41	
	V9	1.0	no change from TY41	

MIXED CHAPARRAL, MONTANE HARDWOOD, MONTANE HARDWOOD CONIFER ASSUMPTIONS
MP5 - FUTURE WITH MANAGEMENT (continued)

Weighted mean HSI's for both cover types for the quail are:

TY0	0.43
TY1	0.43
TY5	0.43
TY36	0.16
TY41	0.30
TY105	0.30

Downy Woodpecker HSI Model
Montane Hardwood

TY0 - no change from MP1, MP2 & MP3, TY0
TY1 - no change from MP1, MP2 & MP3, TY1
TY5 - no change from MP1, MP2 & MP3 TY5
TY36 - no change from MP1, MP2 & MP3, TY36
TY41 - V1 0.0 HSI = 0.0
V2 0.0
TY105 - V1 0.0 HSI = 0.0
V2 0.0

CROPLAND
ASSUMPTIONS
PA1 - FUTURE WITHOUT THE PROJECT

General

1. Variables for cropland were measured south of Douglas City at a working ranch.

Ground Squirrel HSI Model

TY0 - V1 0.55 HSI = 0.70
V2 0.90
V3 0.55
V4 0.80
TY1 - no change from TY0
TY5 - no change from TY1
TY105 - no change from TY5

California Quail HSI Model

TY0 - V1 1.0 HSI = 0.13
V2 1.0
V3 1.0
V4 0.85
V5 0.875
V7 0.60
TY1 - no change from TY0
TY5 - no change from TY0
TY105 - no change from TY5

Appendix G (continued)

CROPLAND
ASSUMPTIONS
PA2 - FUTURE WITH THE PROJECT

General

1. No habitat exists in the reservoirs.

Ground Squirrel HSI Model

TY0 - no change from PA1, TY0
TY1 - V1 0.0 HSI = 0.0
V2 0.0
V3 0.0
V4 0.0
TY5 - no change from TY1
TY105 - no change from TY5

California Quail HSI Model

TY0 - no change from PA1, TY0
TY1 - V1 0.0 HSI = 0.0
V2 0.0
V3 0.0
V4 0.0
V5 0.0
V7 0.0
TY5 - no change from TY1
TY105 - no change from TY5

CROPLAND
ASSUMPTIONS
MP1 - FUTURE WITHOUT MANAGEMENT

General

1. See montane hardwood and mixed chaparral, California quail.

California Quail HSI Model
Chaparral

```
TY0 - V1   1.0   (< .25 mi)        HSI = .24
      V2   1.0   (< .25 mi)
      V4   0.3   (12.98%)
      V5   0.6   (40%)
      V6   0.1   (65.66%)
      V9   1.0
TY1 - no change from TY0
TY5 - no change from TY0
TY36 - V1   1.0                   HSI =  0.32
       V2   1.0
       V4   1.0
       V5   0.8
       V6   0.125
       V9   1.0
TY105 - no change from TY36
```

Montane Hardwood

```
TY0 - V1    0.5                   HSI= = 0.63
      V2    1.0  (< .25 mi)
      V4    1.0  (90%)
      V5    0.6  (45%)
      V6    1.0  (20%)
      V9    0.5
TY1 - no change from TY0
TY5 - no change from TY0
TY36 - V1   0.5                 HSI = 0.0
       V2   1.0
       V4   1.0
       V5   0.525
       V6   0.0
       V9   0.5
TY105 - no change from TY36
```

Appendix G (continued)

CROPLAND
ASSUMPTIONS
MP1 - FUTURE WITHOUT MANAGEMENT (continued)

Weighted mean HSI's for both cover types for the quail are:

TY0	0.43
TY1	0.43
TY5	0.43
TY36	0.16
TY105	0.16

CROPLAND
ASSUMPTIONS
MP2 - FUTURE WITH MANAGEMENT

<u>General</u>

1. See montane hardwood and mixed chaparral, California quail.

<u>California Quail HSI Model</u>
Chaparral

TY0 - no change from MP1, TY0
TY1 - no change from MP1, TY1
TY5 - no change from MP1, TY5
TY36 - no change from MP1, TY36

TY41 -	V1	1.0	no change from TY36	HSI = 0.6
	V2	1.0	no change from TY36	
	V4	0.8	(40%)	
	V5	0.9	(15%)	
	V6	0.4	(40%)	
	V9	1.0	no change from TY36	

TY46 - no change from TY41
TY56 - no change from TY46
TY105 - no change from TY56

Montane Hardwood

TY0 - no change from MP1, TY0
TY1 - no change from MP1, TY1
TY5 - no change from MP1, TY1
TY41 - no change from MP1, TY36

TY46 -	V1	1.0	(≤ .25 mi)	HSI = .14
	V2	1.0	(≤ .25 mi)	
	V4	1.0	(90%)	
	V5	0.2	(75%)	
	V6	0.1	(70%)	
	V9	1.0	(< 200 ft.)	
TY56 -	V1	1.0	no change from TY46	HSI = .1
	V2	1.0	no change from TY46	
	V4	1.0	no change from TY46	
	V5	0.1	(90%)	
	V6	0.1	(75%)	
	V9	1.0	no change from TY46	

TY105 - no change from TY56

CROPLAND
ASSUMPTIONS
MP2 - FUTURE WITH MANAGEMENT (continued)

Weighted mean HSI's for both cover types for the quail are:

TY0	0.43
TY1	0.43
TY5	0.43
TY36	0.16
TY41	0.3
TY46	0.37
TY56	0.35
TY105	0.35

APPENDIX H

Acres of cover types impacted, HSIs, HUs, AAHUs, and areas needed for compensation.

Table 1. Acres of each cover type in the impact area at various target years used in the Trinity River HEP analysis (PA1, PA2).

COVER TYPE/ SCENARIO	ACRES TY0	TY1	TY5	TY105
Montane Riparian				
Future without Project	68.61	68.61	68.61	68.61
Future with Project	68.61	68.61	0.00	0.00
Riverine				
Future without Project	1,503.73	1,503.73	1,503.73	1,503.73
Future with Project	1,503.73	1,503.73	0.00	0.00
Wet Meadow				
Future without Project	311.08	311.08	311.08	311.08
Future with Project	311.08	311.08	0.00	0.00
Montane Hardwood				
Future without Project	7,245.86	7,245.86	7,245.86	7,245.86
Future with Project	7,245.86	7,245.86	0.00	0.00
Montane Hardwood Conifer				
Future without Project	2,759.95	2,759.95	2,759.95	2,759.95
Future with Project	2,759.95	2,759.95	0.00	0.00
Mixed Chaparral				
Future without Project	1,066.46	1,066.46	1,066.46	1,066.46
Future with Project	1,066.46	1,066.46	0.00	0.00
Cropland				
Future without Project	1,072.36	1,072.36	1,072.36	1,072.36
Future with Project	1,072.36	1,072.36	0.00	0.00
TOTAL				
Future without Project	14,028.05	14,028.05	14,028.05	14,028.05
Future with Project	14,028.05	14,028.05	0.00	0.00

Table 2. Maximum acres of each cover type in the compensation areas by the end of the period of analysis (MP1-MP5).

COVER TYPE/ SCENARIO	ACRES TYO-105
Montane Riparian	
Future without Management	6.14
Future with Management	6.14
Riverine	
Future without Management	6.14
Future with Management	6.14
Wet Meadow	
Future without Management	110.00
Future with Management	110.00
Montane Hardwood	
Future without Management	28.8
Future with Management	28.8
Montane Hardwood Conifer[1]	
Future without Management	58.5
Future with Management	58.5
Mixed Chaparral	
Future without Management	29.7
Future with Management	29.7
Cropland	
Future without Management	58.5
Future with Management	58.5
TOTAL	
Future with Management	239.28
Future without Management	239.28

1 This cover type was compensated for with montane hardwood and mixed chaparral.

Table 3. Habitat units for future without the project scenario in the impact area (PA1).

COVER TYPE/ SPECIES	HABITAT UNITS TYO-105
Riparian, Riverine	
Mink	1,179.26
Wood duck	298.74
Riparian	
Downy woodpecker	20.58
Wet Meadow	
California quail	171.09
Red-winged blackbird	248.86
Montane Hardwood, Montane Hardwood Conifer	
Downy woodpecker	5,703.31
Montane Hardwood Conifer	
Blue Grouse	220.80
Montane Hardwood, Montane Hardwood Conifer, Mixed Chaparral	
Black-tailed deer	6,643.36
Bobcat	8,304.20
Montane Hardwood, Mixed Chaparral	
California quail	6,234.24
Cropland	
California ground squirrel	750.65
California quail	139.41

APPENDIX H (continued)

Table 4. Acres of available habitat and HSIs ( ) for future without the project scenario in the impact area (PA1).

COVER TYPE/ SPECIES	ACRES[1] (HSI) TYO-105
Riparian, Riverine	
Mink	1,572.34 (.75)
Wood duck	1,572.34 (.19)
Riparian	
Downy woodpecker	68.61 (.30)
Wet Meadow/Wetlands	
California quail	311.08 (.55)
Red-winged blackbird	311.08 (.80)
Montane Hardwood, Montane Hardwood Conifer	
Downy woodpecker	10,005.81 (.57)
Montane Hardwood Conifer	
Blue Grouse	2,759.95 (.08)
Montane Hardwood, Montane Hardwood Conifer, Mixed Chaparral	
Black-tailed deer	11,072.27 (.60)
Bobcat	11,072.27 (.75)
Montane Hardwood, Mixed Chaparral	
California quail	8,312.32 (.75)
Cropland	
California ground squirrel	1,072.36 (.70)
California quail	1,072.36 (.13)

1 The acreage values were obtained by combining the cover types.

APPENDIX H (continued)

Table 5. Acres of available habitat and HSI's ( ) for future with project scenario in the impact area (PA2).

COVER TYPE/ SPECIES	ACRES[1] (HSI) TY0	TY1, 5, 105
Riparian/Riverine		
Mink	1,572.34 (.75)	1,572.34 (0.00)
Wood duck	1,572.34 (.19)	1,572.34 (0.00)
Riparian		
Downy woodpecker	68.61 (.30)	68.61 (0.00)
Wet Meadow		
California quail	311.08 (.55)	311.08 (0.00)
Red-winged blackbird	311.08 (.80)	311.08 (0.00)
Montane Hardwood, Montane Hardwood Conifer		
Downy woodpecker	10,005.81 (.57)	10,005.81 (0.00)
Montane Hardwood Conifer		
Blue grouse	2,759.95 (.08)	2,759.95 (0.00)
Montane Hardwood, Montane Hardwood Conifer, Mixed Chaparral		
Black-tailed deer	11,072.27 (.60)	11,072.27 (0.00)
Bobcat	11,072.27 (.75)	11,072.27 (0.00)
Montane Hardwood, Mixed Chaparral		
California quail	8,312.32 (.75)	8,312.32 (0.00)
Cropland		
California ground squirrel	1,072.36 (.70)	1,072.36 (0.00
California quail	1,072.36 (.13)	1,072.36 (0.00)

[1] The acreage values were obtained by combining the cover types.

Table 6. Habitat Units for future with project scenario in the impact area (PA2).

COVER TYPE/ SPECIES	HABITAT UNITS TY0	TY1, 5, 105
Riparian/Riverine		
Mink	1,179.26	0.00
Wood duck	298.74	0.00
Riparian		
Downy woodpecker	20.58	0.00
Wet Meadow		
California quail	171.09	0.00
Red-winged blackbird	248.86	0.00
Montane Hardwood, Montane Hardwood Conifer		
Downy woodpecker	5,703.31	0.00
Montane Hardwood Conifer		
Blue grouse	220.80	0.00
Montane Hardwood, Montane Hardwood Conifer, Mixed Chaparral		
Black-tailed deer	6,643.36	0.00
Bobcat	8,304.20	0.00
Montane Hardwood, Mixed Chaparral		
California quail	6,234.24	0.00
Cropland		
California ground squirrel	750.65	0.00
California quail	139.41	0.00

Table 7. Acres of available habitat and HSIs ( ) for future without management scenario in the compensation area (MP1).

	ACRES[1] (HSI)		
COVER TYPE/ SPECIES	TY0, 1	TY5	TY36, 105
Riparian, Riverine			
Mink	12.28 (.75)	12.28 (.75)	12.28 (.75)
Wood duck	12.28 (.19)	12.28 (.19)	12.28 (.19)
Riparian			
Downy woodpecker	6.14 (.30)	6.14 (.30)	6.14 (.30)
Wet Meadow			
California quail	110.0 (.87)	110.0 (.87)	110.0 (.35)
Red-winged blackbird	110.0 (.54)	110.0 (.54)	110.0 (.16)
Montane Hardwood			
Downy woodpecker	28.8 (.60)	28.8 (0.00)	28.8 (0.00)
Montane Hardwood, Mixed Chaparral			
Black-tailed deer	58.5 (.60)	58.5 (.20)	58.5 (0.00)
California quail	58.5 (.43)	58.5 (.43)	58.5 (.16)
Bobcat	58.5 (1.00)	58.5 (1.00)	58.5 (1.00)
Cropland			
California quail[2]	58.5 (.43)	58.5 (.43)	58.5 (.16)

1 The acreage values were obtained by combining the cover types.

2 This species is included in the mitigation for montane hardwood and chaparral.

Table 8. Habitat units for future without management scenario in the compensation area (MP1).

	HABITAT UNITS		
COVER TYPE/ SPECIES	**TY0, 1**	**TY5**	**TY36, 105**
Riparian, Riverine			
Mink	9.21	9.21	9.21
Wood duck	2.33	2.33	2.33
Riparian			
Downy woodpecker	1.84	1.84	1.84
Wet Meadow			
California quail	95.70	95.70	38.50
Red-winged blackbird	59.40	59.40	17.60
Montane Hardwood			
Downy woodpecker	17.28	0.00	0.00
Montane Hardwood, Mixed Chaparral			
Black-tailed deer	35.10	11.70	0.00
California quail	25.16	25.16	9.36
Bobcat	58.50	58.50	58.50
Cropland			
California quail[1]	25.16	25.16	9.36

[1] This species is included in the mitigation for montane hardwood and chaparral.

Table 9. Acres of available habitat and HSIs ( ) for future with management scenario in the compensation area (MP2).

	ACRES[1] (HSI)							
COVER TYPE/ SPECIES	**TY0, 1**	**TY5**	**TY36**	**TY37**	**TY39**	**TY41**	**TY46**	**TY56, 105**
Riparian, Riverine								
Mink	12.28 (.75)	12.28 (.75)	12.28 (1.0)	12.28 (1.0)	12.28 (1.0)	12.28 (1.0)	12.28 (1.0)	12.28 (1.0)
Wood duck	12.28 (.19)	12.28 (.19)	12.28 (1.0)	12.28 (1.0)	12.28 (1.0)	12.28 (1.0)	12.28 (1.0)	12.28 (1.0)
Riparian								
Downy woodpecker	6.14 (.30)	6.14 (.30)	6.14 (1.0)	6.14 (1.0)	6.14 (1.0)	6.14 (1.0)	6.14 (1.0)	6.14 (1.0)
Wet Meadow								
California quail	110.0 (.87)	110.0 (.87)	110.0 (.35)	110.0 (1.0)	110.0 (.87)	110.0 (.87)	110.0 (.87)	110.0 (.87)
Red-winged blackbird	110.0 (.54)	110.0 (.54)	110.0 (.16)	110.0 (.20)	110.0 (1.0)	110.00 (1.0)	110.0 (1.0)	110.0 (1.0)
Montane Hardwood								
Downy woodpecker	28.8 (.60)	28.8 (0.00)	28.8 (0.00)	28.8 (0.00)	28.8 (0.00)	28.8 (0.00)	28.8 (0.00)	28.8 (1.0)
Montane Hardwood, Mixed Chaparral								
Black-tailed deer	58.5 (.60)	58.5 (.20)	58.5 (0.00)	58.5 (0.00)	58.5 (0.00)	58.5 (.55)	58.5 (.72)	58.5 (.72)
California quail	58.5 (.43)	58.5 (.43)	58.5 (.16)	58.5 (.16)	58.5 (.16)	58.5 (.30)	58.5 (.37)	58.5 (.35)
Bobcat	58.5 (1.0)	58.5 (1.0)	58.5 (1.0)	58.5 (1.0)	58.5 (1.0)	58.5 (1.0)	58.5 (1.0)	58.5 (1.0)
Cropland								
California quail[2]	58.5 (.43)	58.5 (.43)	58.5 (.16)	58.5 (.16)	58.5 (.16)	58.5 (.30)	58.5 (.37)	58.5 (.35)

[1] The acreage values were obtained by combining the cover types.
[2] This species is included in the mitigation for montane hardwood and mixed chaparral.

APPENDIX H (continued)

Table 10. Habitat units for future with management scenario in the compensation area (MP2).

COVER TYPE/ SPECIES	HABITAT UNITS TY0, 1	TY5	TY36	TY37	TY39	TY41	TY46	TY56, 105
Riparian, Riverine								
Mink	9.21	9.21	12.28	12.28	12.28	12.28	12.28	12.28
Wood duck	2.33	2.33	12.28	12.28	12.28	12.28	12.28	12.28
Riparian								
Downy Woodpecker	1.84	1.84	6.14	6.14	6.14	6.14	6.14	6.14
Wet Meadow								
California quail	95.70	95.70	38.50	110.0	95.70	95.70	95.70	95.70
Red-winged blackbird	59.40	59.40	17.60	22.0	110.00	110.00	110.00	110.00
Montane Hardwood								
Downy woodpecker	17.28	0.00	0.00	0.00	0.00	0.00	0.00	28.80
Montane Hardwood, Mixed Chaparral								
Black-tailed deer	35.10	11.70	0.00	0.00	0.00	32.17	42.12	42.12
California quail	25.16	25.16	9.36	9.36	9.36	17.55	21.65	20.48
Bobcat	58.50	58.50	58.50	58.50	58.50	58.50	58.50	58.50
Cropland								
California quail[1]	25.16	25.16	9.36	9.36	9.36	17.55	21.65	20.48

[1] This species is included in the mitigation for montane hardwood and chaparral.

APPENDIX H (continued)

Table 11. Acres of available habitat and HSIs ( ) for future with management scenario in the compensation area (MP3).

COVER TYPE/ SPECIES	ACRES[1] (HSI) TY0, 1	TY5	TY36	TY37	TY39	TY46	TY56, 105
Wet Meadow							
California quail	110.0 (.87)	110.0 (.87)	110.0 (.35)	110.0 (1.0)	110.0 (.87)	110.0 (.87)	110.0 (.87
Red-winged blackbird	110.0 (.54)	110.0 (.54)	110.0 (.16)	110.0 (0.2)	110.0 (1.0)	110.0 (1.0)	110.0 (1.0)
Montane Hardwood							
Downy Woodpecker	28.8 (.60)	28.8 (0.00)	28.8 (0.00)	28.8 (0.00)	28.8 (0.00)	28.8 (0.00)	28.8 (1.0)
Montane Hardwood, Mixed Chaparral							
Black-tailed deer	58.5 (.60)	58.5 (.20)	58.5 (0.00)	58.5 (0.00)	58.5 (0.00)	58.5 (.70)	58.5 (.70)
California quail	58.5 (.43)	58.5 (.43)	58.5 (.16)	58.5 (.16)	58.5 (.16)	58.5 (.14)	58.5 (.14)
Bobcat	58.5 (1.0)	58.5 (1.0)	58.5 (1.0)	58.5 (1.0)	58.5 (1.0)	58.5 (1.0)	58.5 (1.0)

[1] The acreage values were obtained by combining the cover types.

Table 12. Habitat units for future with management scenario in the compensation area (MP3).

	HABITAT UNITS						
COVER TYPE/ SPECIES	TY0, 1	TY5	TY36	TY37	TY39	TY46	TY56, 105
Wet Meadow							
California quail	95.70	95.70	38.50	110.00	95.70	95.70	95.70
Red-winged blackbird	59.40	59.40	17.60	22.00	110.00	110.0	110.00
Montane Hardwood							
Downy woodpecker	17.28	0.00	0.00	0.00	0.00	0.00	28.8
Montane Hardwood, Mixed Chaparral							
Black-tailed deer	35.10	11.70	0.00	0.00	0.00	40.95	40.95
California quail	25.16	25.16	9.36	9.36	9.36	8.19	8.19
Bobcat	58.50	58.50	58.50	58.50	58.50	58.50	58.50

APPENDIX H (continued)

Table 13. Acres of available habitat and HSIs ( ) for future with management scenario in the compensation area (MP4).

	ACRES[1] (HSI)							
COVER TYPE/ SPECIES	**TY0, 1**	**TY5**	**TY36**	**TY37**	**TY39**	**TY41**	**TY46**	**TY 105**
Wet Meadow								
California quail	110.0 (.87)	110.0 (.87)	110.0 (.35)	110.0 (1.0)	110.0 (.87	110.0 (.87)	110.0 (.87)	110.0 (0.00)
Red-winged blackbird	110.0 (.54)	110.0 (.54)	110.0 (.16)	110.0 (.2)	110.0 (1.0)	110.0 (1.0)	110.0 (1.0)	110.0 (1.0)
Montane Hardwood								
Downy woodpecker	28.8 (.60)	28.8 (0.00)	28.8 (0.00)	28.8 (0.00)	28.8 (0.00)	28.8 (0.00)	28.8 (0.00)	28.8 (0.00)
Montane Hardwood, Mixed Chaparral								
Black-tailed deer	58.5 (.60)	58.5 (.20)	58.5 (0.00)	58.5 (0.00)	58.5 (0.00)	58.5 (1.0)	58.5 (.95)	58.5 (.95)
California quail	58.5 (.43)	58.5 (.43)	58.5 (.16)	58.5 (.16)	58.5 (.16)	58.5 (.41)	58.5 (.37)	58.5 (.37)
Bobcat	58.5 (1.0)	58.5 (1.0)	58.5 (1.0)	58.5 (1.0)	58.5 (1.0)	58.5 (1.0)	58.5 (1.0)	58.5 (1.0)

[1] The acreage values were obtained by combining the cover types.

Table 14. Habitat units for future with management scenario in the compensation area (MP4).

	HABITAT UNITS							
COVER TYPE/ SPECIES	TY0, 1	TY5	TY36	TY37	TY39	TY41	TY46	TY105
Wet Meadow								
California quail	95.70	95.70	38.50	110.00	95.70	95.70	95.70	0.00
Red-winged blackbird	59.40	59.40	17.00	22.00	110.00	110.00	110.00	110.00
Montane Hardwood								
Downy Woodpecker	17.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Montane Hardwood, Mixed Chaparral								
Black-tailed deer	35.10	11.70	0.00	0.00	0.00	58.50	55.58	55.58
California quail	25.16	25.16	9.36	9.36	9.36	23.99	21.65	21.65
Bobcat	58.50	58.50	58.50	58.50	58.50	58.50	58.50	58.50

APPENDIX H (continued)

Table 15. Acres of available habitat and HSIs ( ) for future with management scenario in the compensation area (MP5).

COVER TYPE/ SPECIES	TY0, 1	TY5	TY36	TY37	TY39	TY41	TY105
	ACRES[1] (HSI)						
Wet Meadow							
California quail	110.0 (.87)	110.0 (.87)	110.0 (.35)	110.0 (1.0)	110.0 (.87)	110.0 (.87)	110.0 (0.00)
Red-winged blackbird	110.0 (.54)	110.0 (.54)	110.0 (.16)	110.0 (0.2)	110.0 (1.0)	110.0 (1.0)	110.0 (1.0)
Montane Hardwood							
Downy Woodpecker	28.8 (.60)	28.8 (0.00)	28.8 (0.00)	28.8 (0.00)	28.8 (0.00)	28.8 (0.00)	28.8 (0.00)
Montane Hardwood, Mixed Chaparral							
Black-tailed deer	58.5 (.60)	58.5 (.20)	58.5 (0.00)	58.5 (0.00)	58.5 (0.00)	58.5 (.55)	58.5 (.55)
California quail	58.5 (.43)	58.5 (.43)	58.5 (.16)	58.5 (.16)	58.5 (.16)	58.5 (.30)	58.5 (.30)
Bobcat	58.5 (1.0)	58.5 (1.0)	58.5 (1.0)	58.5 (1.0)	58.5 (1.0)	58.5 (1.0)	58.5 (1.0)

[1] The acreage values were obtained by combining the cover types.

Table 16. Habitat units for future with management scenario in the compensation area (MP5).

COVER TYPE/ SPECIES	HABITAT UNITS						
	TY0, 1	TY5	TY36	TY37	TY39	TY41	TY105
Wet Meadow							
California quail	95.70	95.70	38.50	110.00	95.70	95.70	0.00
Red-winged blackbird	59.40	59.40	17.60	22.00	110.00	110.00	110.00
Montane Hardwood							
Downy Woodpecker	17.28	0.00	0.00	0.00	0.00	0.00	0.00
Montane Hardwood, Mixed Chaparral							
Black-tailed deer	35.10	11.70	0.00	0.00	0.00	32.17	32.17
California quail	25.16	25.16	9.36	9.36	9.36	17.55	17.55
Bobcat	58.50	58.50	58.50	58.50	58.50	58.50	58.50

Table 17. Comparison of AAHUs under with and without project conditions in the impact area (PA1, PA2).

COVER TYPE/ SPECIES	AAHUs WITH ACTION	AAHUs WITHOUT ACTION	AAHUs NET CHANGE
Riparian, Riverine			
Mink	5.62	1,179.26	-1,173.64
Wood duck	1.42	298.74	- 297.32
Riparian			
Downy woodpecker	0.10	20.58	- 20.48
Wet Meadow			
California quail	0.81	171.09	- 170.28
Red-winged blackbird	1.19	248.86	- 247.68
Montane Hardwood, Montane Hardwood Conifer			
Downy Woodpecker	27.16	5,703.31	- 5,676.15
Montane Hardwood Conifer			
Blue grouse	1.05	220.80	- 219.74
Montane Hardwood, Montane Hardwood Conifer, Mixed Chaparral			
Black-tailed deer	31.64	6,643.36	- 6,611.73
Bobcat	39.54	8,304.20	- 8,264.66
Montane Hardwood, Mixed Chaparral			
California quail	29.69	6,234.24	- 6,204.55
			Total -26,976.83
Cropland			
California ground squirrel	3.57	750.65	- 747.08
California quail	0.66	139.41	- 138.74
			Total - 885.82

Table 18. Comparison of AAHUs under with and without management conditions in the compensation area (MP1, MP2).

COVER TYPE/ SPECIES	AAHUs WITH ACTION	AAHUs WITHOUT ACTION	AAHUs NET CHANGE
Riparian, Riverine			
Mink	11.74	9.21	2.53
Wood duck	10.53	2.33	8.19
Riparian			
Downy woodpecker	5.38	1.84	3.54
Wet Meadow			
California quail	86.10	48.58	37.52
Red-winged blackbird	83.99	24.96	59.02
Montane Hardwood			
Downy woodpecker	15.31	0.49	14.81
Montane Hardwood, Mixed Chaparral			
Black-tailed deer	29.16	2.95	26.20
California quail	19.43	12.44	6.98
Bobcat	58.50	58.50	0.00
			Total 47.99
Cropland			
California quail[1]	19.43	12.44	Total 6.98

[1] This species is included in the mitigation for montane hardwood and chaparral.

Table 19. Comparison of AAHUs under with and without management conditions in the compensation area (MP1, MP3).

COVER TYPE/ SPECIES	AAHUs WITH ACTION	AAHUs WITHOUT ACTION	AAHUs NET CHANGE
Wet Meadow			
California quail	86.10	48.58	37.52
Red-winged blackbird	83.99	24.96	59.02
Montane Hardwood			
Downy woodpecker	15.31	0.49	14.81
Montane Hardwood, Mixed Chaparral			
Black-tailed deer	27.91	2.95	24.96
California quail	11.73	12.44	- 0.71
Bobcat	58.50	58.50	0.00
			Total 39.06

Table 20. Comparison of AAHUs under with and without management conditions in the compensation area (MP1, MP4).

COVER TYPE/ SPECIES	AAHUs WITH ACTION	AAHUs WITHOUT ACTION	AAHUs NET CHANGE
Wet Meadow			
California quail	56.02	48.58	7.44
Red-winged blackbird	83.99	24.96	59.02
Montane Hardwood			
Downy woodpecker	0.49	0.49	0.00
Montane Hardwood, Mixed Chararral			
Black-tailed deer	38.29	2.95	35.34
California quail	20.34	12.44	7.89
Bobcat	58.50	58.50	0.0
			Total 43.23

Table 21. Comparison of AAHUs under with and without management conditions in the compensation area (MP1, MP5).

COVER TYPE/ SPECIES	AAHUs WITH ACTION	AAHUs WITHOUT ACTION	AAHUs NET CHANGE
Wet Meadow			
California quail	56.02	48.58	7.44
Red-winged blackbird	83.99	24.96	59.02
Montane Hardwood			
Downy woodpecker	0.49	0.49	0.00
Montane Hardwood, Mixed Chaparral			
Black-tailed deer	23.33	2.95	20.38
California quail	17.63	12.44	5.19
Bobcat	58.50	58.50	0.00
			Total 25.57

Table 22. Changes in AAHUs under the future with project/future with management scenario (PA2, MP2).

	NET CHANGE IN AAHUs		
COVER TYPE[1]/SPECIES	PLAN ALTERNATIVE	MANAGEMENT PLAN	AREA NEEDED FOR COMPENSATION[2]
Montane Riparian, Riverine			
Mink	-1,173.64	2.53	**5,698.60**[3]
Wood duck	- 297.32	8.19	445.57
Riparian			
Downy woodpecker	- 20.48	3.54	71.05
Wet Meadow			
California quail	- 170.28	37.52	**499.21**
Red-winged blackbird	- 247.68	59.02	461.60
Montane Hardwood, Montane Hardwood Conifer			
Downy woodpecker	- 5,676.15	14.81	
Montane Hardwood Conifer			
Blue grouse	- 219.74	0.00	
Montane Hardwood Montane Hardwood Conifer, Mixed Chaparral			
Black-tailed deer	- 6,611.73	26.20	
Bobcat	- 8,264.66	0.00	
Montane Hardwood, Mixed Chaparral			
California quail	- 6,204.55	6.98	
Total	-26,976.83	47.99	32,879.63 acres
Cropland			
California ground squirrel	- 747.08	0.00	
California quail	- 138.74	6.98	
Total	- 885.82	6.98	7,420.12 acres

1 Acres found in Table 9.
2 For montane riparian, riverine, and wet meadow (Resource Category 2), the highest value is the area needed for compensation (in bold).
3 This value can be subtracted by 599.37 acres (already compensated for, see text) to equal 5,099.23 acres.

Table 23. Changes in AAHUs under future with project/future with management scenario (PA2, MP3).

	NET CHANGE IN AAHUs		
COVER TYPE[1]/SPECIES	**PLAN ALTERNATIVE**	**MANAGEMENT PLAN**	**AREA NEEDED FOR COMPENSATION[2]**
Wet Meadow			
California quail	- 170.28	37.52	**499.21**
Red-winged blackbird	- 247.68	59.02	461.60
Montane Hardwood, Montane Hardwood Conifer			
Downy woodpecker	- 5,676.15	14.81	
Montane Hardwood Conifer			
Blue grouse	- 219.74	0.00	
Montane Hardwood, Montane Hardwood Conifer, Mixed Chaparral			
Black-tailed deer	- 6,611.73	24.96	
Bobcat	- 8,264.66	- 0.00	
Montane Hardwood, Mixed Chaparral			
California quail	- 6,204.55	- 0.71	
Total	**-26,976.83**	39.06	**40,404.87 acres**

[1] Acres found in Table 11.
[2] For wet meadow (Resource Category 2), the highest value is the area needed for compensation (in bold).

Table 24. Changes in AAHUs under future with project/future with management scenario (PA2, MP4).

	NET CHANGE IN AAHUs		
COVER TYPE[1]/SPECIES	PLAN ALTERNATIVE	MANAGEMENT PLAN	AREA NEEDED FOR COMPENSATION[2]
Wet Meadow			
California quail	- 170.28	7.44	**2,516.44**
Red-winged blackbird	- 247.68	59.02	461.60
Montane Hardwood, Montane Hardwood Conifer			
Downy woodpecker	- 5,676.15	0.00	
Montane Hardwood Conifer			
Blue grouse	- 219.74	0.00	
Montane Hardwood, Montane Hardwood Conifer, Mixed Chaparral			
Black-tailed deer	- 6,611.73	35.34	
Bobcat	- 8,264.66	0.00	
Montane Hardwood, Mixed Chaparral			
California quail	- 6,204.55	7.89	
Total	-26,976.84	43.23	36,506.87 acres

[1] Acres found in Table 13.
[2] For wet meadow (Resource Category 2), the highest value is the area needed for compensation (in bold).

Table 25. Changes in AAHUs under future with project/future with management scenario (PA2, MP5).

	NET CHANGE IN AAHUs		
COVER TYPE[1]/SPECIES	**PLAN ALTERNATIVE**	**MANAGEMENT PLAN**	**AREA NEEDED FOR COMPENSATION[2]**
Wet Meadow			
California quail	- 170.28	7.44	**2,516.44**
Red-winged blackbird	- 247.68	59.02	461.60
Montane Hardwood, Montane Hardwood Conifer			
Downy woodpecker	- 5,676.15	0.00	
Montane Hardwood Conifer			
Blue grouse	- 219.74	0.00	
Montane Hardwood, Montane Hardwood Conifer, Mixed Chaparral			
Black-tailed deer	- 6,611.73	20.38	
Bobcat	- 8,264.66	0.00	
Montane Hardwood, Mixed Chaparral			
California quail	- 6,204.55	5.19	
Total	-26,976.84	25.57	61,731.89 acres

[1] Acres found in Table 15.
[2] For wet meadow (Resource Category 2), the highest value is the area needed for compensation (in bold).

APPENDIX I

Animals species occurring at Trinity Reservoir and the surrounding area.

COMMON NAME	SCIENTIFIC NAME
AMPHIBIANS	
Long-toed salamander	*Ambystoma macrodactylum*
Pacific giant salamander	*Dicamptodon ensatus*
Rough-skinned newt	*Taricha granulosa*
Ensatina	*Ensatina eschscholtzi*
Tailed frog	*Ascaphus truei*
Western toad	*Bufo borealis*
Pacific treefrog	*Hyla regilla*
Red-legged frog	*Rana aurora*
Foothill yellow-legged frog	*Rana boylei*
Bullfrog	*Rana catesbeiana*
REPTILES	
Western pond turtle	*Clemmys marmorata*
Western fence lizard	*Sceloporus occidentalis*
Sagebrush lizard	*Sceloporus graciosus*
Western skink	*Eumeces skiltonianus*
Southern alligator lizard	*Gerrhonotus multicarinatus*
Northern alligator lizard	*Gerrhonotus coeruleus*
Rubber boa	*Charina bottae*
Ringneck snake	*Diadophis punctatus*
Sharp-tailed snake	*Contia tenuis*
Racer	*Coluber constrictor*
California whipsnake	*Masticophis lateralis*
Gopher snake	*Pituophis melanoleucus*
Common kingsnake	*Lampropeltis getulus*
California mountain kingsnake	*Lampropeltis zonata*
Common garter snake	*Thamnophis sirtalis*
Western terrestrial garter snake	*Thamnophis elegans*
Western aquatic garter snake	*Thamnophis couchi*
Western rattlesnake	*Crotalis viridis*
BIRDS	
Pied-billed grebe	*Podilymbus podiceps*
Eared grebe	*Podiceps nigricollis*
Western grebe	*Aechmorphorus occidentalis*
Canada goose	*Branta canadensis*
Gadwall	*Anas strepera*
Mallard	*Anas platyrhynchos*
Northern pintail	*Anas acuta*
American wigeon	*Anas americana*
Wood duck	*Aix sponsa*
Green-winged teal	*Anas crecca*
Cinnamon teal	*Anas cyanoptera*
Scoter	*Melanitta* spp.

APPENDIX I (continued)

COMMON NAME	SCIENTIFIC NAME
BIRDS	
Redhead	*Aythya americana*
Ring-necked duck	*Aythya collaris*
Lesser scaup	*Aythya affinis*
Common goldeneye	*Bucephala clangula*
Bufflehead	*Bucephala albeola*
Ruddy duck	*Oxyura jamaicensis*
Common merganser	*Mergus merganser*
Hooded merganser	*Lophodytes cucullatus*
American coot	*Fulica americana*
California gull	*Larus californicus*
Ring-billed gull	*Larus delawarensis*
Great blue heron	*Ardea herodias*
Green-backed heron	*Butorides striatus*
Common egret	*Casmerodius albus*
Killdeer	*Charadrius vociferus*
Spotted sandpiper	*Actitus macularia*
Common snipe	*Gallinago gallinago*
Mountain plover	*Charadrius montanus*
Blue grouse	*Dendragapus obscurus*
Ruffed grouse	*Bonasa umbellus*
California quail	*Callipepla californica*
Mountain quail	*Oreortyx pictus*
Sharp-shinned hawk	*Accipiter striatus*
Cooper's hawk	*Accipiter cooperii*
Northern goshawk	*Accipiter gentilis*
Red-tailed hawk	*Buteo jamaicensis*
Bald eagle	*Haliaeetus leucocephalus*
Golden eagle	*Aquila chrysaetos*
Turkey vulture	*Cathartes aura*
Osprey	*Pandion haliaetus*
American kestrel	*Falco sparverius*
Peregrine falcon	*Falco peregrinus*
Band-tailed pigeon	*Columba fasciata*
Mourning dove	*Zenaida macroura*
Common barn owl	*Tyto alba*
Flammulated owl	*Otus flammeolus*
Western screech owl	*Otus kennicottii*
Great horned owl	*Bubo virginianus*
Northern pygmy owl	*Glaucidium gnoma*
Northern spotted owl	*Strix occidentalis*
Northern saw-whet owl	*Aegolius acadicus*
Common nighthawk	*Chordeiles minor*
Common poorwill	*Phalaenoptilus nuttallii*
Vaux's swift	*Chaetura vauxi*
Anna's hummingbird	*Calypte anna*
Calliope hummingbird	*Stellula calliope*
Rufous hummingbird	*Selasphorus rufus*
Belted kingfisher	*Ceryle alcyon*

COMMON NAME	SCIENTIFIC NAME
BIRDS	
Lewis' woodpecker	*Melanerpes lewis*
Acorn woodpecker	*Melanerpes formicivorus*
Red-breasted sapsucker	*Sphyrapicus ruber*
Downy woodpecker	*Picoides pubescens*
Hairy woodpecker	*Picoides villosus*
White-headed woodpecker	*Picoides albolarvatus*
Northern flicker	*Colaptes auratus*
Pileated woodpecker	*Dryocopus pileatus*
Olive-sided flycatcher	*Contopus borealis*
Western wood-pewee	*Contopus sordidulus*
Willow flycatcher	*Empidonax traillii*
Hammond's flycatcher	*Empidonax hammondii*
Dusky flycatcher	*Empidonax oberholseri*
Western flycatcher	*Empidonax* sp.
Black phoebe	*Sayornis nigricans*
Purple martin	*Progne subis*
Tree swallow	*Tachycineta bicolor*
Violet-green swallow	*Tachycineta thalassina*
Cliff swallow	*Hirundo pyrrhonota*
Barn swallow	*Hirundo rustica*
Steller's jay	*Cyanocitta stelleri*
Scrub jay	*Aphelocoma coerulescens*
Common raven	*Corvus corax*
Mountain chickadee	*Parus gambeli*
Chestnut-backed chickadee	*Parus rufescens*
Red-breasted nuthatch	*Sitta canadensis*
White-breasted nuthatch	*Sitta carolinensis*
Brown creeper	*Certhia americana*
Bewick's wren	*Thryomanes bewickii*
House wren	*Troglodytes aedon*
Winter wren	*Troglodytes troglodytes*
American dipper	*Cinclus mexicanus*
Golden-crowned kinglet	*Regulus satrapa*
Ruby-crowned kinglet	*Regulus calendula*
Western bluebird	*Sialia mexicana*
Mountain bluebird	*Sialia currucoides*
Townsend's solitaire	*Myadestes townsendi*
Swainson's thrush	*Catharus ustulatus*
Hermit thrush	*Catharus guttatus*
American robin	*Turdus migratorius*
Varied thrush	*Ixoreus naevius*
Wrentit	*Chamaea fasciata*
Water pipit	*Anthus spinoletta*
Cedar waxwing	*Bombycilla cedrorum*
European starling	*Sturnus vulgaris*
Solitary vireo	*Vireo solitarius*
Hutton's vireo	*Vireo huttoni*
Warbling vireo	*Vireo gilvus*

APPENDIX I (continued)

COMMON NAME	SCIENTIFIC NAME
BIRDS	
Orange-crowned warbler	*Vermivora celata*
Nashville warbler	*Vermivora ruficapilla*
Yellow warbler	*Dendroica petechia*
Yellow-rumped warbler	*Dendroica coronata*
Black-throated gray warbler	*Dendroica nigrescens*
Hermit warbler	*Dendroica occidentalis*
MacGillivrays's warbler	*Oporornis tolmiei*
Common yellowthroat	*Geothlypis trichas*
Wilson's warbler	*Wilsonia pusilla*
Yellow-breasted chat	*Icteria virens*
Western tanager	*Piranga ludoviciana*
Black-headed grosbeak	*Pheucticus melanocephalus*
Lazuli bunting	*Passerina amoena*
Green-tailed towhee	*Pipilo chlorurus*
Rufous-sided towhee	*Pipilo erythrophthalmus*
Chipping sparrow	*Spizella passerina*
Fox sparrow	*Passerella iliaca*
Song sparrow	*Melospiza melodia*
Golden-crowned sparrow	*Zonotrichia atricapilla*
Dark-eyed junco	*Junco hyemalis*
Red-winged blackbird	*Agelaius phoeniceus*
Western meadowlark	*Sturnella neglecta*
Brewer's blackbird	*Euphagus cyanocephalus*
Brown-headed cowbird	*Molothrus ater*
Northern oriole	*Icterus galbula bullockii*
Purple finch	*Carpodacus purpureus*
Cassin's finch	*Carpodacus cassinii*
House finch	*Carpodacus mexicanus*
Red crossbill	*Loxia curvirostra*
Pine siskin	*Carduelis pinus*
Lesser goldfinch	*Carduelis psaltria*
American goldfinch	*Carduelis tristis*
Evening grosbeak	*Coccothraustes vespertina*
MAMMALS	
Vagrant shrew	*Sorex vagrans*
Trowbridge's shrew	*Sorex trowbridgei*
Shrew-mole	*Neurotrichus gibbsi*
Little brown myotis	*Myotis lucifugus*
Yuma myotis	*Myotis yumanensis*
Long-eared myotis	*Myotis evotis*
Fringed myotis	*Myotis thysanodes*
Long-legged myotis	*Myotis volans*
California myotis	*Myotis californicus*
Silver-haired bat	*Lasionycteris noctivagans*
Big brown bat	*Eptesicus fuscus*
Hoary bat	*Lasiurus cinereus*

COMMON NAME	SCIENTIFIC NAME
MAMMALS	
Brush rabbit	*Sylvilagus bachmani*
Snowshoe hare	*Lepus americanus*
Black-tailed jackrabbit	*Lepus californicus*
Mountain beaver	*Aplodontia rufa*
California ground squirrel	*Spermophilus beecheyi*
Western gray squirrel	*Sciurus griseus*
Douglas squirrel	*Tamiasciurus douglasi*
Northern flying squirrel	*Glaucomys sabrinus*
Beaver	*Castor canadensis*
Western harvest mouse	*Reithrodontomys megalotis*
Deer mouse	*Peromyscus maniculatus*
Brush mouse	*Peromyscus boylei*
Piñyon mouse	*Peromyscus truei*
Bushy-tailed woodrat	*Neotoma cinerea*
California redback vole	*Clethrionomys occidentalis*
Longtail vole	*Microtus longicaudus*
House mouse	*Mus musculus*
Porcupine	*Erethizon dorsatum*
Coyote	*Canis latrans*
Gray fox	*Urocyon cinereoargenteus*
Black bear	*Ursus americanus*
Ringtail	*Bassariscus astutus*
Raccoon	*Procyon lotor*
Marten	*Martes americana*
Fisher	*Martes pennanti*
Ermine	*Mustela erminea*
Long-tailed weasel	*Mustela frenata*
Mink	*Mustela vison*
Badger	*Taxidea taxus*
Western spotted skunk	*Spilogale putorius*
Striped skunk	*Mephitis mephitis*
River otter	*Lutra canadensis*
Mountain lion	*Felis concolor*
Bobcat	*Lynx rufus*
Black-tailed deer	*Odocoileus hemionus columbianus*
Roosevelt elk	*Cervus elaphus roosevelti*

(Source: CDFG 1968, 1989b)

APPENDIX J

Recommended vegetation species to plant in the wet meadow compensation site.

Common Name	Botanical Name
ROOSTING COVER FOR CALIFORNIA QUAIL	
Blue elderberry	*Sambucus caerulea*
Redberry	*Ramnus crocea*
Sandbar willow	*Salix hindsiana*
Arroyo willow	*Salix lasiolepis*
California black oak	*Quercus kelloggii*
Fremont cottonwood	*Populus fremontii*
ESCAPE COVER FOR CALIFORNIA QUAIL	
California blackberry	*Rhubus vitifolius*
Blue elderberry	*Sambucus caerulea*
Coyote brush	*Baccharis pilularis*
Redberry	*Ramnus crocea*
Gooseberry	*Ribes* sp.
Meadow barley	*Hordeum brachyantherum*
Squaw bush	*Rhus trilobata*
Wild rose	*Rosa californica*
Sandbar willow	*Salix hindsiana*
Vine maple	*Acer circinatum*
FOOD SOURCE FOR CALIFORNIA QUAIL	
Filaree	*Erodium* sp.
Red clover	*Trifolium pratense*
Redberry	*Ramnus crocea*
Miner's lettuce	*Montia perfoliata*
Geranium	*Pelargonium* sp., *Geranium* sp.
Ryegrass	*Lolium* sp.
Bur clover	*Medicago hispida*
Vetch, all species	*Vicia* spp.
Pigweed, all species	*Chenopodium* spp.
Sheep sorrel	*Rumex acetosella*
Fiddle neck	*Amsinckia intermedia*
Plantain, all species	*Plantago* spp.
Kentucky bluegrass	*Poa pratensis*
Gambleweed and other sanicles	*Sanicula* spp.
ROOSTING AND NESTING HABITAT FOR RED-WINGED BLACKBIRD	
Tules	*Scirpus* sp.
Cattails	*Typha* sp.
California blackberry	*Rhubus vitifolius*
Sandbar willow	*Salix hindsiana*
Arroyo willow	*Salix lasiolepis*

note: The vegetation recommended for planting in the compensation areas is targeted for the evaluation species, however, many other wildlife species would benefit as well.

Sources: Christensen 1986, CDFG 1989a, K. Fuller, pers. comm., Natural Resources 1989, SCS 1980, USFWS 1985.

APPENDIX K

Common shrub species in Trinity County and their value as deer browse (modified from: Sampson and Jespersen 1963. California Range Brushlands and Browse Plants Calif. Agric. Exp. Sta. 162 pp. *in* Kie and Menke 1980).

SCIENTIFIC NAME	COMMON NAME	SPROUTER OR NON-SPROUTER	DECIDUOUS OR EVERGREEN	DEER BROWSE VALUE[1]
Arctostaphylos patula	Greenleaf manzanita	both	evergreen	3-4
A. viscida	Whiteleaf manzanita	non-sprouter	evergreen	3-4
Adenostoma fasciculatum	Chamise	sprouter	evergreen	2-3
Ceanothus cuneatus	Wedgeleaf ceanothus	non-sprouter	evergreen	1
C. lemmonii	Lemon ceanothus	sprouter	semi-deciduous	1-2
C. cordulatus	Mountain whitethorn	both	evergreen	1-2
C. integerrimus	Deerbrush	both	deciduous	1-2
C. prostratus	Squaw carpet	non-sprouter	evergreen	2-4
Cercocarpus betuloides	Birchleaf mountain mahogany	sprouter	semi-deciduous	1
Eriodictyon californicum	Yerba santa	sprouter	evergreen	3-4
Garrya fremontii	Silktassel	sprouter	evergreen	2-4
Prunus emarginata	Bitter cherry	sprouter	deciduous	1-2
Quercus wislizenii	Interior live oak	sprouter	evergreen	2-3
Q. chrysolepis	Canyon live oak	sprouter	evergreen	3-4
Q. kelloggii	California black oak	sprouter	deciduous	1-2
Q. garryana	Oregon white oak	sprouter	deciduous	2-3

[1] Rating: 1 = excellent, 2 = good, 3 = fair, 4 = poor.

APPENDIX L

Recommended vegetation species to plant in the montane hardwood compensation site.

Common Name	Botanical Name
ROOSTING COVER FOR CALIFORNIA QUAIL	
California black oak	*Quercus kelloggii*
Canyon live oak	*Quercus chrysolepis*
Oregon white oak	*Quercus garryana*
ESCAPE COVER FOR CALIFORNIA QUAIL	
Oregon grape	*Berberis aquifolium*
Chamise	*Adenostoma fasciculatum*
Wedgeleaf ceanothus	*Ceanothus cuneatus*
Deerbrush ceanothus	*Ceanothus integerrimus*
Lemon ceanothus	*Ceanothus lemmonii*
Interior live oak	*Quercus wislizenii*
FOOD FOR CALIFORNIA QUAIL	
Red-stem filaree	*Erodium cicutarium*
White-stem filaree	*Erodium moschatum*
Yellow-sweet clover	*Melilotus indica*
Birdsfoot lotus	*Lotus corniculatus*
Vetch, all species	*Vicia* spp.
Lupine, small seeded species	*Lupinus* spp.
Dandelions, all species	*Taraxacum* spp.
Prickly lettuce	*Lactuca scariola*
Mayweed	*Anthemis cotula*
Turkey mullein	*Eremocarpus setigerus*
Filaree, all species	*Erodium* spp.
Pigweed, all species	*Chenopodium* spp.
Tumbleweed	*Amaranthus graecizans*
Rough pigweed	*Amaranthus retroflexus*
Mustards, all species	*Brassica* spp.
Wild radish	*Raphanus sativus*
Shepherd's purse	*Capsella bursa-pastoris*
Chickweeds, all species	*Cerastium* spp., *Stellaria* spp.
Wild geranium	*Geranium dissectum*
Red maids, all species	*Calandrinia* spp.
Chess, species with small seeds	*Bromus* spp.
Ryegrass, all species	*Lolium* spp.
Pimpernel or poor man's weatherglass	*Anagallis arvensis*
Plantain, all species	*Plantago* spp.
Gambleweed and sanicles	*Sanicula* spp.
BROWSE AND COVER FOR BLACK-TAILED DEER AND COVER FOR OTHER WILDLIFE	
Wedgeleaf ceanothus	*Ceanothus cuneatus*
Deerbrush ceanothus	*Ceanothus integerrimus*
Lemon ceanothus	*Ceanothus lemmonii*
Mountain whitethorn	*Ceanothus cordulatus*
Flannel bush	*Fremontia californica*
Birchleaf mountain mahogany	*Cercocarpus betuloides*
Western serviceberry	*Amelanchier alnifolia*