APPENDICES VOLUME 1

STUDY OF SKAGIT DAMS ORIGINAL IMPACTS ON WILDLIFE AND FISH HABITATS AND POPULATIONS

SEATTLE CITY LIGHT

envirosphere company
A Division of EBASCO SERVICES INCORPORATED

Efish
3636

STUDY OF SKAGIT DAMS ORIGINAL IMPACTS ON WILDLIFE AND FISH HABITAT AND POPULATIONS

FINAL REPORT

APPENDICES VOLUME 1

Prepared By

envirosphere company
A Division of EBASCO SERVICES INCORPORATED
BELLEVUE, WASHINGTON

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John J. Brueggeman

TECHNICAL MANAGER
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PREPARED FOR

SEATTLE CITY LIGHT
PROJECT MANAGER
Richard E. Rutz

MAY 1988

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APPENDIX A

Your
Seattle
City Light

Randall W. Hardy, Superintendent
Charles Royer, Mayor

March 27, 1987

Mr. Brian Hauger
Washington Dept. of Wildlife
600 N. Capital Way
Olympia, WA 98501

SUBJECT: SEATTLE CITY LIGHT/SKAGIT DAMS ORIGINAL IMPACTS STUDY
TRANSMITTAL OF 2/24/87 HEP TEAM MEETINGS NOTES

Dear Brian:

Enclosed is a copy of the February 24, 1987 HEP team meeting notes for the Skagit Dams Original Impacts Study. Decisions were made on the study area boundaries and the habitat classification system. The meeting notes include the details of the decisions reached and assignments made by the HEP team.

Please review these notes and acknowledge your acceptance of the decisions and assignments in the designated place below and return this letter to Seattle City Light

If you have any questions, please call me (206) 625-3108, or Jay Brueggeman (206) 451-4625.

Sincerely,

Richard Rutz

Richard Rutz, Environmental Analyst
Environmental Affairs Division

RR:gv

As a representative of WA DEPT. OF WILDLIFE, I accept the decitions and assignments documented in the February 24, 1987 HEP team meeting for the Skagit Original Impacts Study.

Brian Hauger
(Name) (Date)

Your
Seattle
City Light

Randall W. Hardy, Superintendent
Charles Royer, Mayor

RECEIVED
1987 MAR 30 P 11: 20
NOCA

March 27, 1987

John Jarvis
North Cascades National Park Complex
2105 Highway 20
Sedro Woolley, WA 98284

SUBJECT: SEATTLE CITY LIGHT/SKAGIT DAMS ORIGINAL IMPACTS STUDY
TRANSMITTAL OF 2/24/87 HEP TEAM MEETINGS NOTES

Dear Mr. Jarvis:

Enclosed is a copy of the February 24, 1987 HEP team meeting notes for the Skagit Dams Original Impacts Study. Decisions were made on the study area boundaries and the habitat classification system. The meeting notes include the details of the decisions reached and assignments made by the HEP team.

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If you have any questions, please call me (206) 625-3108, or Jay Brueggeman (206) 451-4625.

Sincerely,

Richard Rutz

Richard Rutz, Environmental Analyst
Environmental Affairs Division

RR:gv

As a representative of North Cascades Nat. Park Service, I accept the decitions and assignments documented in the February 24, 1987 HEP team meeting for the Skagit Original Impacts Study.

Jonathan B. Jarvis
(Name)

3-31-87
(Date)

Your
Seattle
City Light

Randall W. Hardy, Superintendent
Charles Royer, Mayor

March 27, 1987

Estyn R. Mead
Division of Ecological Services
U.S. Fish & Wildlife Service
2625 Parkmont Lane SW, Bldg. B-3
Olympia, WA 98502

SUBJECT: SEATTLE CITY LIGHT/SKAGIT DAMS ORIGINAL IMPACTS STUDY
TRANSMITTAL OF 2/24/87 HEP TEAM MEETINGS NOTES

Dear Mr. Mead:

Enclosed is a copy of the February 24, 1987 HEP team meeting notes for the Skagit Dams Original Impacts Study. Decisions were made on the study area boundaries and the habitat classification system. The meeting notes include the details of the decisions reached and assignments made by the HEP team.

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If you have any questions, please call me (206) 625-3108, or Jay Brueggeman (206) 451-4625.

Sincerely,

Richard Rutz

Richard Rutz, Environmental Analyst
Environmental Affairs Division

RR:gv

As a representative of US Fish and Wildlife Service, I accept the decitions and assignments documented in the February 24, 1987 HEP team meeting for the Skagit Original Impacts Study.

Estyn R. Mead (Name)   4-27-87 (Date)

SCL SKAGIT DAMS ORIGINAL IMPACTS STUDY

HEP TEAM MEETING

FEBRUARY 24, 1987

On Tuesday, February 24, 1987 a HEP Team Meeting was held for the Seattle City Light Skagit Dams Original Impacts Study. The purpose of this meeting was to: 1) determine the study area boundary; 2) select a habitat classification system; and 3) identify sources of data for evaluating succession, logging, fire and development.

Attendees: Christine Psyk; SCL
Joe and Margaret Miller; N3C
Jon Jarvis; NPS
Estyn Mead; USFWS
Brian Hauger; WDG
Jay Brueggeman, Dave Every, and Colleen McShane; Envirosphere

I. Study Area Boundary

A. Purpose of Post-Project Mapping

1. The reasons for post-project mapping are:

a. To help identify sites for sampling habitat quality.

b. To aid in verifying pre-project cover types. This can be accomplished by photo-interpretation without entering the data onto the GIS map.

2. The following conditions for establishing a study area boundary were discussed:

a. The study area boundary should include the zone of vegetation impacted by the project but not extend a long distance up-slope from the inundation area since habitat types are likely to be encountered that were not present under pre-project conditions.

b. It is likely that the cover types on the slopes above the reservoirs will not represent all pre-project conditions and that certain inundated habitats will have to be sampled in representative areas outside the project boundary.

c. Big Beaver Valley and the Skagit Valley in Canada may contain the best representatives of cover types present prior to project construction. These areas will be photo interpreted but not mapped on the GIS.

B. Ross Lake

1. The established boundary around Ross Lake will be the 1725 ft contour, or an area approximately 125 ft above the high water mark.

   a. At Big Beaver Valley, the area mapped on the GIS will extend to the western edge of the forested patch located at the mouth of the stream.

   b. For tributaries flowing into Ross Lake, aerial photographs will be examined for cover-type changes to determine the study area boundary mapped on the GIS for these areas.

2. Since FERC only deals with the U.S., the Canadian section of Ross Lake and the surrounding lands will not be mapped on the GIS.

3. The cover-type map of Big Beaver Valley currently being prepared by Ron Vanbianche will be used as a reference for identifying pre-project cover types and choosing sampling locations as necessary.

   a. A cross check of the photo interpretation of Big Beaver Valley will be done.

   b. Other than the forested area at the stream outlet, no additional area will be mapped in Big Beaver Valley.

4. Cover types in Canada and other stream valleys will be delineated on aerial photos, as necessary, to identify sampling areas for pre-project cover types that do not currently exist elsewhere in the Ross Lake area.

C. Diablo and Gorge Reservoirs

1. No pre-project aerial photographs exist for Diablo and Gorge Reservoirs.

   a. Oblique photos available from SCL will be used to identify cover-types, to the extent possible.

   b. The Journal of Hydroelectric Engineering (in the UW Engineering Library) has some photographs taken during construction.

2. A boundary of 125 ft above the high wat-- mark will be mapped on a GIS for Gorge and Diablo reservoirs.

   a. As with Ross Lake, current aerial photographs will be examined for cover-type changes to determine the study area boundaries for the tributary valleys.

b. Areas such as Thunder Arm and Buster Brown Flats may contain areas that are good representatives of pre-project conditions and certain cover types in these areas will be marked on aerial photos as necessary.

3. Brian Hauger of WDG requested that impacts from transmission lines in the vicinity of Gorge and Diablo reservoirs be considered; however, since these impacts were never previously identified as a concern by the intervenors, they are not part of this study.

II. Habitat Classification

A. Background

1. The cover type classification system chosen for the Skagit should be compatible with that used on the Cowlitz Study.

   a. The classification system used on the Cowlitz study followed the Classification of Wetlands and Deepwater Habitats of the U.S. by Cowardin et al (1979) and An Ecological Characterization of the Pacific Northwest Coastal Region (USFWS 1980).

   b. The system chosen for the Skagit should be hierarchical and correspond with USGS mapping in order to incorporate information previously mapped in the Skagit area.

2. A matrix of all the classification systems used to date on the Skagit was presented.

B. Habitat Classification and Mapping

1. The following habitat classification system was agreed upon for mapping:

Conifer Forest
- Old Growth
- Closed Canopy (Separate lodgepole pine if possible)
- Open Canopy (Separate lodgepole pine if possible)
- Regeneration

Broadleaf Forest

Mixed Forest

Regeneration Broadleaf/Mixed

Riparian
- Old Growth
- Closed Canopy Conifer
- Open Canopy Conifer
- Regeneration Conifer
- Broadleaf
- Mixed
- Regeneration Broadleaf/Mixed
- Shrub Thickets
- Sand/Gravel Bars

Shrub Dominated
- Avalanche Tracks
- Shrub/Exposed Rock

Herbaceous Dominated
- Grassland
- Forb/Fern

Riverine
- River 1% Gradient
- River 1-3% Gradient
- River 3-6% Gradient
- River 6-12% Gradient
- River 12% Gradient
- Tributary

Lacustrine
- Reservoir
- Lake

Palustrine
- Pond (Aquatic Bed)
- Marsh (Persistent Emergent Wetland)
- Bog (Moss Wetland)
- Shrub Swamp (Scrub-Shrub Wetland)
- Forested Swamp (Forested Wetland)
  - Conifer
  - Broadleaf

Non-Vegetated Areas
- Talus
- Exposed Rock

Agricultural
- Crops
- Pasture

Developed/Recreational
- Residential - Cabins, Resorts
  - Low Density
  - High Density
- Commercial/Services
- Industrial
- Transportation/Utilities
  - Highway/Road R.O.W.
  - Powerline R.O.W.

- Extractive
- Park/Campground

2. The definition of Old Growth Conifer will conform to the description provided by Franklin and Dyrness (1973) in Natural Vegetation of Oregon and Washington. Wetland types will follow Cowardin, et al. (1979) and other types will follow USFWS 1980 or Anderson, et al. (1976).

3. All riparian areas will be mapped in the same colors as the upland types, but will be distinguished by cross-hatching, etc.

4. The minimum mapping unit will be different for Ross than for Gorge and Diablo because it has better pre-project photography.

   a. Ross - 5 acre minimum mapping unit for all cover types except wetlands, which will be mapped at 1 acre whenever possible.

   b. Gorge and Diablo - will be mapped as fine as possible given the coarseness of the photography.

C. Plant Communities of Special Significance

1. Plant communities of special significance will be described within the proposed habitat classification system.

2. It will not be possible to quantify unique plants on the map; they will be qualitatively discussed in the narrative of the final report.

III. Succession, Logging, Fire and Development

A. Target Years and Succession

1. The post-project aerial photography available for the entire project area is from: 1976-1978

2. The pre-project aerial photography available for the Ross Lake area is from: 1946 (northern part of Ross into Canada) and 1936.

3. It will be necessary to locate aerial photos for the 1950s or 1960s for succession estimates (succession is determined by following a given polygon over time using a series of aerial photographs).

4. Target years will be different for each reservoir; the following baseline target years were agreed on:

   a. Ross TYO = 1936

   b. Diablo TYO = 1926

   c. Gorge TYO = 1918

B. Logging, Fire and Development

1. A hypothetical cutting rate for the Skagit Area for 1918 to 1968 is needed assuming the project had not been built (North Cascades National Park was established in 1968).

2. Jon Jarvis will check on the primitive area status of the upper Skagit prior to the establishment of North Cascades National Park.

3. The NPS currently has a let-burn policy in North Cascades National Park. Jon Jarvis will try to determine the year the policy changed from suppression to let-burn.

4. Christine Psyk will check on any developments, such as campgrounds (and dates) associated with the reservoirs.

IV. Next HEP Team Meeting

The next HEP Team meeting is scheduled for Wednesday, April 1, 1987 at 9:00 a.m. The meeting will be held at Envirosphere's office. The primary purpose of this meeting will be to choose the evaluation species for the HEP. Envirosphere will prepare copies of models available for the species evaluated by the 1980-1981 HEP and any other species that should be considered. These models will be sent to HEP team members approximately two weeks prior to the meeting.

Your
Seattle
City Light

Randall W. Hardy, Superintendent
Charles Royer, Mayor

April 13, 1987

Mr. Brian Hauger
Washington Dept. of Wildlife
600 N. Capital Way
Olympia, WA 98501

Dear Brian:

Enclosed is a copy of the April 1, 1987 HEP team meeting notes for the Skagit Dams Original Impacts Study. The notes include the details of the decisions reached and assignments made by the HEP team during the meeting. Please review the notes and acknowledge your acceptance of the decisions and assignments by signing in the designated place below and returning this letter to Envirosphere Company, 10900 N.E. 8th Street, Bellevue, WA 98004-4405.

Also enclosed are four additional species models (red-tailed hawk, marten, black-capped chickadee, and dipper) to complement those already distributed.

If you have any questions, please call me or Jay Brueggeman.

Sincerely,

Richard Rutz

Rick Rutz
Project Manager

RR:mbm

Enclosures: as noted

As a representative of Wash. Dept. of Wildlife, I accept the decisions and assignments documented in this letter for the Skagit Dams Original Impacts Study

Brian D. Hauger

Your
Seattle
City Light

Randall W. Hardy, Superintendent
Charles Royer, Mayor

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NOCA

April 13, 1987

John Jarvis
North Cascades Park Complex
2105 Highway 20
Sedro Woolley, WA 98284

Dear John:

Enclosed is a copy of the April 1, 1987 HEP team meeting notes for the Skagit Dams Original Impacts Study. The notes include the details of the decisions reached and assignments made by the HEP team during the meeting. Please review the notes and acknowledge your acceptance of the decisions and assignments by signing in the designated place below and returning this letter to Envirosphere Company, 10900 N.E. 8th Street, Bellevue, WA 98004-4405.

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If you have any questions, please call me or Jay Brueggeman.

Sincerely,

Richard Rutz

Rick Rutz
Project Manager

RR:mbm

Enclosures: as noted

As a representative of North Cascades NPSC., I accept the decisions and assignments documented in this letter for the Skagit Dams Original Impacts Study

Jonathan B. Jarvis
(Name)

4-27-87
(Date)

Your
Seattle
City Light

Randall W. Hardy, Superintendent
Charles Royer, Mayor

April 13, 1987

Estyn R. Mead
Division of Ecological Services
U. S. Fish and Wildlife Service
2625 Parkmont Lane S.W., Bldg. B-3
Olympia, WA 98502

Dear Estyn:

Enclosed is a copy of the April 1, 1987 HEP team meeting notes for the Skagit Dams Original Impacts Study. The notes include the details of the decisions reached and assignments made by the HEP team during the meeting. Please review the notes and acknowledge your acceptance of the decisions and assignments by signing in the designated place below and returning this letter to Envirosphere Company, 10900 N.E. 8th Street, Bellevue, WA 98004-4405.

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Sincerely,

Richard Rutz

Rick Rutz
Project Manager

RR:mbm

Enclosures: as noted

As a representative of US Fish and Wildlife Service, I accept the decisions and assignments documented in this letter for the Skagit Dams Original Impacts Study

Estyn R. Mead 4-27-87

SCL Skagit Dams Original Impacts Study
HEP Team Meeting
April 1, 1987

On Wednesday, April 1, 1987 a HEP Team Meeting was held for the Skagit Dams Original Impacts Study. The purpose of the meeting was to: 1) review the habitat inventory program, and 2) select a preliminary list of evaluation species.

Attendees: Rick Rutz, SCL
Jonathan Jarvis, NPS
Brian Hauger and Art Stendall, WDG
Estyn Mead, USFWS
Jay Brueggeman, Dave Every and Colleen McShane, Envirosphere

I. Habitat Mapping Progress

A. Photo Interpretation Key

- An important step in habitat mapping was the development of a photo interpretation key for the Skagit project area and this key was presented (Attachment A). The photo-interpretation key provides a set of written criteria to aid in identifying cover types on aerial photographs. The purpose of this key is to ensure the accuracy and repeatability of the the photo-interpretation process.

B. Cover-Type Mapping

Progress to date on the cover type mapping was presented. Specifically, the following topics were discussed.

- Cover-types identified on the aerial photographs will be mapped on the edit plots and their acreages stored on the GIS. However, some cover-types may be grouped and mapped as one type on the presentation map in the final report. The intended use of this map by SCL will determine which cover-types will be grouped.

- The tributaries into Ross, Gorge, and Diablo reservoirs are too narrow to map accurately on the GIS. The length of the stream can be mapped but an average width will have to be used to calculate the area. This information can then be entered into the GIS, so that the appropriate riverine acreage can be subtracted from the cover types adjoining the river. Sources of information for estimating an average stream width include fisheries reports and actual measurements.

- For the photo interpretation process it is important to define when a shrub becomes a tree. Dave Every will be responsible for making this determination from the literature and incorporating it into the cover mapping.

- Riparian habitats, particularly in the Ross area, are not easily identified on many of the pre-project photographs. The valley in the Ross area was wide and guidelines are needed to define riparian areas. Establishing such guidelines will require data on the three to five year flood. Rick Rutz will try to obtain this information from the SCL Engineering Department. The data will be used to construct hydrographs for specific sections of the Skagit river. If these data are available, they will be used by the HEP team to define riparian habitat.

  On some pre-project photographs for Ross, riparian habitat is easily identified by topographic breaks or distinct vegetation changes.

In the Diablo and Gorge areas the Skagit River was in a canyon and riparian habitat was confined to a narrow strip in many places and was virtually non-existent in others.

II. Selection of Evaluation Species

A. Selection Criteria

A set of criteria was discussed to guide the process of selecting species. One set of criteria is for evaluating the appropriateness of a given species for a particular project area. A second set of criteria is applied to the list of evaluation species to evaluate the mix of species selected. Once the evaluation species are selected, the suitability of the HSI models to the project area will be evaluated by a species expert.

B. Species Selection

The process of selecting evaluation species involved considering each of the major habitat types in the project area. These habitat types and the preliminary list of species selected by the HEP team to represent them are given in Table 1 and described as follows:

- Riverine

  Species chosen to represent riverine habitat included the beaver, dipper, and osprey. The <u>beaver</u> represents the relationship between riparian and riverine, palustrine, and lacustrine habitat in the Ross area. The <u>dipper</u> represents the relationship between the river and the non-vegetated steep canyon walls in the Gorge and Diablo areas, which would be unsuitable for the beaver. The <u>osprey</u> represents species dependent on riverine and riparian habitats where there are fish populations. This species will be considered for the HEP if a model can be located by Brian Hauger.

o Lacustrine

Most of the waterfowl using the reservoir are migratory. The species chosen to represent lacustrine habitat in the project area is the common merganser. Brian Hauger will try to locate a common merganser model.

o Palustrine

Most of the pre-project palustrine habitat appears to have been shrub dominated. The yellow warbler was chosen to represent palustrine habitat dominated by hydrophytic shrubs.

o Riparian

The shrub component of riparian habitat is represented by the yellow warbler. The black-capped chickadee was chosen to represent the overstory tree component of riparian areas.

o Conifer Forest

The pileated woodpecker and marten were chosen to represent coniferous forest habitat in the project area. The pileated woodpecker represents species that inhabit older growth conifer forests, that nest or feed on snags, logs, and stumps. The marten represents species inhabiting mature conifer forests, especially those dependent on fir or spruce. Art Stendall will try to locate trapping records to confirm the occurrence of marten in the project area.

- Mixed Conifer Forest

The species chosen to represent the mixed deciduous/coniferous forest areas is the ruffed grouse. Other species such as the pileated woodpecker and black-capped chickadee also use mixed conifer stands.

- Broadleaf Forest

Broadleaf forest has relatively low value as wildlife habitat and covers a small percentage of the project area. No particular species was selected to represent this cover type. Multicover species such as black-tailed deer and black-capped chickadee use broadleaf forest and will represent this habitat type.

- Shrub Dominated

Deer were chosen to represent shrub dominated habitats. Deer also represent the juxtaposition of open and forested habitats. Both mule deer and black-tailed deer were selected as evaluation species and the project area will be stratified for the data collection and analysis to reflect their specific distributions. Mule deer are confined to the eastern side of Ross Reservoir and use this area mainly for wintering. Both species intermix in this area and black-tailed deer use the western side of Ross Reservoir as well as some of the area in the vicinity of Gorge and Diablo reservoirs.

- o Herbaceous Dominated

  The red-tailed hawk was chosen to represent herbaceous dominated habitats and other open habitats where it feeds on small mammal populations. In addition, it nests in open forested habitats.

III. Next Meeting

The next HEP team meeting will be held on Tuesday, April 28, 1987 to finalize the list of evaluation species and review the pre-impoundment cover type mapping.

TABLE 1
SKAGIT DAMS ORIGINAL IMPACTS HEP STUDY---PRELIMINARY SPECIES LIST AND HABITATS

SPECIES	COMMON NAME	LIFE FORM	MODEL STATUS^	HABITAT TYPE										
				CONIFEROUS FOREST	BROADLEAF FOREST	MIXED FOREST	REGENERATION BROADLEAF/MIXED	SHRUB DOMINATED	HERBACEOUS DOMINATED	NON-VEGETATED	PALUSTRINE	RIPARIAN-	RIVERINE	LACUSTRINE
Cinclus mexicanus	American Dipper	3	1							x			x	
Bonasa umbellus	Ruffed Grouse	5	3	x	x	x	x					x		
Odocoileus hemionus hemionus	Mule Deer	5	2	x	x	x	x	x	x			x		
Odocoileus hemionus columbianus	Black-tailed Deer	5	1	x	x	x	x	x	x			x		
Dendroica petechia	Yellow Warbler	8	3								x*	x		
Pandion haliaetus	Osprey	12	?									x	x	x
Buteo jamaicensis	Red-tailed Hawk	12	2	x		x			x	x		x		
Dryocopus pileatus	Pileated Woodpecker	13	3	x	x	x						x		
Mergus merganser	Common Merganser	14	?										x	x
Parus atricapillus	Black-capped Chickadee	14	3	x	x	x	x				x**	x		
Martes americana	Marten	14	3	x		x						x		
Castor canadensis	Beaver	16	3								x	x	x	x

^Model Status: 1=preliminary
2=USFWS draft
3=USFWS final

* shrub swamp only
** palustrine forest only

ATTACHMENT A

PHOTOINTERPRETATION KEY FOR COVER TYPES SKAGIT DAMS PROJECT

1.a. Land 2

2.a. Lands where human use or activity is the dominant characteristic. . 3

3.a. Reservoir drawdown area . . . . (RD)

3.b. Disturbed lands nearly barren of vegetative cover ($<30\%$)[1/]. . . . . (DI) or 4

4.a. Industrial sites (dam, powerhouse, mine, etc.). . . . (I)

4.b. Commercial. . . . . (CS)

4.c. High density residential. . . . . (RH)

4.d. Intensive-use recreational sites. . . . . (RI)

4.e. Roads, parking lots . . . . (RP)

3.c. Developed lands with vegetative cover ($>30\%$). 5

5.a. Agricultural cropland or pastureland. . . . . (AG)

5.b. Low density residential . . . . (RL)

5.c. Forest campground . . . . (CA)

5.d. Transmission or highway right-of-way. . . . . (ROW)

2.b. Lands with a "natural" character 6

6.a. Non-vegetated (cover $<30\%$ herb., 20% shrub, or 10% forest)[1/] 7

7.a. Exposed bedrock Exposed Rock. . . (ER)

7.b. Rockpile on a slope Talus. . . (T)

7.c. Gravel or sand bars (a riverine type) Gravel Bar . . (Gr)

6.b. Vegetated lands (cover $\geq 30\%$ herb., 20% shrub, or 10% forest) 8

8.a. Uplands (without wetland or riparian characteristics) 9

9.a. Forested ($\geq 10\%$ tree cover)[1/]. 10

10.a. Conifers comprise $\geq 70\%$ of forest cover[1/]. 11

COVER TYPES (CONTINUED)
SKAGIT DAMS PROJECT

11.a. Large trees, broken tops, canopy openings
Old Growth Conifer . . . . (COG)

11.b. Mature trees, continuous canopy (≥50% closure)[3/]
Closed Canopy Conifer . . . (CC)

11.c. Mature trees, open canopy (10% - 50% closure)
Open Canopy Conifer . . . (CO)

11.d. Young trees, sapling to pole stage
Regeneration Conifer . . . (CR)

10.b. Forest cover <70% conifer 12

12.a. Young trees, sapling to pole stage (< 10% mature trees) Regeneration Broadlead/Mixed (R)

12.b. At least 10% of the trees mature 13

13.a. Tree cover ≥ 70% broadleaf[1/]
Broadleaf forest . . . (B)

13.b. Tree cover < 70% broadleaf Mixed forest . . (M)

9.b. Shrub or herbaceous dominated (< 10% tree cover) 14

14.a. Herbaceous vegetation (< 20% shrub cover)[5/] 15

15.a. Grasses and grass-like plants dominant
Grassland/meadow . . . . (HG)

15.b. Forbs or ferns dominant Forb/Fern . . . . . . (HF)

14.b. Shrubs dominant (≥ 20% shrub cover) 16

16.a. Restricted to avalanche chutes Avalanche Tracks (SA)

16.b. Occurring elsewhere Shrublands (S)

.b. Riparian or wetland areas, vegetation showing the influence of the water or stream 17

17.a. Lands with saturated soils, with standing water at least part of the growing season, supporting hydrophytic plants (Palustrine wetlands)[2/] 18

18.a. Herbaceous vegetation dominant 19

19.a. Emergent plants dominate, little or no Sphagnum, photo image grey or green (Palustrine Emergent)
Wet Meadow/Marsh . . . . . (PM)

19.b. Sphagnum characteristic, often with low shrubs and sedges, photo image white or yellow (Palustrine moss) Bog . . . . (PB)

18.b. Trees or shrubs dominant 20

20.a. Shrubs dominant (Palustrine Scrub-shrub) Shrub Swamp . . (PS)

20.b. Trees dominant (Palustrine Forest, ≥ 10% tree cover) 21

21.a. Tree cover ≥ 70% conifer Conifer Swamp . . . (PFC)

21.b. Tree cover ≥ 70% broadleaf Broadleaf Swamp. . (PFB)

21.c. Tree cover 30-70% conifer Mixed Swamp . . (PFM)

17.b. Lands adjacent to streams, in floodplain, vegetation influenced by the stream....Riparian types--- go back to leads 9.a. and 9.b. to determine the type of Riparian cover (codes will be the upland types preceded by a small "r"

Water (± permanent) 22

22.a. Lake, reservoir, or pond 23

23.a. Large impoundment (Lacustrine) Reservoir . . . . (RES)

23.b. Natural waterbody > 20 acres and >2 meters deep (Lacustrine) Lake . . . (L)

23.c. Small, shallow natural waterbody (< 20 acres and <2 meters deep) (Palustrine) Pond . . (PP)

22.b. Stream (Riverine) 24

24.a. Tributary of the Skagit River Tributary (T)

24.b. Main Skagit River 25

25.a. Stream gradient < 1% Riverine . . . . (R_1)

25.b. Stream gradient 1-3% Riverine . . . . (R_2)

25.c. Stream gradient 3-6% Riverine . . . . (R_3)

25.d. Stream gradient 6-12% Riverine. . . . . (R_4)

25.e. Stream gradient >12% Riverine . . . . (R_5)

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5. Verner, J. and A.S. Boss (Tech. Coord.). 1980. California Wildlife and Their Habitats: Western Sierra Nevada. USDA Forest Service, Pacific Southwest Forest and Range Exp. Stn., Berkeley, CA. Gen. Tech. Rep. PSW-37.

HSI MODELS:

Red-Tailed Hawk

Marten

Black-Capped Chickadee

Dipper

Your
Seattle
City Light

Randall W. Hardy, Superintendent
Charles Royer, Mayor

May 12, 1987

Brian Hauger
Washington Department of Wildlife
600 N. Capital Way MS GJ-11
Olympia, WA 98504

MAY 14 1987

Dear Mr. Hauger:

Enclosed is a copy of the April 28, 1987 HEP Team Meeting notes for the Skagit Dams Original Impacts Study. The notes include the details of the decisions reached and assignments made by the HEP Team during the meeting. Please review the notes and acknowledge your acceptance of the decisions and assignments by signing in the designated place below and returning this letter to Envirosphere Company, 10900 N.E. 8th St., Bellevue, WA 98004-4405. Please note that the next meeting has been shifted to Monday, June 1.

If you have any questions, please call me (625-3108) or Jay Brueggeman (451-4625).

Sincerely,

Richard Rutz

Richard Rutz
Project Manager

RR:lsh

Enclosure

As a representative of WASHINGTON DEPT. OF GAME, I accept the decisions and assignments documented in this letter for the Skagit Dams Original Impacts Study.

Brian D. Hauger
Name

MAY 15, 1987
Date

RECEIVED
MAY 27 1987
ENVIROSPHERE
SEATTLE

Your
Seattle
City Light

Randall W. Hardy, Superintendent
Charles Royer, Mayor

RECEIVED
DEC 8 1987
ENVIROSPHERE COMPANY
SEATTLE

May 12, 1987

Jon Jarvis
US Dept. of Interior
National Park Service
N. Cascades Nat'l Park Complex
2105 Highway 20
Sedro Woolley, WA 98284

Dear Jon:

Enclosed is a copy of the April 28, 1987 HEP Team Meeting notes for the Skagit Dams Original Impacts Study. The notes include the details of the decisions reached and assignments made by the HEP Team during the meeting. Please review the notes and acknowledge your acceptance of the decisions and assignments by signing in the designated place below and returning this letter to Envirosphere Company, 10900 N.E. 8th St., Bellevue, WA 98004-4405. Please note that the next meeting has been shifted to Monday, June 1.

If you have any questions, please call me (625-3108) or Jay Brueggeman (451-4625).

Sincerely,

Richard Rutz
Project Manager

RR:lsh

Enclosure

As a representative of North Cascades N.P.S.C, I accept the decisions and assignments documented in this letter for the Skagit Dams Original Impacts Study.

Jonathan B. Jarvis
Name

12-7-87
Date

Your
Seattle
City Light

Randall W. Hardy, Superintendent
Charles Royer, Mayor

May 12, 1987

RECEIVED
FEB 04 1987
ENVIROSPHERE COMPANY

Estyn R. Mead
U.S. Fish and Wildlife Service
Division of Ecological Services
2625 Parkmont Lane S.W. Bldg. B-3
Olympia, WA 98502

Dear Mr. Mead:

Enclosed is a copy of the April 28, 1987 HEP Team Meeting notes for the Skagit Dams Original Impacts Study. The notes include the details of the decisions reached and assignments made by the HEP Team during the meeting. Please review the notes and acknowledge your acceptance of the decisions and assignments by signing in the designated place below and returning this letter to Envirosphere Company, 10900 N.E. 8th St., Bellevue, WA 98004-4405. Please note that the next meeting has been shifted to Monday, June 1.

If you have any questions, please call me (625-3108) or Jay Brueggeman (451-4625).

Sincerely,

Richard Rutz

Richard Rutz
Project Manager

RR:lsh

Enclosure

As a representative of US Fish and Wildlife Service, I accept the decisions and assignments documented in this letter for the Skagit Dams Original Impacts Study.

Name Estyn R. Mead　　　　Date 6/3/87

SCL SKAGIT DAMS ORIGINAL IMPACTS STUDY
HEP TEAM MEETING
April 28, 1987

On Tuesday, April 28, 1987, a HEP Team Meeting was held for the Skagit Dams Original Impacts Study. The purpose of this meeting was to: 1) review the pre-project habitat mapping progress; 2) finalize the list of evaluation species; 3) review the habitat parameters to be sampled for each evaluation species; and 4) establish the dates for the field sampling program.

Attendees: Rick Rutz, SCL
Jonathan Jarvis, NPS
Art Stendall and Brian Hauger, WDG
Estyn Mead, USFWS
Pat Goldsworthy, N3C
Joe and Margaret Miller, N3C
Jay Brueggeman, Dave Every, and Colleen McShane, Envirosphere

I. COVER TYPE MAPPING

Progress to date on the cover type mapping was presented. Specifically, the following topics were discussed:

o The post-project cover type mapping is complete and has been field verified for all of Gorge and Diablo reservoirs and about one-fourth of Ross Reservoir (just north of Big Beaver Valley). The field verification trip was on April 8-9, 1987 and it was conducted by car and boat. Accessibility problems prevented field verification of the cover-type mapping for most of Ross Reservoir. Field verification of the uncompleted portion of Ross Reservoir is scheduled for May 8 and will be conducted by helicopter.

- The pre-project mapping has been completed for the Ross area. The Gorge and Diablo areas are currently being mapped from oblique photographs and ancillary information. There are no aerial photographs available for this time period in these areas.

- Riparian habitat has been delineated on most of the pre-project photographs for the Ross area. Where there is no clear distinction between riparian and upland habitats, riparian habitat will be identified from data provided by Rick Rutz on the three to five year flood elevation for the Skagit River prior to impoundment.

- The cover type mapping will be put on the GIS by Northwest Cartography Inc. and edit plots will be available at the next HEP Team Meeting.

II. SELECTION OF EVALUATION SPECIES

The final evaluation species are listed in Table 1. The HEP Team selected most of the evaluation species during the April 1, 1987, meeting except for the common merganser, osprey, and dipper. Aspects of these species that were discussed at the April 28 meeting are presented below.

A. Common Merganser

- A common merganser HSI model is not available. The HEP Team agreed that the common merganser is represented by other species using riverine and lacustrine habitat. If a model can be developed, the common merganser will be used as a "secondary species."

- Information obtained by Estyn Mead and Colleen McShane on habitat parameters for the common merganser will be used by Envirosphere to explore developing a draft model for this species.

B. Osprey

- o The HEP team agreed to retain the osprey as an evaluation species to represent riverine and lacustrine habitat.

- o The applicability of the osprey model to the Skagit area will be assessed by a WDG nongame biologist at the direction of Brian Hauger.

- o A few pairs of osprey nest in the Ross area. Data available from the NPS on osprey use of the Ross area may be suitable to verify the model.

C. American Dipper

- o It was agreed to retain the dipper to represent the rock/talus habitats in association with riverine habitats.

- o The HSI model for the dipper lacks equations to define relationships between the habitat parameters. In addition, several of the graphical categories for the habitat parameters need to be quantified. The model will be reviewed by Gary White, Colorado State University.

- o The HEP Team agreed that the parameter measuring months of open water was not applicable to the Skagit area. It will be eliminated from the equation or assigned an SI value of 1.0.

III. HABITAT PARAMETERS

The habitat parameters to be sampled for each of the evaluation species are presented in Table 2. The HEP Team agreed that most of the variables were acceptable as defined. However, several models need modification to be applicable to the project area. These models are discussed below.

A. Marten

One of the parameters in the marten model is the percent of the canopy composed of spruce or fir. In the Skagit area marten may also use lodgepole pine and other conifer species. Envirosphere will review the literature and contact species experts to determine the conifer species used by marten in the Cascades. Rick Rutz will send Envirosphere a copy of a report on marten in the Mt. Baker area.

B. Ruffed Grouse

One of the parameters for the ruffed grouse model identifies the buds of mature aspen trees as a primary food source. Since there are few aspen in the Skagit area, ruffed grouse use other food sources, such as cottonwood catkins. Art Stendall will send a copy of the ruffed grouse model to Larry Brewer to adopt it to the project area.

C. Beaver

The HEP Team agreed that percent of water lily coverage was not an appropriate parameter for the lacustrine habitat in the project area, so it will not be measured.

D. Deer

- Some of the slopes in the project area are too steep to be suitable deer habitat. Envirosphere will review the literature and determine the maximum slope of habitats used by deer. Polygons with slopes exceeding the maximum will be marked on the GIS and excluded from sampling and area calculations for deer.

- The HEP team agreed to change the shrub height parameter in the mule deer model to match the 2 m value used in the black-tailed deer model.

- o Envirosphere will identify palatable shrub species for mule and black-tailed deer from the literature.

- o Rich Rutz will send Envirosphere copies of Taber's deer distribution maps from Exhibit W of the FERC license.

E. Red-tailed Hawk

The red-tailed hawk model was written for the eastern U.S. Envirosphere will be responsible for having this model reviewed by a species expert to ensure it applies to the project area.

IV. FIELD SAMPLING

A. Field Sampling Design

The foundation of the field sampling plan will incorporate the following elements:

- o Field sampling will be stratified by reservoir to ensure adequate representation of each reservoir.

- o The polygons to be sampled will be selected randomly.

- o The number of polygons to be sampled in each cover type will be apportioned according to the availability of that cover type during the pre-impoundment period and its importance as wildlife habitat.

B. Field Sampling Planning

- o The field program will be from June 15 to 19 and from June 22 to 26.

- o SCL will provide food, lodging, and boat transportation for all field team members.

- Preliminary personnel commitments for field studies:

WDG -	Art Stendall, 10 days; possibly a few other WDG personnel will participation.
NPS -	Jonathon Jarvis, 3 days most likely from June 23 to 25; possibly 1 or 2 seasonal staff will participate for a few days during June 22 to 26.
USFWS -	Estyn Mead, 5 days
SCL -	Rich Rutz, 10 days; 1 or 2 SCL staff will participate for a few days.
NSC -	Joe and Margaret Miller, 3 days each, from June 24 to 26; Patrick Goldsworthy will possibly participate during the week of June 22.
Envirosphere -	Two people for 10 days each.

V. NEXT HEP TEAM MEETING

The next HEP Team meeting was scheduled for Tuesday, June 2, 1987, at 9:00 a.m. at Envirosphere's offices. The purpose of the meeting will be to: 1) review the cover type edit plots, 2) finalize the field sampling design and data collection sheets, and 3) finalize commitments for the sampling program.

TABLE 1
SKAGIT DAMS ORIGINAL IMPACTS HEP STUDY---FINAL SPECIES LIST LIFE REQUITSITES

SPECIES	COMMON NAME	LIFE FORM	HABITAT TYPE: CONIFEROUS FOREST	BROADLEAF FOREST	MIXED FOREST	REGENERATION BROADLEAF/MIXED	SHRUB DOMINATED	HERBACEOUS DOMINATED	NON-VEGETATED	PALUSTRINE	RIPARIAN	RIVERINE	*LACUSTRINE
Cinclus mexicanus	American Dipper	3							R			F,W	
Bonasa umbellus	Ruffed Grouse	5	C	C,WF	C,WF	C,WF					C,WF		
Odocoileus hemionus hemionus	Mule Deer	5	C,WF	WF	C,WF	C,WF	C,WF	WF			C,WF		
Odocoileus hemionus columbianus	Black-tailed Deer	5	C,F,WS	F,WS	C,F,WS	F,WS	F,WS	F,WS			F,WS		
Dendroica petechia	Yellow Warbler	8								R*	R		
Pandion haliaetus	Osprey	12									R	F	F
Buteo jamaicensis	Red-tailed Hawk	12	R		R			F	F		R		
Dryocopus pileatus	Pileated Woodpecker	13	C,F,R	C,F,R	C,F,R						C,F,R		
Parus atricapillus	Black-capped Chickadee	14	F,R	F,R	F,R	F,R				F,R**	F,R		
Martes americana	Marten	14	WC		WC						WC		
Castor canadensis	Beaver	16								WF,W	WF	W	WF,W
Mergus merganser^	Common Merganser^	14									R	F	F

C=cover
WC=winter cover
W=water
F=food
WF=winter food
R=reproduction
WS=winter stress

* Shrub swamp only
** Palustrine forest only

^"secondary species"--will be used only if an HSI model can be developed

TABLE 2

SPECIES PARAMETERS AND SAMPLING METHODS FOR THE SKAGIT DAMS ORIGINAL IMPACTS

Species	Parameters to be Sampled	Method	Habitats
Dipper	stream gradient	topographic maps	riverine
	bottom substrate	site inspection	riverine
	abundance of vertical rock walls, waterfalls, bridges	site inspection, aerial photos	riverine, rock/talus, and exposed rock in association with riverine habitat
Ruffed Grouse	average radius of circles encompassing 20 mature male aspen 1/	tape measure or optical range finder	mixed, broadleaf, regenerative/broadleaf mixed, riparian
	density of deciduous shrub stems	quadrat count	conifer, mixed, broadleaf, regenerative/broadleaf mixed, riparian
	density of deciduous trees	quadrat count	conifer, mixed, broadleaf, regenerative/broadleaf mixed, riparian
	density of coniferous trees	quadrat count	conifer, mixed, broadleaf, regenerative/broadleaf mixed, riparian
	average lowest branch height above ground	transect, graduated rod	conifer, mixed, broadleaf, regenerative/broadleaf mixed, riparian

1/ Pending expert review.

5706a

TABLE 2 (continued)

SPECIES PARAMETERS AND SAMPLING METHODS FOR THE SKAGIT DAMS ORIGINAL IMPACTS

Species	Parameters to be Sampled	Method	Habitats
Ruffed Grouse (continued)	average height of woody stems	transect, graduated rod, trigonometric hypsometry	conifer, mixed, broadleaf, regenerative/broadleaf mixed, riparian
Mule Deer	percent canopy cover of evergreen woody vegetation $\geq$3.0 m in height	line intercept, graduated rod	conifer, mixed, broadleaf shrub dominated, riparian, regeneration/broadleaf mixed
	percent shrub crown cover $\leq$2.0 m in height	line intercept, graduated rod	conifer, mixed, broadleaf shrub dominated, riparian, regeneration/broadleaf mixed
	percent shrub crown cover of preferred shrubs <2.0 m in height	line intercept, graduated rod	conifer, mixed, broadleaf shrub dominated, riparian, regeneration/broadleaf mixed
	percent herbaceous canopy cover	line intercept, plot frame	conifer, mixed, broadleaf shrub dominated, agriculture, riparian, herbaceous dominated, regenerative broadleaf/mixed
	topographic diversity	topographic map	entire study area
Black-tailed deer	percent palatable herbaceous canopy cover	line intercept	conifer, mixed, broadleaf, regenerative broadleaf/mixed, shrub dominated, herbaceous dominated, riparian

TABLE 2 (continued)

SPECIES PARAMETERS AND SAMPLING METHODS FOR THE SKAGIT DAMS ORIGINAL IMPACTS

Species	Parameters to be Sampled	Method	Habitats
Black-tailed Deer (continued)	percent shrub canopy ≤ 2 m in height	line intercept	conifer, mixed, broadleaf, regenerative broadleaf/mixed, shrub dominated, herbaceous dominated, riparian
	percent palatable shrub canopy ≤ 2 m in height	line intercept	conifer, mixed, broadleaf, regenerative broadleaf/mixed, shrub dominated, herbaceous dominated, riparian
	percent less palatable shrub canopy ≤ 2 m in height	line intercept	conifer, mixed, broadleaf, regenerative broadleaf/mixed, shrub dominated, herbaceous dominated, riparian
	average distance from forage area to cover	aerial photos	broadleaf, regenerative broadleaf/mixed, herbaceous dominated, shrub dominated, riparian
	average distance from cover to forage area	aerial photos	conifer, mixed, riparian
	road density per square mile	aerial photos	conifer, mixed, broadleaf, regenerative broadleaf/mixed, shrub dominated, herbaceous dominated, riparian

TABLE 2 (Continued)

SPECIES PARAMETERS AND SAMPLING METHODS FOR THE SKAGIT DAMS ORIGINAL IMPACTS

Species	Parameters to be Sampled	Method	Habitats
Black-tailed Deer (continued)	winter stress cover-forage equivalent value	calculated	conifer, mixed, broadleaf, regenerative broadleaf/mixed, shrub dominated, herbaceous dominated, riparian
Yellow Warbler	percent deciduous shrub canopy	line intercept	riparian, palustrine
	average height of deciduous shrub canopy	graduated rod, transect	riparian, palustrine
	percent of deciduous shrub canopy comprised of hydrophytic shrubs	line intercept	riparian, palustrine
Osprey	Water clarity1/	Secchi disc	riverine, lacustrine
	Availability of perch sites per mile of shoreline (within 200 ft of water or in water)1/	site inspection/count	riverine, lacustrine
	Availability of pilot trees immediately surrounding nest sites and within suitable nesting habitat1/	site inspection/count	riverine, lacustrine
	Nest tree (>75 ft tall, 40 inch dbh, ponderosa pine, douglas fir, sugar pine) availability (number per 100 acres)1/	site inspection/count	riverine, lacustrine

1/ Pending expert review.

5706a

TABLE 2 (continued)

SPECIES PARAMETERS AND SAMPLING METHODS FOR THE SKAGIT DAMS ORIGINAL IMPACTS

Species	Parameters to be Sampled	Method	Habitats
Red-tailed Hawk	percent herbaceous canopy cover[1/]	transect, plot frame	herbaceous dominated, non-vegetated
	percent herbaceous canopy cover 8 to 46 cm tall[1/]	transect, plot frame, meter stick	herbaceous dominated, non-vegetated
	number of trees ≥25 cm dbh per 0.4 ha[1/]	quadrat count, dbh tape	herbaceous dominated, non-vegetated
	percent tree canopy closure[1/]	line intercept	conifer, mixed, riparian
	number of trees ≥50 cm dbh per 0.4 ha[1/]	quadrat count, dbh tape	conifer, mixed, riparian
	percent area in optimum food[1/]	aerial photos	entire study area
	percent area in optimum reproduction[1/]	aerial photos	entire study area
	distance between cover types[1/]	aerial photos	entire study area
Pileated Woodpecker	percent tree canopy closure	line intercept	conifer, mixed, broadleaf, riparian
	number of trees >51 cm dbh/0.4 ha	quadrat, dbh tape	conifer, mixed, broadleaf, riparian
	number of tree stumps ≥0.3 m in height and >18 cm diameter and/or logs >18 cm diameter/0.4 ha	quadrat, dbh tape	conifer, mixed, broadleaf, riparian

1/ Pending expert review.

TABLE 2 (continued)

SPECIES PARAMETERS AND SAMPLING METHODS FOR THE SKAGIT DAMS ORIGINAL IMPACTS

Species	Parameters to be Sampled	Method	Habitats
Pileated Woodpecker (cont.)	number of snags >51 cm dbh/0.4 ha	quadrat, dbh tape	conifer, mixed, broadleaf, riparian
	average dbh of snags >51 cm	quadrat, dbh tape	conifer, mixed, broadleaf, riparian
Black-capped Chickadee	percent tree canopy closure	line intercept	conifer, mixed conifer, broadleaf, regeneration broadleaf/mixed, riparian
	average height of overstory trees	graduated rod, trigonometric hypsometry	conifer, mixed conifer, broadleaf, regeneration broadleaf/mixed, riparian
	number of snags 10 to 25 cm dbh per 0.4 ha	quadrat count	conifer, mixed conifer, broadleaf, regeneration broadleaf/mixed, riparian
Marten	percent tree canopy closure	line intercept	conifer, mixed
	percent of the overstory canopy closure comprised of fir or spruce[1/]	line intercept	conifer, mixed
	successional stage of stand	visual examination	conifer, mixed
	percent of ground surface covered by downfall ≥7.6 cm in diameter	line intercept	conifer, mixed

1/ Pending expert review.

TABLE _ (Continued)

SPECIES PARAMETERS AND SAMPLING METHODS FOR THE SKAGIT DAMS ORIGINAL IMPACTS

Species	Parameters to be Sampled	Method	Habitats
Beaver	percent tree canopy closure	line intercept	riparian, palustrine
	percent of trees 2.5 to 15.2 cm dbh	quadrat count, dbh tape	riparian, palustrine
	percent shrub crown cover	line intercept	riparian, palustrine
	average height of shrub canopy	transect, graduated rod	riparian, palustrine
	species composition of woody vegetation	line intercept	riparian, palustrine
	percent of lacustrine surface dominated by yellow and/or white water lily	aerial photos or line intercept, plot frame	pond
	percent stream gradient	topographic maps	riverine
	average annual water fluctuation	local data	riverine, lacustrine
	shoreline development	topographic map, map wheel	lacustrine

Your
Seattle
City Light

Randall W. Hardy, Superintendent
Charles Royer, Mayor

August 13, 1987

Mr. Brian Hauger
Washington Dept. of Wildlife
600 N. Capital Way
Olympia, WA 98501

SUBJECT: SEATTLE CITY LIGHT/SKAGIT DAMS ORIGINAL IMPACTS STUDY
TRANSMITTAL OF 6/3/87 HEP TEAM MEETINGS NOTES

Dear Brian:

Enclosed is a copy of the June 3, 1987 HEP team meeting notes for the Skagit Dams Original Impacts Study. The notes include the details of the decisions reached by the HEP team during the meeting. Please review the notes and acknowledge your acceptance of the decisions by signing in the designated place below and returning this letter to Envirosphere Company.

If you have any questions, please call me at (206) 625-3108, or Jay Brueggeman at (206) 451-4625.

Sincerely,

Richard Rutz

Richard Rutz, Environmental Analyst
Environmental Affairs Division

RR: gv

Enclosures

As a representative of WASH. DEPT. OF WILDLIFE, I accept the decisions documented in this letter for the Skagit Dams Original Impacts Study.

Brian D. Hauger
(Name) (Date)

Your
Seattle
City Light

Randall W. Hardy, Superintendent
Charles Royer, Mayor

RECEIVED
AUG 25 1987
ENVIROSPHERE
SEATTLE

August 13, 1987

Jon Jarvis
North Cascades National Park Complex
2105 Highway 20
Sedro Woolley, WA 98284

SUBJECT: SEATTLE CITY LIGHT/SKAGIT DAMS ORIGINAL IMPACTS STUDY
TRANSMITTAL OF 6/3/87 HEP TEAM MEETINGS NOTES

Dear Jon:

Enclosed is a copy of the June 3, 1987 HEP team meeting notes for the Skagit Dams Original Impacts Study. The notes include the details of the decisions reached by the HEP team during the meeting. Please review the notes and acknowledge your acceptance of the decisions by signing in the designated place below and returning this letter to Envirosphere Company.

If you have any questions, please call me at (206) 625-3108, or Jay Brueggeman at (206) 451-4625.

Sincerely,

Richard Rutz

Richard Rutz, Environmental Analyst
Environmental Affairs Division

RR:gv

Enclosures

As a representative of North Cascades NPSC, I accept the decisions documented in this letter for the Skagit Dams Original Impacts Study.

Jonathan B. Jarvis — 8-21-87
(Name) (Date)

Your
Seattle
City Light

Randall W. Hardy, Superintendent
Charles Royer, Mayor

August 13, 1987

Estyn R. Mead
Division of Ecological Services
U.S. Fish & Wildlife Service
2625 Parkmont Lane SW, Bldg. B-3
Olympia, WA 98502

SUBJECT: SEATTLE CITY LIGHT/SKAGIT DAMS ORIGINAL IMPACTS STUDY
TRANSMITTAL OF 6/3/87 HEP TEAM MEETINGS NOTES

Dear Estyn:

Enclosed is a copy of the June 3, 1987 HEP team meeting notes for the Skagit Dams Original Impacts Study. The notes include the details of the decisions reached by the HEP team during the meeting. Please review these notes and acknowledge your acceptance of the decisions and assignments in the designated place below and return this letter to Envirosphere Company.

If you have any questions, please call me at (206) 625-3108, or Jay Brueggeman at (206) 451-4625.

Sincerely,

Richard Rutz

Richard Rutz, Environmental Analyst
Environmental Affairs Division

RR:gv

Enclosures

As a representative of U.S Fish and Wildlife Service, I accept the decisions documented in this letter for the Skagit Dams Original Impacts Study.

Estyn R. Mead (Name)   1/29/88 (Date)

SKAGIT DAMS ORIGINAL IMPACTS STUDY
HEP TEAM MEETING
June 3, 1987

On Wednesday, June 3, 1987, a HEP Team Meeting was held for the Skagit Dams Original Impacts Study. The purpose of this meeting was to: 1) review the edit plots of the pre- and post-project cover types; 2) finalize changes in several species models; 3) determine the distribution of sites to be sampled during the field studies; 4) review the field sampling procedures; and 5) finalize the logistics of the field program.

Attendees: Rick Rutz, SCL
Art Stendall, WDG
Estyn Mead, USFWS
Jay Brueggeman, Dave Every and Colleen McShane, Envirosphere

I. Cover-Type Mapping

Progress to date on the cover-type mapping was presented. Specifically, the following topics were discussed:

- Both pre- and post-project mapping have been completed. Field verification of post-project cover types for Ross Reservoir was completed by helicopter on May 8, 1987.

- Northwest Cartography Inc. (NCI) has finished digitizing the cover-type maps. This information is now on the GIS and pre- and post-project edit plots were reviewed and approved by the HEP team.

- Information on the GIS was used to calculate the acreage of each habitat type for pre- and post-project conditions for Ross, Diablo, and Gorge reservoirs. For each habitat type and reservoir, tables were prepared that summarized information on the number of polygons, the average polygon size, the acreage lost, and the percent of the total acreage covered by a given habitat type (Tables 1, 2, 3, and 4). The acreage data were used to design the field sampling program and will be used to calculate habitat units (HUs) for the analysis. A few modifications will be required to the database to correct small discrepancies between pre- and post-project acreage totals for the Ross and Diablo areas.

II. Field Sampling Program

A. Cover Types

The cover types to be characterized at each reservoir are listed in Tables 5, 6, 7, 8, and 9. For sampling purposes, the HEP team agreed that certain cover types could be combined or eliminated from the field program. The HEP team agreed to discuss, at a later date, the quality of the habitats excluded from the field sampling program and to assign HSI values for the species that use them. These habitat include the following:

- The drawdown, gravel bar, and developed areas were eliminated from the field program because of their low value to wildlife.

- Bogs were eliminated from the field program because of their small area and low contribution to wildlife habitat in the project area.

- The HEP team agreed that although cliff/rock talus areas are used by the red-tailed hawk, it will not be possible to sample these locations safely. The HEP team will assign an HSI for the red-tailed to these areas at a later meeting.

- The Skagit River below Gorge Dam will be sampled for the dipper because the exposed rock and rock talus habitats in this area are representative of pre-project conditions for Gorge and Diablo. The measurements required for the dipper can be made from a distance and the sampling will primarily be done by scanning the river and cliff areas from promontories. Measures such as bottom substrate (rock vs. sand) are readily detectable.

- Agricultural lands were eliminated from the field program because they occurred only before the project area was flooded and covered less than nine acres. This acreage is too small to significantly contribute to wildlife habitat.

- Several cover types were combined because of similarities in structure and use by wildlife. These cover types were: closed and open canopy lodgepole pine; avalanche and riparian shrubland; regenerative conifer and lodgepole; and riparian open and closed mature conifer.

- The HEP team agreed to combine the few small patches (< 8 acres) of grasslands with open conifer since these two cover types are intermixed.

B. Sampling Distribution

The strategy for distributing the field sampling effort among habitat types and reservoirs as agreed on by the HEP team is summarized as follows:

- The objective of the field sampling program is to characterize habitat quality in the project area for each evaluation species.

- The maximum number of sites possible to sample in a two-week period is approximately 120. This is based on each of the two teams completing six sites per day for the ten-day field period.

- The sampling effort will be stratified by reservoir to reduce spatial variability at the habitat measurements. Representative polygons of all pre- and post-project habitats for each reservoir will be sampled.

- A number of pre-project cover types were completely eliminated by the reservoirs or remain in patches too small or too inaccessible to sample. Representatives of these cover types will be located and sampled off-project in areas that are in as close proximity to the project as possible. Off-project sampling locations for Ross will include Big Beaver Valley, Ruby Arm, and the lower end of the Canadian Skagit. Off-project sampling for Diablo will concentrate in Thunder Arm. Off-project sampling for Gorge will occur downstream of Gorge Dam.

- A minimum of three sites will be sampled in the habitat types present at Gorge and Diablo. These three sites will be distributed among three polygons, where possible. For small habitats or for habitats not available in the project area, all three sites may have to be located in one polygon.

- A minimum of five sites will be sampled in the habitat types at Ross. Three sites will be sampled in one polygon to estimate the variability of parameter values within a polygon. Two additional sites will be sampled in different polygons to estimate the spatial variability of the parameter values in the Ross reservoir area. It may not be possible to sample five sites in some habitat types because of their small size or small number of polygons.

- All polygons to be sampled will be chosen randomly. If a polygon is inaccessible or too small to permit sampling, it will be rejected and another will be randomly chosen. Field sampling on Ross reservoir will be stratified by side (east, west) because of its large size and varied physiography.

- The sampling plan at each reservoir is presented in Tables 5, 6, 7, 8, and 9. If time is available, an additional polygon with three sites will be sampled for each habitat type on Ross.

- Osprey parameters will be measured only in old growth, closed and open canopy conifer, and mixed conifer/broadleaf habitats along the reservoirs. Measurement will be in randomly selected polygons.

III. Field Sampling Procedures

- The objectives of the field sampling procedures are to eliminate bias in choosing sampling locations and to ensure that the sites sampled are representative of a given habitat type. The procedures to be followed in locating sampling sites in the field are described in Attachment A and were reviewed and approved by the HEP team.

- The beaver model requires that sampling be done in two "bands" (0 to 100 m and 100 m to 200 m) surrounding each wetland as well as in the wetland itself. Sampling is also required within 100 m and between 100 to 200 m of a river (riverine) or lake (lacustrine). The procedure presented in the model for sampling beaver habitat parameters in the bands surrounding wetlands and adjacent to riverine areas is described in Attachment A and was reviewed and approved by the HEP team.

- The HEP team agreed that using a boat is the most efficient way to make the osprey measurements.

IV. Data Sheets

The purpose of the data sheets is to ensure that data on the appropriate parameters are collected in each habitat type and to allow efficient data entry. The parameters to be sampled in each habitat type have been incorporated into data sheets (Attachment B). The data sheets were reviewed at the meeting and their format approved by the HEP team.

V. Sampling Methods

The methods approved by the HEP team for sampling each parameter are listed in Attachment C. These lists will be printed on the reverse side of the appropriate data sheet for easy reference in the field.

VI. Species Models

HEP team agreed to the following modifications and clarifications of the species models.

A. Red-tailed Hawk

- One of the parameters for the red-tailed hawk is the number of trees greater than 50 cm dbh. To reduce field effort, the HEP team agreed to change this parameter to 51 cm dbh to be consistent with a measurement required for the pileated woodpecker model.

- Red-tailed hawk parameters will be measured in open canopy conifer habitats as well as in shrub and marsh areas.

- One of the red-tailed hawk parameters is the number of trees greater than 25 cm dbh. The SI value for this parameter is 1.0 when there are more than three trees greater than 25 cm dbh per acre. The HEP team agreed that the value of this parameter would always be optimal in the open canopy conifer habitat on the project area and that it would not be necessary to measure in the field.

- Dense shrub cover reduces the ability of the red-tailed hawk to locate prey. The HEP team agreed to use a measure of shrub canopy cover to weight habitat quality for the food life requisite.

B. Osprey

- The HEP team agreed that osprey measurements should focus on the number of snags and broken trees. Secchi disc readings will be taken only in Diablo or in other areas where it is apparent that water clarity is less than one meter.

C. Ruffed Grouse

- According to the model, the availability of aspen as a food source for ruffed grouse decreases in importance in areas where winter snow cover is of short duration. Aspen are not present in the project area and winter snow cover in this region is generally of short duration. The HEP team agreed that the winter food parameter for the ruffed grouse does not need to be measured.

D. Marten

- o Based on data presented in several research papers, lodgepole pine and riparian conifer areas apparently provide habitat for the marten. Lodgepole and riparian conifer habitats as well as upland conifer areas will, therefore, be evaluated for martin.

E. Deer

- o The HEP team agreed to the following group of palatable and less palatable shrubs, and unpalatable forbs species for deer.

  - Less palatable shrubs: salal, salmonberry, hazelnut, devil's club, snowberry, alder, Oregon grape, hemlock, Douglas fir, lodgepole pine, ninebark, thimbleberry, hawthorn, ribes, oceanspray, buffalo berry, kinnikinnick.

  - Palatable shrubs: serviceberry, elderberry, blackcap, trailing blackberry, mountain box, cherry, willow, red cedar, dogwood, twinberry, hardhack, huckleberry, goatsbeard, rose, Indian plum).

  - Unpalatable forbs: foxglove, thistle, tansy ragwort, poison hemlock, equisetum, fern, skunk cabbage, ginger, twisted stalk, bedstraw, twinflower.

F. Common Merganser

- o Envirosphere reviewed the material available on the habitat requirements of the common merganser and concluded that there was not enough information readily available to write a model for this species before the start of the field program.

- o The HEP team agreed to drop the common merganser as an evaluation species.

H. Black-capped Chickadee

- Some discrepancies in the definition of black-capped chickadee habitat were noted between the HEP model and that provided by Brown (1985) in Fish and Wildlife Habitats in Forest of Western Oregon and Washington. Brown (1985) does not include old growth, second growth, riparian conifer, and conifer swamp as primary or secondary habitat for the black-capped chickadee. The HEP model, however, includes all conifer areas as black-capped chickadee habitat. The HEP team agreed that the black-capped chickadee probably occurs in most forested areas in the Skagit region and that the parameters for this species should be measured in all forested habitats.

VII. Schedule and Next HEP Team Meeting

- The field program was scheduled for June 15 to 19 and June 22 to 26.

- The next HEP team meeting will be scheduled at a later date.

TABLE 1 - Net Change in Area by Community Type for Project Area

ACREAGES--SKAGIT DAMS ORIGINAL IMPACTS

SUMMARY--SKAGIT DAMS PROJECT AREA

Community Type	Pre-project # Polygons	Pre-project Acreage	Pre-project Percent of Total	Pre-project Average Polygon Size	With-project # Polygons	With-project Acreage	With-project Percent of Total	With-project Average Polygon Size	Lost Acreage	Gained Acreage	Percent Loss	Relative Percent Loss
old growth conifer	42	1501.60	9.55%	35.75	9	309.00	1.97%	34.33	1192.60	0.00	-79.42%	9.14%
closed mature conifer	75	4139.02	26.33%	55.19	95	1609.04	10.24%	16.94	2529.98	0.00	-61.13%	19.39%
open mature conifer	59	721.12	4.59%	12.22	36	181.36	1.15%	5.04	539.75	0.00	-74.85%	4.14%
closed canopy lodgepole pine	19	518.81	3.30%	27.31	26	174.61	1.11%	6.72	344.20	0.00	-66.34%	2.64%
open canopy lodgepole pine	7	114.60	0.73%	16.37	4	11.60	0.07%	2.90	103.00	0.00	-89.88%	0.79%
regenerative conifer	41	1497.25	9.52%	36.52	17	195.52	1.24%	11.50	1301.73	0.00	-86.94%	9.98%
regenerative lodgepole	10	161.07	1.02%	16.11	0	0.00	0.00%	0.00	161.07	0.00	-100.00%	1.23%
regenerative broadleaf/mixed	1	3.55	0.02%	3.55	5	82.96	0.53%	16.59	0.00	79.41	0.00%	0.00%
broadleaf	7	40.25	0.25%	5.75	12	88.73	0.56%	7.39	0.00	48.48	0.00%	0.00%
mixed conifer/broadleaf	0	0.00	0.00%	0.00	18	95.18	0.61%	5.29	0.00	95.18	0.00%	0.00%
grassland/meadow	2	8.81	0.06%	4.41	3	8.51	0.05%	2.84	0.30	0.00	-3.41%	0.00%
agriculture	1	9.44	0.06%	9.44	0	0.00	0.00%	0.00	9.44	0.00	-100.00%	0.07%
avalanche shrub	4	25.40	0.16%	6.35	1	2.10	0.01%	2.10	23.30	0.00	-91.73%	0.18%
shrubland	19	364.76	2.32%	19.20	1	5.09	0.03%	5.09	359.67	0.00	-98.60%	2.76%
rock talus	12	40.81	0.26%	3.40	17	32.20	0.20%	1.89	8.61	0.00	-21.10%	0.07%
exposed rock	10	33.00	0.21%	3.30	12	32.99	0.21%	2.75	0.01	0.00	-0.03%	0.00%
wet meadow/marsh	2	7.05	0.04%	3.53	0	0.00	0.00%	0.00	7.05	0.00	-100.00%	0.05%
bog	2	8.30	0.05%	4.15	0	0.00	0.00%	0.00	8.30	0.00	-100.00%	0.06%
shrub swamp	30	384.75	2.45%	12.83	1	2.10	0.01%	2.10	382.65	0.00	-99.45%	2.93%
conifer swamp	7	38.25	0.24%	5.46	0	0.00	0.00%	0.00	38.25	0.00	-100.00%	0.29%
broadleaf swamp	3	32.41	0.21%	10.80	9	9.31	0.06%	0.00	23.10	0.00	-71.27%	0.18%
mixed swamp	4	44.84	0.29%	11.21	0	0.00	0.00%	0.00	44.84	0.00	-100.00%	0.34%
pond	4	55.38	0.35%	13.85	0	0.00	0.00%	0.00	55.38	0.00	-100.00%	0.42%
reservoir	0	0.00	0.00%	0.00	8	5424.00	34.51%	678.00	0.00	5424.00	0.00%	0.00%
tributary	5	64.08	0.41%	12.82	2	30.57	0.19%	15.29	33.51	0.00	-52.29%	0.26%
riverine	15	721.36	4.59%	48.09	0	0.00	0.00%	0.00	721.36	0.00	-100.00%	5.53%
gravelbar	10	35.24	0.22%	3.52	3	5.26	0.03%	1.75	29.98	0.00	-85.07%	0.23%
drawdown area	0	0.00	0.00%	0.00	8	6965.58	44.31%	870.70	0.00	6965.58	0.00%	0.00%
riparian old growth conifer	62	3105.73	19.76%	50.09	0	0.00	0.00%	0.00	3105.73	0.00	-100.00%	23.81%
riparian closed mature conifer	38	794.48	5.05%	20.91	3	78.29	0.50%	26.10	716.19	0.00	-90.15%	5.49%
riparian open conifer	2	16.02	0.10%	8.01	0	0.00	0.00%	0.00	16.02	0.00	-100.00%	0.12%
riparian regenerative conifer	1	25.29	0.16%	25.29	0	0.00	0.00%	0.00	25.29	0.00	-100.00%	0.19%
riparian regenerative broadleaf/conifer	0	0.00	0.00%	0.00	1	8.96	0.06%	8.96	0.00	8.96	0.00%	0.00%
riparian broadleaf	47	542.41	3.45%	11.54	2	27.17	0.17%	13.59	515.24	0.00	-94.99%	3.95%
riparian mixed conifer/broadleaf	29	445.53	2.83%	15.36	0	0.00	0.00%	0.00	445.53	0.00	-100.00%	3.42%
riparian shrubland	38	198.59	1.26%	5.23	1	3.29	0.02%	3.29	195.30	0.00	-98.34%	1.50%
developed--campground	0	0.00	0.00%	0.00	16	187.68	1.19%	11.73	0.00	187.68	0.00%	0.00%
developed--industrial	0	0.00	0.00%	0.00	5	44.73	0.28%	8.95	0.00	44.73	0.00%	0.00%
developed--intensive recreational	0	0.00	0.00%	0.00	1	1.34	0.01%	1.34	0.00	1.34	0.00%	0.00%
developed--low density residential	3	21.94	0.14%	7.31	1	6.85	0.04%	6.35	15.09	0.00	-68.78%	0.12%
developed--high density residential	0	0.00	0.00%	0.00	2	10.74	0.07%	5.37	0.00	10.74	0.00%	0.00%
developed--roads, parking	0	0.00	0.00%	0.00	4	48.01	0.31%	12.00	0.00	48.01	0.00%	0.00%
transmission right-away	0	0.00	0.00%	0.00	6	36.52	0.23%	6.09	0.00	36.52	0.00%	0.00%
TOTALS	511	15721.22	100.00%	25.73	320	15719.29	100.00%	49.12	13045.25	12950.62	-2533.79%	99.25%

TABLE 2 - Net Change in Area by Community Type for Ross

ACREAGES--SKAGIT DAMS ORIGINAL IMPACTS

	ROSS AREA											
	Pre-project				With-project							Relative
Community Type	# Polygons	Acreage	Percent of Total	Average Polygon Size	# Polygons	Acreage	Percent of Total	Average Polygon Size	Lost Acreage	Gained Acreage	Percent Loss	Percent Loss
old growth conifer	40	1300.64	10.05	34.52	7	192.30	1.40	27.47	1108.34	0.00	-86.07	10.11%
closed mature conifer	58	3105.82	22.62	53.55	57	1214.08	8.35	21.30	1891.74	0.00	-60.91	16.09%
open mature conifer	47	616.02	4.49	13.11	21	114.62	0.84	5.46	501.40	0.00	-81.39	4.26%
closed canopy lodgepole pine	13	284.32	2.07	21.87	16	106.72	0.78	6.67	177.60	0.00	-62.46	1.51%
open canopy lodgepole pine	5	85.40	0.62	17.08	4	11.60	0.08	2.90	73.80	0.00	-86.42	0.63%
regenerative conifer	36	1313.62	9.57	36.49	15	192.21	1.40	12.81	1121.41	0.00	-85.37	9.54%
regenerative lodgepole	10	161.07	1.17	16.11			0.00	0.00	161.07	0.00	-100.00	1.37%
regenerative broadleaf/mixed	1	3.55	0.03	3.55	5	82.96	0.60	16.59	0.00	79.41	0.00	0.00%
broadleaf	2	3.32	0.02	1.66	9	71.19	0.52	7.91	0.00	67.87	0.00	0.00%
mixed conifer/broadleaf			0.00	0.00	13	65.63	0.48	5.05	0.00	65.63	0.00	0.00%
grassland/meadow	2	8.81	0.06	4.41	3	8.51	0.06	2.84	0.30	0.00	-3.41	0.00%
agriculture	1	9.44	0.07	9.44			0.00	0.00	9.44	0.00	-100.00	0.08%
avalanche shrub	3	22.14	0.16	7.38	1	2.10	0.02	2.10	20.04	0.00	-90.51	0.17%
shrubland	19	364.76	2.66	19.20	1	5.09	0.04	5.09	359.67	0.00	-98.60	3.06%
rock talus	10	28.81	0.21	2.88	6	14.45	0.11	2.41	14.36	0.00	-49.84	0.12%
exposed rock	7	20.08	0.15	2.87	7	21.27	0.15	3.04	0.00	1.19	0.00	0.00%
wet meadow/marsh	2	7.05	0.05	3.53			0.00	0.00	7.05	0.00	-100.00	0.06%
bog	2	8.30	0.06	4.15			0.00	0.00	8.30	0.00	-100.00	0.07%
shrub swamp	30	384.75	2.80	12.83	1	2.10	0.02	2.10	382.65	0.00	-99.45	3.25%
conifer swamp	7	38.25	0.28	5.46			0.00	0.00	38.25	0.00	-100.00	0.33%
broadleaf swamp	3	32.41	0.24	10.80		9.31	0.07	0.00	23.10	0.00	-71.27	0.20%
mixed swamp	4	44.84	0.33	11.21			0.00	0.00	44.84	0.00	-100.00	0.38%
pond	4	55.38	0.40	13.85			0.00	0.00	55.38	0.00	-100.00	0.47%
reservoir			0.00	0.00	3	4450.26	32.42	1483.42	0.00	4450.26	0.00	0.00%
tributary	5	64.00	0.47	12.82	1	7.44	0.05	7.44	56.64	0.00	-88.39	0.48%
riverine	9	557.26	4.06	61.92			0.00	0.00	557.26	0.00	-100.00	4.74%
gravelbar	9	29.36	0.21	3.26	2	4.30	0.03	2.15	25.06	0.00	-85.35	0.21%
drawdown area			0.00	0.00	8	6965.58	50.75	870.70	0.00	6965.58	0.00	0.00%
riparian old growth conifer	61	3094.40	22.53	50.73			0.00	0.00	3094.40	0.00	-100.00	26.31%
riparian closed mature conifer	37	777.89	5.66	21.02	2	60.77	0.44	30.39	717.12	0.00	-92.19	6.10%
riparian open conifer	2	16.02	0.12	8.01			0.00	0.00	16.02	0.00	-100.00	0.14%
riparian regenerative conifer	1	25.29	0.18	25.29			0.00	0.00	25.29	0.00	-100.00	0.22%
riparian regenerative broadleaf/conifer			0.00	0.00	1	8.96	0.07	8.96	0.00	8.96	0.00	0.00%
riparian broadleaf	47	542.41	3.95	11.54			0.00	0.00	542.41	0.00	-100.00	4.61%
riparian mixed conifer/broadleaf	29	445.53	3.24	15.36			0.00	0.00	445.53	0.00	-100.00	3.79%
riparian shrubland	38	198.59	1.45	5.23			0.00	0.00	198.59	0.00	-100.00	1.69%
developed--campground			0.00	0.00	14	113.13	0.82	8.08	0.00	113.13	0.00	0.00%
developed--industrial			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
developed--intensive recreational			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
developed--low density residental	1	2.59	0.02	2.59			0.00	0.00	2.59	0.00	-100.00	0.02%
developed--high density residental			0.00	0.00	1	1.20	0.01	1.20	0.00	1.20	0.00	0.00%
developed--roads, parking			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
transmission right-away			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
TOTALS	545	13732.20	100.00	25.20	198	13725.78	100.00	69.32	11759.65	11753.23	-2641.65	100.00%

TABLE 3 - Net Change in Area by Community Ty[illegible] r Diablo

SKAGIT DAMS ORIGINAL IMPACTS
PROJECT

DIABLO AREA

Community Type	Pre-project # Polygons	Pre-project Acreage	Pre-project Percent of Total	Pre-project Average Polygon Size	With-project # Polygons	With-project Acreage	With-project Percent of Total	With-project Average Polygon Size	Lost Acreage	Gained Acreage	Percent Loss	Relative Percent Lost
old growth conifer	2	121.04	8.34	60.52	2	116.70	8.02	58.35	4.34	0.00	-3.59	0.46%
closed mature conifer	11	679.31	46.83	61.76	26	243.91	16.76	9.38	435.40	0.00	-64.09	46.11%
open mature conifer	8	69.60	4.80	8.70	12	49.33	3.39	4.11	20.27	0.00	-29.12	2.15%
closed canopy lodgepole pine	6	234.49	16.16	39.08	10	67.89	4.66	6.79	166.60	0.00	-71.05	17.65%
open canopy lodgepole pine	2	29.20	2.01	14.60			0.00	0.00	29.20	0.00	-100.00	3.09%
regenerative conifer	3	166.60	11.48	55.53	2	3.31	0.23	1.66	163.29	0.00	-98.01	17.29%
regenerative lodgepole			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
regenerative broadleaf/mixed			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
broadleaf	5	36.93	2.55	7.39	3	17.54	1.21	5.85	19.39	0.00	-52.50	2.05%
mixed conifer/broadleaf			0.00	0.00	3	11.28	0.78	3.76	0.00	11.28	0.00	0.00%
grassland/meadow			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
agriculture			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
avalanche shrub			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
shrubland			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
rock talus			0.00	0.00	9	9.25	0.64	1.03	0.00	9.25	0.00	0.00%
exposed rock	2	10.49	0.72	5.25	4	7.82	0.54	1.96	2.67	0.00	-25.45	0.28%
wet meadow/marsh			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
bog			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
shrub swamp			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
conifer swamp			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
broadleaf swamp			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
mixed swamp			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
pond			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
reservoir			0.00	0.00	3	760.63	52.27	253.54	0.00	760.63	0.00	0.00%
tributary			0.00	0.00	1	23.13	1.59	23.13	0.00	23.13	0.00	0.00%
riverine	4	103.01	7.10	25.75			0.00	0.00	103.01	0.00	-100.00	10.91%
gravelbar			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
drawdown area			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
riparian old growth conifer			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
riparian closed mature conifer			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
riparian open conifer			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
riparian regenerative conifer			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
riparian regenerative broadleaf/conifer			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
riparian broadleaf			0.00	0.00	2	27.17	1.87	13.59	0.00	27.17	0.00	0.00%
riparian mixed conifer/broadleaf			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
riparian shrubland			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
developed--campground			0.00	0.00	2	74.55	5.12	37.28	0.00	74.55	0.00	0.00%
developed--industrial			0.00	0.00	3	11.67	0.80	3.89	0.00	11.67	0.00	0.00%
developed--intensive recreational			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
developed--low density residental			0.00	0.00	1	6.85	0.47	6.85	0.00	6.85	0.00	0.00%
developed--high density residental			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
developed--roads, parking			0.00	0.00	3	20.30	1.39	6.77	0.00	20.30	0.00	0.00%
transmission right-away			0.00	0.00	3	3.98	0.27	1.33	0.00	3.98	0.00	0.00%
TOTALS	43	1450.67	100.00	33.74	89	1455.31	100.00	16.35	944.17	948.81	-543.82	100.00%

TABLE 4 - Net Change in Area by Community Type Gorge

SKAGIT DAMS ORIGINAL IMPACTS
PROJECT

GORGE AREA

Community Type	Pre-project				With-project				Lost Acreage	Gained Acreage	Percent Loss	Relative Percent Loss
	# Polygons	Acreage	Percent of Total	Average Polygon Size	# Polygons	Acreage	Percent of Total	Average Polygon Size				
old growth conifer			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
closed mature conifer	6	353.89	65.74	58.98	12	151.05	28.07	12.59	202.84	0.00	-57.32	59.41%
open mature conifer	4	35.50	6.59	8.88	3	17.41	3.23	5.80	18.09	0.00	-50.96	5.30%
closed canopy lodgepole pine			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
open canopy lodgepole pine			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
regenerative conifer	2	17.03	3.16	8.52			0.00	0.00	17.03	0.00	-100.00	4.99%
regenerative lodgepole			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
regenerative broadleaf/mixed			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
broadleaf			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
mixed conifer/broadleaf			0.00	0.00	2	18.27	3.39	9.14	0.00	18.27	0.00	0.00%
grassland/meadow			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
agriculture			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
avalanche shrub	1	3.26	0.61	3.26			0.00	0.00	3.26	0.00	-100.00	0.95%
shrubland			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
rock talus	2	12.00	2.23	6.00	2	8.50	1.58	4.25	3.50	0.00	-29.17	1.03%
exposed rock	1	2.43	0.45	2.43	1	3.90	0.72	3.90	0.00	1.47	0.00	0.00%
wet meadow/marsh			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
bog			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
shrub swamp			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
conifer swamp			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
broadleaf swamp			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
mixed swamp			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
pond			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
reservoir			0.00	0.00	2	213.11	39.60	106.56	0.00	213.11	0.00	0.00%
tributary			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
riverine	2	61.09	11.35	30.55			0.00	0.00	61.09	0.00	-100.00	17.89%
gravelbar	1	5.88	1.09	5.88	1	0.96	0.18	0.96	4.92	0.00	-83.67	1.44%
drawdown area			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
riparian old growth conifer	1	11.33	2.10	11.33			0.00	0.00	11.33	0.00	-100.00	3.32%
riparian closed mature conifer	1	16.59	3.08	16.59	1	17.52	3.26	17.52	0.00	0.93	0.00	0.00%
riparian open conifer			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
riparian regenerative conifer			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
riparian regenerative broadleaf/conifer			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
riparian broadleaf			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
riparian mixed conifer/broadleaf			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
riparian shrubland			0.00	0.00	1	3.29	0.61	3.29	0.00	3.29	0.00	0.00%
developed—campground			0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00%
developed—industrial			0.00	0.00	2	33.06	6.14	16.53	0.00	33.06	0.00	0.00%
developed--intensive recreational			0.00	0.00	1	1.34	0.25	1.34	0.00	1.34	0.00	0.00%
developed—low density residental	2	19.35	3.59	9.68			0.00	0.00	19.35	0.00	-100.00	5.67%
developed—high density residental			0.00	0.00	1	9.54	1.77	9.54	0.00	9.54	0.00	0.00%
developed—roads, parking			0.00	0.00	1	27.71	5.15	27.71	0.00	27.71	0.00	0.00%
transmission right-away			0.00	0.00	3	32.54	6.05	10.85	0.00	32.54	0.00	0.00%
TOTALS	23	538.35	100.00	23.41	33	538.20	100.00	16.31	341.41	341.26	-721.12	100.00%

TABLE 5 - Sampling Distribution by Community Type for Ross

SAMPLING PLAN--HABITATS, ACREAGES, AND POLYGONS TO BE SAMPLED
SKAGIT DAMS ORIGINAL IMPACTS

ROSS AREA SUMMARY

Community Type	Pre-project			With-project						Sampling Distribution					
	# Polygons	Acreage	Average Polygon Size	# Polygons	Acreage	Average Polygon Size	Lost Acreage	Gained Acreage	Percent Loss	On-project Polygons	Sites/ Polygon	Alternatives	Off-project Areas	Sites/ Polygon	Total Sites
old growth conifer	40	1380.64	34.52	7	192.3	27.47	1188.34	0.00	-86.07	P-5^,P-52,P-31	3/1/1	P-59			5
closed mature conifer	58	3105.82	53.55	57	1214.08	21.30	1891.74	0.00	-60.91	H-74,P-65^,H-21	1/3/1	P-85			5
open mature conifer	49	624.83	12.75	24	123.13	5.13	501.70	0.00	-80.29	P-9,H-25^,P-68	1/3/1	H-29,H-70			5
lodgepole pine	18	369.36	20.52	20	118.32	5.92	251.04	0.00	-67.97	P-84,R-98^,P-27	1/3/1	P-15			5
regenerative conifer	47	1499.98	31.91	15	192.21	12.81	1307.77	0.00	-87.19	H-53^,H-20,H-39	3/1/1	H-55			5
regenerative broadleaf/mixed	1	3.55	3.55	5	82.96	16.59	0.00	79.41	0.00	H-64^,H-61,H-15	3/1/1	P-80			5
broadleaf	2	3.32	1.66	9	71.19	7.91	0.30	67.87	0.00	H-54^,H-67,H-44	3/1/1	P-55			5
mixed conifer/broadleaf			0.00	13	65.63	5.05	0.00	65.63	0.00	R-83^,P-70,H-24	3/1/1	P-88,P-42			5
shrubland	19	364.76	19.20	1	5.09	5.09	359.67	0.00	-98.60	H-66	1		LC-1,LC-2^	1/3	5
wet meadow/marsh	2	7.05	3.53			0.00	7.05	0.00	-100.00				BBV-3^,BBV-8,CS-5	3/1/1	5
shrub swamp	30	384.75	12.83	1	2.10	2.10	302.65	0.00	-99.45	P-34	1		BBV-2^,BBV-11	3/1	5
conifer swamp	7	38.25	5.46			0.00	38.25	0.00	-100.00				BBV-6^	3	3
broadleaf swamp	3	32.41	10.80		9.31	0.00	23.10	0.00	-71.27	P-8^	3				3
mixed swamp	4	44.84	11.21			0.00	44.84	0.00	-100.00				CS-4^	3	3
riparian old growth conifer	61	3094.40	50.73			0.00	3094.40	0.00	-100.00	P-5a	1	BBV-10	R-10a^,R-11a	3/1	5
riparian mature conifer	39	793.91	20.36	2	60.77	30.39	733.14	0.00	-92.35				BBV-4^,CS-3	3/1	4
riparian regenerative broadleaf/conifer			0.00	1	8.96	8.96	0.00	8.96	0.00	H-59^	3				3
riparian broadleaf	47	542.41	11.54			0.00	542.41	0.00	-100.00			CS-2	R-13^,R-14,CS-1	3/1/1	5
riparian mixed conifer/broadleaf	29	445.53	15.36			0.00	445.53	0.00	-100.00				BBV-7^	3	3
riparian/avalanche shrubland	41	220.73	5.38	1	2.10	2.10	218.63	0.00	-99.05	P-74	1		BBV-9^	3	4
TOTALS	497	12956.54	26.07	156	2148.15	13.77	11030.26	221.87							88

LE 6 - Sampling Distribution by Community Type the Eastern Side of Ross

ROSS AREA---EAST

Community Type	Pre-project # Polygons	Pre-project Acreage	Pre-project Average Polygon Size	With-project # Polygons	With-project Acreage	With-project Average Polygon Size	Lost Acreage	Gained Acreage	Sampling Distribution: On-project Polygons	Sites/ Polygon	Alternatives	Off-project Areas	Sites/ Polygon	Total Sites
old growth conifer	20	461.33	23.07	3	21.28	7.09	440.05	0.00	P-52,P-31	1/1	P-59			2
closed mature conifer	35	2655.29	75.87	35	863.86	24.68	1791.43	0.00	P-65^,H-21	3/1				4
open mature conifer	33	497.86	15.09	20	95.27	4.76	402.59	0.00	H-25^,F-68	3/1	H-29			4
lodgepole pine	10	220.11	22.01	14	88.80	6.34	131.31	0.00	R-98^	3				4
regenerative conifer	28	539.30	19.26	3	38.78	12.93	500.52	0.00	H-20,H-39	1/1				2
regenerative broadleaf/mixed	1	3.55	3.55	1	4.28	4.28	0.00	0.73	H-15	1				1
broadleaf	2	3.32	1.66	2	8.26	4.13	0.00	4.94	H-44	1	P-55			1
mixed conifer/broadleaf			0.00	8	38.21	4.78	0.00	38.21	P-70,H-24	1/1				2
shrubland	14	345.11	24.65			0.00	345.11	0.00				LC-1^,LC-2	1/3	4
wet meadow/marsh	1	4.15	4.15			0.00	4.15	0.00				CS-5	1	1
shrub swamp	18	296.37	16.47	1	2.10	2.10	294.27	0.00	P-34	1				1
conifer swamp	6	35.91	5.98			0.00	35.91	0.00						
broadleaf swamp	2	20.93	10.47			0.00	20.93	0.00						
mixed swamp	4	44.84	11.21			0.00	44.84	0.00				CS-4^	3	3
riparian old growth conifer	32	1961.77	61.31			0.00	1961.77	0.00				R-10a^,P-11a	3/1	4
riparian mature conifer	16	374.96	23.44			0.00	374.96	0.00				CS-3	1	1
riparian regenerative broadleaf/conifer			0.00			0.00	0.00	0.00						
riparian broadleaf	26	349.64	13.45			0.00	349.64	0.00				R-13^,R-14,CS-1	3/1/1	5
riparian mixed conifer/broadleaf	18	294.09	16.34			0.00	294.09	0.00						
riparian/avalanche shrubland	13	67.07	5.16			0.00	67.07	0.00						
TOTALS	279	8175.60	29.30	87	1160.84	13.34	7058.64	43.88						39

.BLE 7 - Sampling Distribution by Community Typ[illegible] the Western Side of Ross

ROSS AREA---WEST

Community Type	Pre-project # Polygons	Pre-project Acreage	Pre-project Average Polygon Size	With-project # Polygons	With-project Acreage	With-project Average Polygon Size	Lost Acreage	Gained Acreage	Percent Loss	Sampling Distribution: On-project Polygons	Sites/ Polygon	Alternatives	Off-project Areas	Sites/ Polygon	Total Sites
old growth conifer	20	919.31	45.97	4	171.01	42.75	748.30	0.00	-81.40	P-5	3				3
closed mature conifer	20	450.53	22.53	17	350.22	20.60	100.31	0.00	-22.26	W-74	1	P-35			1
open mature conifer	14	126.97	9.07	4	27.86	6.97	99.11	0.00	-78.06	P-9	1				1
lodgepole pine	7	149.25	21.32	6	29.52	4.92	119.73	0.00	-80.22	P-84	1	P-15			1
regenerative conifer	19	960.68	50.56	12	153.43	12.79	807.25	0.00	-84.03	W-53^	3	W-58,W-55			3
regenerative broadleaf/mixed			0.00	4	78.68	19.67	0.00	78.68	0.00	W-60^,W-61	3/1	P-30			4
broadleaf			0.00	7	62.93	8.99	0.00	62.93	0.00	W-54^,W-67	3/1				4
mixed conifer/broadleaf			0.00	5	27.42	5.48	0.00	27.42	0.00	R-83^	3	P-88			3
shrubland	3	19.65	6.55	1	5.09	5.09	14.56	0.00	-74.10	W-66	1				1
wet meadow/marsh	1	2.90	2.90			0.00	2.90	0.00	-100.00				BBV-3^,B3V-8	3/1	4
shrub swamp	12	88.38	7.36			0.00	88.38	0.00	-100.00				BBV-2^,BBV-11	3/1	4
conifer swamp	1	2.34	2.34			0.00	2.34	0.00	-100.00				BBV-6^	3	3
broadleaf swamp	1	11.48	11.48	1	9.31	9.31	2.17	0.00	-18.90	P-8^	3				3
mixed swamp			0.00			0.00	0.00	0.00	0.00						
riparian old growth conifer	28	1132.63	40.45			0.00	1132.63	0.00	-100.00	P-5a	1	FBV			1
riparian mature conifer	23	418.95	18.22	2	60.77	30.39	358.18	0.00	-85.49				BBV-4^	3	3
riparian regenerative broadleaf/conifer			0.00	1	8.96	8.96	0.00	8.96	0.00	W-59^	3				3
riparian broadleaf	21	192.77	9.18			0.00	192.77	0.00	-100.00						
riparian mixed conifer/broadleaf	11	151.44	13.77			0.00	151.44	0.00	-100.00				BBV-7^	3	3
riparian/avalanche shrubland	27	153.66	5.69	1	2.10	2.10	151.56	0.00	-98.63	P-74	1		BBV-9^	3	4
TOTALS	208	4780.94	22.99	65	987.30	15.19	3971.63	177.99							49

TABLE 8 - Sampling Distribution by Community Type for Diablo

SAMPLING PLAN--HABITATS, ACREAGES, AND Polygons to be Sampled
SKAGIT DAMS ORIGINAL IMPACTS

DIABLO AREA SUMMARY

Community Type	Pre-project # Polygons	Pre-project Acreage	Pre-project Average Polygon Size	With-project # Polygons	With-project Acreage	With-project Average Polygon Size	Lost Acreage	Gained Acreage	Percent Loss	Sampling Distribution: On-project Polygons	Sites/Polygon	Alternatives	Off-project Areas	Sites/Polygon	Total Sites
old growth conifer	2	121.04	60.52	2	116.70	58.35	4.34	0.00	-3.59	R-10,R-11	1/2				3
closed mature conifer	11	679.31	61.76	26	243.91	9.39	435.40	0.00	-64.09	P-50,R-23,P-16	1/1/1	R-15			3
open mature conifer	8	69.60	8.70	12	49.33	4.11	20.27	0.00	-29.12	B-41,R-56,R-71	1/1/1				3
lodgepole pine	8	259.69	32.46	10	67.89	6.79	191.80	0.00	-73.86	R-57, R-32	1/2				3
regenerative conifer	3	166.60	55.53	2	3.31	1.66	163.29	0.00	-98.01				(H-53',H-20,H-39)*	(3/1/1)*	*
regenerative broadleaf/mixed			0.00			0.00	0.00	0.00	0.00						
broadleaf	5	36.93	7.39	3	17.54	5.85	19.39	0.00	-52.50	R-51,R-60	1/2				3
mixed conifer/broadleaf			0.00	3	11.20	3.76	0.00	11.20	0.00	R-67	3				3
shrubland			0.00			0.00	0.00	0.00	0.00						
wet meadow/marsh			0.00			0.00	0.00	0.00	0.00						
shrub swamp			0.00			0.00	0.00	0.00	0.00						
conifer swamp			0.00			0.00	0.00	0.00	0.00						
broadleaf swamp			0.00			0.00	0.00	0.00	0.00						
mixed swamp			0.00			0.00	0.00	0.00	0.00						
riparian old growth conifer			0.00			0.00	0.00	0.00	0.00						
riparian mature conifer			0.00			0.00	0.00	0.00	0.00						
riparian regenerative broadleaf/conifer			0.00			0.00	0.00	0.00	0.00						
riparian broadleaf			0.00	2	27.17	13.59	0.00	27.17	0.00	(R-13,R-14)*	(1/2)*				
riparian mixed conifer/broadleaf			0.00			0.00	0.00	0.00	0.00						
riparian/avalanche shrubland			0.00			0.00	0.00	0.00	0.00						
TOTALS	37	1333.17	36.03	60	537.13	8.95	834.49	38.45							18

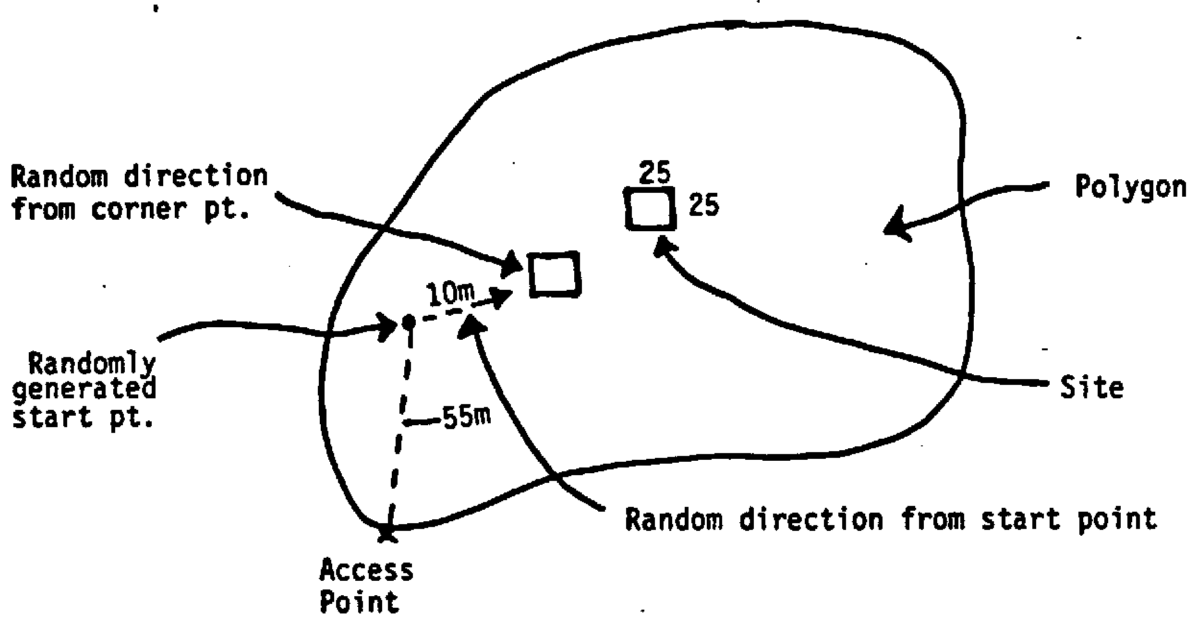
TABLE 9 - Sampling Distribution by Community Type for Gorge

SAMPLING PLAN--HABITATS, ACREAGES, AND Polygons to be Sampled
SKAGIT DAMS ORIGINAL IMPACTS

GORGE SUMMARY

Community Type	Pre-project # Polygons	Pre-project Acreage	Pre-project Average Polygon Size	With-project # Polygons	With-project Acreage	With-project Average Polygon Size	Lost Acreage	Gained Acreage	Percent Loss	Sampling Distribution: On-project Polygons	Sites/ Polygon	Alternatives	Off-project Areas	Sites/ Polygon	Total Sites
old growth conifer			0.00			0.00	0.00	0.00	0.00						
closed mature conifer	6	353.89	58.98	12	151.05	12.59	202.84	0.00	-57.32	D-27,D-9,D-34	1	D-21			3
open mature conifer	4	35.50	8.88	3	17.41	5.80	18.09	0.00	-50.96	D-29	3				2
lodgepole pine			0.00			0.00	0.00	0.00	0.00						
regenerative conifer	2	17.03	8.52			0.00	17.03	0.00	-100.00				(H-53*,H-20,H-39)*	(3/1/1)*	*
regenerative broadleaf/mixed			0.00			0.00	0.00	0.00	0.00						
broadleaf			0.00			0.00	0.00	0.00	0.00						
mixed conifer/broadleaf			0.00	2	18.27	9.14	0.00	18.27	0.00	D-17,D-7	1/2				3
shrubland			0.00			0.00	0.00	0.00	0.00						
wet meadow/marsh			0.00			0.00	0.00	0.00	0.00						
shrub swamp			0.00			0.00	0.00	0.00	0.00						
conifer swamp			0.00			0.00	0.00	0.00	0.00						
broadleaf swamp			0.00			0.00	0.00	0.00	0.00						
mixed swamp			0.00			0.00	0.00	0.00	0.00						
riparian old growth conifer	1	11.33	11.33			0.00	11.33	0.00	-100.00				(R-10a*,R-11a,P-5a)*	(3/1/1)*	*
riparian mature conifer	1	16.59	16.59	1	17.52	17.52	0.00	0.93	0.00	D-22	3				3
riparian regenerative broadleaf/conifer			0.00			0.00	0.00	0.00	0.00						
riparian broadleaf			0.00			0.00	0.00	0.00	0.00						
riparian mixed conifer/broadleaf			0.00			0.00	0.00	0.00	0.00						
riparian/avalanche shrubland	1	3.26	3.26	1	3.29	3.29	0.00	0.03	0.00	D-13	2				2
TOTALS	15	437.60	29.17	19	207.54	10.92	249.29	19.23							13

SAMPLING SITE LOCATION AND ESTABLISHMENT



I. Forest and Shrub Habitats

1. Locate the preselected polygon and the "start" quarter marked on the aerial photo and the map. Land the boat or enter the polygon at the most accessible point in this start quarter. If the polygon is small, enter the polygon at the most accessible location.

2. Locate the start point by pacing 55m in a direction perpendicular to the reservoir shore or trail from the access point. For small polygons the distance may be less than 55m.

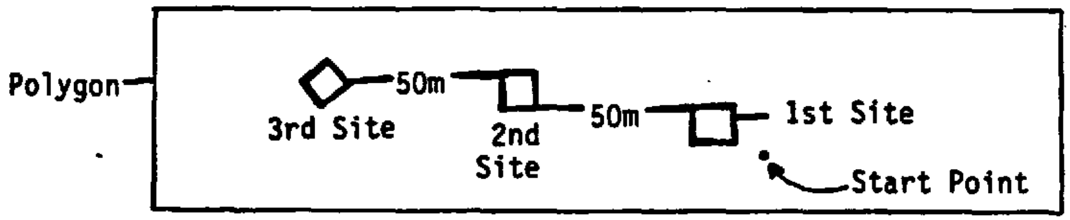
3. After arriving at the start point, walk 10 meters in the preselected compass direction. This point becomes the first corner of the first sampling site. This combination of distance and direction should not put you within 20m of the edge of the polygon. If it does, reject it and choose another combination of numbers.

4. Establish a 25m transect in the preselected direction. Run a second 25m line at 90° to the first (randomly choose the side by flipping a coin or using the random number table). To find the fourth corner, use the compass and pace off approximately 25m. Sight on corners at the ends of the tape. Be sure to flag all corners. Reject direction choices if they would take the sample station outside the polygon or into the 20m edge buffer.

5. o If a second or third site is to be sampled in a narrow polygon, place it 50 meters away from the first site along the long axis of the polygon.

   o If the polygon is a large one, go to any corner of the first site (randomly choose a number between 1 and 4), follow the preselected compass direction, and walk 50m in that direction to establish the first corner point of the second site.

   o If the polygon is small, adjust the distance between sites and choose appropriate random directions in the field. Repeat Step 4.



6. Repeat Steps 4 and 5 for a third site.

II. Wetland Habitats -- Forested

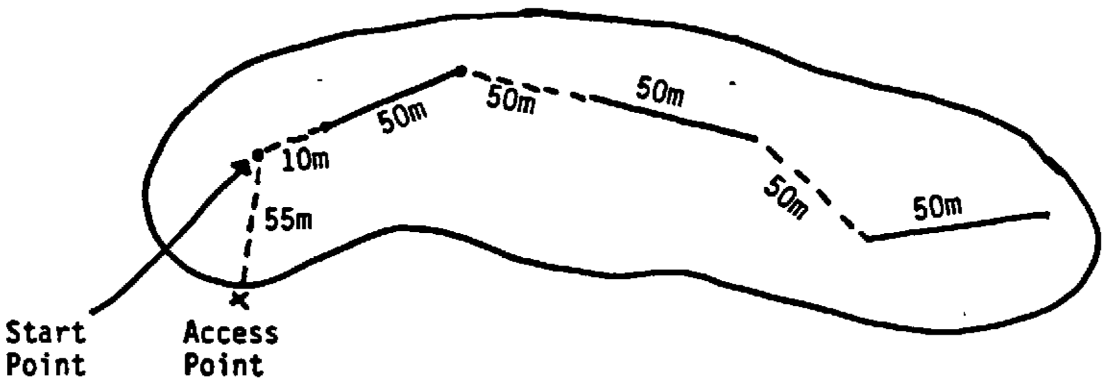
1. Follow same procedures outlined for forested and shrub habitats to locate and establish sample sites.

III. Wetland Habitats -- Marsh

1. Follow the same procedures outlined for forested and shrub habitats to locate sample sites.

2. Establish a 50m transect in the preselected direction. Reject the direction if it appears to extend outside the polygon or into the 20m buffer.

3. If a second site is to be sampled in a narrow polygon, place it 50m away from the first site along the long axis of the polygon. If the polygon is a large one, go to either end of the first transect (randomly choose), choose a random compass direction and walk 50m in that direction to establish the second site. If the polygon is small, adjust the distance between transects (< 50m) and choose appropriate random directions in the field. Repeat Step 2.



4. Repeat Steps 2 and 3 for a third site.

/M-16

III Wetland Habitats -- Beaver

1. Specific polygons have been identified to sample for beaver. Follow the directions for locating the polygons and sites as outlined for wetlands or forest/shrub habitats.

2. In these polygons the only additional parameters to be measured for the beaver are the number of trees and the number of trees between 2.5 and 15.2 cm dbh. These parameters can be measured in the entire 25 x 25 m plot or a belt transect can be established. Adjust the width of the belt transect to achieve a count of 50 trees. Record the width of the belt.

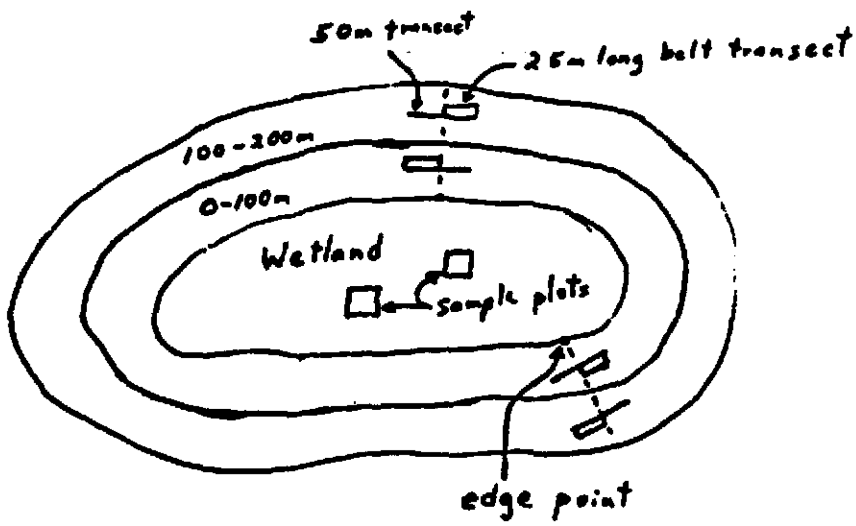
3. Be sure to transfer the measures of tree canopy cover, shrub canopy cover and height of shrub canopy to the beaver data sheet.

4. If 3 sites are being sampled in a polygon the beaver parameters should be measured in all 3 sites.

5. Sampling Adjacent Habitats

   a. Wetland Habitats

   Choose, using random directions, two points on the edges of the wetland in different compass quadrants. Choose a random distance between 0 and 100 meters and another between 100 and 200 meters. Pace the distances in a direction perpendicular to the wetland from the edge point. Establish a 50 m transect at each point ± perpendicular to the direction of travel and centered on the line of travel. One half will become the belt transect. Repeat at the second wetland edge point.



b. Riparian Habitats

- All sampling within riparian habitats will likely be within 100m of a river or stream and this site will represent the sampling needed for beaver within a 100m band of the river.

- For each plot, choose a random distance to ensure that the next site is within 100 to 200m of the river. Walk that distance in a direction perpendicular to the river and establish the second site. This site will be a 50 m transect as described in 5a above.

Reminder to Data Recorders:

1. On arriving at a given polygon, mark the columns containing the parameters appropriate to measure in that habitat type (or visa versa).

2. If a parameter does not get measured in a particular habitat type leave those columns blank.

3. If a parameter is to be measured but is not present (i.e. no shrub cover) put a "0" in those columns.

4. Right justify all entries.

5. Write any applicable notes in the margins.

6. When in doubt, ASK.

WETLANDS 2 : BEAVER

Habitat Type: ☐☐☐ (1 2 3)

Riverine (020), Pond (022), Conifer Swamp (023), Broadleaf Swamp (024), Mixed Swamp (025), Shrub Swamp (026), Wet Meadow / Marsh (027), Riparian Old Growth Conifer (101), Riparian Mature Conifer (102), Riparian Broadleaf (107), Riparian Mixed (108), Riparian Shrub (109), Old Growth Conifer (001), Closed Canopy Conifer (002), Open Canopy Conifer (003), Lodgepole (004), Regenerative Conifer (005), Regenerative Broadleaf / Mixed (006), Broadleaf (007), Mixed (008), Shrub (009).

Location: ☐☐ (4 5) R= Ross, D= Diablo
G= Gorge, TA= Thunder Arm
BV= Big Beaver Valley
CR= Canadian Skagit, LC= Lightening Creek

Polygon Number: ☐☐☐ (6 7 8) Date: ☐☐☐☐☐☐ (9 10 11 12 13 14)

SPECIES : Beaver (11).

Site Number **	habitat type			tree canopy cover (cm) (all)				shrub canopy cover ≤ 5m high (cm) (all)				height of shrub canopy ≤ 5m high (m) (all)				belt transect width for tree count (m) (all)			number of trees (all)			number of trees between 2.5 and 15.2cm dbh (all)			woody vegetation is ≥ 50% : 1= aspen, willow, cottonwood; 2= other decidous species; 3= conifers (all)					% waterlily coverage (022)				* stream gradient (%) (020) *				annual water fluctuation (all)			* shoreline development factor (002)										
15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66

** 1 = in the wetland, 2 & 3= within 100m, 4 & 5= within 200m ; riverine & pond habitats will not have site 1

* not a field measure

WETLANDS 1

Habitat Type: ☐☐☐ (1 2 3)   Riverine (020), Lacustrine (021), Conifer Swamp (023), Broadleaf Swamp (024), Mixed Swamp (025), Shrub Swamp (026), Wet Meadow / Marsh (027)

SPECIES : Dipper (1), Yellow Warbler (5), Osprey (6), Red-tailed Hawk (7), Black-capped Chickadee (9).

Location: ☐☐ (4 5)   R= Ross, D= Diablo; G= Gorge, TA= Thunder Arm; BV= Big Beaver Valley; CS= Canadian Skagit, LC= Lightening Creek

Polygon Number: ☐☐☐ (6 7 8)   Date: ☐☐☐☐☐☐ (9 10 11 12 13 14)

Site Number	deciduous shrub canopy cover ≤ 5m high (cm) (5) (023,024,025, 026)	hydrophytic shrub canopy cover ≤ 5m high (cm) (5) (023,024,025, 026)	height of deciduous shrubs ≤ 5m high (m) (5) (023,024,025, 026)	tree canopy closure (cm) (9) (023,024,025)	% herbaceous canopy (7) (027)	% herbaceous canopy 8 to 46cm tall (7) (027)	height of overstory trees (9) (023,024,025) slope	baseline	%	number of snags 10 to 25 cm dbh (9) (023,024, 025)	stream gradient (%) (1) (020)*	bottom substrate : 1= silt & sand : 2= cobble; 3= rock (1) (020)	number of rock walls, waterfalls, bridges (1) (020)	secchi disc reading (m) (6) (020,021)	number of perch sites / within 200 ft. of water (6) (020,021)	number of nest trees (6) (020,021)	number of pilot perch trees (6) (020,021)	distance between nest habitat & water (ft) (6) (020,021)
15	16 17 18 19	20 21 22 23	24 25 26 27	28 29 30 31	32 33 34	35 36 37	38 39	40 41	42 43 44	45 46 47	48 49 50	51 52 53	54 55 56	57 58 59 60	61 62 63	64 65 66	67	

* not a field measure

FOREST AND SHRUB HABITATS 2

Habitat Type: ☐☐☐ (1 2 3)

Old Growth Conifer (001), Closed Canopy Conifer (002), Open Canopy Conifer (003), Lodgepole (004), Regenerative Conifer (005), Regenerative Broadleaf/Mixed (006), Broadleaf (007), Mixed (008), Shrub (009), Riparian (100)

SPECIES: Ruffed Grouse (2), Mule Deer (3), Black Tailed Deer (4), Yellow Warbler (5), Red-tailed Hawk (7), Pileated Woodpecker (8), Black-capped Chickadee (9), Marten (10).

Location: ☐☐ (4 5) R= Ross, D= Diablo, G= Gorge, TA= Thunder Arm, BV= Big Beaver Valley, CS= Canadian Skagit, LC= Lightening Creek

Polygon Number: ☐☐☐ (6 7 8) Date: ☐☐☐☐☐☐ (9 10 11 12 13 14)

Site Number	shrub canopy cover ≤ 2m high (cm) (3,4) (all): palatable	shrub canopy cover ≤ 2m high (cm) (3,4) (all): less palatable	shrub canopy cover ≤ 5m high (cm) (7) (003)	deciduous shrub canopy cover ≤ 5m high (cm) (5) (100 only)	hydrophytic shrub canopy cover ≤ 5m high (cm) (5) (100 only)	tree canopy cover (cm) (7,8,9,10,11) (all)	conifer cover (cm) (10) (001,002,003, 004,008,100)	evergreen woody vegetation cover ≥ 3m (cm) (3) (all)	cover of downfall ≥ 7.6 cm dbh (cm) (10) (001,002,003, 004,008,100)	depth of woody material (cm) (4) (all)	% palatable herbaceous canopy (3,4) (all)	% herbaceous canopy (7) (003)	% herbaceous canopy 8 to 46cm tall (7) (003)	height of deciduous shrubs (m) (2,5) (all)	height of lowest branch conifer above ground (m) (2) (all)	successional stage: 2= pole sapling; 3= young; 4= mature (10) (001,002,003, 004,008,100)
15	16 17 18 19	20 21 22 23	24 25 26 27	28 29 30 31	32 33 34 35	36 37 38 39	40 41 42 43	44 45 46 47	48 49 50 51	52 53 54 55	56 57 58	59 60 61	62 63 64	65 66 67 68	69 70 71 72 73	74 75 76 77

FOREST AND SHRUB HABITATS 1

Habitat Type: ☐☐☐ (1 2 3)

Old Growth Conifer (001), Closed Canopy Conifer (002), Open Canopy Conifer (003), Lodgepole (004), Regenerative Conifer (005), Regenerative Broadleaf/Mixed (006), Broadleaf (007), Mixed (008), Shrub (009), Riparian (100)

SPECIES: Ruffed Grouse (2), Mule Deer (3), Black Tailed Deer (4), Yellow Warbler (5), Red-tailed Hawk (7), Pileated Woodpecker (8), Black-capped Chickadee (9), Marten (10)

Location: ☐☐ (4 5)

R= Ross, D= Diablo
G= Gorge, TA= Thunder Arm
BV= Big Beaver Valley
CR= Canadian Skagit, LC= Lightening Creek

Polygon Number: ☐☐☐ (6 7 8) Date: ☐☐☐☐☐☐ (9 10 11 12 13 14)

Site Number	density of deciduous shrubs (2) (all)		density of deciduous trees (2) (all)		density of coniferous trees (2) (all)		height of deciduous trees (2) (all) %				height of coniferous trees (2) (all)				height of overstory trees (9) (all except 009)				number of trees > 50 cm dbh (cm) (7,8)	number of snags > 51 cm dbh (8)	dbh of snags > 51 cm dbh (cm) (8)	number of snags 10 to 25 cm dbh (9)	number of logs > 18cm diameter or stumps > 0.3m high & > 18cm in diameter (8)	predominant conifers : 1= spruce, hemlock, fir ; 2= lodgepole ; 3= ponderosa pine (2)
	plot size	#	plot size	#	plot size	#	slope	baseline	%	+	slope	baseline	%	+	slope	baseline	%	+	(001,002,003, 007,008,100)	(001,002,003, 007,008,100)	(001,002,003, 007,008,100)	(all)	(001,002,003, 007,008,100)	(all)
15	16 17	18 19 20	21 22	23 24 25	26 27	28 29 30	31 32	33 34	35 36 37	38	39 40	41 42	43 44 45	46	47 48	49 50	51 52 53	54	55 56 57 58	59 60 61 62	63 64 65 66	67 68 69 70	71 72 73 74 75 76	77 78 79 80

+ = overstory tree (comprises top 20% of the canopy)

Forest and Shrub Habitats 1

Variable	Method Of Measurement
Density of deciduous shrubs (dbh $\leq$ 2.5cm; height $\geq$ 0.9m).	Plot count. If rough count of shrubs in a 5 x 5m is 12, count in entire 25 x 25m plot. If 12, count in two 5 x 5m plots and average.
Density of deciduous trees	Plot count, 25 x 25m plot, mark with chalk.
Density of coniferous trees.	Plot count, 25 x 25m plot, mark with chalk.
Height of trees (conifer and deciduous)	Clinometer and range-finder. Number will be different in each habitat type and will be calculated at the first plot of each type measured. Method: • Locate an area as close to one of the site corners as possible where the tops of several overstory trees within the polygon can be seen. • One person stands here; the other walks out 20-30m and begins to identify trees to be measured by asking "Can you see the top of this one?" If so, the tree is measured and marked. • Continue process until the prescribed number of trees for that area have been measured or it is not possible to measure additional trees without moving a great distance. • If additional trees need to be measured, repeat the process at another site corner until an adequate number of trees have been measured. • Record baseline, % and slope (in stands with trees more than 150 ft tall, record the degrees rather than % and label the data sheet to note that).
Height of overstory trees	An overstory tree is defined as > 80% of the height of the tallest tree in the canopy. Identify overstory trees (either deciduous or conifer) by a "+" in the appropriate column. Transfer the measures for these trees to the overstory tree columns. If less than 20 have been measured, choose additional overstory trees to measure using the procedure described above and choosing only overstory trees.
Number of trees > 50cm dbh	Count and mark, 25 x 25m plot.
Number of snags > 51cm dbh	Count and mark, 25 x 25m plot.
dbh of snags > 51cm dbh (snag = dead tree)	dbh tape, measure all within 25 x 25m plot.
Number of snags 10 to 25cm dbh	Count and mark, 25 x 25m plot.
Number of logs > 18cm diameter or stumps > 0.3m high and 18cm diameter.	Count, 25 x 25m plot.
Predominant conifers	Observation.

/M-13

Wetlands 1

Variable	Method Of Measurement
Deciduous shrub canopy cover ≤ 5m high	Line intercept, 50m transect.
Hydrophytic shrub canopy cover ≤ 5m high	Line intercept, 50m transect (hydrophytic = willow, hardhack, devils club, hawthorn, Indian plum, alder, dogwood, highbush cranberry, ninbark, twinberry, wild crabapple, cottonwood).
Tree canopy closure	Line intercept, 50m transect, upward projection.
% herbaceous canopy	0.5m x 0.2m quadrat, place every 5m along 50m line (10 total); random start point, random side of transect, 5% increments.
% herbaceous canopy 8 to 46cm tall	0.5m x 0.2m quadrat, at same time and location as % herbaceous canopy (10 total).
Height of deciduous shrubs ≤5m high	Graduated rod or meter stick, 50m transect, every 5m, nearest two shrubs (20 total); random start point.
Height of overstory trees	Clinometer and rangefinder. An overstory tree is defined as 80% of the height of the tallest tree in the canopy. Method: • Locate an area as close to one of the site corners as possible where the tops of overstory trees can be seen. • One person stands here; the other walks out 20-30m and begins to identify overstory (large) trees to be measured by asking "Can you see the top of this one?" If so, the tree is measured and marked. • Continue process until 20 overstory trees have been measured, or it is not possible to measure additional trees without moving great distances. • If additional trees need to be measured, repeat process at another site corner until 20 trees have been measured. Record baseline, % and slope.
Number of snags 10 to 25m dbh	Count and mark, 25 x 25m plot.
Stream gradient	Topo maps, not a field observation.
Bottom substrate	Observation, 0.8km transect.
Number of rock walls, waterfalls, bridges	Count, 0.8km transect.
Secchi disc reading	Two readings/mile (to 1.0m).
Number of snags, dead-topped trees or open-crowned live trees within 200 ft of water per mile.	Count/mile, estimate 200 ft from water.
Number of snags, dead-topped trees or open-crowned trees with whorls or witches brooms per mile (same number for nest tree and perch tree columns).	Count/mile, estimate distance from water.

/M-12

Variable	Method Of Measurement
Shrub canopy cover (palatable and less palatable) ($\leq$2m) Note: Includes trees < 2m tall.	Line intercept, 50m transect (palatable = serviceberry, elderberry, blackcap, trailing blackberry, Mt. balm, cherry, willow, red cedar; less palatable = salal, salmonberry, vine maple, hazelnut, devils club, dogwood, snowberry, alder, Oregon grape, hemlock, Douglas fir, lodgepole pine).
Shrub canopy cover $\leq$5m high	Line intercept, 50m transect.
Deciduous shrub canopy cover $\leq$5m high	Line intercept, 50m transect.
Hydrophytic shrub canopy cover $\leq$5m high	Line intercept, 50m transect (hydrophytic = willow, hardhack, devils club, hawthorn, Indian plum, alder, dogwood, highbush cranberry, ninebark, twinberry, wild crabapple, cottonwood).
Tree canopy cover	Line intercept, 50m transect, upward projection.
Conifer cover	Line intercept, 50m transect, upward projection.
Evergreen woody vegetation cover $\geq$ 3.0m high	Line intercept, 50m transect, upward projection.
Cover of downfall $\geq$ 7.6cm diameter	Line intercept, 50m transect.
Depth of woody material	Every 5m along a 50m transect, random start point, meter stick (<u>10 total</u>).
% palatable herbaceous canopy cover	0.5 x 0.2m quadrat, place every 5m along 50m transect (<u>10 total</u>); random start point, random side of transect; 5% increments. (Unpalatable = foxglove, thistle, tansy ragwort, poison hemlock, equisetum, fern).
% herbaceous canopy cover	0.5 x 0.2m quadrat, at same time and location as % palatable herbaceous canopy cover (<u>10 total</u>); 5% increments.
% herbaceous canopy cover 8-46cm tall	0.5 x 0.2m quadrat and meter stick, at same time and location as % palatable herbaceous canopy cover (<u>10 total</u>); 5% increments.
Height of deciduous shrubs	Graduated rod, 50m transect, every 5m, nearest two shrubs, random start point. In riparian areas, if any of the 20 measured shrubs are > 5m high, randomly choose additional shrubs $\leq$5m high to measure, so that at least 20 shrubs $\leq$5m high are measured.
Height of lowest conifer branch above ground	Graduated rod or meter stick, 50m transect, every 5m, nearest two conifers, random start point (<u>20 total</u>).
Successional stage	Observation.

Wetlands 2: Beaver

Variable	Method of Measurement
Habitat type	Observation or aerial photo.
Tree canopy cover	Line intercept, 50m transect, upward projection.
Shrub canopy cover 5m high	Line intercept, 50m transect.
Height of shrub canopy 5m high	Graduated rod, 50m transect, every 5m, nearest two shrubs, random start point (20 total).
Number of trees	Count, belt transect, establish on one side of the 50m transect. Length of the belt transect should always be 25m, width of transect will be variable depending on the number of trees in the area; at least 50 trees should be counted. Record width of transect.
Number of trees between 2.5 and 15.2 cm dbh	dbh tape, count, belt transect of same width and location as total tree count.
Woody vegetation	Observation.
% water lily coverage	Visual estimation.
Stream quadrant	Topo maps - not a field measure.
Water fluctuation	Local data - not a field measure.
Shoreline development	Not a field measure.

Your
Seattle
City Light

Randall W. Hardy, Superintendent
Charles Royer, Mayor

DEC 3 1987

December 1, 1987

Brian Hauger
Washington Dept. of Wildlife
600 N Capital Way, MS GJ-11
Olympia, WA 98504

Dear Brian:

Enclosed is a copy of the November 4, 1987 HEP team meeting notes for the Skagit Dams Original Impacts Study. The notes include the details of the decisions reached by the HEP team during the meeting.

Please review the notes and acknowledge your acceptance of the decisions by signing in the designated place below and returning this letter to Envirosphere Company.

If you have any questions, please call Jay Brueggeman at 451-4625.

Sincerely,

Richard Rutz

Richard Rutz, Project Manager
Environmental Affairs Division

RR:gv

Attachment: November 4 meeting notes

As a representative of WASH. DEPT. OF WILDLIFE, I accept the decisions documented in this letter for the Skagit Dams Original Impacts Study.

Brian D. Hauger
(Name)

12/4/1987
(Date)

Your
Seattle
City Light

Randall W. Hardy, Superintendent
Charles Royer, Mayor

RECEIVED
DEC 09 1987
ENVIROSPHERE COMPANY
SEATTLE

December 1, 1987

Jon Jarvis
North Cascades National Park Complex
2105 Highway 20
Sedro Woolley, WA 98284

Dear Jon:

Enclosed is a copy of the November 4, 1987 HEP team meeting notes for the Skagit Dams Original Impacts Study. The notes include the details of the decisions reached by the HEP team during the meeting.

Please review the notes and acknowledge your acceptance of the decisions by signing in the designated place below and returning this letter to Envirosphere Company.

If you have any questions, please call Jay Brueggeman at 451-4625.

Sincerely,

Richard Rutz

Richard Rutz, Project Manager
Environmental Affairs Division

RR:gv

Attachment: November 4 meeting notes

As a representative of North Cascades N.P.S.C., I accept the decisions documented in this letter for the Skagit Dams Original Impacts Study.

Jonathan B. Jarvis ______ 12-7-87 ______
(Name) (Date)

Your Seattle City Light

Randall W. Hardy, Superintendent
Charles Royer, Mayor

RECEIVED

December 1, 1987

Estyn R. Mead
Division of Ecological Services
U.S. Fish & Wildlife Service
2625 Parkmont Lane SW Bldg. B-3
Olympia, WA 98502

Dear Estyn:

Enclosed is a copy of the November 4, 1987 HEP team meeting notes for the Skagit Dams Original Impacts Study. The notes include the details of the decisions reached by the HEP team during the meeting.

Please review the notes and acknowledge your acceptance of the decisions by signing in the designated place below and returning this letter to Envirosphere Company.

If you have any questions, please call Jay Brueggeman at 451-4625.

Sincerely,

Richard Rutz

Richard Rutz, Project Manager
Environmental Affairs Division

RR:gv

Attachment: November 4 meeting notes

As a representative of U.S. Fish and Wildlife Service, I accept the decisions documented in this letter for the Skagit Dams Original Impacts Study.

Estyn R. Mead (Name) 1-29-88 (Date)

SKAGIT DAMS ORIGINAL IMPACTS STUDY
HEP TEAM MEETING
NOVEMBER 4, 1987

On Wednesday, November 4, 1987, a HEP Team Meeting was held for the Skagit Dams Original Impacts Study. The purpose of this meeting was to: 1) review the final edit plots and cover-types to be included on the color map, 2) finalize the target years for each reservoir, 3) review changes and assumptions made in several species HSI models, and 4) determine HSI values for several species in habitats that were not measured in the field.

Attendees: Rick Rutz, SCL
Art Stendall and Brian Hauger, WDW
Estyn Mead, USFWS
Jon Jarvis, NPS
Joe and Margaret Miller, N3C
Jay Brueggeman, Dave Every, and Colleen McShane, Envirosphere

1.0 Cover Type Mapping

The final edit plots of the cover-type mapping were presented to the HEP Team. The HEP team reviewed the edit plots and agreed upon the cover-types to be displayed on the final color map (Attachment A).

2.0 Target Years

The HEP is designed to project changes in habitat units over the life of the project. It is, therefore, important to identify the years in which major changes in habitat quantity or quality occurred that can be measured or estimated. The initial target year (TY0) always represents the year prior to any disturbance.

TY1 is always the next consecutive year, or the first year of construction. Since it is usually not possible to estimate the acreage disturbed by initial construction, the acreages for TY1 generally do not change from TY0. The next target year is usually the year that construction is completed. The acreages for this year represent the first major change from pre-project conditions. Target years subsequent to the completion of construction are assigned to every year that a major change occurs in the quantity or quality of habitat. The last target year represents the end of the license period, or in the case of SCL, the end of the current temporary license extension, 1987.

The stages of construction for each of the three Skagit Dams were presented and the following target years were agreed upon by the HEP team:

Reservoir	Calendar Year	Target Year	Event	Pool Elevation (feet)	Pool Area (acres)
Gorge	1918	TY0	pre-construction	--	--
	1919	TY1	construction begins	--	--
	1924	TY6	construction completed	780	12
	1961	TY43	concrete dam	880	240
	1987	TY69	project end	880	240
Diablo	1927	TY0	pre-construction	--	--
	1928	TY1	construction begins	--	--
	1929	TY2	construction completed	1,205	910
	1987	TY60	project end	1,205	910
Ross	1936	TY0	pre-construction	--	--
	1937	TY1	construction begins	--	--
	1940	TY4	construction completed	1,380	1,950
	1947	TY11	elevation raised	1,500	5,800

Reservoir	Calendar Year	Target Year	Event	Pool Eleva- tion (feet)	Pool Area (acres)
	1948	TY12	elevation raised	1,560	9,550
	1949	TY13	elevation raised	1,602	11,700
	1987	TY51	project end	1,602	11,700

Gorge had one intermediate stage when the elevation of the dam was raised slightly and the pool surface area increased to 21 acres. The HEP team agreed that this acreage change was too small to assign to a target year. Similarly, Ross had several small and relatively brief incremental changes that were not assigned specific target years.

3.0 Models Changes and Assumptions

3.1 Ruffed Grouse

The ruffed grouse model includes a factor which reduces the value of optimal habitat by 75 percent if conifers are present. The purpose of this "conifer penalty" is to account for the hiding cover provided to avian predators by tall conifers. The HEP team agreed that avian predators are probably not a major source of ruffed grouse mortality in the Skagit area and thus are not likely to result in ruffed grouse avoiding conifer areas. The HEP team decided to drop the conifer penalty from the ruffed grouse model.

3.2 Mule Deer

3.2.1 Small Conifers

Conifer cover less than two meters tall was included in the field measures of winter food for the mule deer. The model specifies exclusion of small conifers but there is evidence that they are browsed by deer in the Skagit area and may be an important winter food source. The HEP team agreed that conifers (<2m) be retained in the cover measurements.

3.2.2 Herbaceous Canopy Cover

The herbaceous canopy cover parameter in the model was refined in the field to include only palatable herbaceous canopy cover. The HEP team agreed that this was an appropriate modification.

3.2.3 Slope

A recent study in Oregon (Ganokopp and Vavra 1987; Slope Use by Cattle, Feral Horses, Deer, and Bighorn Sheep) showed that slopes greater than 80 percent were avoided by deer and that slopes between 40 and 79 percent were utilized at a lower frequency than their occurrence. The HEP team agreed that all slopes greater than 80 percent will not be evaluated as deer habitat. In addition, the food HSI for deer habitat on slopes between 40 and 79 percent will be down-weighted by half (multiplying by 0.5); the cover HSI will not be weighted for slope. Values for slopes between 0 and 39 percent will not be modified.

3.3 Red-tailed Hawk

At an earlier meeting, the HEP team agreed that shrub cover would be used to down-weight the food value of open canopy conifer and shrub land cover-types. The HEP team decided that this down-weighting will be accomplished by applying the same graph that is used to determine the effect of tree canopy cover in these habitats. The SI for this additional parameter will be included in the HSI equation and given a weight equal to that of the other variables.

3.4 Osprey

3.4.1 Interspersion

The HEP team agreed that the distance between nesting and feeding habitat was not a limiting factor for osprey in the Skagit area; therefore, the SI value for this parameter was assigned a 1.0.

3.4.2 Multi-Cover

The HEP team agreed that the osprey model should be applied as a multi-cover model. Multi-cover models weight each life requisite HSI by the area of the different habitats used to meet that particular life requisite.

3.5 Black-tailed Deer

Based on the field data collection, additional literature review and consultation with species experts, the black-tailed deer model does not appear to be appropriate for the Skagit Area. The deer in this region of the North Cascades are an integrade mix of mule deer and black-tailed deer and are more characteristic of mule deer in behavior and size. As a result of this information, the HEP team agreed to use the mule deer model for evaluating deer habitat quality in the Skagit Project Area.

4.0 HSI Values for Habitats Not Measured in the Field

A number of cover types could not be measured during the field sampling program because they: 1) were present during pre-project but not under post-project conditions and not represented adjacent to the project area (i.e., agriculture), 2) represented a very small percent of the project area (i.e., grassland), or 3) were impossible to sample safely (i.e., exposed rock). Because a number of these cover types have value as habitat for several evaluation species, the HEP team agreed to assign HSIs to the habitat for the following species:

Mule Deer

- Campgrounds are only minimally disturbed and will be assigned the same food and cover HSIs as the cover-type in which they are located (usually open or closed canopy conifer).

- Transmission lines are generally maintained as shrublands and will be assigned the same HSI as shrublands.

- A food HSI will be calculated for grasslands and agricultural areas assuming no shrub cover and 100 percent palatable herbaceous cover (food HSI = 0.333).

Red-tailed Hawk

- Exposed rock and talus areas will be assigned a food HSI of 0.75, since these areas are likely good habitat for red-tailed hawk prey.

- Transmission lines will be assigned the same food HSI as shrublands.

- Agricultural areas and grasslands will be assigned a food HSI of 1.0 due to their importance as small mammal habitat.

Black-capped Chickadee

- o Campgrounds will be assigned a 0.75 SI value for snags; SI values for the other model parameters will be the same as those measured in the cover-type in which the campground is located.

Beaver

- o Ponds will be assigned an HSI of 1.0, since they usually represent excellent beaver habitat.

- o Bogs will be assigned an HSI of 0.0, since their habitat value for beavers is probably poor.

5.0 Schedule

The first draft of the report on the Skagit Dams Original Impacts Study is due to SCL on November 20, 1987.

After the comments made by SCL are incorporated into the report, a second draft will be submitted to the HEP team for review by mid-January 1988.

The next HEP team meeting will be on Wednesday, February 10, 1988, to discuss comments on the report.

SCL SKAGIT PROJECT COVER TYPES

Attatchment A

FINAL MAP COLOR*		COVER TYPE NAME	CODE
1	1	Old Growth Conifer	(COG)
2	2	Closed Canopy Conifer	(CC)
	3	Open Canopy Conifer	(CO)
3	4	Conifer Regeneration	(CR)
	5	Closed Canopy Lodgepole	(CLC)
4	6	Open Canopy Lodgepole	(CLO)
	7	Lodgepole Regeneration	(CLR)
5	8	Broadleaf Forest	(B)
6	9	Mixed Forest	(M)
5	10	Regenerating Broadleaf/Mixed	(R)
1r	11	Riparian Old Growth Conifer	(rCOG)
2r	12	Riparian Closed Canopy Conifer	(rCC)
	13	Riparian Open Canopy Conifer	(rCO)
3r	14	Riparian Conifer Regeneration	(rCR)
5r	15	Riparian Broadleaf Forest	(rB)
6r	16	Riparian Mixed Forest	(rM)
7r	17	Riparian Shrub	(rS)
8	18	Gravel Bar	(Gr)
7	19	Shrublands	(S)
	20	Avalanche Tracks	(SA)
9	21	Grassland/Meadow	(HG)
10	22	Exposed Rock	(ER)
	23	Talus	(T)
	24	Palustrine Forest (Conifer Swamp)	(PFC)
11	25	Palustrine Forest (Broadleaf Swamp)	(PFB)
	26	Palustrine Forest (Mixed Swamp)	(PFM)
	27	Palustrine Scrub-Shrub (Shrub Swamp)	(PS)
12	28	Palustrine Emergent (Marsh)	(PM)
	29	Palustrine Moss (Bog)	(PB)
	30	Palustrine Aquatic Bed (Pond)	(PP)
	31	Lacustrine; Reservoir	(RES)
	32	Riverine, mainstem, gradient 1%	(R1)
8	33	Riverine, mainstem, gradient 1-3%	(R2)
	34	Riverine, tributary, gradient 1%	(TrR1)
	35	Riverine, tributary, gradient 1-3%	(TrR2)
	36	Riverine, tributary, gradient 3-6%	(TrR3)
	37	Riverine, tributary, gradient 6-12%	(TrR4)
	38	Reservoir Drawdown	(RD)
9	39	Agriculture	(AG)
13	40	Industrial Sites	(I)
14	41	High Density Residential	(RH)
	42	Low Density Residential	(RL)
13	43	Roads, Parking Lots	(RP)
14	44	Transmission or highway right-of-way	(ROW)
	45	Forest Campground	(CA)

*Cover Types on Final Map

1. Old-growth Conifer Forest
2. Mature Conifer Forest
3. Young Conifer Forest
4. Lodgepole Pine Forest
5. Broadleaf Forest
6. Mixed (conifer/broadleaf) Forest
7. Shrub
8. Lake/stream (Lacustrine/ Riverine
9. Grass/Agriculture
10. Rock/Talus
11. Forested Wetland - Palustrine
12. Non-Forested Wetland - Palustrine
13. Road/Parking Lot/ Industrial Site
14. Campground/Residential/ Right-of-way

r-Riparian: the colored border outlines each group of riparian cover types; some wetland types occur within the riparian border.

STUDY OF SKAGIT DAMS ORIGINAL IMPACTS
ON FISH AND WILDLIFE HABITATS AND POPULATIONS
PROGRESS REPORT
OCTOBER 1987

1.0 Summary of Work Performed

During September 1987, Envirosphere performed the following work on the Study of Skagit Dams Original Impacts on Fish and Wildlife Habitats and Populations:

Task 1 - Identify, Review, Analyze and Summarize Reference Materials

This task was completed in June, 1987.

Task 2 - Wildlife Habitat Inventory

The final edit plots and acreage summaries were received from NCI. The color proof of the final display map was checked and sent for printing.

Task 3 - Wildlife Population Inventory

Summarization of published data on important wildlife species in the Skagit Area was begun.

Task 4 - Wildlife Habitat Evaluation

All field data were summarized and the statistical analysis completed. The HSI analyses were completed for the marten, ruffed grouse, black-capped chickadee, and pileated woodpecker. In addition, the models and spreadsheets required for the HSI anaysis for the osprey, red-tailed hawk, and mule deer were designed and programmed for computer analysis.

Task 5 - Anadromous Fish

The draft report was submitted to SCL in September.

Task 6 - Synthesis Report

The introduction, study area and methodology sections of the synthesis report were written and several graphics prepared.

Task 7 - Consultation, Coordination and Meetings

No formal coordination or HEP team meetings were held in October. However, several informal meetings were held to discuss mapping issues.

Task 8 - Management

Normal management activities were performed during October.

2.0 Summary of Significant Problems

The complexity of the target year analysis may cause a slight delay in delivery of the draft report.

3.0 Summary of Major HEP Decisions

No major HEP decisions were made during October.

4.0 Significant Meetings/Contacts

No significant meetings were held during October.

5.0 Work Activities Scheduled for November 1987

Work scheduled for November 1987 on the Skagit Dams Original Impacts Project includes:

- o Finishing the HSI analyses.
- o Incorporating all target year acreage data and completing the HEP analysis.
- o Completing the draft synthesis report.

6.0 Budget

Approximately $6,000 was spent during October. The cummulative total spent on the project is approximately $92,000.

MCM:trpS60

APPENDIX B

APPENDIX TABLE B-1

LIFE FORM 1:	Reproduces in water, feeds in water.
LIFE FORM 2:	Reproduces in water, feeds on the ground, in bushes, and/or trees.
LIFE FORM 3:	Reproduces on the ground around water, feeds on the ground, in bushes, trees, and/or water.
LIFE FORM 4:	Reproduces on cliffs, in caves, rimrock or talus, feeds on the ground or in the air.
LIFE FORM 5:	Reproduces on the ground, without specific association to water, cliff, rimrock, or talus, and feeds on the ground.
LIFE FORM 6:	Reproduces on the ground, feeds in bushes, trees or in the air.
LIFE FORM 7:	Reproduces in bushes, feeds on the ground, in water or the air.
LIFE FORM 8:	Reproduces in bushes, feeds in trees, bushes or air.
LIFE FORM 9:	Reproduces in primarily deciduous trees, feeds in trees, bushes, or air.
LIFE FORM 10:	Reproduces primarily in coniferous trees, feeds in trees, bushes, or air.
LIFE FORM 11:	Reproduces in coniferous or decidous trees, feeds in trees, bushes, on the ground, or in the air.
LIFE FORM 12:	Reproduces on very thick branches, feeds on the ground or in the water.
LIFE FORM 13:	Reproduces in own hole excavated in tree, feeds in trees, bushes, on the ground or in the air.
LIFE FORM 14:	Reproduces in hole made by another species or in natural hole, feeds on the ground, in water or air.
LIFE FORM 15:	Reproduces in burrow, feeds on or under ground.
LIFE FORM 16:	Reproduces in burrows, feeds in air or water.

Table B-2.

SKAGIT DAMS ORIGINAL IMPACTS HEP STUDY -- Mammals and Ranking Parameters (source: Tabor, R.D., 1971. Biotic Survey of Ross Lake Basin)

SPECIES	COMMON NAME	LIFE FORM*	SEASONALITY	ABUNDANCE	AVAILABLE INFORMATION	HEP MODELS	VERSATILITY	RANK
CERVIDAE								
Cervus elaphus roosevelti	Roosevelt Elk	5	4	1	1	1	2	9
Alces alces	Moose	5	4	1	1	1	3	10
Odocoileus hemionus columbianus	Black-tailed Deer	5	4	4	2	1	2	13
Odocoileus hemionus hemionus	Mule Deer	5	4	4	2	1	2	13
BOVIDAE								
Oreamnos americanus	Mountain Goat	4	4	3	1	0	3	11
FELIDAE								
Felis concolor	Mountain Lion	4	4	1	1	0	2	8
Felis rufus	Bobcat	4	4	3	1	0	2	10
MUSTELIDAE								
Lutra canadensis	River Otter	16	4	1	1	2	3	11
Martes americana	Marten	14	4	1	1	3	3	12
Mustela vison	Mink	16	4	1	1	3	3	12
Mustela frenata	Long-tailed Weasel	15	4	1	1	0	3	9
PROCYONIDAE								
Procyon lotor	Raccoon	14	4	1	1	0	1	7
URSIDAE								
Ursus americanus	Black Bear	15	2	3	2	0	2	9
CANIDAE								
Canus latrans	Coyote	15	4	2	1	0	1	8
Vulpes vulpes	Red Fox	15	4	1	1	0	2	8
ERETHIZONTIDAE								
Erethizon dorsatum	Porcupine	6	4	1	1	0	2	8
ARVICOLIDAE								
Phenacomys intermedius	Heather Vole	15	4	1	2	0	3	10
Clethrionomys gapperi	Southern Red-backed Vole	15	4	1	2	3	3	13
Microtus montanus	Mountane Vole	15	4	2	1	0	2	9
Microtus townsendii	Townsend's Vole	15	4	2	1	0	2	9
Microtus longicaudus	Long-tail Vole	15	4	2	1	0	1	8
Microtus richardsoni	Water Vole	15	4	2	1	0	2	9
Microtus oregoni	Creeping Vole	15	4	2	1	0	1	8
ZAPODIDAE								
Zapus princeps	Jumping Mouse	3	4	2	1	0	2	9
CRICETINAE								
Peromyscus maniculatus	White-footed Deer Mouse	15	4	4	2	0	1	11
Neotoma cinerea	Bushy-tailed Woodrat	15	4	1	1	0	2	8
CASTORIDAE								
Castor canadensis	Beaver	16	4	2	1	3	2	12
APLODONTIDAE								

* See Table B-1 for life forms

Table B-2 (cont'd).

SPECIES	COMMON NAME	LIFE FORM *	SEASONALITY	ABUNDANCE	AVAILABLE INFORMATION	HEP MODELS	VERSATILITY	RANK
Aplodontia rufa	Mountain Beaver	15	4	1	1	0	2	8
SCIURIDAE								
Glaucomys sabrinus	Northern Flying Squirrel	14	4	2	1	0	2	9
Tamiasciurus hudsonicus	Red Squirrel	10	4	2	2	0	2	10
Tamiasciurus douglasii	Douglas' Squirrel	10	4	1	2	1	2	10
Spermophilus saturatus	Cascade Ground Squirrel	15	4	2	2	0	2	10
Marmoata frenta	Hoary Marmot	15	4	3	1	0	3	11
Marmota flaviventris	Yellow-bellied Marmot	4	4	1	1	0	3	9
Eutamias amoenus	Yellow Pine Chipmunk	15	4	4	2	0	2	12
Eutamias townsendii	Townsend's Chipmunk	15	4	3	2	0	2	11
LEPORIDAE								
Lepus americanus	Snowshoe Hare	5	4	2	2	3	3	14
Ochotona princeps	Pika	15	4	2	2	0	3	11
VESPERTILIONIDAE								
Myotis lucifugus	Little Brown Myotis	14	4	3	1	0	2	10
SORICIDAE								
Sorex vagrans	Wandering Shrew	15	4	2	2	0	1	9
Sorex cinereus	Masked Shrew	15	4	1	2	0	2	9
Sorex palustria	Northern Water Shrew	16	4	1	2	0	3	10
Sorex trowbridgii	Trowbridge's Shrew	15	4	3	2	0	2	11
TALPIDAE								
Neurotrichus gibbsii	Shrew-mole	15	4	1	2	0	2	9

seasonality: 4=annual resident; 3=winter resident; 2=summer resident; 1=migrant
abundance: 4=abundant; 3=frequent; 2=occassional; 1=rare
information availability: 2=site-specific studies; 1=observed on site; 0=general/none
HEP models: 3=yes (final); 2=yes (draft)); 1=yes (preliminary); 0=no model
versatility (based on the number of cover types and successional stages used in feeding and reproduction): 3=low; 2=medium; 1=high
rank=sum of all parameters

* See Table B-1 for life forms.

Table B-2 (cont'd).
SKAGIT DAMS ORIGINAL IMPACTS HEP STUDY -- Amphibians and Reptiles and Ranking Parameters (source: Tabor, R.D. , 1971. Biotic Survey of Ross Lake Basin)

SPECIES	COMMON NAME	LIFE FORM*	SEASONALITY	ABUNDANCE	AVAILABLE INFORMATION	HEP MODELS	VERSATILITY	RANK
AMBYSTOMATIDAE								
Ambystoma macrodactylum	Long-toed Salamander	2	4	0	0	0	2	6
ASCAPHIDAE								
Ascaphus truii	Tailed Frog	2	4	0	0	0	3	7
BUFONIDAE								
Bufo boreas	Western Toad	2	4	4	1	0	2	10
HYLIDAE								
Hyla regila	Pacific Tree Frog	2	4	1	0	0	2	7
RANIDAE								
Rana cascade	Cascade Frog	2	4	1	1	0	3	8
Rana aurora	Red-legged Frog	2	4	0	0	0	2	6
Rana pipiens	Western Leopard Frog	2	4	0	0	0	3	7
Rana catesbeiana	Bull Frog	1	4	0	0	2	1	7
ANGUIDAE								
Gerrhonotus coreruleus	Northern Alligator Lizard	5	4	2	1	1	1	8
BOIDAE								
Charina bottae	Rubber Boa	5	4	3	1	0	1	8
COLUBRIDAE								
Thamnophis sirtalis	Common Garter Snake	3	4	4	1	0	1	9
Thamnophis elegans	Wandering Garter Snake	3	4	3	1	0	1	8
Thamnophis ordinoides	Northwestern Garter Snake	3	4	3	1	0	2	9

seasonality: 4=annual resident; 3=winter resident; 2=summer resident; 1=migrant
abundance: 4=abundant; 3=frequent; 2=occassional; 1=rare; 0=unknown
information availability: 2=site-specific studies; 1=observed on site; 0=general/none
HEP models: 3=yes (final); 2=yes (draft)); 1=yes (preliminary); 0=no model
versatility (based on the number of cover types and successional stages used in feeding and reproduction): 3=low; 2=medium; 1=high
rank=sum of all parameters

* See Table B-1 for life forms.

Table B-2 (cont'd).

SKAGIT DAMS ORIGINAL IMPACTS HEP STUDY--BIRDS AND RANKING PARAMETERS (source: Tabor, R.D., 1971. Biotic survey of Ross Lake Basin)

SPECIES	COMMON NAME	LIFE FORM*	SEASONALITY	ABUNDANCE	AVAILABLE INFORMATION	HEP MODELS	VERSATILITY	RANK
GAVIIDAE								
Gavia immer	Common Loon	3	4	2	1	0	3	10
PODICIPEDIDAE								
Podiceps auritus	Horned Grebe	3	1	2	1	0	3	7
Podiceps nigricollis	Eared Grebe	3	1	1	1	0	3	6
Aechmophorus occidentalis	Western Grebe	3	1	1	1	3	3	9
*Podilymbus podiceps	Pied-billed Grebe	3	1	0	0	0	3	4
PHALACROCORACIDAE								
*Phalacrocorax auritus	Double-crested Cormorant	3	1	0	1	0	3	5
ARDEIDAE								
*Ardea herodias	Great Blue Heron	12	1	0	0	3	3	7
Butorides striatus	Green-backed Heron	12	1	1	1	0	3	6
ANATIDAE								
Cygnus columbianus	Tundra Swan	3	1	1	1	0	3	6
Branta canadensis	Canada Goose	3	1	1	1	1	3	7
Anas platyrhynchos	Mallard	3	2	2	1	1	3	9
Anas acuta	Northern Pintail	3	1	1	1	0	3	6
Anas discors	Blue-winged Teal	3	1	1	1	3	3	9
Anas clypeata	Northern Shoveler	3	1	1	1	0	3	6
Aythya americana	Redhead	3	1	1	1	3	3	9
Aythya marila	Greater Scaup	3	1	1	1	0	3	6
Aythya affinis	Lesser Scaup	3	1	1	1	3	3	9
Bucephala clangula	Common Goldeneye	14	1	1	1	0	3	6
Bucephala islandica	Barrow's Goldeneye	14	4	3	1	1	3	12
Bucephala albeola	Bufflehead	14	3	3	1	1	2	10
Histrionicus histrionicus	Harlequin Duck	3	2	1	1	0	3	7
Melanitta deglandi	White-winged Scoter	3	1	2	1	0	3	7
Lophodytes cucullatus	Hooded Merganser	14	2	1	1	0	2	6
Mergus merganser	Common Merganser	14	1	3	1	0	2	7
Mergus serrator	Red-breasted Merganser	3	1	1	1	0	2	5
Aix sponsa	Wood Duck	14	4	0	0	3	3	10
ACCIPITRIDAE								
Accipiter gentilis	Northern Goshawk	11	2	2	1	1	3	9
Accipiter striatus	Sharp-shinned Hawk	11	2	1	1	0	2	6
Accipiter cooperii	Cooper's Hawk	11	2	1	1	0	2	6
Buteo jamaicensis	Red-tailed Hawk	12	2	3	1	2	2	10
Aquila chrysaetos	Golden Eagle	12	2	2	1	0	2	7
Haliaeetus leucocephalus^	Bald Eagle^	12	1	1	1	3	2	8
Circus cyaneus	Northern Harrier	5	1	1	1	0	3	6
Pandion haliaetus	Osprey	12	2	1	1	0	2	6
FALCONIDAE								
Falco peregrinus^	Peregrine Falcon^	4	2	1	1	0	1	5
Falco columbarius	Merlin	11	2	1	1	0	2	6
Falco sparverius	American Kestrel	14	2	3	1	0	2	8

* See Table B-1 for life forms.

Table B-2 (cont'd).

SKAGIT DAMS ORIGINAL IMPACTS HEP STUDY--BIRDS AND RANKING PARAMETERS (source: Tabor, R.D., 1971. Biotic survey of Ross Lake Basin)

SPECIES	COMMON NAME	LIFE FORM*	SEASONALITY	ABUNDANCE	AVAILABLE INFORMATION	HEP MODELS	VERSATILITY	RANK
PHASIANIDAE								
Dendragapus obscurus	Blue Grouse	5	4	4	1	3	2	14
Canachites canadensis	Spruce Grouse	5	4	1	1	0	2	8
Bonasa umbellus	Ruffed Grouse	5	4	3	1	3	3	14
Lagopus leucurus	White-tailed Ptarmigan	5	4	1	1	0	3	9
RALLIDAE								
*Rallus limicola	Virginia Rail	3	1	0	0	0	3	4
*Porzana carolina	Sora	3	1	0	0	0	3	4
*Fulica americana	American Coot	3	1	0	0	3	3	7
CHARADRIIDAE								
Charadrius vociferus	Killdeer	3	2	4	1	0	3	10
SCOLOPACIDAE								
Gallinago gallinago	Common Snipe	3	1	1	1	0	3	6
Actitis macularia	Spotted Sandpiper	3	2	4	1	0	3	10
LARIDAE								
Larus glaucescens	Glaucous-winged Gull	3	1	1	1	0	3	6
Larus californicus	California Gull	3	1	2	1	0	3	7
Larus delawarensis	Ring-billed Gull	3	1	1	1	0	3	6
Larus canus	Mew Gull	3	1	1	1	0	3	6
Larus philadelphia	Bonaparte's Gull	3	1	1	1	0	3	6
COLUMBIDAE								
Columba fasciata	Band-tailed Pigeon	11	2	3	1	0	3	9
Zenaida macroura	Mourning Dove	11	2	2	1	2	2	9
STRIGIDAE								
*Otus kennicottii	Western Screech-owl	14	4	1	0	0	1	6
Bubo virginianus	Great Horned Owl	12	4	1	1	2	1	9
Glaucidium gnoma	Northern Pygmy-owl	14	4	1	1	0	1	7
Strix occidentalis	Northern Spotted Owl	14	4	1	1	3	3	12
*Strix varia	Barred Owl	14	4	1	0	0	2	7
*Aegolius acadicus	Northern Saw-whet Owl	14	4	1	0	0	2	7
CAPRIMULGIDAE								
Chordeiles minor	Common Nighthawk	6	2	3	1	0	1	7
APODIDAE								
Cypseloides niger	Black Swift	4	2	[illegible]	[illegible]	[illegible]	[illegible]	7
Chaetura vauxi	Vaux's Swift	14	2	[illegible]	[illegible]	[illegible]	[illegible]	7
TROCHILIDAE								
Selasphorus rufus	Rufous Hummingbird	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Stellula calliope	Calliope Hummingbird	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
*Calypte anna	Anna's Hummingbird	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
ALCEDINIDAE								
Ceryle alcyon	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Table B-2 (cont'd).

SKAGIT DAMS ORIGINAL IMPACTS HEP STUDY--BIRDS AND RANKING PARAMETERS (source: Tabor, R.D., 1971. Biotic survey of Ross Lake Basin)

SPECIES	COMMON NAME	LIFE FORM *	SEASONALITY	ABUNDANCE	AVAILABLE INFORMATION	HEP MODELS	VERSATILITY	RANK
PICIDAE								
Colaptes auratus	Northern Flicker	13	4	4	1	1	2	12
Dryocopus pileatus	Pileated Woodpecker	13	4	2	1	3	2	12
Melanerpes lewis	Lewis' Woodpecker	13	2	1	1	3	3	10
Sphyrapicus varius	Yellow-bellied Sapsucker	13	2	1	1	0	3	7
Picoides villosus	Hairy Woodpecker	13	4	1	1	0	3	9
Picoides pubescens	Downy Woodpecker	13	4	1	1	3	3	12
Picoides tridactylus	Three-toed Woodpecker	13	4	1	1	0	3	9
TYRANNIDAE								
Tyrannus verticalis	Western Kingbird	11	2	1	1	0	3	7
Empidonax traillii	Willow Flycatcher	7	2	1	1	1	2	7
Contopus sordidulus	Western Wood-pewee	11	2	1	1	0	2	6
Contopus borealis	Olive-sided Flycatcher	10	2	1	1	0	2	6
*Empidonax difficilis	Western Flycatcher	10	2	1	0	1	2	6
ALAUDIDAE								
Eremophila alpestris	Horned Lark	5	1	1	1	0	3	6
HIRUNDINIDAE								
Tachycineta thalassina	Violet-green Swallow	14	1	3	1	0	3	8
Tachycineta bicolor	Tree Swallow	14	1	3	1	0	3	8
Riparia riparia	Bank Swallow	16	1	1	1	0	3	6
Stelgidopteryx serripennis	Northern Rough-winged Swallow	16	1	3	1	0	3	8
Hirundo rustica	Barn Swallow	4	2	3	1	0	3	9
Hirundo pyrrhonota	Cliff Swallow	4	1	3	1	0	3	8
CORVIDAE								
Perisoreus canadensis	Gray Jay	11	4	1	1	0	3	9
Cyanocitta stelleri	Steller's Jay	11	4	2	1	0	2	9
Pica pica	Black-billed Magpie	7	1	1	1	0	1	4
Corvus corax	Common Raven	4	4	4	1	0	1	10
Corvus brachyrhynchos	American Crow	11	2	3	1	0	1	7
Nucifraga columbiana	Clark's Nutcracker	10	4	2	1	0	2	9
PARIDAE								
Parus atricapillus	Black-capped Chickadee	14	4	4	1	3	3	15
Parus gambeli	Mountain Chickadee	14	4	1	1	0	2	8
Parus rufescens	Chestnut-backed Chickadee	14	2	2	1	0	2	7
AEGITHALIDAE								
*Psaltriparus minimus	Bushtit	8	2	1	0	0	2	5
SITTIDAE								
Sitta canadensis	Red-breasted Nuthatch	13	4	2	1	0	3	10
CERTHIIDAE								
Certhia americana	Brown Creeper	14	4	1	1	0	3	9
CINCLIDAE								

* See Table B-1 for life forms.

Table B-2 (cont'd).

SKAGIT DAMS ORIGINAL IMPACTS HEP STUDY--BIRDS AND RANKING PARAMETERS (source: Tabor, R.D., 1971. Biotic survey of Ross Lake Basin)

SPECIES	COMMON NAME	LIFE FORM*	SEASONALITY	ABUNDANCE	AVAILABLE INFORMATION	HEP MODELS	VERSATILITY	RANK	
Cinclus mexicanus	American Dipper	3	4	3	1	1	3	12	
TROGLODYTIDAE									
Troglodytes troglodytes	Winter Wren	14	4	4	1	0	2	11	
MUSCICAPIDAE									
Turdus migratorius	American Robin	7	2	4	1	0	1	8	0
Ixoreus naevius	Varied Thrush	11	4	3	1	0	2	10	
Catharus guttatus	Hermit Thrush	5	2	3	1	0	2	8	
Catharus ustulatus	Swainson's Thrush	7	2	3	1	0	2	8	
Sialis currucoides	Mountain Bluebird	14	1	1	1	0	2	5	
Myadestes townsendi	Townsend's Solitaire	6	2	1	1	0	2	6	
Regulus satrapa	Golden-crowned Kinglet	10	3	4	1	0	2	10	
Regulus calendula	Ruby-crowned Kinglet	10	3	1	1	0	2	7	
MOTACILLIDAE									
Anthus spinoletta	Water Pipit	5	1	1	1	0	3	6	
BOMBYCILLIDAE									
Bombycilla garrulus	Bohemian Waxwing	8	2	1	1	0	3	7	
Bombycilla cedrorum	Cedar Waxwing	9	2	2	1	0	3	8	
STURNIDAE									
Sturnus vulgaris	European Starling	14	1	1	1	0	1	4	
VIREONIDAE									
Vireo solitarius	Solitary Vireo	11	2	1	1	0	2	6	
Vireo olivaceus	Red-eyed Vireo	11	1	1	1	0	3	6	
Vireo gilvus	Warbling Vireo	11	2	3	1	0	3	9	
EMBERIZIDAE									
*Vermivora celata	Orange-crowned Warbler	6	1	1	0	0	3	5	
Vermivora ruficapilla	Nashville Warbler	6	1	1	1	0	3	6	
Dendroica petechia	Yellow Warbler	8	2	1	1	3	3	10	
Dendroica coronata	Yellow-rumped Warbler	10	2	2	1	0	2	7	
Dendroica nigrescens	Black-throated Gray Warbler	10	1	2	1	0	2	6	
Dendroica townsendi	Townsend's Warbler	10	2	1	1	0	3	7	
Oporornis tolmiei	MacGillivray's Warbler	8	2	1	1	0	2	6	
Wilsonia pusilla	Wilson's Warbler	5	1	2	1	0	3	7	
Sturnella neglecta	Western Meadowlark	5	1	1	1	0	3	6	
Xanthocephalus xanthocephalus	Yellow-headed Blackbird	7	1	1	1	3	3	9	
Agelaius phoeniceus	Red-winged Blackbird	7	2	2	1	3	3	11	
Euphagus cyanocephalus	Brewer's Blackbird	7	1	1	1	0	2	5	
Molothrus ater	Brown-headed Cowbird	7	2	2	1	0	2	7	
Piranga ludoviciana	Western Tanager	10	2	3	1	0	2	8	
Pheucticus melanocephalus	Black-headed Grosbeak	11	2	1	1	0	2	6	
Pipilo erythrophthalmus	Rufous-sided Towhee	7	2	2	1	0	3	8	
Junco hyemalis	Dark-eyed Junco	5	4	4	1	0	2	11	
Spizella passerina	Chipping Sparrow	7	2	1	1	0	2	6	
Zonotrichia leucophrys	White-crowned Sparrow	7	1	3	1	0	2	7	
Zonotrichia atricapilla	Golden-crowned Sparrow	5	1	2	1	0	3	7	

* See Table B-1 for life forms

Table B-2 (cont'd).

SKAGIT DAMS ORIGINAL IMPACTS HEP STUDY--BIRDS AND RANKING PARAMETERS (source: Tabor, R.D., 1971. Biotic survey of Ross Lake Basin)

SPECIES	COMMON NAME	LIFE FORM*	SEASONALITY	ABUNDANCE	AVAILABLE INFORMATION	HEP MODELS	VERSATILITY	RANK
Melospiza melodia	Song Sparrow	7	1	1	1	1	3	7
FRINGILLIDAE								
Coccothraustes vespertina	Evening Grosbeak	11	2	1	1	0	2	6
Carpodacus cassinii	Cassin's Finch	11	1	1	1	0	2	5
Pinicloa enucleator	Pine Grosbeak	11	3	1	1	0	3	8
Carduelis pinus	Pine Siskin	11	4	3	1	0	2	10
Carduelis tristis	American Goldfinch	8	1	1	1	0	2	5

^ federal threatened or endangered species
#not on Tabor's list but known to occur in the Skagit area

seasonality: 4=annual resident; 3=winter resident; 2=summer resident; 1=migrant
abundance: 4=abundant; 3=common; 2=uncommon; 1=rare; 0=no information
available information: 2=site specific studies; 1=observed on site; 0=none/general
HEP models: 3=yes (final); 2=yes (draft); 1=yes (incomplete); 0=no model
versatility (based on the number of cover types and successional stages used in feeding and reproduction): 3=low; 2=medium; 1=high
rank=sum of all parameters

* See Table B-1 for life forms.

Table B-3.

SKAGIT DAMS ORIGINAL IMPACTS HEP STUDY---MAMMALS ORDERED BY LIFE FORM AND RANK
(source: Taber, R.D., 1971. Biotic Survey of Ross Lake Basin)

SPECIES	COMMON NAME	LIFE FORM *	RANK	HABITAT TYPE: CONIFEROUS FOREST	BROADLEAF FOREST	MIXED FOREST	REGENERATION BROADLEAF/MIXED	SHRUB DOMINATED	HERBACEOUS DOMINATED	AGRICULTURE	ROCK/ TALUS	PALUSTRINE	RIPARIAN	RIVERINE	LACUSTRINE	# HEP MODELS
Zapus princeps	Jumping Mouse	3	9	x		x	x		x	x				x		0
Felis concolor	Mountain Lion	4	8	x	x	x	x	x	x		x		x			0
Marmota flaviventris	Yellow-bellied Marmot	4	9						x		x					0
Felis rufus	Bobcat	4	10	x	x	x	x	x	x		x		x			0
Oreamnos americanus	Mountain Goat	4	11						x		x					0
Cervus elaphus roosel veltii	Roosevelt Elk	5	9	x	x	x	x	x	x	x		x	x			1
Alces alces	Moose	5	10	x								x	x			1
Odocoileus hemionus hemionus	Mule Deer	5	13	x	x	x	x	x	x	x			x			1
Odocoileus hemionus columbianus	Black-tailed Deer	5	13	x	x	x	x	x	x	x			x			1
Lepus americanus	Snowshoe Hare	5	14	x	x	x	x									3
Erethizon dorsatum	Porcupine	6	8	x	x	x	x						x			0
Tamiasciurus douglasii	Douglas' Squirrel	10	10	x		x							x			1
Tamiasciurus hudsonicus	Red Squirrel	10	10	x		x							x			0
Procyon lotor	Raccoon	14	7						x	x		x	x		x	0
Glaucomys sabrinus	Northern Flying Squirrel	14	9	x		x										0
Myotis lucifugus	Little Brown Myotis	14	10	x	x	x	x	x	x	x			x			0
Martes americana	Marten	14	12	x		x							x			3
Microtus longicaudus	Long-tail Vole	15	8	x								x	x			0
Neotoma cinerea	Bushy-tailed Woodrat	15	8	x	x	x	x				x		x			0
Canus latrans	Coyote	15	8	x	x	x	x	x	x	x		x	x			0
Aplodontia rufa	Mountain Beaver	15	8	x	x	x	x						x			0
Vulpes vulpes	Red Fox	15	8	x	x	x		x	x	x		x	x			0
Microtus oregoni	Creeping Vole	15	8	x	x	x	x	x	x			x	x			0
Sorex cinereus	Masked Shrew	15	9	x	x	x							x			0
Ursus americanus	Black Bear	15	9	x	x	x	x	x	x				x			0
Neurotrichus gibbsii	Shrew-mole	15	9	x	x	x	x					x	x			0
Sorex vagrans	Wandering Shrew	15	9	x	x	x	x		x			x	x			0
Microtus townsendii	Townsend's Vole	15	9	x		x							x			0
Microtus richardsoni	Water Vole	15	9									x	x			0
Microtus montanus	Mountane Vole	15	9		x			x	x	x			x			0
Mustela frenata	Long-tailed Weasel	15	9	x	x	x	x	x	x	x			x			0
Spermophilus saturatus	Cascade Ground Squirrel	15	10	x		x					x					0
Phenacomys intermedius	Heather Vole	15	10	x					x				x			0
Sorex trowbridgii	Trowbridge's Shrew	15	11	x	x	x	x						x			0
Eutamias townsendii	Townsend's Chipmunk	15	11	x	x	x	x	x					x			0
Ochotona princeps	Pika	15	11								x					0
Marmoata frenta	Hoary Marmot	15	11						x		x					0
Peromyscus maniculatus	White-footed Deer Mouse	15	11	x	x	x	x	x	x	x			x			0
Eutamias amoenus	Yellow Pine Chipmunk	15	12	x		x	x	x					x			0
Clethrioncmys gapperi	Southern Red-backed Vole	15	13	x	x	x							x			3
Sorex palustria	Northern Water Shrew	16	10									x	x	x		0
Lutra canadensis	River Otter	16	11									x	x	x	x	2
Mustela vison	Mink	16	12									x	x	x	x	3
Castor canadensis	Beaver	16	12									x	x	x	x	3

#HEP models: 3=yes (final); 2=yes (draft)); 1=yes (preliminary); 0=no model

* See Table B-1 for life forms.

Table B-3 (cont'd).

SKAGIT DAMS ORIGINAL IMPACTS HEP STUDY---REPTILES AND AMPHIBIANS ORDERED BY LIFE FORM AND RANK
(source: Taber, R.D., 1971. Biotic Survey of Ross Lake Basin)

SPECIES	COMMON NAME	LIFE FORM*	RANK	# HEP MODELS	CONIFEROUS FOREST	BROADLEAF FOREST	MIXED FOREST	REGENERATION BROADLEAF/MIXED	SHRUB DOMINATED	HERBACEOUS DOMINATED	AGRICULTURE	ROCK/ TALUS	PALUSTRINE	RIPARIAN	RIVERINE	LACUSTRINE
					HABITAT TYPE											
Rana catesbeiana	Bull Frog	1	7	2									x	x	x	x
Rana aurora	Red-legged Frog	2	6	0	x								x	x		x
Ambystoma macrodactylum	Long-toed Salamander	2	6	0	x		x						x	x		x
Ascaphus truei	Tailed Frog	2	7	0	x		x						x	x	x	
Rana pipiens	Western Leopard Frog	2	7	0									x	x		x
Hyla regila	Pacific Tree Frog	2	7	0	x	x	x						x	x		x
Rana cascade	Cascade Frog	2	9	0	x								x	x		x
Bufo boreas	Western Toad	2	11	0	x	x	x	x					x	x		x
Thamnophis elegans	Wandering Garter Snake	3	9	0	x	x	x	x					x	x		
Thamnophis sirtalis	Common Garter Snake	3	10	0		x	x	x					x	x		
Thamnophis ordinoides	Northwestern Garter Snake	3	10	0	x		x	x					x	x		
Gerrhonotus coreruleus	Northern Alligator Lizard	5	9	1	x	x	x									
Charina bottae	Rubber Boa	5	9	0	x	x	x									

#HEP models: 3=yes (final); 2=yes (draft)); 1=yes (preliminary); 0=no model

* See Table B-1 for life forms.

Table B-3 (cont'd).

SKAGIT DAMS ORIGINAL IMPACTS HEP STUDY -- Birds Ordered by Life Form and Rank (source: Tabor, R.D., 1971. Biotic Survey of Ross Lake Basin)

SPECIES	COMMON NAME	LIFE FORM *	RANK	*HEP MODELS	HABITAT TYPES: CONIFER FOREST	BROADLEAF FOREST	MIXED FOREST	REGENERATION BROADLEAF/MIXED	SHRUB DOMINATED	HERBACEOUS DOMINATED	AGRICULTURE	ROCK/ TALUS	PALUSTRINE	RIPARIAN	RIVERINE	LACUSTRINE
*Porzana carolina	Sora	3	4	0									x	x	x	x
*Podilymbus podiceps	Pied-billed Grebe	3	4	0												x
*Rallus limicola	Virginia Rail	3	4	0									x	x		x
Mergus serrator	Red-breasted Merganser	3	5	0											x	x
*Phalacrocorax auritus	Double-crested Cormorant	3	5	0												x
Cygnus columbianus	Tundra Swan	3	6	0									x			x
Larus glaucescens	Glaucous-winged Gull	3	6	0												x
Anas clypeata	Northern Shoveler	3	6	0									x		x	x
Gallinago gallinago	Common Snipe	3	6	0									x			x
Larus philadelphia	Bonaparte's Gull	3	6	0											x	x
Aythya marila	Greater Scaup	3	6	0									x		x	x
Anas acuta	Northern Pintail	3	6	0							x		x		x	x
Larus delawarensis	Ring-billed Gull	3	6	0											x	x
Podiceps nigricollis	Eared Grebe	3	6	0												x
Larus canus	Mew Gull	3	6	0												x
Branta canadensis	Canada Goose	3	7	1							x		x		x	x
Podiceps auritus	Horned Grebe	3	7	0.												x
Histrionicus histrionicus	Harlequin Duck	3	7	0											x	
*Fulica americana	American Coot	3	7	3									x			x
Larus californicus	California Gull	3	7	0												x
Melanitta deglandi	White-winged Scoter	3	7	0												x
Aythya affinis	Lesser Scaup	3	9	3									x		x	x
Aechmophorus occidentalis	Western Grebe	3	9	3												x
Anas platyrhynchos	Mallard	3	9	1							x		x		x	x
Aythya americana	Redhead	3	9	3									x			x
Anas discors	Blue-winged Teal	3	9	3									x		x	x
Actitis macularia	Spotted Sandpiper	3	10	0									x		x	x
Charadrius vociferus	Killdeer	3	10	0						x			x		x	x
Gavia immer	Common Loon	3	10	0												x
Cinclus mexicanus	American Dipper	3	12	1											x	
Falco peregrinus^	Peregrine Falcon^	4	5	0					x	x						x
Cypseloides niger	Black Swift	4	7	0												x
Hirundo pyrrhonota	Cliff Swallow	4	8	0							x	x				
Hirundo rustica	Barn Swallow	4	9	0							x	x				
Corvus corax	Common Raven	4	10	0	x	x	x	x	x	x	x	x		x		
Eremophila alpestris	Horned Lark	5	6	0						x						
Anthus spinoletta	Water Pipit	5	6	0						x			x	x		x
Circus cyaneus	Northern Harrier	5	6	0					x	x	x		x			
Sturnella neglecta	Western Meadowlark	5	6	0					x	x	x					
Zonotrichia atricapilla	Golden-crowned Sparrow	5	7	0					x	x						
Wilsonia pusilla	Wilson's Warbler	5	7	0		x	x		x					x		
Canachites canadensis	Spruce Grouse	5	8	0	x					x						
Catharus guttatus	Hermit Thrush	5	8	0	x		x							x		
Lagopus leucurus	White-tailed Ptarmigan	5	9	0						x						
Junco hyemalis	Dark-eyed Junco	5	11	0	x	x	x	x	x					x		
Bonasa umbellus	Ruffed Grouse	5	14	3	x	x	x	x						x		
Dendragapus obscurus	Blue Grouse	5	14	3	x		x		x	x						
*Vermivora celata	Orange-crowned Warbler	6	5	0	x	x	x	x	x					x		
[redacted]	[redacted]	6	6	0	x	x	x	x	[redacted]							
[redacted]	[redacted]	6	[redacted]	[redacted]	x	x	[redacted]							x	[redacted]	

Table B-3 (cont'd).

SPECIES	COMMON NAME	LIFE FORM*	RANK	*HEP MODELS	HABITAT TYPES: CONIFER FOREST	BROADLEAF FOREST	MIXED FOREST	REGENERATION BROADLEAF/MIXED	SHRUB DOMINATED	HERBACEOUS DOMINATED	AGRICULTURE	ROCK/ TALUS	PALUSTRINE	RIPARIAN	RIVERINE	LACUSTRINE
Chordeiles minor	Common Nighthawk	6	7	0					x	x						x
Pica pica	Black-billed Magpie	7	4	0					x	x	x			x		
*Calypte anna	Anna's Hummingbird	7	5	0		x										
Euphagus cyanocephalus	Brewer's Blackbird	7	5	0	x		x	x	x	x	x			x		
Stellula calliope	Calliope Hummingbird	7	6	0					x							
Spizella passerina	Chipping Sparrow	7	6	0	x	x	x	x	x	x				x		
Molothrus ater	Brown-headed Cowbird	7	7	0					x	x	x			x		
Zonotrichia leucophrys	White-crowned Sparrow	7	7	0					x	x						
Melospiza melodia	Song Sparrow	7	7	1					x					x		
Empidonax traillii	Willow Flycatcher	7	7	1			x		x					x		
Pipilo erythrophthalmus	Rufous-sided Towhee	7	8	0				x	x					x		
Turdus migratorius	American Robin	7	8	0	x	x	x	x	x	x	x			x		
Catharus ustulatus	Swainson's Thrush	7	8	0	x	x	x							x		
Xanthocephalus xanthocephalus	Yellow-headed Blackbird	7	9	3						x				x		
Agelaius phoeniceus	Red-winged Blackbird	7	11	3						x	x			x		
*Psaltriparus minimus	Bushtit	8	5	0		x	x	x	x							
Carduelis tristis	American Goldfinch	8	5	0	x			x	x	x				x		
Oporornis tolmiei	MacGillivray's Warbler	8	6	0	x	x	x		x							
Bombycilla garrulus	Bohemian Waxwing	8	7	0	x	x	x							x		
Dendroica petechia	Yellow Warbler	8	10	3		x								x		
Bombycilla cedrorum	Cedar Waxwing	9	8	0	x	x	x							x		
Contopus borealis	Olive-sided Flycatcher	10	6	0	x		x									
Dendroica nigrescens	Black-throated Gray Warbler	10	6	0	x		x		x							
*Empidonax difficilis	Western Flycatcher	10	6	1	x	x	x							x		
Regulus calendula	Ruby-crowned Kinglet	10	7	0	x		x									
Dendroica coronata	Yellow-rumped Warbler	10	7	0	x	x	x							x		
Dendroica townsendi	Townsend's Warbler	10	7	0	x		x									
Piranga ludoviciana	Western Tanager	10	8	0	x	x	x	x						x		
Nucifraga columbiana	Clark's Nutcracker	10	9	0	x											
Regulus satrapa	Golden-crowned Kinglet	10	10	0	x		x									
Carpodacus cassinii	Cassin's Finch	11	5	0	x		x	x		x				x		
Vireo solitarius	Solitary Vireo	11	6	0	x	x	x							x		
Contopus sordidulus	Western Wood-pewee	11	6	0	x		x			x				x		
Vireo olivaceus	Red-eyed Vireo	11	6	0		x								x		
Falco columbarius	Merlin	11	6	0			x	x	x							
Accipiter striatus	Sharp-shinned Hawk	11	6	0	x											
Accipiter cooperii	Cooper's Hawk	11	6	0	x									x		
Pheucticus melanocephalus	Black-headed Grosbeak	11	6	0	x	x	x							x		
Coccothraustes vespertina	Evening Grosbeak	11	6	0	x		x							x		
Corvus brachyrhynchos	American Crow	11	7	0	x	x	x	x			x			x		
Tyrannus verticalis	Western Kingbird	11	7	0					x					x		
Pinicola enucleator	Pine Grosbeak	11	8	0	x		x									
Selasphorus rufus	Rufous Hummingbird	11	9	0	x	x	x							x		
Accipiter gentilis	Northern Goshawk	11	9	1	x											
Cyanocitta stelleri	Steller's Jay	11	9	0	x	x	x							x		
Vireo gilvus	Warbling Vireo	11	9	0		x	x							x		
Zenaida macroura	Mourning Dove	11	9	2					x	x	x					
Perisoreus canadensis	Gray Jay	11	9	0	x		x									
Columba fasciata	Band-tailed Pigeon	11	9	0	x	x	x									
Ixoreus naevius	Varied Thrush	11	10	0	x	x	x	x						x		
Carduelis pinus	Pine Siskin	11	10	0	x		x	x	x	x						
Butorides striatus	Green-backed Heron	12	6	0											x	

* See Table B-1 for life forms.

Table B-3 (cont'd).

SPECIES	COMMON NAME	LIFE FORM*	RANK	*HEP MODELS	HABITAT TYPES: CONIFER FOREST	BROADLEAF FOREST	MIXED FOREST	REGENERATION BROADLEAF/MIXED	SHRUB DOMINATED	HERBACEOUS DOMINATED	AGRICULTURE	ROCK/ TALUS	PALUSTRINE	RIPARIAN	RIVERINE	LACUSTRINE
Pandion haliaetus	Osprey	12	6	0	x									x		
Aquila chrysaetos	Golden Eagle	12	7	0	x				x	x		x				
*Ardea herodias	Great Blue Heron	12	7	3									x	x	x	x
Haliaeetus leucocephalus^	Bald Eagle^	12	8	3	x									x		
Bubo virginianus	Great Horned Owl	12	9	2	x	x	x				x	x		x		
Buteo jamaicensis	Red-tailed Hawk	12	10	2	x	x	x		x	x	x	x		x		
Sphyrapicus varius	Yellow-bellied Sapsucker	13	7	0		x								x		
Picoides villosus	Hairy Woodpecker	13	9	0	x		x									
Picoides tridactylus	Three-toed Woodpecker	13	9	0	x											
Sitta canadensis	Red-breasted Nuthatch	13	10	0	x		x									
Melanerpes lewis	Lewis' Woodpecker	13	10	3			x							x		
Dryocopus pileatus	Pileated Woodpecker	13	12	3	x	x	x									
Picoides pubescens	Downy Woodpecker	13	12	3		x								x		
Colaptes auratus	Northern Flicker	13	12	1	x	x	x							x		
Sturnus vulgaris	European Starling	14	4	0	x	x	x			x	x			x		
Sialis currucoides	Mountain Bluebird	14	5	0	x				x	x						
Lophodytes cucullatus	Hooded Merganser	14	6	0									x	x	x	x
Bucephala clangula	Common Goldeneye	14	6	0											x	x
*Otus kennicottii	Western Screech-owl	14	6	0	x	x	x								x	
*Strix varia	Barred Owl	14	7	0	x	x	x							x		
Parus rufescens	Chestnut-backed Chickadee	14	7	0	x	x	x							x		
Glaucidium gnoma	Northern Pygmy-owl	14	7	0	x	x	x									
*Aegolius acadicus	Northern Saw-whet Owl	14	7	0	x	x	x							x		
Mergus merganser	Common Merganser	14	7	0										x	x	x
Chaetura vauxi	Vaux's Swift	14	7	0	x	x	x						x		x	x
Falco sparverius	American Kestrel	14	8	0	x	x	x	x	x	x	x			x		
Tachycineta bicolor	Tree Swallow	14	8	0	x	x	x							x		
Tachycineta thalassina	Violet-green Swallow	14	8	0	x	x	x					x		x		
Parus gambeli	Mountain Chickadee	14	8	0	x		x							x		
Certhia americana	Brown Creeper	14	9	0	x	x	x							x		
Bucephala albeola	Bufflehead	14	10	1									x	x		x
Aix sponsa	Wood Duck	14	10	3										x		
Troglodytes troglodytes	Winter Wren	14	11	0	x	x	x							x		
Strix occidentalis	Northern Spotted Owl	14	12	3	x											
Bucephala islandica	Barrow's Goldeneye	14	12	1											x	x
Parus atricapillus	Black-capped Chickadee	14	15	3		x	x							x		
Riparia riparia	Bank Swallow	16	6	0										x		
Stelgidopteryx serripennis	Northern Rough-winged Swallow	16	8	0										x		
Ceryle alcyon	Belted Kingfisher	16	13	3									x	x	x	x

* See Table B-1 for life forms.

*HEP models: 3 = yes (published)
2 = yes (draft)
1 = yes (preliminary)
0 = no model

Table B-4

SAMPLING PLAN--ACTUAL VS PLANNED
SKAGIT DAMS ORIGINAL IMPACTS

GORGE SUMMARY

Community Type	Planned Sampling Distribution: On-project Polygons	Sites/ Polygon	Alternatives	Off-project Areas	Sites/ Polygon	Total Sites	Actual Sampling Distribution: On-project Polygons	Sites/ Polygon	Off-project Areas	Sites/ Polygon	Total Sites
old growth conifer											
closed mature conifer	D-27,D-9,D-34	1/1/1	D-21			3	D-27,D-34,D21	1/1/1			3
open mature conifer	D-29	3				3	D-29	1			1
lodgepole pine											
regenerative conifer				(H-53^,H-20,H-39)*	(3/1/1)*	*			(H-53^,H-39,H-64a,H-22)*	(3/1/1/1)*	*
regenerative broadleaf/mixed											
broadleaf											
mixed conifer/broadleaf	D-17,D-7	1/2				3	D-17	2			2
shrubland											
wet meadow/marsh											
shrub swamp											
conifer swamp											
broadleaf swamp											
mixed swamp											
riparian old growth conifer			BBV-10	(R-10a^,R-11a,P-5a)*	(3/1/1)*	*			(P-5a,BBV-6,R-10a)*	(1/2/4)*	*
riparian mature conifer	D-22	3				3			R-11a*	1*	
riparian broadleaf											
riparian mixed conifer/broadleaf											
riparian/avalanche shrubland	D-13	2				2	D-13	2			2
TOTALS						14					8

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* sampling effort is included in Ross Summary

Planned vs Actual Changes

closed mature conifer
D-21 replaced D-9 (small with large wash-out area; retyped as mixed conifer/broadleaf)

open mature conifer
D-29 too small & steep to fit 3 sites

regenerative conifer
H-64a (northern part of H-64) replaced H-20

mixed conifer/broadleaf
D-7 inaccessable (too steep)
D-17 too small to fit 3 sites

riparian old growth conifer
BBV-6 (retyped from conifer swamp) replaced R-11a (retyped as riparian mature conifer)

riparian mature conifer
D-22 (retyped as mature closed conifer); no other sites available

riparian/avalanche shrub
actual=planned

Table B-4, cont'd

SAMPLING PLAN--ACTUAL VS PLANNED
SKAGIT DAMS ORIGINAL IMPACTS

DIABLO SUMMARY

Community Type	Planned Sampling Distribution: On-project Polygons	Sites/ Polygon	Alternatives	Off-project Areas	Sites/ Polygon	Total Sites	Actual Sampling Distribution: On-project Polygons	Sites/ Polygon	Off-project Areas	Sites/ Polygon	Total Sites
old growth conifer	R-10,R-11	2/1				3	R-10,R-11	3/1			4
closed mature conifer	R-50,R-23,R-16	1/1/1	R-15			3	R-50,R-16,R-15	1/1/2			4
open mature conifer	D-41,R-56,R-71	1/1/1	D-43,R-49			3	R-71,R-49,D-43	1/1/1			3
lodgepole pine (open & closed)	R-57, R-32	1/2				3	R-32,R-57	2/1			3
regenerative conifer				(H-53^,H-20,H-39)*	(3/1/1)*	*			(H-53^,H-39,H-64a,H-22)*	(3/1/1/1)*	*
regenerative broadleaf/mixed											
broadleaf	R-51,R-60	1/2				3	R-51,R-60	2/1			3
mixed conifer/broadleaf	R-67	3				3	R-67	3			3
shrubland											
wet meadow/marsh											
shrub swamp											
conifer swamp											
broadleaf swamp											
mixed swamp											
riparian old growth conifer							R-10a*	4*			
riparian mature conifer							R-11a*	2*			*
riparian broadleaf	(R-13^,R-14)*	(3/1)*				*	(R-14,R10b)*	(3/1)*			*
riparian mixed conifer/broadleaf							H-59*	1*			
riparian/avalanche shrubland											
TOTALS						18					20

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* sampling effort is included in Ross Summary

Planned vs Actual Changes

old growth conifer
planned=actual

closed mature conifer
R-15 replaced R-23 (inaccessable)

open mature conifer
D-43 replaced D-41 (retype as mixed)
R-49 replaced R-56 (inaccessable & too small)

riparian old growth conifer
planned=actual

lodgepole pine
planned=actual

regenerative conifer
H-64a (northern part of H-64) replaced H-20

broadleaf
R-60 too small for 2 sites; put in R-51

riparian mixed conifer/broadleaf
H-59 (retyped from riparian regenerative broadleaf/conifer); represents only on-project polygon

mixed conifer/broadleaf
planned=actual (reduced)

riparian mature conifer
R-11a (retyped from riparian old growth conifer) replaced BBV-4 (retyped as mature closed conifer)

riparian broadleaf
R-10b replaced R-13 (retyped as riparian mixed; stream has changed course; trees are dying; inaccessable)

Table B-4, cont'd
SAMPLING PLAN--ACTUAL VS PLANNED
SKAGIT DAMS ORIGINAL IMPACTS

ROSS SUMMARY

Community Type	Planned Sampling Distribution: On-project Polygons	Sites/ Polygon	Alternatives	Off-project Areas	Sites/ Polygon	Total Sites	Actual Sampling Distribution: On-project Polygons	Sites/ Polygon	Off-project Areas	Sites/ Polygon	Total Sites
old growth conifer	P-5^,P-52,P-31	3/1/1	P-59,P-17,P-19			5	P-59,P-5,P-31,P-17a	3/3/1/1			8
closed mature conifer	H-74,P-65^,H-21	1/3/1	P-49,H-32,R-94 P-44,P-85			5	P-52,P-65^,H-60,H-74^ P-17,P-44,R-94,H-32,P-49	1/3/1/3 1/1/1/1/1			13
open mature conifer	P-9,H-25^,P-68	1/3/1	H-29,H-70,H-30/31			5	H-25,P-68,H-30/31	2/1/3			6
lodgepole pine (open & closed)	P-84,R-98^,P-27	1/3/1	P-33,P-15			5	R-98^,P-84,P-33	3/1/1			5
regenerative conifer (& reg. lodgepole)	H-53^,H-20,H-39	3/1/1	H-22,H-55			5	H-53^,H-39,H-64a,H-22	3/1/1/1			6
regenerative broadleaf/mixed	H-64^,H-61,H-15	3/1/1	P-80			5	H-64,H-15,P-80	3/1/1			5
broadleaf	H-54^,H-67,H-44	3/1/1	P-55			5	H-44,H-54^,P-55	1/3/1			5
mixed conifer/broadleaf	R-83^,P-70,H-24	3/1/1	P-88,P-42			5	P-42,H-24,R-83^	1/1/3			5
shrubland	H-66	1		LC-1,LC-2^	1/3	5			LC-1,LC-2	2/2	4
wet meadow/marsh				BBV-3^,BBV-8,CS-5	3/1/1	5			BBV-3^,CS-5,BBV-8	3/1/1	5
shrub swamp	P-34	1		BBV-2^,BBV-11	3/1	5	P-34	1	BBV-2^,BBV-11	3/1	5
conifer swamp				BBV-6^	3	3					0
broadleaf swamp	P-8^	3				3	P-8^	3			3
mixed swamp				CS-4^	3	3			CS-4^	3	3
riparian old growth conifer	P-5a	1	BBV-10	R-10a^,R-11a	3/1	5	P-5a	1	BBV-6,R-10a	2/4	7
riparian mature conifer				BBV-4^,CS-3	3/1	4			R-11a	2	2
riparian broadleaf			CS-2	R-13^,R-14,CS-1	3/1/1	5			CS-1,R-14,R-10b	1/3/1	5
riparian mixed conifer/broadleaf				BBV-7^	3	3	H-59	1	BBV-7^	3	4
riparian/avalanche shrubland	P-74	1		BBV-9^	3	4	P-74	1	BBV-9	2	3
TOTALS						85					94

Table B-4, cont'd

Planned vs Actual Changes

old growth conifer
  P-59 replaced P-52 (retyped as closed mature conifer)
  P-19 retyped as closed mature conifer
  P-17 most retyped as closed mature conifer;
    P-17a small portion remains old growth

closed mature conifer
  P-52 (retyped from old growth conifer)
  H-60 (mistakenly sampled instead of H-61) replaced H-21
  P-17 (retyped from old growth conifer)

open mature conifer
  H-30/31 replaced P-9 (inaccessable)
  H-70, H-29 inaccessable
  H-25 could only fit 2 sites

lodgepole pine
  P-33 replaced P-27 (retyped as closed canopy conifer)

regenerative conifer
  H-64a (northern part of H-64) replaced H-20;
   (retyped as regenerative mixed)

regenerative broadleaf/mixed
  P-80 replaced H-61 (retyped as mixed conifer/broadleaf)

broadleaf
  P-55 replaced H-67 (retyped as avalanche shrub)

mixed conifer/broadleaf
  P-42 replaced P-70 (retyped as open mature conifer)

shrubland
  H-66 (retyped as broadleaf);
    no on-site replacements available
  LC-2 could only fit 2 sites

wet meadow/marsh
  planned=actual

shrub swamp
  planned=actual

conifer swamp
  BBV-6 (retyped as riparian old growth conifer);
    no other sites available

broadleaf swamp
  planned=actual

mixed swamp
  planned=actual

riparian old growth conifer
  BBV-6 (retyped from conifer swamp) replaced R-11a (retyped as riprain mature conifer)

riparian mature conifer
  R-11a (retyped from riparian old growth conifer); replaced BBV-4 (retyped as closed conifer)
  CS-3 (retyped as mature closed conifer); no other sites available

riparian regenerative broadleaf/conifer
  H-59 (retyped as riparian mixed conifer/broadleaf);
    no other sites available; entire habitat type is eliminated

riparian broadleaf
  R-10b (a broadleaf inclusion in R-10) replaced R-13 (retyped as mixed swamp; stream has
    changed course; trees are dying; inaccessible)

riparian mixed conifer/broadleaf
  H-59 (retyped from riparian regenerative broadleaf/conifer); represents the only on-project
    polygon)

riparian/avalanche shrubland
  planned=actual

Table B-5. Aerial photograph and cover type map measurements -- red-tailed hawk habitat interspersion indices. Scale of map 1:100,000.

ROSS - Pre-project

COG Map distances from random points within cover polygon to open habitat

	9mm	14	4	8	10		SI
	5	4	1	6	2		
	4	8	-	23	4		
	$\bar{X}$ = 7.286mm = 0.45 miles						1.0
CC	44mm	10	2	16	6		
	6	38	3	23	6		
	31	12	9	2	4		
	$\bar{X}$ = 14.133mm = 0.88 miles						0.900

M No mixed pre-project

B	2mm	2	no more broadleaf pre-project	
	-	-		
	-	-		
	$\bar{X}$ = 2mm = 0.12 miles			1.0

Table B-5 (cont'd).

ROSS - Pre-project

rCOG Map distances from random points within cover polygons to open habitat

rCOG	7mm	12	17	35	11		SI
	6	16	2	11	17		
	10	22	26	20	13		
	$\bar{X}$ = 15mm = 0.93 miles						0.87
rCC	5mm	3	16	25	6		
	18	10	18	15	13		
	14	6	--	11	23		
	$\bar{X}$ = 13.273mm = 0.82 miles						0.95
rM	28mm	4	34	23	35		
	33	8	--	21	39		
	21	-	--	--	36		
	$\bar{X}$ = 25.636mm = 1.59 miles						0.43
rB	16mm	5	12	17	23		
	27	4	26	27	29		
	16	-	--	26	--		
	$\bar{X}$ = 19mm = 1.18 miles						0.73

Table B-5 (cont'd).

DIABLO - Pre-project

COG Map distances from random points within cover polygon to open habitat

	4mm					SI
	3					
	3					
	$\bar{X}$ = 3.333mm = 0.21 miles					1.0
CC	5mm	3	3	7	6	
	3	5	6	15	7	
	1	12	11	-	5	
	$\bar{X}$ = 6.357mm = 0.40 miles					1.0
M No pre-project mixed						
B	2mm	2	3			
	7	1	3			
	4	-	8			
	$\bar{X}$ = 3.75mm = 0.23 miles					1.0

Table B-5 (cont'd)

DIABLO - Pre-project

rCOG Map distances from random points within cover polygon to open habitat

	3mm	5	SI
	4	-	
	-	-	
	$\bar{X}$ = 4mm = 0.25 miles		1.0
rCC	5		
	-		
	-		
	$\bar{X}$ = 5mm = 0.31 miles		1.0

rM No rM pre-project

rB No rB pre-project

Table B-5 (cont'd).

GORGE - Pre-project

COG No COG

					SI
CC	2mm	1	4	6	
	7	2	10	8	
	-	2	-	-	
	$\bar{X}$ = 4.714mm = 0.29 miles				1.0

M No pre-project mixed

B No pre-project broadleaf

rCOG	5mm	
	9	
	-	
	$\bar{X}$ = 7mm = 0.43 miles	1.0
rCC	10mm	
	7	
	12	
	$\bar{X}$ = 9.667mm = 0.60 miles	1.0

Table B-5 (cont'd).

ROSS - Post-project

COG Map distances from random points within cover polygon to open habitat

	11mm	5	3	11			SI
	6	-	-	15			
	4	-	-	--			
	$\bar{X}$ = 8.5mm = 0.53 miles						1.0
CC	21mm	16	7	4	28		
	17	9	8	5	33		
	11	18	4	6	30		
	$\bar{X}$ = 14.467mm = 0.90 miles						0.91
M	8mm	7	9	5	2		
	5	8	7	2	2		
	3	-	-	2	-		
	$\bar{X}$ = 5mm = 0.31 miles						1.0
B	3mm	1	3	4	3	3	
	4	-	2	-	-	7	
	-	-	-	-	-	-	
	$\bar{X}$ = 2.857mm = 0.18 miles						1.0

Table B-5 (cont'd).

ROSS - Post-project

rCOG Map distances from random points within cover polygon to open habitat

		SI
	8mm	
	-	
	-	
	$\bar{X}$ = 8mm = 0.50 miles	1.0
rM	4mm	
	5	
	-	
	$\bar{X}$ = 4.5mm = 0.28 miles	1.0

Table B-5 (cont'd).

DIABLO - Post-project

COG Map distances from random points within cover polygon to open habitat

						SI
COG	4mm					
	3					
	4					
	$\bar{X}$ = 3.667mm = 0.23 miles					1.0
CC	5mm	10	8	15	8	
	-	10	9	16	4	
	-	11	-	16	12	
	$\bar{X}$ = 10.333mm = 0.64 miles					1.0
M	1mm	8	8			
	-	-	-			
	-	-	-			
	$\bar{X}$ = 5.667mm = 0.35 miles					1.0
B	13mm	8	12			
	15	-	--			
	--	-	--			
	$\bar{X}$ = 12mm = 0.75 miles					1.0

Table B-5 (cont'd).

DIABLO - Post-project

rCOG Map distances from random points within cover polygon to open habitat

		SI
	11mm	
	12	
	11	
	$\bar{X}$ = 11.333mm = 0.70 miles	1.0
rCC	13mm	
	$\bar{X}$ = 13mm = 0.81 miles	0.96
rM	11mm	
	$\bar{X}$ = 11mm = 0.68 miles	1.0
rB	10mm	
	12	
	--	
	$\bar{X}$ = 11mm = 0.68 miles	1.0

Table B-5 (cont'd).

GORGE - Post-Project

CC Map distances from random points within cover polygon to open habitat

	3mm	2	3	3	SI
	5	4	8	-	
	2	-	-	-	
	$\bar{X}$ = 3.7mm = 0.23 miles				1.0
M	3mm	5	2		
	$\bar{X}$ = 3.333mm = 0.21 miles				1.0

TABLE B-6

BIRDS REQUIRING SHRUBS FOR COVER, FEEDING AND PROTECTION AND FOUND PRIMARILY IN RIPARIAN AND WETLAND HABITATS

Riparian/Wetland Old Growth Conifer	Riparian/Wetland Mature Conifer	Mixed Conifer/ Broadleaf	Riparian/Wetland Broadleaf	Riparian/Wetland Shrubland
Evening grosbeak	Evening grosbeak	Wilson's warbler	Wilson's warbler	Hutton's vireo
			Bewick's wren	Warbling vireo
				Yellow warbler
				House wren
				Brewer's blackbird
				MacGillivray's warbler
				Common yellowthroat
				Wilson's warbler
				Black-headed grosbeak
				Song sparrow
				Red-winged blackbird
				American goldfinch
				Bewick's wren
				Green-wing teal

TABLE B-7

BIRDS REQUIRING LARGE TREES FOR REPRODUCTION AND/OR FEEDING

Upland	Riparian
Bald eagle	Bald eagle
Sharp-shinned hawk	Cooper's hawk
Cooper's hawk	Red-tailed hawk
Northern goshawk	Ruffed grouse
Red-tailed hawk	Northern flicker
Vaux's swift	Western wood-pewee
Hairy woodpecker	Western flycatcher
Northern flicker	Tree swallow
Pileated woodpecker	Violet-green swallow
Western wood-pewee	Gray jay
Western flycatcher	American crow
Tree swallow	Common raven
Gray jay	Osprey
Common raven	Chestnut-backed chickadee
Mountain chickadee	Red-breasted nuthatch
Chestnut-backed chickadee	Brown creeper
Spotted owl	Winter wren
Red-breasted nuthatch	Golden-crowned kinglet
Brown creeper	Ruby-crowned kinglet
Winter wren	Swainson's thrush
Golden-crowned kinglet	Varied thrush
Ruby-crowned kinglet	Western tanager
Swainson's thrush	Purple finch
Varied thrush	Pine siskin
Solitary vireo	Evening grosbeak
Western tanager	
Dark-eyed junco	
Purple finch	
Pine siskin	
Evening grosbeak	

TABLE B-8

BIRDS REQUIRING SNAGS FOR REPRODUCTION AND/OR FEEDING

Species	Nest Snag Cavity Diameter (inches)	Excavates vs. Occupies	Sound Wood vs. Decayed Wood	Minimum Nest Snag Height (feet)
Wood Duck	25	Occupies		10
Barrow's Goldeneye	25	Occupies		10
Bufflehead	17	Occupies		10
Hooded Merganser	17	Occupies		10
Common Merganser	25	Occupies		10
Osprey	N/A	Occupies		
American Kestrel	17	Occupies		20
Vaux's Swift	25	Occupies		40
Lewis' Woodpecker	17	Excavates	Decayed	30
Downy Woodpecker	11	Excavates	Sound & Decayed	10
Hairy Woodpecker	15	Excavates	Decayed	20
Northern Flicker	17	Excavates	Decayed	10
Pileated Woodpecker	25	Excavates	Sound	40
Tree Swallow	15	Occupies		20
Violet-Green Swallow	15	Occupies		20
Black-capped Chickadee	9	Occupies		10
Mountain Chickadee	9	Occupies		10
Chestnut-backed Chickadee	9	Occupies		10
Red-breasted Nuthatch	17	Excavates	Decayed	20
White-breasted Nuthatch	17	Excavates		20
Brown Creeper	15	Occupies		20
Europeon Starling	15	Occupies		10

TABLE B-9

HABITAT PARAMETERS MEASURED USING A QUADRAT

Parameter	Species	Cover-Types
Deciduous Shrub Density	Ruffed Grouse	All Upland and Riparian Types
Deciduous Tree Density	Ruffed Grouse	All Upland and Riparian Types
Conifer Tree Density	Ruffed Grouse	All Upland and Riparian Types
Conifer Tree Height	Ruffed Grouse	All Upland and Riparian Types
Deciduous Tree Height	Ruffed Grouse	All Upland and Riparian Types
Overstory Tree Height	Black-capped Chickadee	All Forested Types
Density of Trees 51 cm dbh	Pileated Woodpecker Red-tailed Hawk	All Mature Forest Types Except Lodgepole Pine
Density of Snags 51 cm dbh	Pileated Woodpecker	All Mature Forest Types Except Lodgepole Pine
dbh of Snags 51 cm dbh	Pileated Woodpecker	All Mature Forest Types Except Lodgepole Pine
Density of Snags 10-25 cm dbh	Black-capped Chickadee	All Forested Types
Density of Trees 2.5-15.2 cm dbh	Beaver	All Terrestrial Types
Density of Logs 18 cm dia. and Stumps 1.3 m high and 18 cm dia.	Pileated Woodpecker	All Mature Forest Types Except Lodgepole Pine
Shrub Height	Beaver, Yellow Warbler Ruffed Grouse	All Terrestrial Types

TABLE B-10

HABITAT PARAMETERS MEASURED USING LINE INTERCEPT AND PLOT FRAME

PARAMETER	SPECIES	COVER-TYPES
Shrub Canopy <5 m high	Red-tailed Hawk	Open Conifer and Shrubland
Deciduous Shrub Canopy <5 m high	Yellow Warbler	All Palustrine and Riparian Types
Hydrophytic Shrub Canopy <5 M high	Yellow Warbler	All Palustrine and Riparian Types
Shrub Cover <2 m high Palatable To Deer	Mule Deer	All Upland and Riparian Types
Shrub Cover <2 m high Less Palatable To Deer	Mule Deer	All Upland and Riparian Types
Tree Canopy Cover	Red-tailed Hawk, Pileated Woodpecker, Black-capped Chickadee, Marten, Beaver	All Cover Types
Conifer Canopy Cover	Marten	All Mature Forests
Evergreen Woody Vegetation Cover	Mule Deer	All Upland and Riparian Types
Cover of Downfall ≥7.6m diameter	Marten	All Mature Forests
Palatable Herbaceous Canopy Cover[a/]	Mule Deer	All Upland and Riparian Types
Herbaceous Canopy Cover[a/]	Red-tailed Hawk	Open Conifer, Shrubland, Marsh
Herbaceous Canopy Cover 8-46cm tall[a/]	Red-tailed Hawk	Open Conifer, Shrubland, Marsh
Height of Lowest Conifer Branch[b/]	Ruffed Grouse	All Upland and Riparian Types

a/ Plot Frame
b/ Measured Near Line

Table B-11. Common and Scientific Names of Plant Species Mentioned in the Text

Common Name	Scientific Name
western red cedar	Thuja plicata
lodgepole pine	Pinus contorta
ponderosa pine	Pinus ponderosa
Douglas-fir	Psuedotsuga menziesii
western hemlock	Tsuga hetrophylla
Pacific yew	Taxus brevifolia
prostrate juniper	Juniperus horizontalis
black cottonwood	Populus trichocarpa
paper birch	Betula papyrifera
red alder	Alnus rubra
bigleaf maple	Acer macrophyllum
salmonberry	Rubus spectabilis
trailing blackberry	Rubus ursinus
vine maple	Acer circinatum
Alaska huckleberry	Vaccinium alaskaense
red huckleberry	Vaccinium parvifolium
bunchberry	Cornus canadensis
red osier dogwood	Cornus stolonifera
Nootka rose	Rosa nutkana
willow	Salix sp.
salal	Gaultheria shallon
Oregon grape	Berberis nervosa
mountain box	Pachistima myrsinites
oceanspray	Holodiscus discolor
serviceberry	Amelanchier alnifolia
clustered wild rose	Rosa pisocarpa
little wild rose	Rosa gymnocarpa
mountain balm	Ceonothus velutinus
bittercherry	Prunus emarginata
mock orange	Philadelphus lewisii
devil's club	Oplopanax horridum
hazelnut	Corylus cornuta
hardhack	Spirea betulifolia
ninebark	Physocarpus capitalus
Sitka alder	Alnus sinuata
highbush cranberry	Viburnum opulus
common snowberry	Symphoricarpos albus
kinnikinnick	Artostaphylos nevadensis
skunk cabbage	Lysichitum americanum
false lily-of-the-valley	Maianthemum dilatatum
strawberry	Fragaria sp.
twinberry	Linnaea borealis

Table B-11 (Continued). Common and Scientific Names of Plant Species Mentioned in the Text

Common Name	Scientific Name
thimbleberry	Rubus parviflorus
star-flowered Solomon's seal	Smilacina stellata
starflower	Trientalis latifolia
foam flower	Limnanthus douglasii
larkspur	Delphinium sp.
arrowleaf balsamroot	Balsamorhiza sagittata
enchanter's nightshade	Circaea alpina
sundew	Drosera sp.
meadow death-camas	Zigadenus venenosus
microsteris	Microsteris gracilis
swale desert-parsley	Lomatium ambiguum
lomatium	Lomatium sp.
goatsbeard	Aruncus sylvester
horsetail	Equisetum sp.
sword fern	Polystichum munitum
deer fern	Blechnum spicant
bracken fern	Pteridium aquilinum
mountain wood-fern	Dryopteris austraca
lady fern	Athyrium filix-femina
stairstep moss	Hylocomnium splendens
bog clubmoss	Lycopodium inundatum
clubmoss	Lycopodium sp.
sphagnum moss	Sphagnum sp.
pine grass	Calamagrostis rubescens
bluebunch wheatgrass	Agropyron spicatum
sedge	Carex sp.
poor sedge	Carex paupercula

APPENDIX C

TABLE C-1 -- HABITAT AND LOCATION CODES
USED IN DATA SUMMARY

HABITAT CODES

Code	Habitat Type
001	Old Growth Conifer
002	Closed Canopy Coniver
003	Open Canopy Conifer
004	Lodgepole Pine
005	Regenerative Conifer
006	Regenerative Broadleaf/Mixed
007	Broadleaf
008	Mixed
009	Shrub
022	Pond
023	Conifer Swamp
024	Broadleaf Swamp
025	Mixed Swamp
026	Shrub Swamp
027	Wet Meadow/Marsh
101	Riparian Old Growth Conifer
102	Riparian Mature Conifer
107	Riparian Broadleaf
108	Riparian Mixed
109	Riparian Shrub

LOCATION CODES

Code	Location
BV	Big Beaver Valley
CS or CR	Canadian Skagit
D	Diablo
G	Gorge
LC	Lightning Creek
R	Ross

Table C-2.

FOREST AND SHRUB HABITATS I
POLYGON SUMMARY

LOCATION	HABITAT	POLYGON	DECIDUOUS SHRUBS	DECIDUOUS TREES	CONIFEROUS TREES	AVERAGE HEIGHT DECIDUOUS TREES	AVERAGE HEIGHT CONIFEROUS TREES	AVERAGE HEIGHT OVERSTORY TREES	NUMBER TREES >50CM	NUMBER SNAGS >51CM	AVERAGE DBH SNAGS >51CM	NUMBER SNAGS 10><25CM	NUMBER LOGS OR STUMPS
BV*	101*	BV6	304.000	528.000	688.000	6.098	16.475	15.244	184.000	16.000	199.000	8.000	176.000
	108	BV7	2.464.000	1.797.333	202.667	12.624	6.098	15.244	138.667	5.333	233.000	90.667	181.333
	109	BV9	11.400.000	592.000	16.000	8.155	76.220	-9.000	.000	.000	-9.000	24.000	.000
CS	107	CS1	4.800.000	1.440.000	128.000	6.098	7.996	15.244	48.000	.000	-9.000	80.000	384.000
D	001	R10	2,058.667	21.333	912.000	3.582	6.402	15.244	69.333	5.333	74.000	26.667	416.000
		R11	3.456.000	816.000	192.000	6.296	45.732	45.732	112.000	.000	-9.000	.000	64.000
	002	R15	1.424.000	352.000	512.000	11.826	6.098	15.244	136.000	24.000	75.000	40.000	208.000
		R16	768.000	16.000	1,312.000	3.049	30.488	30.488	64.000	.000	-9.000	144.000	272.000
		R50	96.000	112.000	672.000	10.264	34.299	15.244	144.000	.000	-9.000	48.000	176.000
	003	D43	112.000	160.000	128.000	6.098	6.098	15.244	.000	.000	-9.000	.000	32.000
		R49	752.000	128.000	16.000	11.303	6.098	15.244	16.000	.000	-9.000	16.000	.000
		R71	352.000	.000	96.000	0.000	6.098	15.244	48.000	.000	-9.000	.000	.000
	004	R32	96.000	72.000	1.480.000	5.091	9.001	13.574	.000	.000	-9.000	232.000	.000
		R57	.000	.000	5.056.000	0.000	11.714	11.714	.000	.000	-9.000	.000	.000
	007	R51	728.000	1,256.000	184.000	6.098	6.098	15.244	40.000	.000	-9.000	8.000	352.000
		R60	112.000	960.000	192.000	6.098	6.098	15.244	16.000	.000	-9.000	112.000	384.000
	008	R67	298.667	597.333	154.667	6.098	6.098	15.244	48.000	5.333	58.000	176.000	138.667
	101	R10A	5.516.000	488.000	128.000	5.170	9.240	15.244	56.000	36.000	97.500	.000	140.000
	102	R11A	27.504.000	672.000	96.000	9.985	30.488	37.076	112.000	16.000	105.000	8.000	136.000
	107	R10B	7.248.000	992.000	96.000	6.098	3.760	15.244	.000	.000	-9.000	16.000	80.000
		R14	906.667	2,314.667	117.333	12.458	5.346	15.244	.000	.000	-9.000	26.667	304.000
G	002	D21	1.936.000	416.000	560.000	8.292	6.098	15.244	96.000	.000	-9.000	96.000	400.000
		D27	1.440.000	320.000	400.000	10.366	29.775	15.244	80.000	.000	-9.000	16.000	128.000
		D34	672.000	352.000	1.312.000	6.098	6.098	6.098	176.000	.000	-9.000	32.000	432.000
	003	D29	2.304.000	144.000	144.000	9.450	17.356	18.764	.000	.000	-9.000	16.000	.000
	008	D17	848.000	1,184.000	568.000	6.098	6.098	25.104	8.000	.000	-9.000	24.000	168.000
	109	D13	14.600.000	2,320.000	312.000	8.227	6.098	-9.000	.000	.000	-9.000	.000	.000
LC	009	LC1	50,800.000	40.000	40.000	3.659	9.242	10.305	.000	.000	-9.000	8.000	.000
		LC2	26.200.000	72.000	40.000	4.535	5.793	-9.000	.000	.000	-9.000	.000	.000
R	001	P05	421.333	250.667	592.000	7.209	6.098	15.244	149.333	26.667	71.125	53.333	186.667
		P17A	960.000	64.000	1,616.000	4.650	6.098	15.244	96.000	.000	-9.000	48.000	192.000
		P31	560.000	256.000	624.000	6.098	6.098	22.866	176.000	16.000	63.000	.000	240.000
		P59	325.333	602.667	3.061.333	15.471	16.591	33.569	298.667	80.000	104.370	229.333	410.667
	002	H32	3.632.000	608.000	544.000	9.273	6.098	15.244	80.000	.000	-9.000	16.000	32.000
		H60	3.392.000	720.000	224.000	7.615	10.173	13.052	.000	.000	-9.000	.000	448.000
		H74	32.000	325.333	3,477.333	5.590	6.098	15.244	10.667	.000	-9.000	80.000	314.667
		P17	32.000	.000	896.000	0.000	6.098	15.244	128.000	.000	-9.000	.000	96.000
		P44	1.328.000	80.000	1.184.000	7.571	6.098	15.244	.000	.000	-9.000	32.000	32.000
		P49	1.312.000	144.000	1.296.000	6.436	6.098	15.976	.000	.000	-9.000	48.000	.000
		P52	304.000	336.000	3.072.000	9.272	17.470	17.470	640.000	48.000	81.333	352.000	240.000
		P65	4.640.000	853.333	1.317.333	13.320	26.000	15.244	42.667	.000	-9.000	128.000	250.667
		R94	608.000	256.000	720.000	6.098	6.098	15.244	80.000	.000	-9.000	80.000	160.000
	003	H25	3.672.000	1,096.000	448.000	4.029	12.386	19.245	48.000	.000	-9.000	16.000	216.000
		H30	1.573.333	10.667	69.333	6.098	6.098	15.244	5.333	.000	-9.000	5.333	16.000
		P68	28.800.000	64.000	208.000	5.259	10.777	12.835	.000	.000	-9.000	32.000	.000
	004	P33	48.000	.000	2.384.000	-9.000	6.098	15.244	.000	.000	-9.000	.000	.000
		F84	704.000	208.000	5.760.000	11.715	6.098	25.148	.000	.000	-9.000	.000	.000
		R98	10.667	.000	2.170.667	-9.000	6.098	10.941	.000	.000	-9.000	181.333	.000
	005	H22	2.432.000	80.000	624.000	3.150	6.098	9.858	.000	.000	-9.000	.000	.000
		H39	8.800.000	1,504.000	992.000	8.783	8.544	14.369	.000	.000	-9.000	.000	.000
		H53	645.333	768.000	1.360.000	5.170	7.254	12.226	.000	.000	-9.000	10.667	549.333

Table C-2 (cont'd).

FOREST AND SHRUB HABITATS 1
POLYGON SUMMARY

LOCATION	HABITAT	POLYGON	DECIDUOUS SHRUBS	DECIDUOUS TREES	CONIFEROUS TREES	AVERAGE HEIGHT DECIDUOUS TREES	AVERAGE HEIGHT CONIFEROUS TREES	AVERAGE HEIGHT OVERSTORY TREES	NUMBER TREES >50CM	NUMBER SNAGS >51CM	AVERAGE DBH SNAGS >51CM	NUMBER SNAGS 10><25CM	NUMBER LOGS OR STUMPS
R	005	H64A	10,000.000	576.000	5,712.000	6.640	8.918	10.283	.000	.000	-9.000	.000	.000
	006	H15	41,200.000	1,296.000	176.000	5.163	9.553	11.003	.000	.000	-9.000	.000	.000
		H64	11,000.000	6,282.667	469.333	7.571	7.945	14.277	.000	.000	-9.000	21.333	.000
		P80	43,200.000	3,520.000	16.000	6.098	4.268	10.671	.000	.000	-9.000	.000	.000
	007	H44	1,184.000	6,592.000	48.000	20.171	7.361	33.840	.000	.000	-9.000	.000	480.000
		H54	12,133.333	1,818.667	96.000	12.364	8.027	19.478	10.667	.000	-9.000	117.333	512.000
		P55	960.000	1,216.000	384.000	6.098	6.098	15.244	16.000	.000	-9.000	16.000	304.000
	008	H24	3,760.000	1,504.000	512.000	6.098	6.098	15.244	.000	.000	-9.000	32.000	224.000
		P42	2,240.000	1,392.000	704.000	12.185	16.833	38.835	384.000	48.000	194.000	128.000	496.000
		R83	874.667	506.667	645.333	16.709	6.098	15.244	.000	.000	-9.000	10.667	74.667
	101	P05A	1,584.000	400.000	400.000	5.122	6.005	15.244	208.000	.000	-9.000	.000	96.000
	108	H59	1,856.000	1,984.000	960.000	6.098	6.098	15.244	.000	.000	-9.000	144.000	880.000
	109	P74	6,000.000	12,736.000	240.000	9.471	10.697	11.299	.000	.000	-9.000	64.000	.000

* See Table C-1 for location and habitat codes.

Table C-3.

SKAGIT RIVER HEP PROJECT
FOREST AND SHRUB HABITATS 2
POLYGON SUMMARY

LOCATION	HABITAT	POLYGON	PALATABLE SHRUB COVER	NONPALATABLE SHRUB COVER	TOTAL SHRUB COVER	SHRUB COVER <5M	DECIDUOUS SHRUB COVER	PERCENT HYDROPHYTIC SHPUBS	TREE COVER	CONIFER COVER	EVERGREEN COVER	DOWNFALL COVER	DEPTH WOODY DEBRIS	PALATABLE HERBACEOUS	HERBACEOUS COVER	HERBACEOUS B()46 CM	HEIGHT DECIDUOUS SHRUBS	HEIGHT CONIFER BRANCH
BV *	101 *	BV6	20.950	23.350	44.300	-99.000	6.650	7.050	97.800	98.382	56.200	20.700	54.850	4.000	-99.000	-99.000	4.991	4.435
	108	BV7	2.467	30.267	32.733	-99.000	36.133	8.900	90.267	70.931	42.867	27.100	44.167	2.000	-99.000	-99.000	2.330	5.640
	109	BV9	34.700	67.800	102.500	-99.000	99.000	81.350	42.500	-99.000	4.000	-99.000	35.775	1.228	-99.000	-99.000	3.813	-99.000
CS	107	CS1	21.800	39.600	61.400	-99.000	57.400	41.800	89.400	-99.000	31.800	-99.000	33.100	2.500	-99.000	-99.000	1.904	1.065
D	001	R10	6.767	29.333	36.100	-99.000	-99.000	-99.000	83.000	100.000	83.000	19.733	34.700	7.400	-99.000	-99.000	1.912	5.697
		R11	3.200	44.400	47.600	-99.000	-99.000	-99.000	99.000	100.000	99.000	1.100	16.800	8.400	-99.000	-99.000	2.067	6.305
	002	R15	1.100	4.350	5.450	-99.000	-99.000	-99.000	100.000	99.000	99.000	7.650	30.100	7.750	-99.000	-99.000	2.768	8.630
		R16	31.000	30.400	61.400	-99.000	-99.000	-99.000	100.000	100.000	100.000	4.300	16.700	.500	-99.000	-99.000	1.470	3.235
		R50	.600	27.800	28.400	-99.000	-99.000	-99.000	95.400	100.000	95.400	5.600	20.800	4.500	-99.000	-99.000	1.180	5.365
	003	D43	.000	7.800	7.800	8.200	.000	-99.000	40.800	100.000	40.800	1.800	2.500	.000	.000	.000	1.667	.733
		R49	4.400	.600	5.000	4.400	-99.000	-99.000	55.500	85.045	47.200	.000	17.900	.000	.000	.000	1.837	3.756
		R71	.000	.000	.000	.000	-99.000	-99.000	36.000	100.000	36.000	1.000	12.500	.000	.000	.000	1.885	2.595
	004	R32	.050	67.900	67.950	-99.000	-99.000	-99.000	41.700	100.000	37.200	.950	18.250	3.850	-99.000	-99.000	1.513	7.748
		R57	.000	5.200	5.200	-99.000	-99.000	-99.000	68.600	100.000	68.600	.500	7.700	.000	-99.000	-99.000	.550	4.250
	007	R51	.300	51.100	51.400	-99.000	-99.000	-99.000	96.400	-99.000	23.600	-99.000	19.150	.000	-99.000	-99.000	2.463	10.572
		R60	.900	49.800	50.700	-99.000	-99.000	-99.000	96.000	-99.000	41.000	-99.000	18.600	.000	-99.000	-99.000	2.153	3.725
	008	R67	3.533	22.133	25.667	-99.000	-99.000	-99.000	97.333	45.944	44.867	4.700	25.400	.833	-99.000	-99.000	2.267	5.978
	101	R10A	12.175	45.625	57.800	-99.000	55.800	40.775	70.250	82.988	61.300	9.900	30.663	30.500	-99.000	-99.000	2.408	5.750
	102	R11A	17.400	13.550	30.950	-99.000	69.600	99.450	75.200	93.120	70.700	8.350	33.550	18.300	-99.000	-99.000	2.161	5.353
	107	R14	13.600	7.633	21.233	-99.000	19.767	18.633	98.000	-99.000	14.000	-99.000	17.588	23.439	-99.000	-99.000	2.262	1.361
		R10B	10.800	23.500	34.300	-99.000	36.100	71.700	96.000	-99.000	.000	-99.000	19.000	5.500	-99.000	-99.000	2.085	.800
6	002	D21	1.500	55.900	57.400	-99.000	-99.000	-99.000	96.000	100.000	96.000	5.400	17.800	3.500	-99.000	-99.000	1.480	13.285
		D27	1.100	18.900	20.000	-99.000	-99.000	-99.000	92.600	93.305	10.200	.600	12.500	8.500	-99.000	-99.000	2.210	7.365
		D34	1.800	5.800	7.600	-99.000	-99.000	-99.000	88.800	94.820	84.800	10.000	29.600	.500	-99.000	-99.000	1.935	10.540
	003	D29	17.000	19.200	36.200	23.600	-99.000	-99.000	59.000	100.000	59.000	.300	4.600	4.500	5.000	20.000	2.185	.895
	008	D17	13.000	15.400	28.400	-99.000	-99.000	-99.000	99.400	67.268	66.900	3.800	17.000	1.500	-99.000	-99.000	2.458	3.348
	009	D13	.700	40.900	41.600	-99.000	-99.000	-99.000	33.900	-99.000	15.600	-99.000	42.000	1.250	-99.000	-99.000	4.032	2.681
LC	009	LC1	48.900	7.100	56.000	48.900	-99.000	-99.000	15.600	-99.000	12.300	-99.000	14.550	32.750	28.750	52.750	1.503	1.250
		LC2	40.900	9.900	50.800	46.100	-99.000	-99.000	13.900	-99.000	11.300	-99.000	5.800	17.750	21.250	67.750	1.942	1.663
R	001	P05	1.933	10.733	12.667	-99.000	-99.000	-99.000	99.667	98.653	98.333	7.367	20.300	4.667	-99.000	-99.000	1.996	7.125
		P31	7.500	27.600	35.100	-99.000	-99.000	-99.000	85.400	100.000	87.000	6.300	18.200	4.500	-99.000	-99.000	1.955	4.695
		P59	21.967	5.500	27.467	-99.000	-99.000	-99.000	99.667	92.696	93.933	10.200	28.458	.167	-99.000	-99.000	2.268	5.328
		P17A	.000	20.800	20.800	-99.000	-99.000	-99.000	100.000	100.000	100.000	4.900	15.700	1.500	-99.000	-99.000	1.845	8.685
	002	H32	22.400	49.600	72.000	-99.000	-99.000	-99.000	79.800	100.000	82.400	1.900	28.300	.000	-99.000	-99.000	3.045	5.245
		H60	21.700	41.700	63.400	-99.000	-99.000	-99.000	52.000	92.692	48.200	.000	12.300	.000	-99.000	-99.000	2.220	.560
		H74	11.867	10.167	22.033	-99.000	-99.000	-99.000	95.733	100.000	96.400	12.267	49.827	.000	-99.000	-99.000	2.324	4.103
		P17	.400	9.900	10.300	-99.000	-99.000	-99.000	100.000	100.000	100.000	8.200	19.900	.000	-99.000	-99.000	1.690	7.310
		P44	.800	26.700	27.500	-99.000	-99.000	-99.000	82.000	100.000	82.000	1.000	16.300	.500	-99.000	-99.000	2.325	6.415
		P49	5.400	29.000	34.400	-99.000	-99.000	-99.000	78.200	100.000	78.200	1.400	23.600	9.000	-99.000	-99.000	2.340	4.925
		P52	2.000	4.600	6.600	-99.000	-99.000	-99.000	100.000	98.000	98.000	19.900	17.200	1.500	-99.000	-99.000	2.171	10.350
		P65	22.600	43.733	66.333	-99.000	-99.000	-99.000	89.533	82.542	82.267	9.367	28.033	3.333	-99.000	-99.000	2.098	3.587
		R94	5.400	18.200	23.600	-99.000	-99.000	-99.000	95.800	97.495	93.400	2.800	14.400	.500	-99.000	-99.000	2.165	7.570
	003	H25	11.750	15.350	27.100	29.150	-99.000	-99.000	78.000	100.000	78.000	2.550	13.950	8.750	9.750	6.750	1.553	5.513
		H30	4.867	6.167	11.033	11.100	-99.000	-99.000	5.400	66.667	5.400	.333	2.267	6.333	6.667	4.167	1.460	2.372
		P68	41.000	15.600	56.600	42.000	-99.000	-99.000	31.200	58.333	18.200	.000	10.900	5.455	6.818	45.455	1.570	.800
	004	P33	.900	9.000	9.900	-99.000	-99.000	-99.000	70.800	100.000	70.800	.600	4.900	.500	-99.000	-99.000	1.69	6.021
		P84	3.300	14.400	17.700	-99.000	-99.000	-99.000	74.000	96.216	71.200	3.400	5.100	.000	-99.000	-99.000	1.855	6.475
		R98	2.900	44.600	47.500	-99.000	-99.000	-99.000	42.900	100.000	42.900	.333	10.567	.167	-99.000	-99.000	1.529	5.093
	005	H22	9.200	22.600	31.800	-99.000	-99.000	-99.000	34.600	-99.000	34.600	-99.000	8.500	.000	-99.000	-99.000	2.095	.710
		H39	63.800	53.000	116.800	-99.000	-99.000	-99.000	81.800	-99.000	70.800	-99.000	30.500	.000	-99.000	-99.000	2.165	.964
		H53	37.533	12.400	49.933	-99.000	-99.000	-99.000	92.267	-99.000	88.267	-99.000	17.891	5.773	-99.000	-99.000	1.129	2.069

Table C-3 (cont'd).

SKAGIT RIVER HEP PROJECT
FOREST AND SHRUB HABITATS 2
POLYGON SUMMARY

LOCATION	HABITAT	POLYGON	PALATABLE SHRUB COVER	NONPALATABLE SHRUB COVER	TOTAL SHRUB COVER	SHRUB COVER <5M	DECIDUOUS SHRUB COVER	PERCENT HYDROPHYTIC SHRUBS	TREE COVER	CONIFER COVER	EVERGREEN COVER	DOWNFALL COVER	DEPTH WOODY DEBRIS	PALATABLE HERBACEOUS	HERBACEOUS COVER	HERBACEOUS B<>46	HEIGHT DECIDUOUS SHRUBS	HEIGHT CONIFER BRANCH
R	005	H64A	28.400	70.400	98.800	-99.000	-99.000	-99.000	96.200	-99.000	97.600	-99.000	31.300	2.000	-99.000	-99.000	1.625	1.440
	006	H15	40.800	42.700	83.500	-99.000	-99.000	-99.000	73.500	-99.000	13.800	-99.000	22.300	6.500	-99.000	-99.000	2.091	.856
		H64	19.867	44.700	64.567	-99.000	-99.000	-99.000	89.400	-99.000	41.200	-99.000	16.733	1.667	-99.000	-99.000	2.797	.893
		P80	41.800	43.100	84.900	-99.000	-99.000	-99.000	57.600	-99.000	6.000	-99.000	19.000	1.500	-99.000	-99.000	3.275	.800
	007	H44	40.000	27.600	67.600	-99.000	-99.000	-99.000	100.000	-99.000	31.000	-99.000	25.500	.000	-99.000	-99.000	1.375	1.015
		H54	7.667	54.167	61.833	-99.000	-99.000	-99.000	90.800	-99.000	7.333	-99.000	31.667	7.500	-99.000	-99.000	1.653	1.145
		P55	12.800	36.900	49.700	-99.000	-99.000	-99.000	42.200	-99.000	48.800	-99.000	24.000	1.000	-99.000	-99.000	2.365	2.585
	008	H24	15.100	22.300	37.400	-99.000	-99.000	-99.000	81.100	92.602	81.100	9.700	35.200	1.000	-99.000	-99.000	1.965	3.000
		P42	12.800	35.000	47.800	-99.000	-99.000	-99.000	86.200	89.327	77.000	5.200	19.000	7.000	-99.000	-99.000	2.105	3.995
		R83	4.433	27.467	31.900	-99.000	-99.000	-99.000	85.067	77.149	66.200	.333	20.367	.000	-99.000	-99.000	2.530	2.987
	101	P05A	1.400	24.800	26.200	-99.000	11.600	59.500	100.000	100.000	100.000	19.800	44.600	13.500	-99.000	-99.000	2.295	4.515
	108	H59	9.800	27.200	37.000	-99.000	27.000	20.700	70.000	85.714	62.000	14.200	36.100	.500	-99.000	-99.000	1.471	1.100
	109	P74	4.600	47.100	51.700	-99.000	90.200	.000	99.600	-99.000	6.600	.000	10.300	.000	-99.000	-99.000	2.005	1.890

* See Table C-1 for location and habitat codes.

Table C-4.

SKAGIT RIVER HEP PROJECT
WETLANDS 1
POLYGON SUMMARY

LOCATION	HABITAT	POLYGON	DECIDUOUS SHRUB COVER	PERCENT HYDROPHYTIC SHRUBS	HEIGHT DECIDUOUS SHRUBS	TREE CANOPY CLOSURE	HERBACEOUS COVER	HERBACEOUS COVER B()46CM	OVERSTORY HEIGHT	NUMBER SNAGS	STREAM GRADIENT	BOTTOM SUBSTRATE	NUMBER WALLS	SECCHI DISC	PERCH SITES	NEST TREES	PILOT PERCH SITES	DIST NEST TO WATER
BV *	026*	BV11	45.700	100.000	1.605	.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000
		BV2	44.533	100.000	1.336	5.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000
	027	BV3	-99.000	-99.000	-99.000	-99.000	70.667	24.167	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000
		BV8	-99.000	-99.000	-99.000	-99.000	93.000	.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000
CR	025	CS4	80.133	45.246	1.871	73.933	-99.000	-99.000	16.269	.667	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000
	027	CS5	-99.000	-99.000	-99.000	-99.000	25.500	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000
D	002	R15	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	.933	34.000	.000	30.000	.000
		R16	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	.933	18.000	2.000	10.000	.000
	003	R25	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	.950	5.000	1.000	3.000	.000
		R49	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	2.500	2.000	.000	.000	.000
		R50	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	2.500	.000	1.000	2.000	.000
		R74	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	2.250	12.000	9.000	20.000	.000
	008	R40	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	.933	2.000	.000	-99.000	-99.000
G	002	D12	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	2.300	.000	.000	.000	.000
		D18	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	3.000	1.000	5.000	50.000	400.000
		D34	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	3.000	.000	.000	.000	.000
	003	D5	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	3.000	2.000	.000	.000	.000
	020	ZZZ	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	2.750	3.125	-99.000	-99.000	-99.000	-99.000	-99.000
R	001	P31	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	1.000	6.000	.500	2.000	.000
		P59	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	1.000	3.000	.000	.000	.000
	002	H32	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	1.000	12.000	3.000	15.000	300.000
		H60	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	1.000	1.000	.000	2.000	200.000
		H74	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	1.000	82.000	9.000	100.000	.000
		P17	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	1.000	21.000	1.000	3.000	200.000
		P49	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	1.000	5.000	.000	5.000	.000
		P52	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	1.000	.500	.000	.000	.000
		P65	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	1.000	4.000	1.000	7.000	.000
		P85	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	1.000	7.000	1.000	9.000	50.000
	003	H25	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	1.000	2.000	1.000	7.000	300.000
		H30	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	1.000	11.000	9.000	24.000	200.000
		P68	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	1.000	.000	.000	.000	.000
	024	P8	55.400	71.797	1.898	93.000	-99.000	-99.000	15.244	.333	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000
	026	P34	100.000	100.000	1.800	.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000	-99.000

* See Table C-1 for location and habitat codes.

Table C-5. Polygon habitat data summary - - Wetlands 2

SKAGIT RIVER HEP PROJECT
WETLAND2:BEAVER DATA
POLYGON SUMMARY

LOCATION	HABITAT	POLYGON	TREE COVER	SHRUB COVER	SHRUB HEIGHT	NUMBER TREES	NUMBER SMALL TREES	PERCENT SMALL TREES
BV *	002*	B12	87.900	34.500	1.389	56.500	52.000	91.629
	026	BV11	.000	45.700	1.600	.000	.000	.000
		BV2	5.533	42.867	1.336	17.000	17.000	100.000
	027	BV3	.000	2.233	.582	.000	.000	.000
		BV8	.000	.000	1.700	.000	.000	.000
	101	BV6	97.800	23.940	1.991	76.000	62.000	81.079
	108	BV7	90.267	35.400	2.269	125.000	114.667	85.590
	109	BV9	42.500	94.000	3.813	38.000	17.000	22.369
CR	025	CS4	64.600	54.133	2.083	122.000	104.667	84.335
	027	CS5	4.000	9.400	.980	1.000	1.000	100.000
	107	CS1	89.400	30.800	1.958	98.000	53.000	54.082
D	001	R10	81.800	6.300	1.917	58.333	45.667	78.256
		R11	99.000	43.400	2.730	63.000	56.000	88.889
	002	R15	100.000	.900	2.768	54.000	26.500	42.121
		R16	100.000	9.100	1.470	83.000	33.000	39.759
		R50	95.400	1.300	1.180	49.000	22.000	44.898
	003	D43	40.800	.000	1.667	18.000	5.000	27.778
		R49	55.500	4.400	1.826	18.000	14.000	77.778
		R71	36.000	.000	1.932	6.000	.000	.000
	004	R32	41.700	.050	1.675	97.000	48.000	50.075
		R57	68.600	.000	.850	316.000	301.000	95.253
	007	R51	96.400	6.400	2.463	90.000	61.000	67.241
		R60	96.000	.700	2.338	72.000	42.000	58.333
	008	R67	97.333	5.933	2.120	47.000	22.333	37.171
	101	R10A	70.250	31.775	2.452	38.500	33.250	81.091
	102	R11A	75.200	32.300	2.580	57.000	48.000	82.479
	107	R10B	96.000	15.000	2.250	68.000	28.000	41.176
		R14	98.000	9.000	2.274	152.000	113.000	73.214
G	002	D21	96.000	13.800	1.480	61.000	33.000	54.098
	003	D29	28.000	23.600	1.929	23.000	17.000	73.913
	008	D17	99.400	14.400	2.458	109.000	84.500	75.544
	109	D13	33.900	93.400	4.002	164.500	148.500	90.517
LC	009	LC1	19.200	48.400	1.468	81.500	80.000	98.993
		LC2	12.000	37.300	1.913	35.500	35.000	99.243
R	001	P05	99.667	4.267	2.027	52.667	36.333	69.155
		P17A	100.000	3.400	1.889	105.000	53.000	50.476
		P31	85.400	8.400	1.955	64.000	40.000	62.500
		P59	99.667	5.933	2.126	228.333	184.333	80.695
	002	H32	79.800	55.000	3.045	72.000	52.000	72.222
		H60	98.000	25.200	2.205	52.000	50.000	96.154
		H74	95.733	1.200	1.755	237.667	185.667	75.983
		P17	100.000	.000	1.690	56.000	17.000	30.357
		P44	82.000	2.400	2.126	79.000	45.000	56.962
		P49	69.600	19.400	2.788	90.000	73.000	81.111
		P52	100.000	.600	2.127	213.000	178.000	83.568
		R94	95.800	20.400	3.220	61.000	33.000	54.098
	003	H25	78.000	26.850	1.553	96.500	59.000	55.543
		H30	5.400	1.467	1.500	6.000	4.000	60.909
		P68	31.200	41.000	1.550	101.000	89.000	88.119
	004	P33	70.800	.200	-99.000	149.000	125.000	83.893
		P84	74.000	9.800	1.855	373.000	359.000	96.247

* See Table C-1 for location and habitat codes.

Table C-5 (cont'd)

SKAGIT RIVER HEP PROJECT
WETLAND2:BEAVER DATA
POLYGON SUMMARY

LOCATION	HABITAT	POLYGON	TREE COVER	SHRUB COVER	SHRUB HEIGHT	NUMBER TREES	NUMBER SMALL TREES	PERCENT SMALL TREES
5	004	R98	42.893	9.700	.882	135.667	104.333	75.113
	005	H22	34.600	13.400	2.050	72.000	52.000	72.222
		H39	81.800	29.000	1.850	156.000	144.000	92.308
		H64A	96.200	24.800	1.935	392.000	389.000	99.235
	006	H15	15.000	72.500	2.091	92.000	87.000	94.565
		H64	89.400	47.267	2.890	342.333	301.333	70.961
		P80	57.600	74.400	3.275	221.000	221.000	100.000
	007	H44	100.000	38.000	1.435	415.000	414.000	99.759
		P55	42.200	8.820	2.180	100.000	66.000	66.000
	008	H24	81.100	32.700	1.965	136.000	118.000	86.765
		P42	86.200	31.200	2.105	131.000	110.000	83.969
		R83	68.400	13.433	2.533	72.000	44.000	60.065
	024	P8	89.667	55.400	1.895	78.000	40.333	51.822
	026	P34	.000	100.000	1.800	.000	.000	.000
	101	P5A	100.000	4.000	2.310	50.000	36.000	72.000
	108	H59	70.000	27.000	1.491	184.000	163.000	88.587
	109	P74	99.600	53.200	2.005	413.000	398.000	96.368

Table C-6. Descriptive Statistics - - Forest and Shrub 1

FOREST AND SHRUB 1

Note: Please refer to end of table for variable descriptions.

HAB*	VAR	MEAN	STD DEV	MAX	STD ERR	MIN	N	CV
1	DSN	1116	1095.57	3456	316.264	0	12	98.17
1	DTN	313.333	281.416	816	81.238	0	12	89.81
1	CTN	1344	1184.57	4192	341.956	192	12	88.14
1	HTDEC	8.867	6.41	24.349	2.027	3.582	10	72.29
1	HTCON	12.1	12.202	45.732	3.522	6.098	12	100.84
1	HTOVER	23.001	12.71	45.732	3.669	15.244	12	55.26
1	NT50	161.333	198.843	768	57.401	16	12	123.25
1	NLS	29.333	42.515	144	12.273	0	12	144.94
1	DBHS	84.623	25.002	136	9.45	63	7	29.55
1	NSS	81.333	127.172	464	36.711	0	12	156.36
1	NLOG	294.667	159.046	512	45.913	64	12	53.97
2	DSN	1619.2	1818.508	6000	406.631	0	20	112.31
2	DTN	380	356.597	1408	79.737	0	20	93.84
2	CTN	1380	1166.735	4720	260.89	224	20	84.55
2	HTDEC	8.669	3.643	17.553	0.836	3.049	19	42.02
2	HTCON	13.669	10.699	34.299	2.392	6.098	20	78.27
2	HTOVER	15.587	4.129	30.488	0.923	6.098	20	26.49
2	NT50	96	139.871	640	31.276	0	20	145.70
2	NLS	4.8	12.821	48	2.867	0	20	267.10
2	DBHS	77.111	23.289	98	13.446	52	3	30.20
2	NSS	78.4	79.899	352	17.866	0	20	101.91
2	NLOG	226.4	141.62	464	31.667	0	20	62.55
3	DSN	4438.4	8707.34	28800	2753.503	112	10	196.18
3	DTN	272	478.813	1504	151.414	0	10	176.03
3	CTN	169.6	178.997	624	56.604	16	10	105.54
3	HTDEC	6.609	2.811	11.303	1.062	3.125	7	42.53
3	HTCON	8.949	5.005	18.673	1.583	6.098	10	55.93
3	HTOVER	16.155	2.866	23.246	0.906	12.835	10	17.74
3	NT50	17.6	21.925	48	6.933	0	10	124.57
3	NLS	0	0	0	0	0	10	0.00
3	DBHS	0	0	0	0	0	0	
3	NSS	11.2	13.172	32	4.165	0	10	117.61
3	NLOG	51.2	88.54	240	27.999	0	10	172.93
4	DSN	122	238.692	704	84.39	0	8	195.65
4	DTN	44	76.852	208	27.171	0	8	174.66
4	CTN	2834	1686.365	5760	596.22	1472	8	59.50
4	HTDEC	7.299	3.912	11.715	2.259	4.268	3	53.60
4	HTCON	7.526	2.644	11.904	0.935	6.098	8	35.13
4	HTOVER	14.01	5.442	25.148	1.924	6.098	8	38.84
4	NT50	0	0	0	0	0	8	0.00
4	NLS	0	0	0	0	0	8	0.00
4	DBHS	0	0	0	0	0	0	
4	NSS	126	161.238	384	57.006	0	8	127.97
4	NLOG	0	0	0	0	0	8	0.00
5	DSN	3861.333	4373.894	10000	1785.635	256	6	113.27
5	DTN	744	463.255	1504	189.123	80	6	62.27
5	CTN	1901.333	1913.279	5712	781.093	624	6	100.63

* See Table C-1 for habitat codes.

Table C-6 (cont'd).

FOREST AND SHRUB 1

HAB*	VAR	MEAN	STD DEV	MAX	STD ERR	MIN	N	CV
5	HTDEC	5.681	1.973	8.783	0.805	3.15	6	34.73
5	HTCON	7.553	1.042	8.918	0.425	6.098	6	13.80
5	HTOVER	11.948	1.796	14.869	0.733	9.858	6	15.03
5	NT50	0	0	0	0	0	6	0.00
5	NLS	0	0	0	0	0	6	0.00
5	DBHS	0	0	0	0	0	0	0.00
5	NSS	5.333	13.064	32	5.333	0	6	244.97
5	NLOG	274.667	313.603	704	128.028	0	6	114.18
6	DSN	23480	17167.17	43200	7677.395	8600	5	73.11
6	DTN	4732.8	4443.832	12000	1987.342	1248	5	93.89
6	CTN	320	232.964	608	104.184	16	5	72.80
6	HTDEC	6.795	2.12	10.518	0.948	5.163	5	31.20
6	HTCON	7.531	2.284	9.553	1.021	4.268	5	30.33
6	HTOVER	12.901	3.532	19.106	1.58	10.671	5	27.38
6	NT50	0	0	0	0	0	5	0.00
6	NLS	0	0	0	0	0	5	0.00
6	DBHS	0	0	0	0	0	0	
6	NSS	12.8	13.387	32	5.987	0	5	104.59
6	NLOG	0	0	0	0	0	5	0.00
7	DSN	5014	6533.073	17600	2309.79	112	8	130.30
7	DTN	2092	2047.085	6592	723.754	624	8	97.85
7	CTN	160	130.826	384	46.254	0	8	81.77
7	HTDEC	10.207	7.713	24.897	2.727	6.098	8	75.57
7	HTCON	6.829	1.441	9.92	0.545	6.098	7	21.10
7	HTOVER	19.156	7.413	33.84	2.621	15.244	8	38.70
7	NT50	18	19.943	64	7.051	0	8	110.79
7	NLS	0	0	0	0	0	8	0.00
7	DBHS	0	0	0	0	0	0	
7	NSS	62	61.931	160	21.896	0	8	99.89
7	NLOG	426	99.346	608	35.124	304	8	23.32
8	DSN	1121.6	1156.742	3760	365.794	128	10	103.13
8	DTN	857.6	456.504	1504	144.359	192	10	53.23
8	CTN	475.2	274.348	832	86.756	96	10	57.73
8	HTDEC	9.89	5.286	20.02	1.672	6.098	10	53.45
8	HTCON	7.171	3.395	16.833	1.073	6.098	10	47.34
8	HTOVER	19.575	9.176	38.835	2.902	15.244	10	46.88
8	NT50	54.4	118.107	384	37.349	0	10	217.11
8	NLS	6.4	15.457	48	4.888	0	10	241.52
8	DBHS	126	96.167	194	68	58	2	76.32
8	NSS	76.8	97.703	304	30.897	0	10	127.22
8	NLOG	169.6	136.433	496	43.144	16	10	80.44
9	DSN	38500	21831.77	68800	10915.89	16800	4	56.71
9	DTN	56	38.088	80	19.044	0	4	68.01
9	CTN	40	46.188	80	23.094	0	4	115.47
9	HTDEC	4.243	0.764	5.107	0.441	3.659	3	18.01
9	HTCON	7.517	2.439	9.242	1.724	5.793	2	32.45
9	HTOVER	10.305	0	10.305	0	10.305	1	0.00

* See Table C-1 for habitat codes.

Note: Please refer to end of table for variable descriptions.

Table C-6 (cont'd).

FOREST AND SHRUB 1

Note: Please refer to end of table for variable descriptions.

HAB *	VAR	MEAN	STD DEV	MAX	STD ERR	MIN	N	CV
9	NT50	0	0	0	0	0	4	0.00
9	NLS	0	0	0	0	0	4	0.00
9	DBHS	0	0	0	0	0	0	
9	NSS	4	8	16	4	0	4	200.00
9	NLOG	0	0	0	0	0	4	0.00
101	DSN	3465.143	5125.471	14800	1937.246	224	7	147.92
101	DTN	486.857	319.046	1104	120.588	160	7	65.53
101	CTN	326.857	267.868	736	101.245	96	7	81.95
101	HTDEC	5.428	1.099	6.657	0.415	3.963	7	20.25
101	HTCON	10.845	8.315	26.851	3.143	6.005	7	76.67
101	HTOVER	15.244	0.008	15.244	0.003	15.244	7	0.05
101	NT50	114.286	79.157	208	29.919	16	7	69.26
101	NLS	25.143	22.356	64	8.45	0	7	88.92
101	DBHS	117.8	50.762	199	22.702	75.5	5	43.09
101	NSS	2.286	6.047	16	2.286	0	7	264.52
101	NLOG	144	77.287	240	29.212	0	7	53.67
102	DSN	27504	26157.29	46000	18496	9008	2	95.10
102	DTN	672	565.685	1072	400	272	2	84.18
102	CTN	96	113.137	176	80	16	2	117.85
102	HTDEC	9.985	0	9.985	0	9.985	2	0.00
102	HTCON	30.488	0	30.488	0	30.488	2	0.00
102	HTOVER	37.076	0	37.076	0	37.076	2	0.00
102	NT50	112	45.255	144	32	80	2	40.41
102	NLS	16	0	16	0	16	2	0.00
102	DBHS	105	43.841	136	31	74	2	41.75
102	NSS	8	11.314	16	8	0	2	141.43
102	NLOG	136	79.196	192	56	80	2	58.23
107	DSN	2953.6	2957.028	7248	1322.423	304	5	100.12
107	DTN	1875.2	680.649	2608	304.396	992	5	36.30
107	CTN	115.2	67.314	224	30.104	48	5	58.43
107	HTDEC	9.914	8.533	25.179	3.816	6.098	5	86.07
107	HTCON	5.559	1.782	7.996	0.797	3.76	5	32.06
107	HTOVER	15.244	0.006	15.244	0.003	15.244	5	0.04
107	NT50	9.6	21.466	48	9.6	0	5	223.60
107	NLS	0	0	0	0	0	5	0.00
107	DBHS	0	0	0	0	0	0	
107	NSS	35.2	30.777	80	13.764	0	5	87.43
107	NLOG	275.2	250.542	656	112.046	48	5	91.04
108	DSN	2312	2028.596	5200	1014.298	448	4	87.74
108	DTN	1844	989.879	2880	494.94	496	4	53.68
108	CTN	392	387.649	960	193.825	144	4	98.89
108	HTDEC	10.992	3.263	12.624	1.631	6.098	4	29.69
108	HTCON	6.098	0.002	6.098	0.001	6.098	4	0.03
108	HTOVER	15.244	0.005	15.244	0.002	15.244	4	0.03
108	NT50	104	104.919	240	52.46	0	4	100.88
108	NLS	4	8	16	4	0	4	200.00
108	DBHS	233	0	233	0	233	1	0.00

* See Table C-1 for habitat codes.

Table C-6 (cont'd).

FOREST AND SHRUB 1

HAB*	VAR	MEAN	STD DEV	MAX	STD ERR	MIN	N	CV
108	NSS	104	30.638	144	15.319	80	4	29.46
108	NLOG	356	353.542	880	176.771	128	4	99.31
109	DSN	11600	4707.441	18800	2105.231	6000	5	40.58
109	DTN	3712	5138.716	12736	2298.104	0	5	138.44
109	CTN	179.2	193.13	480	86.37	0	5	107.77
109	HTDEC	8.52	0.651	9.471	0.326	8.049	4	7.64
109	HTCON	24.778	34.363	76.22	17.181	6.098	4	138.68
109	HTOVER	11.299	0	11.299	0	11.299	1	0.00
109	NT50	0	0	0	0	0	5	0.00
109	NLS	0	0	0	0	0	5	0.00
109	DBHS	0	0	0	0	0	0	
109	NSS	22.4	31.19	64	13.948	0	5	139.24
109	NLOG	0	0	0	0	0	5	0.00

* See Table C-1 for habitat codes.

Note: Please refer to end of table for variable descriptions.

VARIABLES - FOREST AND SHRUB 1

Variable	Description
DSN	No. deciduous shrubs/ha
DTN	No. deciduous trees/ha
CTN	No. coniferous trees/ha
HTDEC	Height deciduous trees (m)
HTCON	Height coniferous trees (m)
HTOVER	Height overstory trees (m)
NT50	No. trees $\geq$ 51cm dbh/ha
NLS	No. snags $\geq$ 51cm dbh/ha
DBHS	Dbh of snags $\geq$51cm
NSS	No. snags 10 to 25cm dbh/ha
NLOG	No. logs or stumps/ha

Table C-7. Descriptive Statistics - - Forest and Shrub 2

FOREST AND SHRUB 2

HAB*	VAR	MEAN	ST DEV	MAX	STD ERR	MIN	N	CV
1	SC2P	8.558	9.707	30.2	2.802	0	12	113.43
1	SC2N	19.125	18.502	57.9	5.341	0.2	12	96.74
1	SC5M	20.8	0	20.8	0	20.8	0	
1	DSC5	20.8	0	20.8	0	20.8	0	
1	HYDRO	20.8	0	20.8	0	20.8	0	
1	TREEC	94.283	12.588	100	3.634	56.6	12	13.35
1	CONC	97.837	4.27	100	1.233	88.687	12	4.36
1	EVGC	92.65	12.249	100	3.536	56.6	12	13.22
1	DOWNF	10.35	7.692	30.5	2.22	1.1	12	74.32
1	WOOD	25.089	11.053	46	3.191	13.4	12	44.06
1	PHERB	4.258	5.079	16.5	1.466	0	12	119.28
1	HERB	1.5	0	1.5	0	1.5	0	
1	HERB46	1.5	0	1.5	0	1.5	0	
1	HTDEC	2.011	0.378	2.482	0.114	1.3	11	18.80
1	HTCONBR	6.178	2.537	11.8	0.733	2.29	12	41.07
2	SC2P	9.985	11.975	44.4	2.678	0.4	20	119.93
2	SC2N	24.445	18.37	55.9	4.108	0.9	20	75.15
2	SC5M	18.2	0	18.2	0	18.2	0	
2	DSC5	18.2	0	18.2	0	18.2	0	
2	HYDRO	18.2	0	18.2	0	18.2	0	
2	TREEC	90.82	11.967	100	2.676	52	20	13.18
2	CONC	96.097	7.716	100	1.725	67.021	20	8.03
2	EVGC	85.13	21.809	100	4.877	10.2	20	25.62
2	DOWNF	7.065	6.219	22.7	1.391	0	20	88.03
2	WOOD	26.159	14.12	65.3	3.157	12.3	20	53.98
2	PHERB	2.725	4.2	15.5	0.939	0	20	154.13
2	HERB	0.5	0	0.5	0	0.5	0	
2	HERB46	0.5	0	0.5	0	0.5	0	0.00
2	HTDEC	2.152	0.633	3.765	0.142	1.18	20	29.41
2	HTCONBR	6.125	3.167	13.285	0.708	0.56	20	51.71
3	SC2P	10.05	12.587	41	3.98	0	10	125.24
3	SC2N	9.24	8.107	24.4	2.564	0	10	87.74
3	SC5M	16.98	15.975	47	5.052	0	10	94.08
3	DSC5	0	0	0	0	0	1	
3	HYDRO	0	0	0	0	0	0	
3	TREEC	39.47	28.342	80	8.963	0	10	71.81
3	CONC	84.338	32.501	100	10.278	0	10	38.54
3	EVGC	37.34	28.618	80	9.05	0	10	76.64
3	DOWNF	0.92	1.105	3.3	0.35	0	10	120.11
3	WOOD	8.31	6.436	17.9	2.035	0.4	10	77.45
3	PHERB	4.645	4.176	13.5	1.321	0	10	89.90
3	HERB	5.132	4.719	15.5	1.492	0	10	91.95
3	HERB46	9.146	14.359	45.455	4.541	-0	10	157.00
3	HTDEC	1.663	0.243	2.185	0.077	1.389	10	14.61
3	HTCONBR	2.692	1.913	6.76	0.605	0.733	10	71.06
4	SC2P	1.625	1.823	4.6	0.645	0	8	112.18
4	SC2N	37.275	29.735	76.4	10.513	5.2	8	79.77

Note: Please refer to end of table for variable descriptions.

* See Table C-1 for habitat codes.

Table C-7 (cont'd).

FOREST AND SHRUB 2

HAB*	VAR	MEAN	ST DEV	MAX	STD ERR	MIN	N	CV
4	SC5M	11.4	0	11.4	0	11.4	0	
4	DSC5	11.4	0	11.4	0	11.4	0	
4	HYDRO	11.4	0	11.4	0	11.4	0	
4	TREEC	53.187	17.553	74	6.206	27	8	33.00
4	CONC	99.527	1.338	100	0.473	96.216	8	1.34
4	EVGC	51.712	19.209	71.2	6.791	18	8	37.15
4	DOWNF	0.925	1.073	3.4	0.379	0	8	116.00
4	WOOD	10.737	5.566	19	1.968	4.9	8	51.84
4	PHERB	1.087	2.297	6.7	0.812	0	8	211.32
4	HERB	0	0	0	0	0	0	
4	HERB46	0	0	0	0	0	0	
4	HTDEC	1.605	0.244	1.855	0.1	1.275	6	15.20
4	HTCONBR	5.94	1.355	8.425	0.479	4.25	8	22.81
5	SC2P	35.667	19.818	63.8	8.091	9.2	6	55.56
5	SC2N	30.533	25.334	70.4	10.342	5.8	6	82.97
5	SC5M	70.4	0	70.4	0	70.4	0	
5	DSC5	70.4	0	70.4	0	70.4	0	
5	HYDRO	70.4	0	70.4	0	70.4	0	
5	TREEC	81.567	23.6	96.2	9.635	34.6	6	28.93
5	CONC	96.2	0	96.2	0	96.2	0	
5	EVGC	77.967	22.97	97.6	9.378	34.6	6	29.46
5	DOWNF	97.6	0	97.6	0	97.6	0	
5	WOOD	20.662	12.128	32.9	4.951	7.5	6	58.70
5	PHERB	3.22	4.421	11.818	1.805	0	6	137.30
5	HERB	2	0	2	0	2	0	
5	HERB46	2	0	2	0	2	0	
5	HTDEC	1.545	0.496	2.165	0.202	1.035	6	32.10
5	HTCONBR	1.554	0.685	2.46	0.28	0.71	6	44.08
6	SC2P	28.44	13.07	41.8	5.845	12	5	45.96
6	SC2N	43.98	7.68	54	3.435	32.9	5	17.46
6	SC5M	43.1	0	43.1	0	43.1	0	
6	DSC5	43.1	0	43.1	0	43.1	0	
6	HYDRO	43.1	0	43.1	0	43.1	0	
6	TREEC	81.86	16.101	100	7.200	57.6	5	19.67
6	CONC	57.6	0	57.6	0	57.6	0	
6	EVGC	28.68	19.483	49.2	8.713	6	5	67.93
6	DOWNF	6	0	6	0	6	0	
6	WOOD	18.3	6.005	24.7	2.686	9.2	5	32.81
6	PHERB	2.6	2.434	6.5	1.089	0	5	93.62
6	HERB	1.5	0	1.5	0	1.5	0	
6	HERB46	1.5	0	1.5	0	1.5	0	
6	HTDEC	2.751	0.725	3.7	0.324	2.06	5	26.35
6	HTCONBR	0.867	0.173	1.13	0.077	0.655	5	19.95
7	SC2P	9.662	13.279	40	4.695	0	8	137.44
7	SC2N	47.375	13.3	71.4	4.702	27.6	8	28.07
7	SC5M	49.8	0	49.8	0	49.8	0	
7	DSC5	49.8	0	49.8	0	49.8	0	

Note: Please refer to end of table for variable descriptions.

* See Table C-1 for habitat codes.

Table C-7 (cont'd).

FOREST AND SHRUB 2

HAB*	VAR	MEAN	ST DEV	MAX	STD ERR	MIN	N	CV
7	HYDRO	49.8	0	49.8	0	49.8	0	
7	TREEC	87.925	18.84	100	6.661	42.2	8	21.43
7	CONC	96	0	96	0	96	0	
7	EVGC	23.75	16.129	48.8	5.703	2.6	8	67.91
7	DOWNF	41	0	41	0	41	0	
7	WOOD	25.175	7.693	40.5	2.72	16.2	8	30.56
7	PHERB	2.938	4.57	13	1.616	0	8	155.55
7	HERB	0	0	0	0	0	0	
7	HERB46	0	0	0	0	0	0	
7	HTDEC	1.972	0.451	2.57	0.159	1.375	8	22.87
7	HTCONBR	3.988	4.396	13.143	1.554	0.8	8	110.23
8	SC2P	7.78	5.96	16.8	1.885	0	10	76.61
8	SC2N	23.69	15.329	55.6	4.847	1.8	10	64.71
8	SC5M	1.8	0	1.8	0	1.8	0	
8	DSC5	1.8	0	1.8	0	1.8	0	
8	HYDRO	1.8	0	1.8	0	1.8	0	
8	TREEC	91.33	10.482	100	3.315	69	10	11.48
8	CONC	68.575	20.697	92.602	6.545	31.915	10	30.18
8	EVGC	62.51	18.784	90.6	5.94	30	10	30.05
8	DOWNF	3.76	3.087	9.7	0.976	0	10	82.10
8	WOOD	22.55	11.695	43.5	3.698	4.8	10	51.86
8	PHERB	1.35	2.212	7	0.699	0	10	163.85
8	HERB	0	0	0	0	0	0	
8	HERB46	0	0	0	0	0	0	
8	HTDEC	2.337	0.495	3.093	0.157	1.485	10	21.18
8	HTCONBR	4.058	2.408	7.788	0.761	0.78	10	59.34
9	SC2P	44.9	15.87	58.6	7.935	23.2	4	35.35
9	SC2N	8.5	1.778	10	0.889	6.2	4	20.92
9	SC5M	47.5	12.823	60.6	6.412	31.6	4	27.00
9	DSC5	31.6	0	31.6	0	31.6	0	
9	HYDRO	31.6	0	31.6	0	31.6	0	
9	TREEC	14.75	12.101	27.8	6.051	0	4	82.04
9	CONC	0	0	0	0	0	0	
9	EVGC	11.8	11.462	22.6	5.731	0	4	97.14
9	DOWNF	0	0	0	0	0	0	
9	WOOD	10.175	11.309	25.5	5.654	0	4	111.14
9	PHERB	25.25	13.118	40.5	6.559	8.5	4	51.95
9	HERB	25	6.545	30.5	3.272	15.5	4	26.18
9	HERB46	60.25	17.428	85	8.714	46	4	28.93
9	HTDEC	1.722	0.293	1.95	0.146	1.325	4	17.02
9	HTCONBR	1.525	0.288	1.825	0.166	1.25	3	18.89
101	SC2P	13.143	16.755	40.5	6.333	1	7	127.48
101	SC2N	36.286	21.955	70.2	8.298	7.1	7	60.51
101	SC5M	28.1	0	28.1	0	28.1	0	
101	DSC5	35.443	30.515	81.8	11.534	6.2	7	86.10
101	HYDRO	33.814	31.955	92.9	12.078	0	7	94.50
101	TREEC	82.371	29.317	100	11.081	24	7	35.59

Note: Please refer to end of table for variable descriptions.

* See Table C-1 for habitat codes.

Table C-7 (cont'd).

FOREST AND SHRUB 2

Note: Please refer to end of table for variable descriptions.

HAB*	VAR	MEAN	ST DEV	MAX	STD ERR	MIN	N	CV
101	CONC	89.816	15.103	100	5.708	58.333	7	16.82
101	EVGC	65.371	36.063	100	13.63	14	7	55.17
101	DOWNF	14.4	6.325	23.2	2.391	7.1	7	43.92
101	WOOD	39.565	13.297	61	5.026	20	7	33.61
101	PHERB	20.5	21.243	51.091	8.029	1.5	7	103.62
101	HERB	18.182	0	18.182	0	18.182	0	
101	HERB46	18.182	0	18.182	0	18.182	0	
101	HTDEC	2.273	0.75	3.32	0.283	1.536	7	33.00
101	HTCONBR	5.198	1.169	7.225	0.442	3.805	7	22.49
								ERR
102	SC2P	17.4	1.98	18.8	1.4	16	2	11.38
102	SC2N	13.55	10.677	21.1	7.55	6	2	78.80
102	SC5M	21.1	0	21.1	0	21.1	0	
102	DSC5	69.6	5.374	73.4	3.8	65.8	2	7.72
102	HYDRO	99.45	0.778	100	0.55	98.9	2	0.78
102	TREEC	75.2	13.859	85	9.8	65.4	2	18.43
102	CONC	93.119	9.731	100	6.881	86.239	2	10.45
102	EVGC	70.7	20.223	85	14.3	56.4	2	28.60
102	DOWNF	8.35	3.041	10.5	2.15	6.2	2	36.42
102	WOOD	33.55	7.283	38.7	5.15	28.4	2	21.71
102	PHERB	18.3	2.404	20	1.7	16.6	2	13.14
102	HERB	20	0	20	0	20	0	
102	HERB46	20	0	20	0	20	0	
102	HTDEC	2.161	0.109	2.238	0.077	2.084	2	5.04
102	HTCONBR	5.352	0.364	5.61	0.257	5.095	2	6.80
107	SC2P	14.68	8.635	24.3	3.862	2.9	5	58.82
107	SC2N	17.2	15.128	39.6	6.765	2.2	5	87.95
107	SC5M	23.5	0	23.5	0	23.5	0	
107	DSC5	30.56	18.377	57.4	8.219	7.1	5	60.13
107	HYDRO	33.88	27.307	71.7	12.212	0	5	80.60
107	TREEC	95.88	4.458	100	1.994	89.4	5	4.65
107	CONC	96	0	96	0	96	0	
107	EVGC	14.76	14.611	31.8	6.534	0	5	98.99
107	DOWNF	0	0	0	0	0	0	
107	WOOD	20.973	8.051	33.1	3.6	13.8	5	38.39
107	PHERB	15.664	23.088	56.818	10.325	2.5	5	147.40
107	HERB	5.5	0	5.5	0	5.5	0	
107	HERB46	5.5	0	5.5	0	5.5	0	
107	HTDEC	2.155	0.246	2.49	0.11	1.904	5	11.42
107	HTCONBR	1.147	0.581	1.992	0.291	0.731	4	50.65
108	SC2P	4.3	3.921	9.8	1.96	1.2	4	91.19
108	SC2N	29.5	4.603	36.4	2.301	27	4	15.60
108	SC5M	27.2	0	27.2	0	27.2	0	
108	DSC5	33.85	7.074	43	3.537	27	4	20.90
108	HYDRO	11.85	11.85	23.3	5.925	0	4	100.00
108	TREEC	85.2	14.307	98	7.154	70	4	16.79
108	CONC	74.627	22.92	100	11.46	47.895	4	30.71
108	EVGC	47.65	17.549	63.6	8.774	31	4	36.83

* See Table C-1 for habitat codes.

Table C-7 (cont'd).

FOREST AND SHRUB 2

HAB*	VAR	MEAN	ST DEV	MAX	STD ERR	MIN	N	CV
108	DOWNF	23.875	25.997	62	12.998	3.5	4	108.89
108	WOOD	42.15	19.538	71.2	9.769	30.3	4	46.35
108	PHERB	1.625	2.016	4.5	1.008	0	4	124.06
108	HERB	0.5	0	0.5	0	0.5	0	
108	HERB46	0.5	0	0.5	0	0.5	0	
108	HTDEC	2.115	0.54	2.775	0.27	1.471	4	25.53
108	HTCONBR	4.505	4.28	10.75	2.14	1.1	4	95.01
109	SC2P	15.08	19.104	43.8	8.544	0	5	126.68
109	SC2N	52.9	26.748	73	11.962	8.8	5	50.56
109	SC5M	47.1	0	47.1	0	47.1	0	
109	DSC5	96.067	5.178	100	2.99	90.2	3	5.39
109	HYDRO	54.233	50.535	100	29.176	0	3	93.18
109	TREEC	50.48	40.966	99.6	18.321	0	5	81.15
109	CONC	99.6	0	99.6	0	99.6	0	
109	EVGC	9.16	6.647	16.6	2.973	0	5	72.57
109	DOWNF	0	0	0	0	0	1	
109	WOOD	33.17	14.556	44.55	6.51	10.3	5	43.88
109	PHERB	0.991	1.178	2.5	0.527	0	5	118.87
109	HERB	0	0	0	0	0	0	
109	HERB46	0	0	0	0	0	0	
109	HTDEC	3.539	0.887	4.245	0.397	2.005	5	25.06
109	HTCONBR	2.417	1.714	4.333	0.99	1.029	3	70.91

* See Table C-1 for habitat codes.

Note: Please refer to end of table for variable descriptions.

VARIABLES - FOREST AND SHRUB 2

Variable	Description
SC2P	No. palatable shrubs $\leq$ 2m high/ha
SC2N	No. less palatable shrubs $\leq$ 2m high/ha
SC5M	% Shrub canopy cover
DSC5	% deciduous shrub cover
HYDRO	% of shrub cover (DSC5) that is hydrophytic
TREEC	tree canopy cover (%)
CONC	Conifer cover (%)
EVGCOV	Evergreen cover $\geq$ 3m high (%)
DOWNF	Cover of downfall $\geq$ 7.6cm dbh (%)
WOOD	Depth of woody material (cm)
PHERB	% palatable herbaceous cover
HERB	% herbaceous cover
HERB46	% herbaceous cover
HTDEC	Height deciduous shrubs (cm)
HTCONBR	Height lowest conifer branch (m)

Table C-8. Descriptive Statistics - - Wetlands 1

WETLANDS 1

Note: Please refer to end of table for variable descriptions.

HAB *	VAR	MEAN	ST DEV	MAX	STD ERR	MIN	N	CV
1	DS	1	0	1	0	1	0	
1	HYDRO	1	0	1	0	1	0	
1	HTDS	1	0	1	0	1	0	
1	TCC	1	0	1	0	1	0	
1	HERB	1	0	1	0	1	0	
1	HERB46	1	0	1	0	1	0	
1	HEIGHT	1	0	1	0	1	0	
1	NS	1	0	1	0	1	0	
1	STGR	1	0	1	0	1	0	
1	SUB	1	0	1	0	1	0	
1	WALL	1	0	1	0	1	0	
1	SECCHI	1	0	1	0	1	2	0
1	PERCH	4.5	2.121	6	1.5	3	2	47.133
1	NEST	0.25	0.354	0.5	0.25	0	2	141.6
1	PILOT	1	1.414	2	1	0	2	141.4
1	DIST	0	0	0	0	0	2	
2	DS	1	0	1	0	1	0	
2	HYDRO	1	0	1	0	1	0	
2	HTDS	1	0	1	0	1	0	
2	TCC	1	0	1	0	1	0	
2	HERB	1	0	1	0	1	0	
2	HERB46	1	0	1	0	1	0	
2	HEIGHT	1	0	1	0	1	0	
2	NS	1	0	1	0	1	0	
2	STGR	1	0	1	0	1	0	
2	SUB	1	0	1	0	1	0	
2	WALL	1	0	1	0	1	0	
2	SECCHI	1.397	0.798	3	0.221	0.933	13	57.122
2	PERCH	14.269	22.793	82	6.322	0	13	159.73
2	NEST	1.692	2.658	9	0.737	0	13	157.09
2	PILOT	17.769	28.56	100	7.921	0	13	160.72
2	DIST	88.462	138.67	400	38.462	0	13	156.76
3	DS	1	0	1	0	1	0	
3	HYDRO	1	0	1	0	1	0	
3	HTDS	1	0	1	0	1	0	
3	TCC	1	0	1	0	1	0	
3	HERB	1	0	1	0	1	0	
3	HERB46	1	0	1	0	1	0	
3	HEIGHT	1	0	1	0	1	0	
3	NS	1	0	1	0	1	0	
3	STGR	1	0	1	0	1	0	
3	SUB	1	0	1	0	1	0	
3	WALL	1	0	1	0	1	0	
3	SECCHI	1.775	0.867	3	0.306	0.95	8	48.845
3	PERCH	4.25	4.743	12	1.677	0	8	111.6
3	NEST	2.625	3.962	9	1.401	0	8	150.93
3	PILOT	7	9.607	24	3.396	0	8	137.24
3	DIST	62.5	118.77	300	41.993	0	8	190.03

* See Table C-1 for habitat codes.

Table C-8 (cont'd).

WETLANDS I

HAB*	VAR	MEAN	ST DEV	MAX	STD ERR	MIN	N	CV
8	DS	1	0	1	0	1	0	
8	HYDRO	1	0	1	0	1	0	
8	HTDS	1	0	1	0	1	0	
8	TCC	1	0	1	0	1	0	
8	HERB	1	0	1	0	1	0	
8	HERB46	1	0	1	0	1	0	
8	HEIGHT	1	0	1	0	1	0	
8	NS	1	0	1	0	1	0	
8	STGR	1	0	1	0	1	0	
8	SUB	1	0	1	0	1	0	
8	WALL	1	0	1	0	1	0	
8	SECCHI	0.933	0	0.933	0	0.933	1	
8	PERCH	2	0	2	0	2	1	
8	NEST	0	0	0	0	0	1	
8	PILOT	0	0	0	0	0	0	
8	DIST	0	0	0	0	0	0	
20	DS	8	0	8	0	8	0	
20	HYDRO	8	0	8	0	8	0	
20	HTDS	8	0	8	0	8	0	
20	TCC	8	0	8	0	8	0	
20	HERB	8	0	8	0	8	0	
20	HERB46	8	0	8	0	8	0	
20	HEIGHT	8	0	8	0	8	0	
20	NS	8	0	8	0	8	0	
20	STGR	8	0	8	0	8	0	
20	SUB	2.75	0.378	3	0.134	2	8	13.745
20	WALL	3.125	2.341	5.5	0.828	0	8	74.912
20	SECCHI	1	0	1	0	1	0	
20	PERCH	1	0	1	0	1	0	
20	NEST	1	0	1	0	1	0	
20	PILOT	1	0	1	0	1	0	
20	DIST	1	0	1	0	1	0	
24	DS	55.4	6.954	61.8	4.015	48	3	12.552
24	HYDRO	71.797	24.466	92.90	14.125	44.98	3	34.076
24	HTDS	1.898	0.24	2.135	0.139	1.655	3	12.644
24	TCC	93	9.644	100	5.568	82	3	10.369
24	HERB	100	0	100	0	100	0	
24	HERB46	100	0	100	0	100	0	
24	HEIGHT	15.244	0.006	15.24	0.003	15.24	3	0.0393
24	NS	0.333	0.577	1	0.333	0	3	173.27
24	STGR	1	0	1	0	1	0	
24	SUB	1	0	1	0	1	0	
24	WALL	1	0	1	0	1	0	
24	SECCHI	1	0	1	0	1	0	
24	PERCH	1	0	1	0	1	0	
24	NEST	1	0	1	0	1	0	
24	PILOT	1	0	1	0	1	0	

Note: Please refer to end of table for variable descriptions.

* See Table C-1 for habitat codes.

Table C-8 (cont'd).

WETLANDS 1

Note: Please refer to end of table for variable descriptions.

HAB*	VAR	MEAN	ST DEV	MAX	STD ERR	MIN	N	CV
24	DIST	1	0	1	0	1	0	
25	DS	80.133	16.697	94	9.64	61.6	3	20.836
25	HYDRO	45.246	47.671	100	27.523	12.97	3	105.35
25	HTDS	1.871	0.323	2.233	0.187	1.61	3	17.263
25	TCC	73.933	43.253	99.8	24.972	24	3	58.502
25	HERB	24	0	24	0	24	0	
25	HERB46	24	0	24	0	24	0	
25	HEIGHT	16.269	1.775	18.31	1.025	15.24	3	10.910
25	NS	0.667	1.155	2	0.667	0	3	173.16
25	STGR	2	0	2	0	2	0	
25	SUB	2	0	2	0	2	0	
25	WALL	2	0	2	0	2	0	
25	SECCHI	2	0	2	0	2	0	
25	PERCH	2	0	2	0	2	0	
25	NEST	2	0	2	0	2	0	
25	PILOT	2	0	2	0	2	0	
25	DIST	2	0	2	0	2	0	
26	DS	55.86	25.976	100	11.617	33.8	5	46.501
26	HYDRO	100	0	100	0	100	5	0
26	HTDS	1.483	0.227	1.8	0.101	1.21	5	15.306
26	TCC	1.667	2.887	5	1.667	0	3	173.18
26	HERB	0	0	0	0	0	0	
26	HERB46	0	0	0	0	0	0	
26	HEIGHT	0	0	0	0	0	0	
26	NS	0	0	0	0	0	0	
26	STGR	0	0	0	0	0	0	
26	SUB	0	0	0	0	0	0	
26	WALL	0	0	0	0	0	0	
26	SECCHI	0	0	0	0	0	0	
26	PERCH	0	0	0	0	0	0	
26	NEST	0	0	0	0	0	0	
26	PILOT	0	0	0	0	0	0	
26	DIST	0	0	0	0	0	0	
27	DS	1	0	1	0	1	0	
27	HYDRO	1	0	1	0	1	0	
27	HTDS	1	0	1	0	1	0	
27	TCC	1	0	1	0	1	0	
27	HERB	66.1	24.936	93	11.152	25.5	5	37.724
27	HERB46	18.125	18.647	44	9.324	0	4	102.88
27	HEIGHT	0	0	0	0	0	0	
27	NS	0	0	0	0	0	0	
27	STGR	0	0	0	0	0	0	
27	SUB	0	0	0	0	0	0	
27	WALL	0	0	0	0	0	0	
27	SECCHI	0	0	0	0	0	0	
27	PERCH	0	0	0	0	0	0	
27	NEST	0	0	0	0	0	0	

* See Table C-1 for habitat codes.

Table C-8 (cont'd).

WETLANDS 1

HAB*	VAR	MEAN	ST DEV	MAX	STD ERR	MIN	N	CV
27	PILOT	0	0	0	0	0	0	
27	DIST	0	0	0	0	0	0	

* See Table C-1 for habitat codes.

Note: Please refer to end of table for variable descriptions.

VARIABLES - WETLANDS 1

Variable	Description
DS	% deciduous shrub cover ≤ 5m high
HYDRO	% of shrub cover that is hydrophytic
HTDS	Height of deciduous shrubs ≤ 5m high (m)
TCC	Tree canopy closure (%)
HERB	% herbaceous cover
HERB46	% herbaceous cover 8-46cm tall
HEIGHT	Height of overstory trees
NS	No. snags 10-25cm dbh/ha
STGR	Stream gradient (%)
SUB	Substrate class (1-3)
WALL	No. rock walls, waterfalls, bridges
SECCHI	Secchi disc measurement (m)
PERCH	No. perch sites within 200 ft of water
NEST	No. nest trees within 200 ft of water
PILOT	No. pilot perch trees within 200 ft of water
DIST	Distance between nest habitat and water (ft)

Table C-9. Descriptive Statistics - - Wetlands 2

WETLANDS 2

HAB*	VAR	MEAN	ST DEV	MAX	STD ERR	MIN	N	CV
1	TCC	93.983	12.627	100	3.645	56.6	12	13.44
1	SCC	8.725	12.29	43.4	3.548	0	12	140.86
1	HTSH	2.06	0.419	2.73	0.126	1.315	11	20.34
1	TW	25	0	25	0	25	12	0.00
1	NUMT	104.167	81.569	297	23.547	25	12	78.31
1	NST	79	69.262	247	19.994	11	12	87.67
1	PST	71.849	14.61	89.157	4.218	44	12	20.33
1	DV	3.75	1.865	9	0.538	3	12	49.73
1	WL	3	0	3	0	3	0	
1	STGR	3	0	3	0	3	0	
1	WATF	3	0	3	0	3	0	
1	SHDE	3	0	3	0	3	0	
2	TCC	92.918	9.218	100	2.236	69.6	17	9.92
2	SCC	13.035	16.354	55	3.966	0	17	125.46
2	HTSH	2.053	0.674	3.22	0.163	1.18	17	32.83
2	TW	21.647	7.574	25	1.837	3	17	34.99
2	NUMT	102.941	77.847	302	18.881	33	17	75.62
2	NST	73.529	70.315	264	17.054	8	17	95.63
2	PST	65.216	22.493	96.721	5.455	24.242	17	34.49
2	DV	3	0	3	0	3	16	0.00
2	WL	3	0	3	0	3	0	
2	STGR	3	0	3	0	3	0	
2	WATF	3	0	3	0	3	0	
2	SHDE	3	0	3	0	3	0	
3	TCC	36.37	27.656	80	8.746	0	10	76.04
3	SCC	12.71	17.747	46.1	5.612	0	10	139.63
3	HTSH	1.651	0.19	1.932	0.06	1.419	10	11.51
3	TW	27.5	7.906	50	2.5	25	10	28.75
3	NUMT	37.7	42.682	111	13.497	2	10	113.21
3	NST	25.5	37.766	103	11.943	0	10	148.10
3	PST	56.14	31.387	92.793	9.926	0	10	55.91
3	DV	3.3	0.949	6	0.3	3	10	28.76
3	WL	3	0	3	0	3	0	
3	STGR	3	0	3	0	3	0	
3	WATF	3	0	3	0	3	0	
3	SHDE	3	0	3	0	3	0	
4	TCC	53.185	17.554	74	6.206	27	8	33.01
4	SCC	4.9	8.478	24.1	2.997	0	8	173.02
4	HTSH	1.243	0.539	1.855	0.204	0.355	7	43.36
4	TW	25	0	25	0	25	8	0.00
4	NUMT	179.875	107.676	373	38.069	94	8	59.86
4	NST	149.25	119.38	359	42.207	31	8	79.99
4	PST	75.11	21.418	96.247	7.572	31	8	28.52
4	DV	3	0	3	0	3	8	0.00
4	WL	3	0	3	0	3	0	
4	STGR	3	0	3	0	3	0	

Note: Please refer to end of table for variable descriptions.

* See Table C-1 for habitat codes.

Table C-9 (cont'd)

WETLANDS 2

HAB*	VAR	MEAN	ST DEV	MAX	STD ERR	MIN	N	CV
4	WATF	3	0	3	0	3	0	
4	SHDE	3	0	3	0	3	0	
5	TCC	70.867	32.223	96.2	18.604	34.6	3	45.47
5	SCC	22.4	8.072	29	4.66	13.4	3	36.04
5	HTSH	1.945	0.1	2.05	0.058	1.85	3	5.14
5	TW	25	0	25	0	25	3	0.00
5	NUMT	206.667	165.908	392	95.787	72	3	80.28
5	NST	195	174.192	389	100.57	52	3	89.33
5	PST	87.922	14.031	99.235	8.101	72.222	3	15.96
5	DV	2.5	0.707	3	0.5	2	2	28.28
5	WL	2	0	2	0	2	0	
5	STGR	2	0	2	0	2	0	
5	WATF	2	0	2	0	2	0	
5	SHDE	2	0	2	0	2	0	
6	TCC	68.16	33.786	100	15.11	15	5	49.57
6	SCC	57.74	14.843	74.4	6.638	41.2	5	25.71
6	HTSH	2.807	0.79	3.925	0.353	2.091	5	28.14
6	TW	25	0	25	0	25	5	0.00
6	NUMT	268	273.89	750	122.487	92	5	102.20
6	NST	242.4	281.167	729	125.742	29	5	115.99
6	PST	81.49	31.765	100	14.206	25	5	38.98
6	DV	1.8	0.447	2	0.2	1	5	24.83
6	WL	1	0	1	0	1	0	
6	STGR	1	0	1	0	1	0	
6	WATF	1	0	1	0	1	0	
6	SHDE	1	0	1	0	1	0	
7	TCC	86.2	24.709	100	11.05	42.2	5	28.66
7	SCC	12.064	14.804	38	6.62	0.7	5	122.71
7	HTSH	2.176	0.437	2.57	0.195	1.435	5	20.08
7	TW	25	0	25	0	25	5	0.00
7	NUMT	153.4	148.015	415	66.194	61	5	96.49
7	NST	128.8	160.385	414	71.726	40	5	124.52
7	PST	71.715	16.154	99.759	7.224	58.333	5	22.53
7	DV	1.6	0.548	2	0.245	1	5	34.25
7	WL	2	0	2	0	2	0	
7	STGR	2	0	2	0	2	0	
7	WATF	2	0	2	0	2	0	
7	SHDE	2	0	2	0	2	0	
8	TCC	86.33	20.417	100	6.457	36.2	10	23.65
8	SCC	15.08	12.918	32.7	4.085	0	10	85.66
8	HTSH	2.294	0.602	3.093	0.19	1.005	10	26.24
8	TW	25	0	25	0	25	10	0.00
8	NUMT	84.2	40.232	139	12.723	33	10	47.78
8	NST	59.6	42.885	118	13.562	3	10	71.95
8	PST	61.359	27.308	86.765	8.635	7.692	10	44.51

Note: Please refer to end of table for variable descriptions.

* See Table C-1 for habitat codes.

Table C-9 (cont'd).

WETLANDS 2

Note: Please refer to end of table for variable descriptions.

HAB*	VAR	MEAN	ST DEV	MAX	STD ERR	MIN	N	CV
8	DV	2.2	0.789	3	0.249	1	10	35.86
8	WL	3	0	3	0	3	0	
8	STGR	3	0	3	0	3	0	
8	WATF	3	0	3	0	3	0	
8	SHDE	3	0	3	0	3	0	
9	TCC	15.6	12.751	27.8	6.375	0	4	81.74
9	SCC	42.85	13.305	53.6	6.653	24	4	31.05
9	HTSH	1.69	0.312	1.95	0.156	1.255	4	18.46
9	TW	25	0	25	0	25	4	0.00
9	NUMT	58.5	66.053	149	33.027	5	4	112.91
9	NST	57.5	64.645	146	32.323	5	4	112.43
9	PST	99.118	1.039	100	0.519	97.987	4	1.05
9	DV	2	0	2	0	2	4	0.00
9	WL	2	0	2	0	2	0	
9	STGR	2	0	2	0	2	0	
9	WATF	2	0	2	0	2	0	
9	SHDE	2	0	2	0	2	0	
24	TCC	89.667	9.292	100	5.365	82	3	10.36
24	SCC	55.4	6.954	61.8	4.015	48	3	12.55
24	HTSH	1.895	0.235	2.125	0.136	1.655	3	12.40
24	TW	25	0	25	0	25	3	0.00
24	NUMT	78	8.544	86	4.933	69	3	10.95
24	NST	40.333	5.508	46	3.18	35	3	13.66
24	PST	51.822	5.935	58.228	3.426	46.512	3	11.45
24	DV	2	0	2	0	2	3	0.00
24	WL	2	0	2	0	2	0	
24	STGR	2	0	2	0	2	0	
24	WATF	2	0	2	0	2	0	
24	SHDE	2	0	2	0	2	0	
25	TCC	64.6	35.5	89.8	20.496	24	3	54.95
25	SCC	54.133	5.937	59.2	3.428	47.6	3	10.97
25	HTSH	2.083	0.48	2.53	0.277	1.575	3	23.04
25	TW	20	8.66	25	5	10	3	43.30
25	NUMT	122	71.014	163	41	40	3	58.21
25	NST	104.667	62.931	141	36.333	32	3	60.12
25	PST	84.335	3.755	86.503	2.168	80	3	4.45
25	DV	1.333	0.577	2	0.333	1	3	43.29
25	WL	2	0	2	0	2	0	
25	STGR	2	0	2	0	2	0	
25	WATF	2	0	2	0	2	0	
25	SHDE	2	0	2	0	2	0	
26	TCC	3.32	3.393	8	1.517	0	5	102.20
26	SCC	54.86	26.672	100	11.928	33.8	5	48.62
26	HTSH	1.482	0.226	1.8	0.101	1.21	5	15.25
26	TW	25	0	25	0	25	5	0.00

* See Table C-1 for habitat codes.

Table C-9 (cont'd).

WETLANDS 2

HAB *	VAR	MEAN	ST DEV	MAX	STD ERR	MIN	N	CV
26	NUMT	10.2	9.654	20	4.317	0	5	94.65
26	NST	10.2	9.654	20	4.317	0	5	94.65
26	PST	60	54.772	100	24.495	0	5	91.29
26	DV	1.2	0.447	2	0.2	1	5	37.25
26	WL	2	0	2	0	2	0	
26	STGR	2	0	2	0	2	0	
26	WATF	2	0	2	0	2	0	
26	SHDE	2	0	2	0	2	0	
27	TCC	0.8	1.789	4	0.8	0	5	223.62
27	SCC	3.22	3.843	9.4	1.719	0	5	119.35
27	HTSH	0.885	0.489	1.7	0.219	0.54	5	55.25
27	TW	18.333	11.547	25	6.667	5	3	62.98
27	NUMT	0.2	0.447	1	0.2	0	5	223.50
27	NST	0.2	0.447	1	0.2	0	5	223.50
27	PST	20	44.721	100	20	0	5	223.61
27	DV	2	0	2	0	2	5	0.00
27	WL	2	0	2	0	2	0	
27	STGR	2	0	2	0	2	0	
27	WATF	2	0	2	0	2	0	
27	SHDE	2	0	2	0	2	0	
101	TCC	82.371	29.317	100	11.081	24	7	35.59
101	SCC	25.569	16.771	43.7	6.339	4	7	65.59
101	HTSH	2.3	0.722	3.32	0.273	1.6	7	31.39
101	TW	25	0	25	0	25	7	0.00
101	NUMT	50.857	26.258	86	9.925	18	7	51.63
101	NST	41.857	24.079	73	9.101	10	7	57.53
101	PST	79.789	12.942	93.333	4.892	55.556	7	16.22
101	DV	2.571	0.535	3	0.202	2	7	20.81
101	WL	2	0	2	0	2	0	
101	STGR	2	0	2	0	2	0	
101	WATF	2	0	2	0	2	0	
101	SHDE	2	0	2	0	2	0	
102	TCC	75.2	13.859	85	9.8	65.4	2	18.43
102	SCC	32.3	10.324	39.6	7.3	25	2	31.96
102	HTSH	2.58	0.544	2.965	0.385	2.195	2	21.09
102	TW	25	0	25	0	25	2	0.00
102	NUMT	57	29.698	78	21	36	2	52.10
102	NST	48	28.284	68	20	28	2	58.93
102	PST	82.479	6.648	87.179	4.701	77.778	2	8.06
102	DV	3	0	3	0	3	2	0.00
102	WL	3	0	3	0	3	0	
102	STGR	3	0	3	0	3	0	
102	WATF	3	0	3	0	3	0	
102	SHDE	3	0	3	0	3	0	
107	TCC	95.88	4.458	100	1.994	89.4	5	4.65

Note: Please refer to end of table for variable descriptions.

* See Table C-1 for habitat codes.

Table C-9 (cont'd).

WETLANDS 2

HAB*	VAR	MEAN	ST DEV	MAX	STD ERR	MIN	N	CV
107	SCC	14.56	10.666	30.8	4.77	2.6	5	73.26
107	HTSH	2.206	0.253	2.49	0.113	1.932	5	11.47
107	TW	25	0	25	0	25	5	0.00
107	NUMT	124.4	43.873	168	19.62	68	5	35.27
107	NST	84	48.384	149	21.638	28	5	57.60
107	PST	62.98	17.648	88.69	7.892	41.176	5	28.02
107	DV	1.6	0.548	2	0.245	1	5	34.25
107	WL	1	0	1	0	1	0	
107	STGR	1	0	1	0	1	0	
107	WATF	1	0	1	0	1	0	
107	SHDE	1	0	1	0	1	0	
108	TCC	85.2	14.307	98	7.154	70	4	16.79
108	SCC	33.3	7.364	43	3.682	27	4	22.11
108	HTSH	2.074	0.48	2.638	0.24	1.491	4	23.14
108	TW	25	0	25	0	25	4	0.00
108	NUMT	139.75	63.986	189	31.993	51	4	45.79
108	NST	126.75	65.972	181	32.986	33	4	52.05
108	PST	86.339	14.844	96.296	7.422	64.706	4	17.19
108	DV	2.5	0.577	3	0.289	2	4	23.08
108	WL	3	0	3	0	3	0	
108	STGR	3	0	3	0	3	0	
108	WATF	3	0	3	0	3	0	
108	SHDE	3	0	3	0	3	0	
109	TCC	50.48	40.966	99.6	18.321	0	5	81.15
109	SCC	85.6	18.131	95	8.108	53.2	5	21.18
109	HTSH	3.527	0.882	4.245	0.395	2.005	5	25.01
109	TW	25	0	25	0	25	5	0.00
109	NUMT	163.6	156.647	413	70.055	0	5	95.75
109	NST	145.8	156.835	398	70.139	0	5	107.57
109	PST	64.428	41.606	96.368	18.607	0	5	64.58
109	DV	2	0	2	0	2	5	0.00
109	WL	2	0	2	0	2	0	
109	STGR	2	0	2	0	2	0	
109	WATF	2	0	2	0	2	0	
109	SHDE	2	0	2	0	2	0	

Note: Please refer to end of table for variable descriptions.

* See Table C-1 for habitat codes.

VARIABLES - WETLANDS 2

Variable	Description
TCC	Tree canopy cover (%)
SCC	Shrub canopy cover (%)
HTSH	Height of shrubs $\leq$ 5m (m)
TW	Transect width (m)
NUMT	No. trees/ha
NST	No. trees between 2.5 and 15.2cm dbh/ha
PST	% of trees that are small (NST/NUMT)
DV	Dominant vegetation
WL	Waterlilly cover (%)
STGR	Stream gradient (%)
WATF	Annual water level fluctuation
SHDE	Shoreline development

APPENDIX D

FWS/OBS-82/10.39
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HABITAT SUITABILITY INDEX MODELS: PILEATED WOODPECKER

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CONTENTS

PILEATED WOODPECKER (Dryocopus pileatus)

HABITAT USE INFORMATION

General

The pileated woodpecker (Dryocopus pileatus) inhabits both coniferous and deciduous forests, but is restricted to areas containing mature, dense, productive stands (Bock and Lepthien 1975). These woodpeckers are widely distributed in eastern forests, but are confined in the West to Washington, Oregon, and northern California and, in the Rocky Mountains, to northern Idaho and northwestern Montana (McClelland 1979). Their absence in the central and southern Rocky Mountains is due to a lack of dense, highly productive forests with rapid maturation and decay (Bock and Lepthien 1975).

The critical components of pileated woodpecker habitat are large snags, large trees, diseased trees, dense forest stands, and high snag densities (Bull 1975).

Food

Pileated woodpeckers depend heavily on carpenter ants (Camponotus spp.) and other wood-boring insects for food (McClelland 1979; Bull 1981). A study of the stomach contents of 80 pileated woodpeckers from across the United States, and over the entire year, showed that animal foods comprised about 73% of the diet and vegetable food the remainder (Beal 1911). Over one-half of the animal food was ants, with beetles the next most abundant food item. The majority of the vegetable food was wild fruits.

Pileated woodpeckers in Oregon fed by excavation (subcambial penetration) approximately two-thirds of the time, and by scaling bark, in search of insects, the remainder (Bull 1981). Woodpeckers in Virginia fed primarily by pecking (no subcambial penetration) and excavating during the breeding season, but used excavation techniques more than 70% of the time during the winter months (Conner 1979a). This seasonal variation and narrowing in breadth of foraging techniques is due to the availability and location of prey items during winter months (Conner 1979a, 1981).

Pileated woodpeckers choose foraging habitats that contain high densities of logs and snags, dense canopies, and tall shrub cover (Bull and Meslow 1977). They forage on snags, stumps, and logs that exceed 18 cm (7 inches) in diameter (Bull and Meslow 1977), although they prefer logs greater than 25 cm (10 inches) in diameter and greater than 15 m (49 ft) in length (Bull 1981).

Bull (1981) reported that pileated woodpeckers in Oregon spent 36% of their feeding time foraging on logs, 35% on live trees, and 29% on snags. Foraging sites on the ground were in dead and decayed material, most of which had less than 25% of the bark, branches, and needles remaining. The majority of snags used for foraging were greater than 51 cm (20 inches) dbh, while only 46% of live trees used for foraging exceeded that diameter. Pileated woodpeckers in this study fed mostly on carpenter ants, which were more abundant in larger diameter dead wood.

Pileated woodpeckers in Virginia foraged mostly on dead wood in mature forest habitats (Conner 1980). Pileated woodpeckers foraged extensively on fallen logs in a recently burned pine forest in Mississippi (Schardien and Jackson 1978). Tree stumps greater than 0.3 m (1 ft) in height are used extensively as foraging sites in the East and West (Conner, pers. comm.). Use of snags for foraging increased during the winter months in Montana, as logs and stumps became snow covered (McClelland 1979). Winter food supply was probably the limiting factor for pileated woodpeckers in this northern study area. However, Bull and Meslow (1977) noted, in their Oregon study area, that feeding habitat was probably not as critical as nesting habitat.

Water

Pileated woodpeckers have been observed to drink water before roosting for the night (Kilham 1959). Pileated woodpeckers in Virginia did not nest farther than 150 m (492 ft) from water, and most nests were within 50 m (164 ft) of water (Conner et al. 1975). The average distance between water sources in this study area was 600 m (1,969 ft). The distribution of pileated woodpeckers in this area may have been due to the fact that mesic environments produce more large trees at a faster rate than xeric sites.

Cover

Cover requirements of the pileated woodpecker are very similar to their reproductive requirements. Therefore, cover requirements are included in the following section.

Reproduction

Pileated woodpeckers are primary cavity nesters that require large snags for their nest site (Bull 1981). In Oregon, these woodpeckers selected nest snags from groups of snags in areas of dense forest (Bull and Meslow 1977). They excavate a new cavity each spring and, therefore, need a continual supply of new snags (Bull 1975). Pileated woodpeckers have the strongest year-round pair bond of any North American woodpecker (Kilham 1979), and pairs appear to occupy the same location in successive years (Kilham 1959).

Pileated woodpeckers nest tree search image in Montana was summarized by McClelland (1979:291, 294) as: "a broken top snag [Western larch (*Larix occidentalis*), ponderosa pine (*Pinus ponderosa*), or black cottonwood (*Populus trichocarpa*)] at least 60 cm (24 inches) dbh, taller than 18 m (59 ft) (usually much taller), with heartwood substantially affected by decay, within a forest with an old growth component and a basal area of at least 23 m^2/ha (100 ft^2/acre)".

Pileated woodpeckers are strong excavators and can excavate in sound dead wood (Bull 1981). Most nest trees in Bull's Oregon study were dead at least 10 years, but showed little evidence of decay at the nest site.

Pileated woodpeckers require large, tall snags because their nest cavity is large and located high in the snag (Bull 1981). A summary of nest tree snag measurements from four studies is presented in Table 1. A dbh of 51 cm (20 inches) is considered to be the minimum size tree suitable for nesting in Oregon (Bull and Meslow 1977) and Montana (McClelland 1979). Forest stands in Virginia with trees 38 to 46 cm (15 to 18 inches) dbh would provide adequate nest sites if some trees were decayed (Conner et al. 1975). However, management for only minimum-sized trees may produce a suboptimum habitat, leading to low nesting success (Conner 1979b). Management to provide conditions in the range between the mean and one standard deviation below the mean of habitat variables is desirable for species such as pileated woodpeckers (Conner 1979b, pers. comm.). Snags used for roosting have similar diameters and heights as snags used for nesting (McClelland 1979).

Table 1. Nest tree and basal area measurements from four study areas.

Type of measurement	Study area and reference			
	Oregon (Bull 1981)	Montana (McClelland 1979)	Virginia (Conner et al. 1975)	Oregon (Mannan et al. 1980)
Mean DBH of nest tree, cm (inches)	76 (30)	74.9 (29.5)	54.6 (21.5)	78 (31)
Mean height of nest tree, m (ft)	28 (92)	28 (92)	20.3 (66.6)	
Mean height of nest hole, m (ft)	15 (49)	15.2 (49.9)	13.6 (44.6)	
Basal area, m^2/ha (ft^2/acre)		25.1 (109.4)	31.5 (137.3)	

The majority of nest trees in Oregon had less than 25% of their original limbs and bark remaining (Bull 1981). Thirteen of eighteen nest trees in Virginia were dead, one had a living cambium but decayed inner core, and four nests were in dead parts of live trees (Conner et al. 1975). Pileated woodpeckers in Virginia were apparently able to detect the presence of heart rot in trees, and selected such trees as nest sites, thus reducing the energy expenditure required for excavation (Conner et al. 1976).

Several researchers have estimated the number of snags needed to support maximum pileated woodpecker populations. Bull and Meslow (1977) reported that optimum habitats in Oregon should contain sound snags greater than 51 cm (20 inches) dbh at a density of 0.35 snag/ha (0.14 snag/acre). Their estimate was based on the following assumptions: (1) a density of two pairs of pileated woodpeckers per 2.59 km^2 (1.0 mi^2); (2) a need for three snags per year per pair, one for nesting and two for roosting; and (3) a need for a reserve of 15 snags for each snag used because not all snags are immediately acceptable. Thomas et al. (1979) stated that optimum pileated woodpecker habitat contained snags greater than 50.8 cm (20 inches) dbh and taller than 9.5 m (31 ft) at a density of 0.32 snag/ha (0.13 snag/acre). This estimate assumes a territory size of 122 ha (300 acres). Optimum pileated woodpecker habitat in the northeastern United States has been characterized as containing snags 45 to 65 cm (18 to 26 inches) dbh and 12 to 21 m (39 to 69 ft) tall at densities of 0.6 snag/ha (0.24 snag/acre) (Evans and Conner 1979). This estimate assumes the following: (1) a territory size of 71 ha (175 acres) per pair of pileated woodpeckers; (2) a need for four snags per year per pair; one for nesting, two for roosting, and one for fledged young; and (3) a need for a reserve of 10 snags for each snag used to account for unusable snags, replacements, feeding habitat needs, and a snag supply for secondary users.

Pileated woodpecker densities in Illinois were positively correlated with the number of large trees [greater than 56 cm (22 inches) dbh] (Graber et al. 1977). Woodpecker densities were highest when there were about 50 large trees/ha (20/acre), and the approximate average dbh was 29 cm (11.5 inches). Woodpecker densities were lowest when there were only about 12.5 large trees/ha (5/acre) and the approximate average dbh was 27 cm (10.5 inches). [Note: Average dbh figures were estimated from graphics in Graber et al. (1977), using the median value of the size classes provided.] Conner (pers. comm.) stated that optimum suitability exists when habitats contain 30 or more trees greater than 51 cm dbh/0.4 ha (20 inches dbh/1.0 acre).

Pileated woodpeckers in Virginia preferred to nest in mesic stands near streams with the following characteristics: greatest basal area [27.1 m^2/ha (118 ft^2/acre)], greatest stem density [475.3/ha (1,174/acre)], and highest crown canopy height [24.2 m (79.4 ft)] available (Conner and Adkisson 1976). Favored nesting habitat in Montana and Oregon was dense forests containing old growth western larch or ponderosa pine (McClelland 1979; Bull 1981). Douglas-fir (Pseudotsuga menziesii) was seldom used in either study, probably due to the fact that its sapwood decayed very rapidly (McClelland 1979; Bull, pers. comm.).

Interspersion

The minimum forest size needed to support pileated woodpeckers is partially dependent on the availability of food (McClelland 1979). A minimum of 200 ha (494 acres) is probably needed in northern Rocky Mountain areas. Nesting pairs in Oregon ranged over 130 to 243 ha (320 to 600 acres), and a minimum requirement of 130 ha (320 acres) has been suggested (Bull and Meslow 1977). The winter foraging range of a pair of pileated woodpeckers in the southeastern United States was 70 ha (173 acres) (Kilham 1976).

Special Considerations

The pileated woodpecker is a key indicator species for the retention of a complete community of hole nesting birds (McClelland 1979), and it is likely that, if the habitat needs of the pileated woodpecker are met, other woodpeckers also would benefit (Bull and Meslow 1977).

Habitat for the pileated woodpecker in the Rocky Mountains is diminishing as old growth forests are cut (McClelland 1979). Silvicultural thinning may negatively affect these woodpeckers due to a loss of decayed trees that provide woodpecker nest sites and habitat for carpenter ants (Conner et al. 1975). Pileated woodpecker habitat may also be threatened by intensive forest harvesting practices (Conner 1980). A cutting rotation in Eastern forests of 80 years would probably provide adequate foraging habitat (Conner 1980), but a 150 year rotation may be needed for nesting habitat (Conner 1978).

Unmanaged, mature stands usually have adequate numbers of snags for resident woodpeckers (Bull et al. 1980). In managed forest stands, snags can be maintained by killing trees or by leaving trees to die, and woodpeckers can then be managed at selected population levels.

HABITAT SUITABILITY INDEX (HSI) MODEL

Model Applicability

Geographic area. This model was developed for application within the entire range of the pileated woodpecker with different variables included for snag diameters for the eastern and western portions of the range.

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

Cover types. This model was developed to evaluate habitat quality in the following cover types: Evergreen Forest (EF); Deciduous Forest (DF); Evergreen Forested Wetland (EFW); and Deciduous Forested Wetland (DFW) (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. It is assumed that a minimum of 130 ha (320 acres) of habitat must exist or the HSI for the pileated woodpecker will equal zero.

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

Model Description

Overview. The food, cover, and reproductive habitat needs of the pileated woodpecker are very similar. Large snags provide a source of food, cover, and nest sites. Mature, dense forest stands contribute to both the food and cover needs of the pileated woodpecker. Therefore, this model combines food, cover, and reproduction into a single component. It is assumed that the presence of water is related to the variables used to assess food, cover, and reproduction. Pileated woodpeckers use different size snags in the eastern and western portions of their range, and this model includes specific variables for each area.

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

The following sections provide a written documentation of the logic and assumptions used to interpret the habitat information for the pileated woodpecker 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 model; (2) definition and justification of the suitability levels of each variable; and (3) description of the assumed relationship between variables.

Food/cover/reproduction component. Dense, mature forest stands with an abundance of logs and stumps, and large decayed snags provide food and cover for the pileated woodpecker. This model assumes that either the availability of dense, mature forests or the abundance of snags can be the limiting factor in determining habitat values for pileated woodpeckers.

The density and maturity of forest stands can be assessed by measuring the tree canopy closure, abundance of large diameter trees, and abundance of fallen logs and stumps. Pileated woodpeckers prefer dense stands, and it is assumed that optimum habitats have 75% or greater tree canopy closures and that stands with less than 25% canopy closure will have no suitability. Pileated woodpeckers are most abundant in forest stands with many large diameter trees. It is assumed that optimum habitats contain 30 or more trees greater than 51 cm dbh/0.4 ha (20 inches dbh/1.0 acre). Habitats with less than three such large trees per 0.4 ha (1.0 acre) are assumed to have no suitability. Optimum pileated woodpecker habitats contain an abundance of fallen logs and stumps, while habitats with no fallen logs or stumps may provide moderate suitability if other resources are available. It is assumed

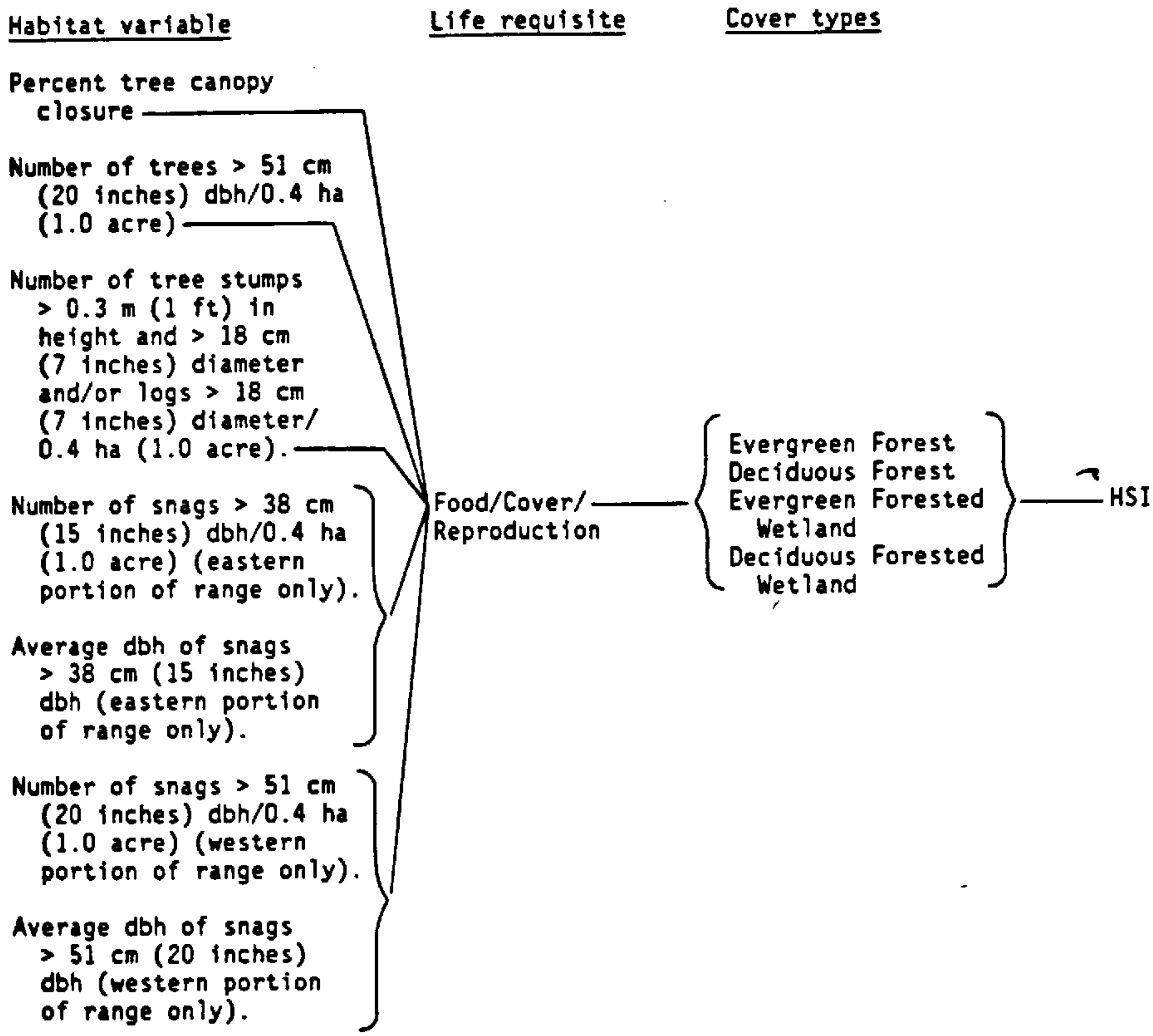


Figure 1. Relationship of habitat variables, life requisites, and cover types in the pileated woodpecker model.

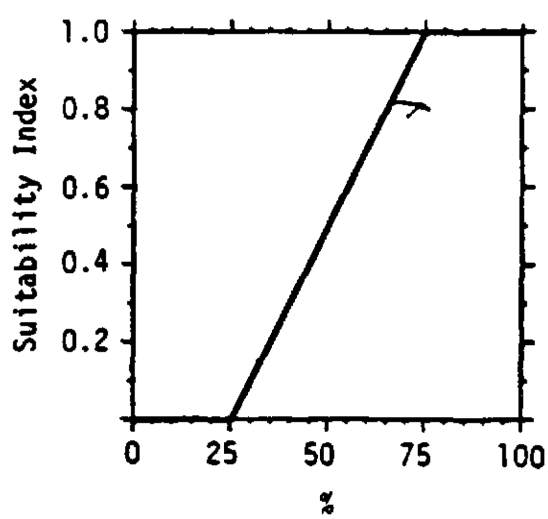
that maximum habitat values occur when there is a total of 10 or more logs greater than 18 cm (7 inches) diameter and/or stumps of the same diameter and greater than 0.3 m (1 ft) in height per 0.4 ha (1.0 acre). Overall suitability related to the density and maturity of forest stands is a function of the tree canopy closure, abundance of large trees, and abundance of logs and stumps. Tree canopy closure and large tree abundance are the most important variables, while log and stump abundance exerts less of an influence in determining habitat values.

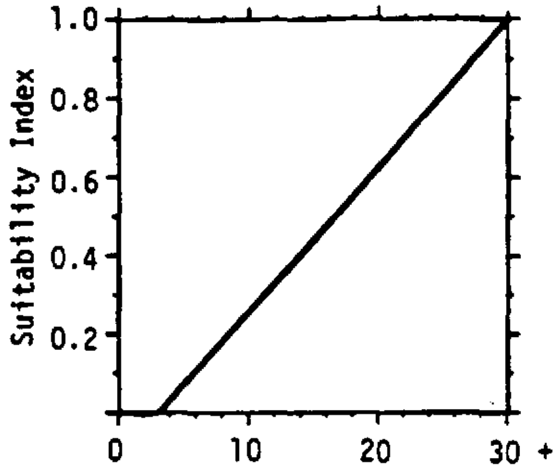
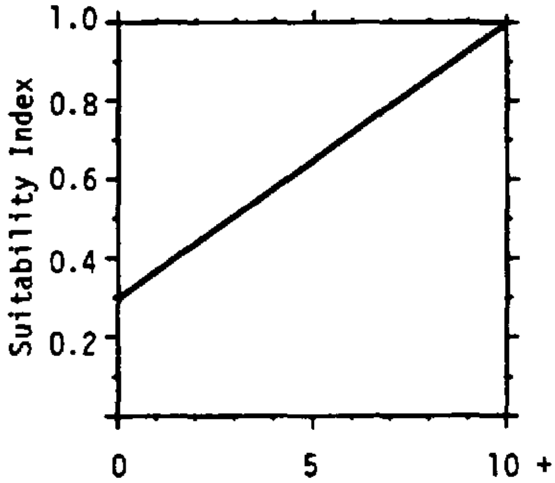
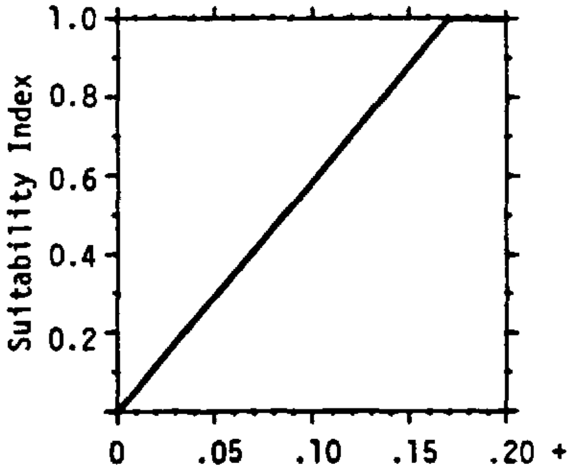
Snag suitability is assumed to be related to the abundance of large diameter snags. It is assumed that pileated woodpeckers, in the Eastern portion of their range, require snags greater than 38 cm (15 inches) dbh for nesting and, in the West, they require snags greater than 51 cm (20 inches) dbh. Maximum suitability in both the East and West exists when 0.17 or more suitably sized snags occur per 0.4 ha (1.0 acre). Habitats with no suitably sized snags provide no suitability. These snag sizes represent the minimum dbh for a useable snag. It is assumed that optimum conditions occur when the average dbh of all snags that meet the minimum size requirement is equal to the average dbh of snags actually selected by pileated woodpeckers for nest sites (see Conner 1979b). In the East, it is assumed that optimum conditions occur when the average dbh of all snags greater than 38 cm (15 inches) dbh is 54 cm (21 inches). In the West, optimum habitats exist when the average dbh of all snags greater than 51 cm (20 inches) is 76 cm (30 inches). Habitats in the East or West with an average snag diameter equal to the minimum suitable size will provide one-half of optimum habitat suitability.

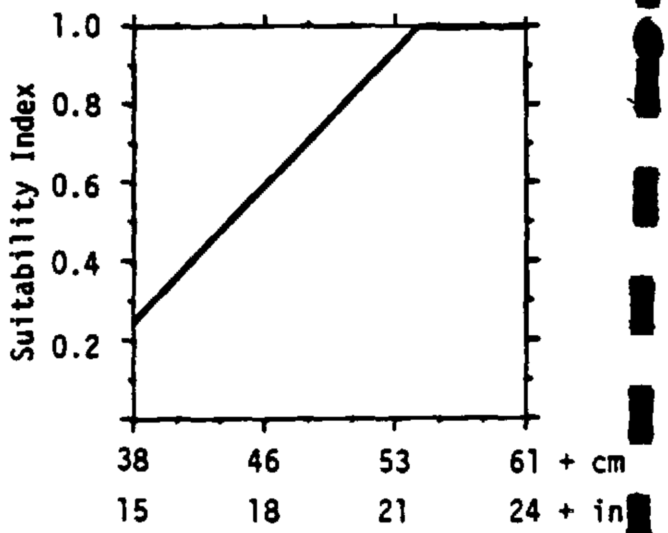
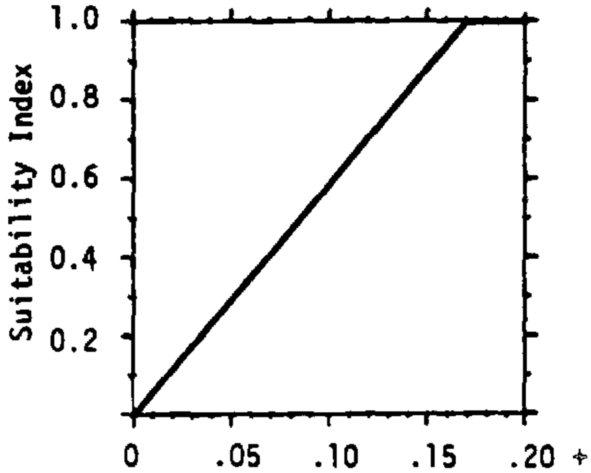
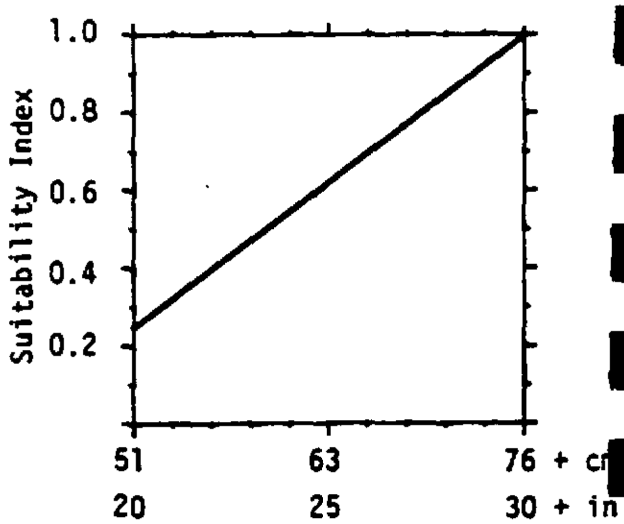
Overall habitat suitability for the pileated woodpecker is assumed to be limited by either the density and maturity of the forest or the abundance of snags.

Model Relationships

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

Cover type	Variable		Suitability graph
EF,DF, EFW,DFW	V_1	Percent tree canopy closure.	

EF,DF, EFW,DFW	V_2	Number of trees > 51 cm (20 inches) dbh/0.4 ha (1.0 acre).	
EF,DF, EFW,DFW	V_3	Number of tree stumps > 0.3 m (1.0 ft) in height and > 18 cm (7 inches) diameter and/or logs > 18 cm (7 inches) diameter/ 0.4 ha (1.0 acre).	
EF,DF, EFW,DFW	V_4	Number of snags > 38 cm (15 inches) dbh/0.4 ha (1.0 acre).	

EF,DF, EFW,DFW	V_5	Average dbh of snags > 38 cm (15 inches) dbh.	
EF,DF, EFW,DFW	V_6	Number of snags > 51 cm (20 inches) dbh/0.4 ha (1.0 acre).	
EF,DF, EFW,DFW	V_7	Average dbh of snags > 51 cm (20 inches) dbh.	

Equations. In order to determine the life requisite value for the pileated woodpecker, the SI values for appropriate variables must be combined through the use of equations. A discussion and explanation of the assumed relationship 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 the food/ cover/reproduction value are presented below.

Life requisite	Cover type	Equation
Eastern portion of range: Food/cover/reproduction	EF,DF,EFW,DFW	Lower of $(V_1 \times V_2 \times V_3)^{1/2}$ or $(V_4 \times V_5)^{1/2}$
Western portion of range: Food/cover/reproduction	EF,DF,EFW,DFW	Lower of $(V_1 \times V_2 \times V_3)^{1/2}$ or $(V_6 \times V_7)^{1/2}$

HSI determination. The HSI for the pileated woodpecker is equal to the life requisite value for food/cover/reproduction.

Application of the Model

Definitions of variables and suggested field measurement techniques (Hays et al. 1981) are provided in Figure 2. Note that V_4 and V_5 are to be measured only in the eastern portion of the range of the pileated woodpecker, and V_6 and V_7 in the western portion of the range.

Variable (definition)		Cover types	Suggested technique
V_1	Percent tree canopy closure [the percent of the ground surface that is shaded by a vertical projection of the canopies of all woody vegetation taller than 5.0 m (16.5 ft)].	EF,DF,EFW, DFW	Line intercept

Figure 2. Definitions of variables and suggested measurement techniques.

Variable (definition)		Cover types	Suggested technique
V_2	Number of trees > 51 cm dbh/0.4 ha (20 inches dbh/1.0 acre) [actual or estimated number of trees that are greater than 51 cm (20 inches) diameter at breast height (1.4 m (4.5 ft) per 0.4 ha (1.0 acre)].	EF,DF,EFW, DFW	Quadrat
V_3	Number of tree stumps > 0.3 m (1.0 ft) in height and > 18 cm (7 inches) diameter and/or logs > 18 cm (7 inches) diameter/ 0.4 ha (1.0 acre) [the actual or estimated number of tree stumps greater than 0.3 m (1.0 ft) in height and greater than 18 cm (7 inches) in diameter, and/or logs greater than 18 cm (7 inches) in diameter present per acre. Log diameter should be measured at the largest point].	EF,DF,EFW, DFW	Quadrat
V_4	Number of snags > 38 cm (15 inches) dbh/0.4 ha (1.0 acre) [the number of standing dead trees or partly dead trees, that are greater than 38 cm (15 inches) diameter at breast height (1.4 m/4.5 ft), and that are at least 1.8 m (6 ft) tall, per 0.4 ha (1.0 acre). 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. (continued).

Variable (definition)		Cover types	Suggested technique
V_5	Average dbh of snags > 38 cm (15 inches) dbh [the average diameter of all snags that exceed 38 cm (15 inches) diameter at breast height (1.4 m/4.5 ft)].	EF,DF,EFW, DFW	Quadrat; Biltmore stick or diameter tape
V_6	Number of snags > 51 cm (20 inches) dbh/0.4 ha (1.0 acre) [the number of standing dead trees or partly dead trees, that are greater than 51 cm (20 inches) diameter at breast height (1.4 m/4.5 ft), and that are at least 1.8 m (6 ft) tall, per 0.4 ha (1.0 acre). 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
V_7	Average dbh of snags > 51 cm (20 inches) dbh [the average diameter of all snags that exceed 51 cm (20 inches) diameter at breast height (1.4 m/4.5 ft)].	EF,DF,EFW, DFW	Quadrat; Biltmore stick or diameter tape

Figure 2. (concluded).

SOURCES OF OTHER MODELS

Conner and Adkisson (1976) have developed a discriminant function model for the pileated 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.

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HABITAT SUITABILITY INDEX MODELS: MARTEN

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CONTENTS

MARTEN (*Martes americana*)

HABITAT USE INFORMATION

General

The marten (*Martes americana*) inhabits late successional forest communities throughout northern North America (Marshall 1951). The species is most abundant in association with mature coniferous forests, but also inhabits forests of mixed deciduous and coniferous species (Hagmeier 1956). Marten in Minnesota were observed or captured most often in conifer-dominated or mixed stands of coniferous and deciduous trees (Mech and Rogers 1977). Marten prefer softwood-dominated mixed stands in undisturbed forests in Maine (Soutiere 1979). The marten is mostly carnivorous, generally nocturnal, and active throughout the year.

Food

Marten consume a wide variety of food items throughout the year. Invertebrates, berries, and passerine birds were the most frequent food items recorded from spring through fall in a Montana study (Weckwerth and Hawley 1962). However, mammals were the most important food item on an annual basis, with the highest utilization of mammalian prey occurring during the winter months. Voles (Microtinae) are utilized more than any other single food item (Cowan and Mackay 1950; Lensink et al. 1955; Weckwerth and Hawley 1962; Koehler and Hornocker 1977; Soutiere 1979).

Mech and Rogers (1977) reported that food availability is probably the most important factor affecting the distribution of marten. Fluctuations in small mammal densities in Montana were believed to directly affect the carrying capacity of the study area for marten (Weckwerth and Hawley 1962). Clark and Campbell (1976) believed that limited access routes to get at prey below deep snow may be more restrictive on marten winter densities than the actual density of rodents present.

Water

No water requirements for the marten were described in the literature.

Cover

Mesic stands of mature coniferous trees with a canopy closure of 30% or more supported the highest marten activity in Montana (Koehler and Hornocker 1977). These sites also supported the greatest number of rodents and contained the highest diversity of understory plant species. Sub-alpine fir (*Abies lasiocarpa*), Engelmann spruce (*Picea engelmannii*), and Douglas fir (*Pseudotsuga menziesii*) stands were the most intensively used by marten during the winter months in Idaho (Marshall 1951). Stands of Ponderosa pine (*Pinus ponderosa*) were frequently used when adjacent to spruce-fir stands. Eighty percent of the marten observations in Colorado were in spruce-fir stands or in forest types which were at least partially comprised of spruce (Yeager and Remington 1956).

Marten in Wyoming frequently select large [35.5 to 60.9 cm dbh (14 to 24 in)], rotten Engelmann spruce or sub-alpine fir snags as refuge sites (Clark and Campbell 1976). Other commonly reported refuge sites include ground burrows, rock piles, and crevices (Mech and Rogers 1977), downfall, stumps, and brush or slash piles (Marshall 1951; Clark and Campbell 1976; Steventon and Major 1982). Downfall, in addition to providing refuge sites, allow marten access to below snow surface galleries of vegetation and fallen trees (Clark and Campbell 1976). These "entry" sites are believed critical to marten winter survival because they provide access to rodent prey active under deep snow. Such entry sites accounted for 92.8% of the recorded marten winter feeding sites in Wyoming. Ninty-seven percent of the marten winter resting sites located in Maine were beneath the snow surface within natural cavities formed around large decayed stumps (Steventon and Major 1982). These refuge sites were repeatedly used for several days at a time. Hagmeier (1956) found that, while marten ranged through a variety of vegetative types, most refuge sites were located within stands of coniferous trees. Summer refuge sites in Maine were in the crowns of conifer trees (Steventon and Major 1982). No refuge sites were located on the ground surface during this season.

Hawley and Newby (1957) believe that large openings serve as psychological barriers to marten, while Koehler and Hornocker (1977) believe that openings, which are avoided in the winter, may be used for foraging in the summer and fall seasons if adequate food and cover are present. Marten occasionally crossed openings up to 164.5 m (180 yd) in width in Maine during the winter months (Soutiere 1979). Although windfall and slash protruding from the snow were investigated by marten, movements across such openings were more direct than movements within uncut forest stands. Marten in Colorado have been observed at distances ranging from 0.8 to 3.2 km (0.5 to 2.0 mi) from forest cover types from May through November (Streeter and Braun 1968). In all such instances but one, the species was observed in large boulder fields which provided a food source [pika (Onchotona princeps)] and cover in the form of large boulders or rockslides.

Yeager (1950) believed that timber harvesting was the single most destructive factor contributing to the decimation of marten populations. Marten in Wyoming did not utilize harvested timber stands for at least 1 year after cutting (Clark and Campbell 1976). Marten in Maine rarely used clearcut areas less than 15 years old but were found in partially harvested stands (Soutiere 1979). Steventon and Major (1982) recorded significant avoidance of clearcut areas by marten during winter. Islands of uncut softwoods within and adjacent to clearcuts were heavily utilized for cover and foraging in summer and winter.

Reproduction

The reproductive requirements of the marten are assumed to be identical with cover requirements, as described above.

Interspersion

Marten populations are structured around male territories, which are rigidly defended during the spring and summer months (Clark and Campbell 1976). Home ranges of male martens are distinct, but female home ranges often overlap those of other females and males. Boundaries of marten home ranges often coincide with the edges of topographic or vegetative features, such as large, open meadows, burns and streams (Hawley and Newby 1957).

The mean home range size for marten in Montana was 2.4 km^2 (0.9 mi^2) and 0.69 km^2 (0.27 mi^2) for males and females, respectively (Hawley and Newby 1957). Similar sizes were reported in Wyoming: 2.4 km^2 (0.93 mi^2) for males and 0.88 km^2 (0.34 mi^2) for females (Clark and Campbell 1976). However, the average home range size in Minnesota was 15.6 km^2 (6.0 mi^2) for males and 4.3 km^2 (1.7 mi^2) for females (Mech and Rogers 1977). The average winter home range for male marten in Maine was 9.25 km^2 (3.57 mi^2) (Steventon and Major 1982). Summer home range size was between 5.0 and 10.0 km^2 (1.93 to 3.86 mi^2).

HABITAT SUITABILITY INDEX (HSI) MODEL

Model Applicability

Geographic area. This HSI model has been developed for application in boreal coniferous forests of the western United States.

Season. This HSI model was developed to evaluate the potential quality of winter habitat for marten. The winter cover requirements of this species are more restrictive than cover requirements during other seasons of the year. It is assumed that if adequate winter cover is available, habitat requirements throughout the balance of the year will not be limiting.

Cover types. This model was developed to evaluate habitat in Evergreen Forests (EF) (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 an area will be occupied by a species. Information on the minimum habitat area for the marten was not reported in the literature, but home ranges in the western United States are approximately 2.38 km^2 (0.92 mi^2) for males. Based on this information, it is assumed that at least 2.59 km^2 (1 mi^2) of suitable habitat must be available before an area will be occupied by this species. If less than 2.59 km^2 (1 mi^2) of suitable habitat is present, the HSI is assumed to be 0.0.

Verification level. This model was reviewed by Tim W. Clark, Ph.D., Biology Department, Idaho State University. Dr. Clark concluded that this Habitat Suitability Index model would yield an accurate representation of marten habitat suitability (Clark, pers. comm.).

Model Description

Overview. All winter habitat requirements of the marten can be satisfied within boreal evergreen forests. The marten is, therefore, treated as utilizing evergreen forests only, and habitat evaluation using this model only considers the quality of life requisites provided by evergreen forests. It is assumed that food availability will not be limiting for the marten if adequate cover is present.

The following sections provide documentation of the logic and assumptions used to translate habitat information for the marten 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 marten.

Habitat variable	Life requisite	Cover types	
Percent tree canopy closure Percent of overstory canopy closure comprised of fir or spruce Successional stage of stand Percent of ground surface covered by downfall	Winter cover	Evergreen forest	HSI

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

Cover component. The marten may range through various forested and non-forested cover types throughout the spring, summer, and fall. Based on the literature, mature stands of evergreen trees, particularly spruce and fir, are required during the winter months in order to provide adequate protective and thermal cover.

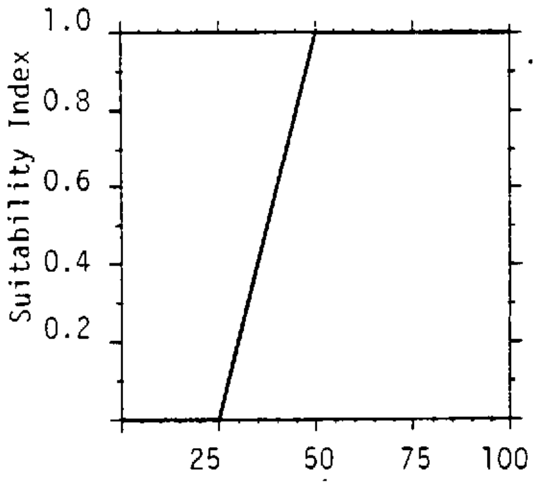
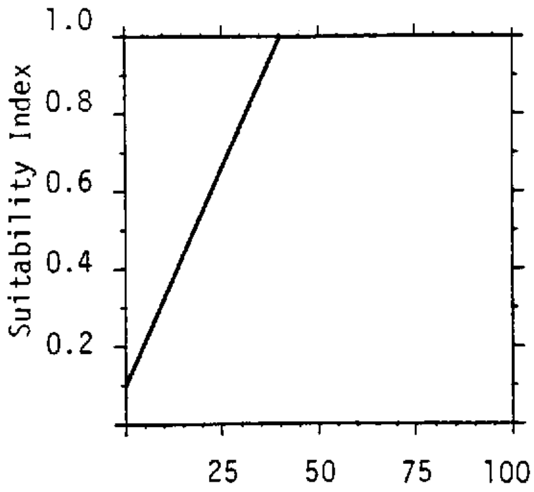
Suitable winter cover is a function of the successional stage of the stand, the percent of the stand which is comprised of spruce or fir, the total percent canopy closure of the stand, and the amount of downfall in the stand. Stands of mature to overmature coniferous forest, comprised of 40% fir or spruce, with a total canopy closure greater than 50%, are assumed to provide near optimal winter habitat. Forest stands which contain an abundance of downfall or windthrow are assumed to have a higher winter cover value because such materials provide refuge sites for the marten and accessibility to small mammals active under the snowpack. Although small diameter woody debris on the forest floor will provide cover for rodents, marten require the presence of partially fallen snags, or large logs, on the ground surface to provide access points for foraging under the snow's surface.

Sparse forest stands are assumed to provide marginal cover for marten; therefore, a tree canopy closure of less than 25% will indicate no value as winter cover for the species. It is also assumed that any tree species present within a forest stand will have some value as winter cover for marten. Therefore, the lowest value which may be obtained for this variable is 0.1. Forest stands dominated by shrubs or seedling sized trees are assumed to provide no value as winter cover for marten. Pole sized and young stands of trees provide some cover, while mature or old growth stands provide optimum cover. A ground surface covered by downfall ranging from 20% to 50% is assumed to have optimum value. However, the absence of downfall or presence of a high density of these materials will not severely limit the cover value for marten.

The percent tree canopy closure and successional stage of the stand are the two most limiting variables for determining the suitability of marten winter habitat. When either of these variables is outside the suitable ranges defined above, marten habitat will not be present. The presence of little or no spruce or fir in a forest stand will lower the value of the habitat for marten. However, the absence of these species will not exclude the area as potential marten habitat. Although the percent of the ground surface covered by downfall has the least amount of influence in the determination of marten winter habitat suitability, such material is essentail to provide optimal winter habitat. An excessive amount of downfall (> 50%) is assumed to decrease the availability and accessibility of prey for marten. It is assumed that mature or old growth forest stands will provide a sufficient number of snags and partially fallen trees to allow entry points under the snow's surface.

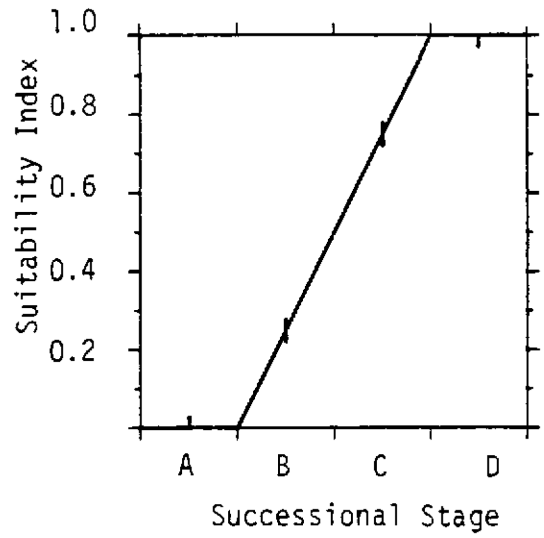
Model Relationships

Suitability Index (SI) graphs for habitat variables. The relationships between various conditions of habitat variables and habitat suitability for the marten are graphically represented in this section.

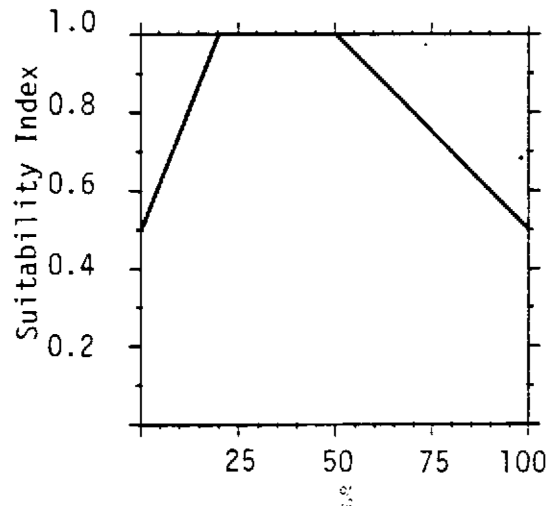
Cover type	Variable		
EF	(V_1)	Percent tree canopy closure.	
EF	(V_2)	Percent of overstory canopy closure comprised of fir or spruce.	

EF (V$_3$) Successional stage of stand.

A) shrub-seedling
B) pole sapling
C) young
D) mature or old growth



EF (V$_4$) Percent of ground surface covered by downfall which is ≥ 7.6 cm (3 in) in diameter.



Equations. In order to obtain life requisite values for the marten, 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 equation in this model was chosen to mimic these perceived biological relationships as closely as possible. The suggested equation for obtaining a winter cover value is presented below.

Life requisite	Cover type	Equations
Winter cover	EF	$(V_1 \times V_2 \times V_3 \times V_4)^{1/2}$

HSI determination. Since winter cover was the only life requisite considered in this model, the HSI equals the winter cover value.

Application of the Model

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

Variable (Definition)	Cover types	Suggested technique
(V_1) Percent tree canopy closure. [The percent of the ground surface that is shaded by a vertical projection of the canopies of all woody vegetation taller than 5.0 m (16.5 ft)].	EF	Line intercept, remote sensing
(V_2) Percent of the overstory canopy closure comprised of fir or spruce. (The percent canopy closure of spruce or fir trees in the overstory divided by the total canopy closure of all overstory trees.)	EF	Line intercept, remote sensing
(V_3) Successional stage of stand. (The structural condition of a forest community which occurs during its development.) Six recognized stages: 1. grass-forb 2. shrub-seedling 3. pole-sapling 4. young 5. mature 6. old growth	EF	On-site inspection, remote sensing

Figure 2. Definitions of variables and suggested measurement techniques.

(V_4) Percent of ground surface covered by downfall which is ≥ 7.6 cm (3 in) in diameter. (The percent of the ground surface which is covered by dead, woody material which may include: tree boles; stumps; root wads; or limbs.)	EF	Line intercept, quadrat

Figure 2. (concluded)

SOURCES OF OTHER MODELS

No other habitat models for the marten were located.

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HABITAT SUITABILITY INDEX MODELS: RUFFED GROUSE

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CONTENTS

RUFFED GROUSE (*Bonasa umbellus*)

HABITAT USE INFORMATION

General

The ruffed grouse (*Bonasa umbellus*) is the most widely distributed species of the Tetraoninae in North America, occurring in forested habitats from central Alaska to northern California; through the central Rocky Mountains of Idaho, Montana, western Wyoming, and north-central Utah; isolated in western South Dakota; from British Columbia east across Canada to southern Labrador; and from Minnesota, Michigan, Wisconsin, northeastern Iowa, Illinois, Missouri, and northern Arkansas east through Indiana, Ohio, New York, New England, and the southern Appalachian Mountains from Pennsylvania to northern Georgia (Aldrich 1963). Ruffed grouse have been successfully introduced outside their original range into Newfoundland and northeastern Nevada (Johnsgard 1973). It is the most widely hunted grouse in North America, providing recreational sport hunting in 43 States and Provinces.

Food

Ruffed grouse feed on a variety of plant foods, with regional and seasonal variations occurring in their diet (Korschgen 1966). Animal foods, primarily insects, are consumed in small quantities (4 to 5% of diet) by adults during summer (Edminster 1954) and in large quantities (50 to 75%) by chicks during their first few weeks of life (Bump et al. 1947; Edminster 1954). Insects decrease in importance in the diet of chicks throughout summer, and by August their diet is similar to adults, consisting primarily of plant foods (Stewart 1956). Kimmel and Samuel (1984) studied the foraging behavior of ruffed grouse chicks imprinted on humans. The diet of chicks up to 3 weeks of age was > 90% invertebrates; plant parts were not predominant until chicks were 8 weeks old.

In regions where snow cover is continuous throughout winter (e.g., northern New England and New York, Great Lakes States, Canada, Alaska, and the Rocky Mountains), the winter diet of ruffed grouse is comprised of buds and catkins of hardwood shrubs and trees (Bump et al. 1947; Gullion and Svoboda 1972; Johnsgard 1973). The staminate flower buds of aspens (*Populus* spp.), especially quaking aspen (*P. tremuloides*), are the critical winter food resource in Minnesota (Svoboda and Gullion 1972). A single mature male quaking aspen in Minnesota provides 8 to 9 days of food for one grouse. Aspens are an important winter food throughout much of the range of ruffed grouse (Brown 1946; Phillips 1967; Schemnitz 1970; Doerr et al. 1974; Gullion 1977, 1981; Kubisiak et al. 1980; Stoll et al. 1980; Schulz et al. 1983).

Other hardwood species also are used, especially when aspens are not predominant. Willow (Salix spp.) and aspen were 29 and 35%, respectively, of the total winter food volume consumed by ruffed grouse in Alberta (Doerr et al. 1974). Willow buds and twigs were 34% and aspen buds and twigs were 55% of the dry weight of food in crops of ruffed grouse collected in interior Alaska during winter (McGowan 1973). Ruffed grouse in central New York preferred buds of black cherry (Prunus serotina) and apple (Malus pumila) to those of aspen (Woehr and Chambers 1975). Winter foods of ruffed grouse in northeastern Ohio included buds of black cherry, hawthorn (Crataegus spp.), and hophornbeam (Ostrya virginiana), as well as aspen (Stoll et al. 1980). Buds and catkins of trees continue to provide food for ruffed grouse into the spring breeding season (Edminster 1954; Gullion and Svoboda 1972).

In regions where snow cover during winter is minimal or of short duration (e.g., Pacific coast, southern Ohio, Indiana, Illinois, southern Appalachians), the winter diet of ruffed grouse is more variable, including buds, fruits, and leaves from a variety of understory shrubs and herbaceous plants, as well as buds and fruits from trees (Korschgen 1966; Johnsgard 1973). Ruffed grouse in western Washington fed on buds and catkins of black cottonwoods (Populus trichocarpa) and leaves of buttercups (Ranunculus spp.) during winter (Brewer 1980). Acorns (Quercus spp.) and hophornbeam catkins were principal winter foods of ruffed grouse in Missouri (Korschgen 1966). Fruits of sumac (Rhus spp.), bittersweet (Celastrus scandens), poison ivy (Toxicodendron radicans), greenbrier (Smilax spp.), and dogwood (Cornus spp.), in addition to buds of hawthorn, aspen, and hophornbeam, were used by ruffed grouse in central and southern Ohio (Stoll et al. 1980). Gilfillan and Bezdek (1944) also noted the importance of understory species as winter food for ruffed grouse in Ohio. Greenbrier, mountain laurel (Kalmia latifolia), Christmas fern (Polystichum acrostichoides), Japanese honeysuckle (Lonicera japonica), and dogwood were important winter food items in eastern Tennessee and western North Carolina (Stafford and Dimmick 1979). Soft and hard fruits from a variety of shrubs and trees were eaten by ruffed grouse in southwestern Virginia (Norman and Kirkpatrick 1984).

Summer foods include numerous fruits, berries, green vegetation, and insects (Bump et al. 1947; Edminster 1954; Korschgen 1966). Ruffed grouse feed on a great variety of berries, herbaceous vegetation, and leaves, buds, and fruits of hardwood trees and shrubs during fall when potential food items are most abundant (Gullion 1966). Hungerford (1957) reported extensive use of insects and limited use of western redcedar (Thuja plicata) leaves during fall in northern Idaho.

Water

Most grouse foods contain considerable moisture (Johnsgard 1973), and it is unlikely that ruffed grouse require free water for drinking. When grouse are found near water, it is because they prefer the food or cover associated with mesic habitats and not because of a dependence on free water (Edminster 1954).

Cover/Reproduction

Cover suitable for drumming grouse during spring is suitable fall and winter cover (Berner and Gysel 1969; Gullion 1977), and suitable fall to spring cover for males also is suitable for females (Gullion 1967, cited by Moulton 1968). Females with broods prefer habitats similar to those preferred by drumming males (Berner and Gysel 1969; Porath and Vohs 1972; Kubisiak 1978).

The seasonal requirements of ruffed grouse are met by a combination of different cover types or age classes of forest (Bump et al. 1947; Gullion and Svoboda 1972; Gullion 1977). Ruffed grouse are associated principally with deciduous hardwood forests (Bump et al. 1947; Edminster 1954; Johnsgard 1973), especially those with aspen as a dominant species (Gullion and Svoboda 1972). However, hardwood trees are absent from some regions inhabited by ruffed grouse, e.g., northern Idaho (Hungerford 1951), and conifers are used for winter and escape cover in many regions (Bump et al. 1947; Edminster 1947; Lewis et al. 1968; Woehr 1974; Stoll et al. 1977).

Although the relationship between ruffed grouse and the distribution of aspens is not obligatory, ruffed grouse achieve their greatest abundance in northern regions where aspens, especially quaking aspen, are a dominant component of the forest (Gullion and Svoboda 1972; Gullion 1977, 1984a). Optimal aspen cover supports 20 to 40 drumming males/100 ha during peak populations. Maximum densities are usually lower, ranging from 2 to 8 males/100 ha, in the peripheral range of ruffed grouse, where aspen often is unavailable (Table 1).

Ruffed grouse males typically drum from a fallen log although other objects also are used (Bump et al. 1947; Sousa 1978). An acceptable drumming log provides sufficient height to allow a view of the surroundings and a relatively level stage (Boag and Sumanik 1969). Throughout their range, ruffed grouse prefer drumming sites that are surrounded by a moderate density of woody stems (Table 2), especially in the tall shrub or sapling layers (Palmer 1963; Boag and Sumanik 1969; Gullion 1970; Woehr 1974; Titus 1976; Salo 1978; Kelly and Major 1979, cited by Backs 1984; Stoll et al. 1979; Brewer 1980; Kubisiak et al. 1980; Stauffer 1983; Hunyadi 1984). The importance of stem density to habitat suitability for drumming grouse was confirmed by an experimental removal of woody stems < 5 cm dbh from a 0.005-ha circle surrounding each of 32 primary drumming logs in southwestern Alberta (Boag 1976a). Occupancy rates and recruitment of males were lower at treatment sites than at 32 control logs, and occupancy of secondary drumming logs was greater in activity centers associated with treatment than with control logs. No preference for high stem densities was observed in northern Georgia (Hale et al. 1982) and Vermont (Sousa 1978), however, and ruffed grouse in central Alberta preferred drumming sites with lower densities of stems < 10.2 cm dbh and greater densities of stems > 10.2 cm dbh (Rusch and Keith 1971).

Suitable drumming cover at the Cloquet Forestry Center in Minnesota occurs when 8 to 12-year old aspen stands have thinned to < 19,800 stems/ha (Gullion and Svoboda 1972). Cover suitability increases with natural thinning

Table 1. Densities of breeding male ruffed grouse throughout their range (values converted to males/100 ha).

Breeding males/100 ha[a] Max	Min	Location	Period	General habitat[b]	Reference
41.7	20.5	Minnesota: Cloquet Forestry Center	1959-77	10-25 year aspen	Gullion (1977)
35.7	10.7	Wisconsin: Sandhill Wildlife Area	1968-77	Aspen-alder	Kubisiak et al. (1980)
22.2	12.3	Central Alberta	1966-68	Aspen	Rusch and Keith (1971)
15.8	5.6	New York: Connecticut Hill	1930-42	Allegheny and northern hardwoods with conifers	Bump et al. (1947)
14.7	5.7	Ontario: Algonquin Park	1971-82	Mixed conifer-aspen, sugar maple-hemlock	Theberge and Gauthier (1982)
14.0	2.5	Minnesota: Cloquet Forestry Center	1959-82	Aspen, northern hardwoods, with some conifers	Gullion and Alm (1983)
10.4	1.0	Michigan: Rifle River Area	1950-58	Mixed conifer, northern hardwoods, aspen, alder	Palmer and Bennett (1963)
10.1	2.7	Wisconsin: Sandhill Wildlife Area	1968-77	Aspen and oak	Kubisiak et al. (1980)
10.1	4.6	Southwestern Alberta	1965-75	Aspen, balsam poplar, white spruce	Boag (1976a)
7.8	0.0	Minnesota: Cloquet Forestry Center	1959-82	Pine, spruce-fir, with some aspen	Gullion and Alm (1983)
7.2	2.7	Indiana: Maumee Grouse Study Area	1969-73, 1975-83	Oak	Backs (1984)
6.9	--	Northeastern Iowa	1967	Maple-basswood, oak-hickory, aspen	Porath and Vohs (1972)

Table 1. (concluded).

Breeding males/100 ha[a] Max	Min	Location	Period	General habitat[b]	Reference
6.2	5.5	Western Washington	1977-79	Black cottonwood, red alder, western hemlock	Brewer (1980)
6.2	2.8	Southeastern Ohio	5 years	Oak-hickory, beech-maple, pine	Stoll et al. (1973)
6.1	3.2	New York: Adirondack area	1932-38	Mixed conifers, northern hardwoods	Bump et al. (1947)
4.6	1.8	Missouri: Ashland Area and Daniel Boone Forest	1963-83	Oak-hickory, sugar maple, hophornbeam	Hunyadi (1984)
4.4	1.2	Wisconsin: Stone Lake Experimental Area	1968-77	Balsam fir, aspen	Kubisiak et al. (1980)
3.9	--	Southeastern Idaho: Wasatch Mountains	1979-82	Aspen, mixed conifer	Stauffer (1983)
2.6	1.8	Northern Georgia	1976-79	Oak-hickory, yellow poplar, pine	Hale et al. (1982)
2.6	--	Vermont: Grafton	1975	Maple, beech, yellow birch, mixed conifers	Sousa (1978)

[a] All estimates based on counts of drumming males except Stauffer (1983) which was a subjective estimate.

[b] Common and scientific names of plants not mentioned in text: balsam poplar (*Populus balsamifera*); basswood (*Tilia americana*); beech (*Fagus grandifolia*); hemlock (*Tsuga canadensis*); hickory (*Carya* spp.); red alder (*Alnus rubra*); sugar maple (*Acer saccharum*); western hemlock (*Tsuga heterophylla*); yellow birch (*Betula alleghaniensis*); and yellow poplar (*Liriodendron tulipifera*).

Table 2. Stem densities at ruffed grouse drumming sites (values converted to stems/ha).

Location	Size category	Stems/ha	Comments	Reference
Minnesota: Cloquet Forestry Center	Aspen > 0.6 m tall	4,900-14,800	Optimal 13-25 year aspen	Gullion (1970, 1977)
Wisconsin: Sandhill Wildlife Area	> 1.8 m tall	4,400-14,800	Optimal 6-25 year aspen	Kubisiak (pers. comm.)
Central Alberta	Shrubs > 0.9 m tall	8,545[ns]	Means for 67 drumming sites compared with 163 random stations	Rusch and Keith (1971)
	Trees < 10.2 cm dbh	3,815[a***]		
	Trees > 10.2 cm dbh	850[b***]		
New York: Tug Hill Plateau	< 30 cm tall	975[a***]	Means for drumming sites compared with available habitat	Woehr (1974)
	> 30 cm tall to 1.25 cm dbh	17,575[ns]		
	2.5 cm dbh	7,712[b***]		
	5.0 cm dbh	912[ns]		
	7.5 cm dbh	350[a**]		
	> 10.0 cm dbh	480[ns]		
Ontario: Algonquin Park	< 10 cm dbh	2,872 and 3,980[ns]	Means for 2 areas with different grouse densities	Theberge and Gauthier (1982)
Michigan: Rifle River Area	< 0.6 m tall	31,849[a**]	Means for habitat within 10.1 m radius of 40 drumming logs compared with habitat 10.1 to 20.1 m distant	Palmer (1963)
	0.6-1.5 m tall	13,289[ns]		
	1.5-2.4 m tall	4,776[ns]		
	> 2.4 m tall to 7.6 cm dbh	8,401[b***]		
	7.6-15.2 cm dbh	1,181[b**]		
	15.2-22.9 cm dbh	138[b**]		
	> 22.9 cm dbh	109		
Southwestern Alberta	< 1.0 m tall	2,120[b]	Means for 80 drumming logs compared with 98 unused logs	Boag and Sumanik (1969)
	> 1.0 m tall to 5 cm dbh	4,720[b]		
	5-10 cm dbh	2,720[b]		
	10-20 cm dbh	620[a]		
	> 20 cm dbh	140[b]		
Indiana	< 13 cm dbh	35,000[b***]	Means for 64 drumming logs compared with unused logs	Kelly and Major (1979, cited by Backs 1984)

Table 2. (concluded).

Location	Size category	Stems/ha	Comments	Reference
Western Washington	> 0.2 m tall	21,592[b**]	Means for 25 drumming logs compared with 26 unused logs	Brewer (1980)
Southeastern Ohio	< 1.0 m tall > 1.0 m tall to 2.5 cm dbh 2.6-5.1 cm dbh 5.2-10.2 cm dbh	80,060[ns] 16,803[b***] 1,977[b***] 988[ns]	Means for 30 perennial logs compared with 27 transient centers	Stoll et al. (1979)
Missouri: Monkey Mt. and Anderson Wildlife Areas, Boone Forest	> 1.0 m tall	15,296[b] 13,412[b] 11,760[b]	Means for drumming logs at 3 areas compared with available habitat	Hunyadi (1984)
Southeastern Idaho	< 7 cm dbh 7-15 cm dbh 15-23 cm dbh > 23 cm dbh	8,509[b*] 494[ns] 174[ns] 100[ns]	Means for 19 drumming logs compared with 19 unused logs	Stauffer (1983)
Northern Georgia	< 0.5 m tall > 0.5 m tall to 10 cm dbh > 10 cm dbh	120,000[ns] 14,000[ns] 556[ns]	Means for 14 drumming logs compared with 14 unused logs	Hale et al. (1982)
Vermont: Grafton	< 2.5 cm dbh 2.5-12.7 cm dbh > 12.7 cm dbh	941-5,651[ns] 2,063-6,098[ns] 494-941[ns]	Densities for 5 drumming logs compared with available habitat in stands	Sousa (1978)

[a]Mean less than mean for available habitat or unused logs.

[b]Mean greater than mean for available habitat or unused log.

[ns]$P > 0.10$

[*]$P < 0.10$

[**]$P < 0.05$

[***]$P < 0.01$

and increasing height of stems associated with maturation of a stand (Gullion and Svoboda 1972; Gullion 1977). Optimal drumming cover occurs in 13 to 25-year old aspen stands with a stem density of 4,900 to 14,800/ha (Gullion 1970:Fig. 3) and a closed canopy about 10 m overhead (Gullion and Svoboda 1972; Gullion 1977). The habitat has "gone-by" and rather abruptly ceases to support drumming grouse when stem densities decrease to < 4,900/ha (Gullion and Svoboda 1972; Gullion 1977). Aspen in central Wisconsin initially are occupied when stands are < 5 years of age and have maximum stem densities of 19,800/ha (Kubisiak et al. 1980; Kubisiak 1985; Kubisiak pers. comm.). Optimal drumming cover is provided by 6 to 25 year old aspen stands having densities of woody stems > 1.8 m tall from 4,400 to 14,800/ha and a canopy height ≥ 4.6 m (Kubisiak pers. comm.).

The age when a tree stand initially provides suitable habitat for ruffed grouse and length of time that it remains suitable habitat will be affected by growth rates of plants providing cover, and this varies among species and growing site environments (Gullion 1984b). Mature hardwood tree stands that have thinned below suitable tree densities continue to provide suitable cover if there is sufficient density and height of woody shrubs in the understory (Kubisiak et al. 1980; Gullion 1984a). Shrubs > 0.9 m in height provide suitable cover when there are 80 to 200 stems within a 3.0 to 3.7 m radius of the drumming stage (Gullion 1972, cited by Boag 1976a), equivalent to densities of 19,000 to 68,700/ha. However, shrubs need to be > 1.5 m tall to provide suitable overhead cover (Kubisiak 1985; Gullion pers. comm.). Forty-three of 112 drumming sites located by Salo (1978) in western Washington were in dense thickets (300,000 stems > 2.5 m tall/ha) of salmonberry (Rubus spectabilis) in the understory of mature, open canopy forests.

Optimal drumming habitat provides cover for ruffed grouse and even stem spacing which allows them to maintain effective surveillance for predators (Gullion and Svoboda 1972; Gullion 1977). This is referred to as vertical cover. Preferred habitats provide optimal cover across the major portion of an activity center and not just immediately surrounding the drumming log (Gullion and Marshall 1968; Gullion 1984b). Grouse territories that include several suitable alternate drumming sites are more likely to be occupied for extended periods (perennial use) than territories without suitable alternate drumming sites (Boag 1976b). Mid-seral aspen stands provide optimal vertical cover during fall through spring and suitable snow conditions for snow-burrow roosting during winter (Gullion and Svoboda 1972).

Conifers can be detrimental to survival of ruffed grouse in drumming habitats (Gullion and Marshall 1968; Gullion 1970; Rusch and Keith 1971), because low-growing conifers provide concealment for mammalian predators, and the "high pine" conifers provide concealment and excellent opportunities for raptors to ambush grouse. Gullion and Marshall (1968) attributed 86% of ruffed grouse kills at Cloquet, Minnesota to raptor predation. Maximum grouse densities during peak populations at Cloquet (Table 1) were twice as high in a predominantly hardwood tract compared to a predominantly coniferous tract of forest (Gullion and Alm 1983). Mean longevity and survival of ruffed grouse also were greater in the predominantly hardwood forest tract. Maximum densities of drumming males (7.5/100 ha) in balsam fir (Abies balsamea) habitats at Stone Lake, Wisconsin were only 20% of maximum densities (35.7/100 ha) in optimal aspen-alder (Alnus spp.) habitat at Sandhill, Wisconsin (Kubisiak et al. 1980). The presence of conifers around drumming sites in central Ontario was not considered detrimental to ruffed grouse populations because avian predators were scarce (Theberge and Gauthier 1982).

Conifers provide the only suitable drumming or winter cover in some regions, but densities of ruffed grouse are lower in these habitats than in optimal aspen habitats (Table 1). Young white spruce (Picea glauca) < 10 cm dbh provided drumming cover in mixed deciduous/coniferous forests in southwestern Alberta (Boag and Sumanik 1969), and young balsam fir in the understory of mature aspen forests provided cover for drumming grouse at Stone Lake, Wisconsin (Kubisiak et al. 1980). Conifers were considered important winter cover in New York (Bump et al. 1947; Edminster 1947; Woehr 1974), Ohio (Stoll et al. 1977), Indiana (Muehrcke and Kirkpatrick 1969), Missouri (Lewis et al. 1968), and Idaho (Hungerford 1951). Ruffed grouse in north-central Minnesota preferred jack pine (Pinus banksiana) forests for cover during winter, a habitat type also used by spruce grouse (Dendragapus canadensis) (Pietz and Tester 1982). Ruffed grouse inhabiting the boreal forest region of New Brunswick used spruce-fir and jack pine forests throughout the year (Keppie pers. comm.). Conifers, especially fir and spruce with branches growing low to the ground, provide important thermal cover for grouse in regions where snow depths or snow conditions during winter limit snow-burrow roosting (Woehr 1974; Chambers pers. comm.; Keppie pers. comm.). More than 90% of winter roosts in central New York were located in conifers during two winters when snow-burrow roosting was prohibited by wet or crusted snow on all but five nights (Woehr 1974).

Ruffed grouse nests typically are located at the base of trees in open hardwood stands although other sites are used, such as the base of stumps, under slash, bushes, or brush piles (Bump et al. 1947; Edminster 1947). Aspen stands in Minnesota with stem densities < 4,900/ha provide preferred nesting cover (Gullion 1977), and nesting females feed extensively on emerging aspen leaves and prefer to locate their nests close to mature aspens (Gullion and Svoboda 1972; Gullion 1977; Maxson 1978). Nearby undergrowth is usually sparse (Bump et al. 1947; Gullion 1977).

Brood cover occurs in transition zones between lowland and upland forests or forest edges and openings with a well-developed herbaceous and shrub understory (Bump et al. 1947; Edminster 1947; Sharp 1963; Porath and Vohs 1972; Stauffer 1983). Optimal brood habitat in Minnesota occurs in regenerating aspen stands with 12,400 to 29,000+ stems/ha (Gullion 1970, 1977). Most upland aspen stands in Wisconsin can provide suitable brood habitat, but optimal habitat occurs in 6 to 25 year old stands or where alder or other equivalent cover exists (Kubisiak 1978).

Interspersion and Composition

Ruffed grouse are not migratory, but they will move short distances among different seasonal habitats (Johnsgard 1973). Optimal interspersion of cover types occurs when all seasonal habitat requirements are contained within 4 ha

(Gullion and Svoboda 1972). In Minnesota, these seasonal requirements are met by an interspersion of seedling (1 to 12 years old), sapling (13 to 25 years old), and mature (> 25 years old) aspen stands (Gullion and Svoboda 1972). Mature male aspen within 91 m of adequate fall to spring cover provide the essential winter food source (Gullion 1977). Kubisiak et al. (1980) found 98% of drumming sites in Wisconsin within 40 m of a mature aspen food source. However, only 53% of drumming logs in southern Ohio were within 100 m of mature aspen (Stoll et al. 1979).

Male ruffed grouse in Minnesota occupied an average of 8.9 ha from March to June but occupied a reduced area of 6.7 ha during the drumming season (Archibald 1975). Females occupied areas of 16.5 ha, moving from lowland-upland edge in early spring to upland sites for nesting. Females gradually reduce their movements from prelaying through incubation (Maxson 1978). Occupied areas averaged 12.1 ha during prelaying, 8.4 ha during laying, and 0.9 ha during incubation. Females can move their broods up to 5.8 km to suitable cover (Schladweiler 1965). The cruising radius of most broods, however, is < 0.4 km (Chambers and Sharp 1958). Juveniles are more mobile than adults during fall (Hale and Dorney 1963), and juvenile females disperse farther than males (Godfrey and Marshall 1969).

Special Considerations

Ruffed grouse are associated with disturbed forest habitats (Gullion 1977). However, elimination of forest cover over an area > 4 ha results in reduced breeding densities (Gullion 1970). Extensive areas of a single cover type are not as valuable to ruffed grouse as the close interspersion of several smaller cover types. Aspen regeneration 1 to 12 years old provides optimal brood cover in Minnesota, aspen saplings 13 to 25 years old provide optimal fall to spring (drumming) cover, and aspens > 25 years old provide an essential winter food source and nesting habitat (Gullion and Svoboda 1972; Gullion 1977).

Small clearcuts (Edminster 1947; Stauffer 1983; Gullion 1984a) and burning (Sharp 1970) can improve grouse habitat by maintaining an interspersion of young through mature successional stages of forest. Grazing by livestock can adversely affect brood habitat (Robertson 1976; Stauffer 1983), extensive timber harvesting reduces breeding densities, and lack of timber management results in large tracts of mature forest that are unsuitable for ruffed grouse (Gullion 1977).

Ruffed grouse occur sympatrically with spruce and/or blue grouse (Dendragapus obscurus) throughout portions of their range (Aldrich 1963). Ruffed and spruce grouse use the same winter habitats in north-central Minnesota (Pietz and Tester 1982), and these two species use similar habitats throughout much of the boreal forest (Keppie pers. comm.). Ruffed and blue grouse in Idaho rarely use the same habitats even though they occupy the same areas (Marshall 1946; Stauffer 1983); ruffed grouse occur in more mesic sites with greater canopy cover. There is no evidence of competition between ruffed and blue or spruce grouse (Pietz and Tester 1982; Stauffer 1983).

HABITAT SUITABILITY INDEX (HSI) MODEL

Model Applicability

Geographical area. This model is intended for application within the region where aspen is a predominant component of the forest ecosystem. With modifications, discussed under Application of the Model, it may be applicable throughout the range of ruffed grouse.

Season. This model was developed to evaluate the year-round habitat of the ruffed grouse.

Cover types. This model was developed to evaluate habitat suitability in Deciduous and Evergreen Forest (DF, EF), Tree Savanna (DTS, ETS), and Shrubland (DS, ES) cover types (U.S. Fish and Wildlife Service 1981). Further subdivision of these cover types is possible and is discussed on page 20 under Application of the Model.

Minimum habitat area. Minimum habitat area is defined as the minimum amount of contiguous suitable habitat that is required before an area will be occupied by a particular species. This information was not found in the literature for ruffed grouse. An activity center for an individual drumming male can be as small as 2.4 ha (Gullion 1977), but a pair of grouse/4 ha is about the highest density grouse population that can be expected under most conditions (Gullion and Svoboda 1972). Therefore, this model should not be applied on an area < 4 ha. Both Stoll (pers. comm.) and Chambers (pers. comm.) recommended a minimum habitat area of 20 ha for isolated blocks of forest surrounded by unsuitable grouse habitat, e.g., a farm woodlot surrounded by cropland.

Verification level. This model was developed with the assistance of Gordon W. Gullion, Project Leader of the University of Minnesota's Forest Wildlife Project at the Cloquet Forestry Center, near Cloquet, Minnesota. The variables in this model are based on Mr. Gullion's experience and long-term data collected on the Cloquet Forest. In 1981, the U.S. Fish and Wildlife Service contracted Mr. Gullion to provide habitat and grouse use data from 20 drumming logs, 20 4-ha activity centers surrounding the logs, and five blocks of forested habitat ranging from 18.1 to 27.5 ha. These data (Cade 1984) were used to refine variable relationships and suitability levels from earlier drafts of the model.

Previous drafts of this model were also reviewed by:

David A. Boag, Professor, Department of Zoology, University of Alberta, Edmonton, Alberta

Robert E. Chambers, Professor, Department of Environmental and Forest Biology, State University of New York, Syracuse, NY

Ralph W. Dimmick, Professor, Department of Forestry, Wildlife, and Fisheries, University of Tennessee, Knoxville, TN

Daniel M. Keppie, Professor, Department of Forest Resources, University of New Brunswick, Fredericton, New Brunswick

John F. Kubisiak, Project Leader, Forest Wildlife Research Group, Wisconsin Department of Natural Resources, Babcock, WI

Keith R. McCaffery, Project Leader, Forest Wildlife Research Group, Wisconsin Department of Natural Resources, Rhinelander, WI

Robert J. Stoll, Jr., Wildlife Biologist, Ohio Department of Natural Resources, New Marshfield, OH

Specific comments from each reviewer were incorporated into the current model. Boag (pers. comm.), Chambers (pers. comm.), Dimmick (pers. comm.), and Stoll (pers. comm.) questioned whether it was possible to develop a single habitat suitability model that would be applicable throughout the range of ruffed grouse. Modifications of this model that may increase its usefulness in various regions are discussed under Application of the Model.

Model Description

Overview. Optimal habitat for ruffed grouse is provided by the interspersion of several forest age classes. The ruffed grouse is considered in this model to be a multicover type species, using different age classes of forests. Winter Food and Fall to Spring Cover are the life requisites considered in this model and are assumed to be the same for both male and female grouse. It is assumed that water is not a limiting factor for ruffed grouse populations. Nesting and brood-rearing habitat are assumed to never be more limiting than winter food and fall to spring cover requirements.

The following sections identify important habitat variables used in the model, describe suitability levels of the variables, and describe the relationships among variables.

Winter food component. Optimal winter food for ruffed grouse is provided by the flower buds of mature male aspens (Svoboda and Gullion 1972; Gullion 1984a). Other plants also provide a winter food source, but they will be of lower value and support fewer grouse than will mature male aspen. Svoboda and Gullion (1972) estimated that one average mature male aspen would provide a grouse with 8 to 9 days of food. Based on a 180 day winter (November-April), one grouse would require 20 mature male aspen during winter (Kubisiak et al. 1980). Suitability of winter food will be determined by the interspersion of mature male aspen and fall to spring cover. Optimal winter food is assumed to exist when ≥ 20 mature male aspen are within 91 m of fall to spring cover (Gullion 1977). Suitability of winter food is assumed to decrease as the distance between 20 mature male aspen and fall to spring cover increases from 91 to 183 m. If there are < 20 mature male aspen within 183 m of fall to spring cover, it is assumed that other deciduous shrubs and trees will provide winter food but at a lower level of suitability. Because mature male aspens can be clustered in clones or scattered throughout a stand, winter food suitability is measured as the average radius of circles encompassing 20 mature male aspen (Fig. 1), i.e., the distance to the 20th mature male aspen from a sampling point. This distance relationship is used whether suitable winter food and fall to spring cover occur in the same or different cover types (stands).

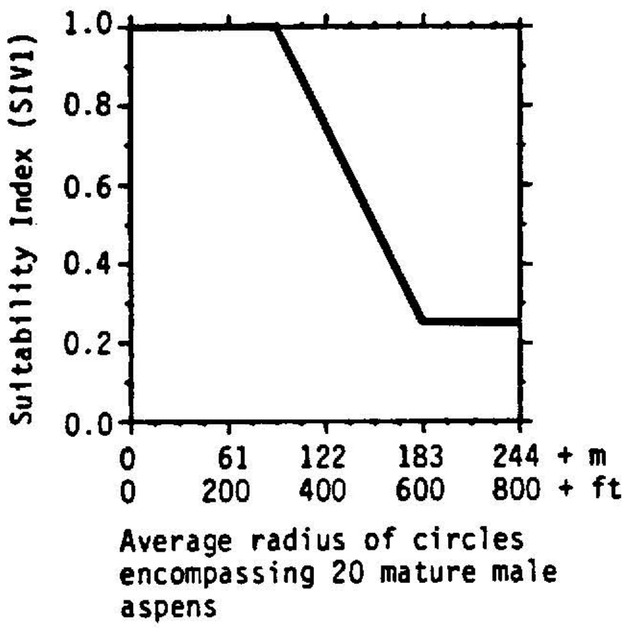

Figure 1. The relationship between the average radius of circles encompassing 20 mature male aspen and suitability indices for winter food.

<u>Fall to spring cover component</u>. Fall to spring cover is a function of the degree of obstruction provided by woody vegetation and is dependent upon density, height, and growth form of woody stems. Dense hardwood stems (trees or shrubs) provide physical obstruction to predators as well as a high level of visibility for the grouse (vertical cover). Coniferous stems also provide physical obstruction to predators but may restrict visibility for ruffed grouse. Overhead cover is provided by suitable density and height of plant growth forms providing vertical cover.

Vertical cover may be provided by deciduous shrubs, deciduous trees, coniferous trees, or by a mixture of these forms. Trees are defined in this model as woody plants having a single, erect stem originating from a single base at the ground, and shrubs are defined as woody plants having multiple, erect stems originating from a single base at the ground. The difference between deciduous trees and deciduous shrubs is even spacing versus clumping of erect stems. This differs from the practice of using stem height to differentiate trees and shrubs, as defined by the U.S. Fish and Wildlife Service (1981) for other HSI models. It is assumed that a certain amount of physical obstruction (vertical cover) is necessary to provide optimal fall to spring cover for ruffed grouse. Cover provided by deciduous trees (especially aspens) has been most thoroughly studied and forms the basis for comparing cover provided by woody vegetation of various growth forms.

Stem densities of deciduous trees ranging from 4,900 to 14,800 stems/ha are considered to be optimum (Gullion 1970). Stem densities of deciduous trees ≤ 4,400 stems/ha are considered too sparse to provide vertical cover, and densities ≥ 21,000 stems/ha are considered too dense to provide suitable vertical cover because mobility and visibility for ruffed grouse will be restricted. Because the growth form of deciduous trees differs considerably from that of deciduous shrubs and conifers, it is necessary to convert shrub and conifer stem densities to an equivalent stem density value in order to compare various growth forms. Equivalent stem density is defined as the number of stems of deciduous shrubs or conifers that will provide the equivalent amount of cover provided by one deciduous tree.

The typical growth form of deciduous shrubs [e.g., beaked hazel (Corylus cornuta)] is that of a woody plant with multiple, clumped, narrow stems (< 2.5 cm dbh). It is assumed in this model that, on the average, four typical deciduous shrub stems ≥ 0.9 m in height will occupy the space and provide equivalent density of vertical cover as one deciduous tree (Gullion pers. comm.). The equivalent stem density coefficient for deciduous shrubs ≥ 0.9 m in height, therefore, is 0.25. Shrubs < 0.9 m in height are assumed to be too short to provide any vertical cover.

The growth form of conifers is that of a woody plant with a dense, wide crown. Because of this growth form, it is assumed that one typical conifer with a low crown height (height to the lowest live branch) between 0.0 and 0.9 m above ground provides the same amount of vertical cover (i.e., physical obstruction) as provided by four deciduous trees. As the low crown height of conifers increases from 0.9 to 4.6 m, the equivalent cover provided by conifers decreases from four times the cover provided by one deciduous tree to a value equal to the cover provided by one deciduous tree. Vertical cover will be provided only by the trunk and not the branches of conifers when lowest branch heights are ≥ 4.6 m. This relationship is shown in Figure 2a.

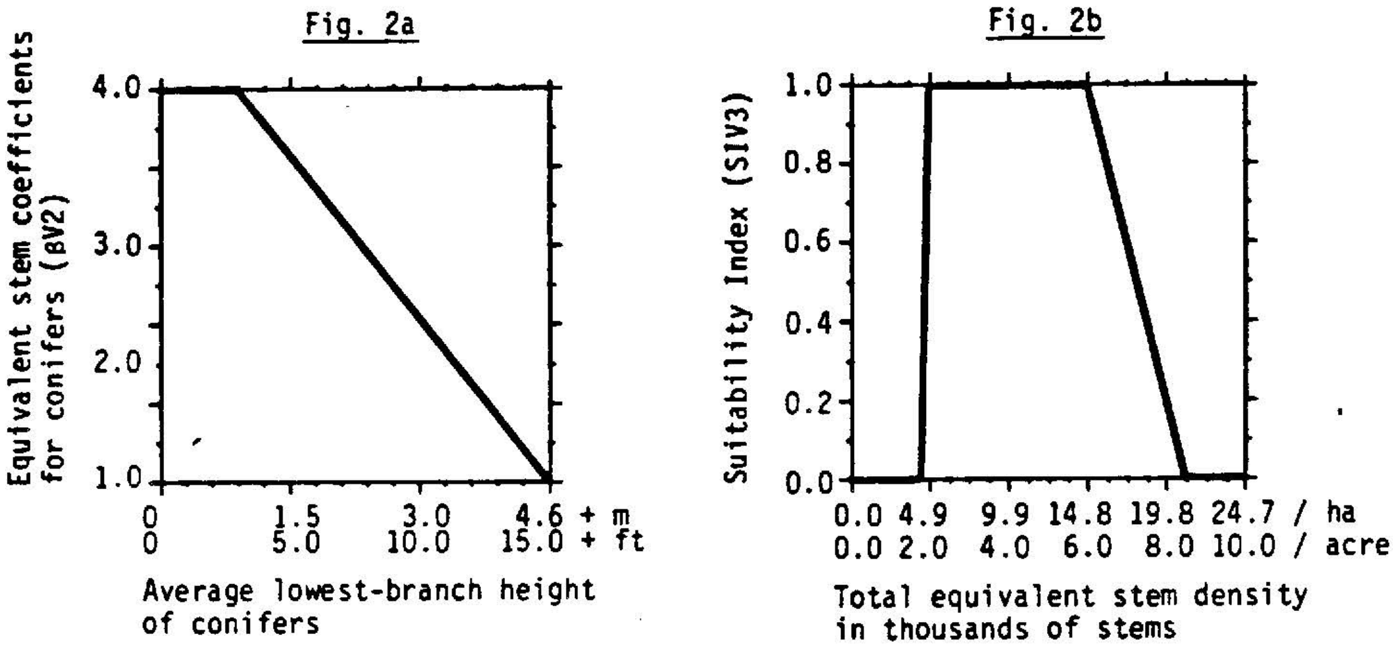

Figure 2. The relationship between lowest-branch height of conifers and equivalent stem density coefficients for conifers (2a) and between total equivalent stem density and suitability indices for vertical cover (2b).

Total equivalent stem density can be determined by Equation 1:

$$\text{Total equivalent stem density} = d + 0.25s + \beta V2c \qquad (1)$$

where d = number of deciduous trees/ha

s = number of deciduous shrub stems/ha

c = number of coniferous trees/ha

$\beta V2$ = equivalent stem density coefficient for conifers

The relationship between habitat suitability and total equivalent stem density is the same as that previously described for deciduous trees and is depicted in Figure 2b.

The suitability of vertical cover for ruffed grouse is determined by total equivalent stem density and height of woody stems providing cover. Woody stems ≥ 4.6 m in height provide optimal suitability for overhead cover (Kubisiak pers. comm.). Suitability decreases when woody stems are < 4.6 m in height, and woody stems ≤ 1.5 m in height do not provide suitable overhead cover (Gullion pers. comm.; Kubisiak pers. comm.) (Fig. 3). The relationship between stem height and suitability is assumed to be the same for all three woody growth forms that may provide vertical cover.

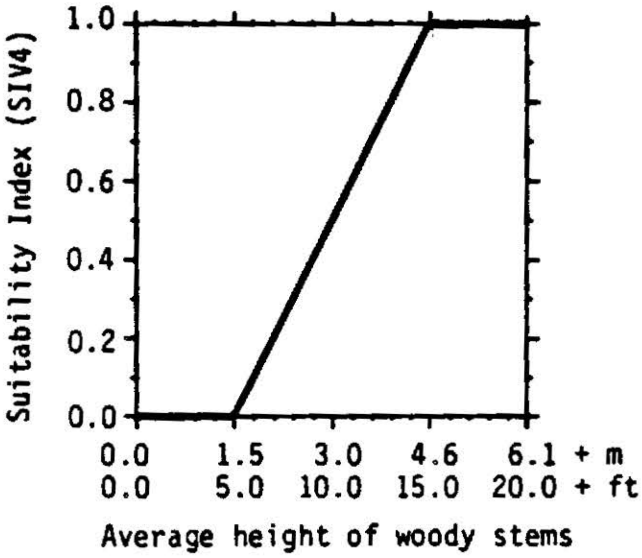

Figure 3. The relationship between woody stem heights and suitability indices for height of vertical cover.

During secondary succession of deciduous forests, suitability of vertical cover for ruffed grouse will increase as total equivalent stem density decreases from 21,000 to 14,800 stems/ha and stem heights increase to ≥ 4.6 m. Most aspen stems will have grown to optimal heights (≥ 4.6 m) when an aspen stand has matured and thinned to optimal total equivalent stem densities (4,900 to 14,800 stems/ha) (Kubisiak pers. comm.). As an aspen stand continues to mature and thins to ≤ 4,400 tree stems/ha, habitat suitability will also depend upon the density and height of understory woody shrubs or conifers (Kubisiak et al. 1980; Gullion 1984a).

Suitability of vertical cover height is assumed to be optimum if there are a minimum of 4,900 equivalent stems/ha at optimal heights (i.e., ≥ 4.6 m). When this minimum height/density relationship is met, additional stems at either suboptimal or optimal heights will not alter the suitability of vertical cover height. Therefore, suitability of vertical cover height is evaluated for the 4,900 equivalent stems/ha having highest suitability for stem height (SIV4) and may include any single or combination of woody growth forms. If total equivalent stem density is > 4,900/ha, then a weighted SIV4 is determined by considering equivalent stems by growth form beginning with the most suitable growth form (i.e., having highest SIV4) and continuing until exactly 4,900 equivalent stems/ha are included in Equation 2:

$$\text{Weighted SIV4} = \sum_{i=1}^{3}\left[\text{SIV4}_i \times \frac{(\text{equivalent stems/ha})_i}{4{,}900/\text{ha}}\right] \qquad (2)$$

where i = 1, 2, and 3 are different woody growth forms (i.e., deciduous shrubs, deciduous trees, or coniferous trees) such that

$$\text{SIV4}_1 \geq \text{SIV4}_2 \geq \text{SIV4}_3\text{, and } \sum_{i=1}^{3} (\text{equivalent stems/ha})_i = 4{,}900/\text{ha}$$

If the growth form with the highest SIV4 (SIV4_1) has > 4,900 equivalent stems/ha, then the weighted SIV4 equals SIV4_1. If growth form 1 has < 4,900 equivalent stems/ha, then the maximum number of equivalent stems/ha that can be entered for growth form 2 equals 4,900 minus the number of stems for growth form 1. If the sum of equivalent stems/ha for growth forms 1 and 2 is < 4,900 stems/ha, then the maximum number of equivalent stems/ha that can be entered for growth form 3 equals 4,900 minus the sum of equivalent stems/ha for growth forms 1 and 2. For example: A cover type has 800 deciduous trees/ha with an average height of 10.0 m (SIV4 = 1.0), 20,000 deciduous shrubs/ha with an average height of 2.4 m (SIV4 = 0.3), and 200 conifers/ha with an average height of 3.0 m (SIV4 = 0.5) and average low-branch height of 0.5 m (βV2 = 4.0). There are 800 equivalent stems of deciduous trees, 5,000 equivalent stems of deciduous shrubs, and 800 equivalent stems for conifers. Therefore, the weighted SIV4 = [(1.0 x 800) + (0.5 x 800) + (0.3 x 3,300)]/ 4,900 = 0.447. Note that 3,300, rather than 5,000, equivalent shrub stems are entered in the weighted SIV4 making the sum of the equivalent stems (800 + 800 + 3,300) equal to 4,900/ha.

If total equivalent stem density is ≤ 4,900 stems/ha, the weighted SIV4 can be determined using equation 2, but without any restrictions on the order that growth forms are entered or that their equivalent stem densities sum to 4,900/ha.

Tall conifers provide concealment for raptors which prey upon ruffed grouse, and conifers with low branches provide concealment for mammalian predators. Maximum densities and survival of ruffed grouse are lower in forests where conifers are the predominant trees (Gullion and Marshall 1968; Kubisiak et al. 1980; Gullion and Alm 1983). An area that provides optimal equivalent stem density and height of vertical cover for ruffed grouse but has only conifers in the tree strata is assumed to provide only 25% of the optimal fall to spring cover value. Similarly, the presence of any conifers in an otherwise suitable habitat will reduce suitability of fall to spring cover because of the additional concealment for predators provided by conifers. The recommended relationship is presented in Equation 3:

$$\text{conifer penalty} = \left[\left(3 \times \frac{c}{c + d}\right) + 1\right]^{-1} \qquad (3)$$

where c = number of coniferous trees/ha

d = number of deciduous trees/ha

This equation represents a curvilinear relationship (Fig. 4) that reduces suitability at a more rapid rate with a low percentage of conifers and at a less rapid rate with higher percentages of conifers. Cover suitability is assumed to decline quickly with a small percentage of conifers which can conceal raptors. However, cover suitability decreases at a lower rate with increasing percentage of conifers, because it is unlikely that there will be a proportional increase in predation opportunities with increasing percentage of conifers.

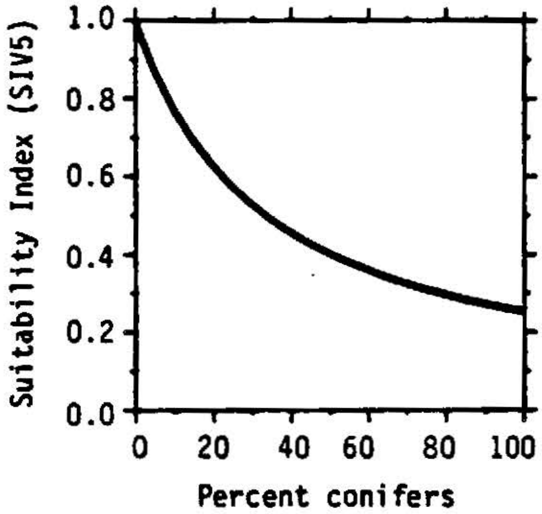

Figure 4. The relationship between percent coniferous trees and the suitability index for the conifer penalty.

Fall to spring cover can be summarized as follows:

1. Vertical cover can be provided by deciduous trees, coniferous trees, deciduous shrubs, or any combination of these growth forms.

2. A certain amount of physical obstruction (stem density) is necessary to provide suitable vertical cover. The equivalent of one deciduous tree is assumed to be four deciduous shrub stems and 0.25 to one coniferous tree, depending on the low crown height. Total equivalent stem density is determined based on these assumed relationships.

3. Suitability of vertical cover also depends upon the height of woody stems providing vertical cover density. However, not all stems need to have suitable heights for vertical cover height to be optimum.

4. As the percentage of cover provided by coniferous trees increases, the suitability of the habitat for ruffed grouse decreases due to increased concealment for predators. If conifers provide the only tree cover, then the maximum value for fall to spring cover will be 0.25, or 25% of the potential of sites with only deciduous trees.

Fall to spring cover value is a function of the suitability of total equivalent stem density (SIV3, Fig. 2b) modified by the weighted suitability of the heights of woody stems (Fig. 3, Equation 2), and further modified by the suitability of the percentage of trees that are conifers (SIV5, Fig. 4). This model evaluates cover for ruffed grouse based on vertical cover suitability modified by predator concealment suitability. Equation 4 is recommended for determining the suitability of Fall to Spring Cover (FSCOV):

$$\text{FSCOV} = \text{SIV3} \times \text{Weighted SIV4} \times \text{SIV5} \tag{4}$$

This equation allows either unsuitable (SI = 0.0) total equivalent stem density or unsuitable height of woody stems to produce unsuitable Fall to Spring Cover. Because none of the variables are considered compensatory and each directly modifies the suitability of the others, suboptimal suitabilities for two or three variables yield a suitability index for Fall to Spring Cover that is lower than the lowest individual suitability index for the variables.

HSI determinations. Calculation of an HSI for a multicover type species involves consideration of both the suitability and the interspersion of life requisites. However, the interspersion of life requisites is incorporated in the Winter Food variable (SIV1, Fig. 1) in this model. Several steps and calculations are necessary to determine an overall HSI for a study area:

1. Compute life requisite values for each cover type by collecting field data for each variable, entering this data into the proper equation, coefficient curve, or suitability curve, and using the resulting index values in the appropriate life requisite equations.

2. The HSI for a cover type equals the lower of the values for Fall to Spring Cover and Winter Food.

3. Determine the weighted HSI score for each cover type by multiplying the area of each cover type by its corresponding HSI value (from 2 above).

4. The overall HSI for a study area is equal to the sum of the weighted HSI scores (from 3 above) divided by the total area of all cover types potentially used by ruffed grouse in the study area.

Application of the Model

Summary of model variables. Seven habitat variables must be sampled to evaluate Fall to Spring Cover for ruffed grouse; one habitat variable is used to evaluate Winter Food (Fig. 5). Definitions of habitat variables and suggested field measurement techniques (Hays et al. 1981) are provided in Figure 6. In order to obtain an HSI for the ruffed grouse using this model, field data for habitat conditions (existing or future) must be measured or estimated and mean habitat characteristics entered into the appropriate equations or suitability curves.

Fall to Spring Cover and Winter Food variables should be measured at the same sampling points. Sampling points should be stratified by cover types or individual timber stands. Stratifying samples by the most homogeneous units possible will provide the greatest accuracy and precision for habitat and HSI estimates. Individual timber stands are likely to be more homogeneous than broad cover types, such as defined by the U.S. Fish and Wildlife Service (1981). If U.S. Fish and Wildlife Service (1981) cover types are used, Forest and Tree Savanna cover types can be subdivided into seedling (stems ≤ 2.5 cm dbh), sapling (stems > 2.5 cm to 15.2 cm dbh), and pole/mature (stems > 15.2 cm dbh) classes to create more homogeneous groups. Failure to stratify samples may result in a suitable Fall to Spring Cover rating for unsuitable grouse habitat if structural characteristics of early and late successional forest stands (both unsuitable Fall to Spring Cover) are averaged together, falsely indicating the presence of suitable mid-seral conditions. This can occur because the SI curve for total equivalent stem density (SIV3) is a non-linear response function.

Model assumptions and modifications. The major assumptions in this model are:

1. Winter food and fall to spring cover are the limiting requirements for ruffed grouse populations.

2. Optimal winter food for ruffed grouse is provided by mature male aspens.

3. Vertical cover for ruffed grouse is dependent on growth form, density and height of woody stems.

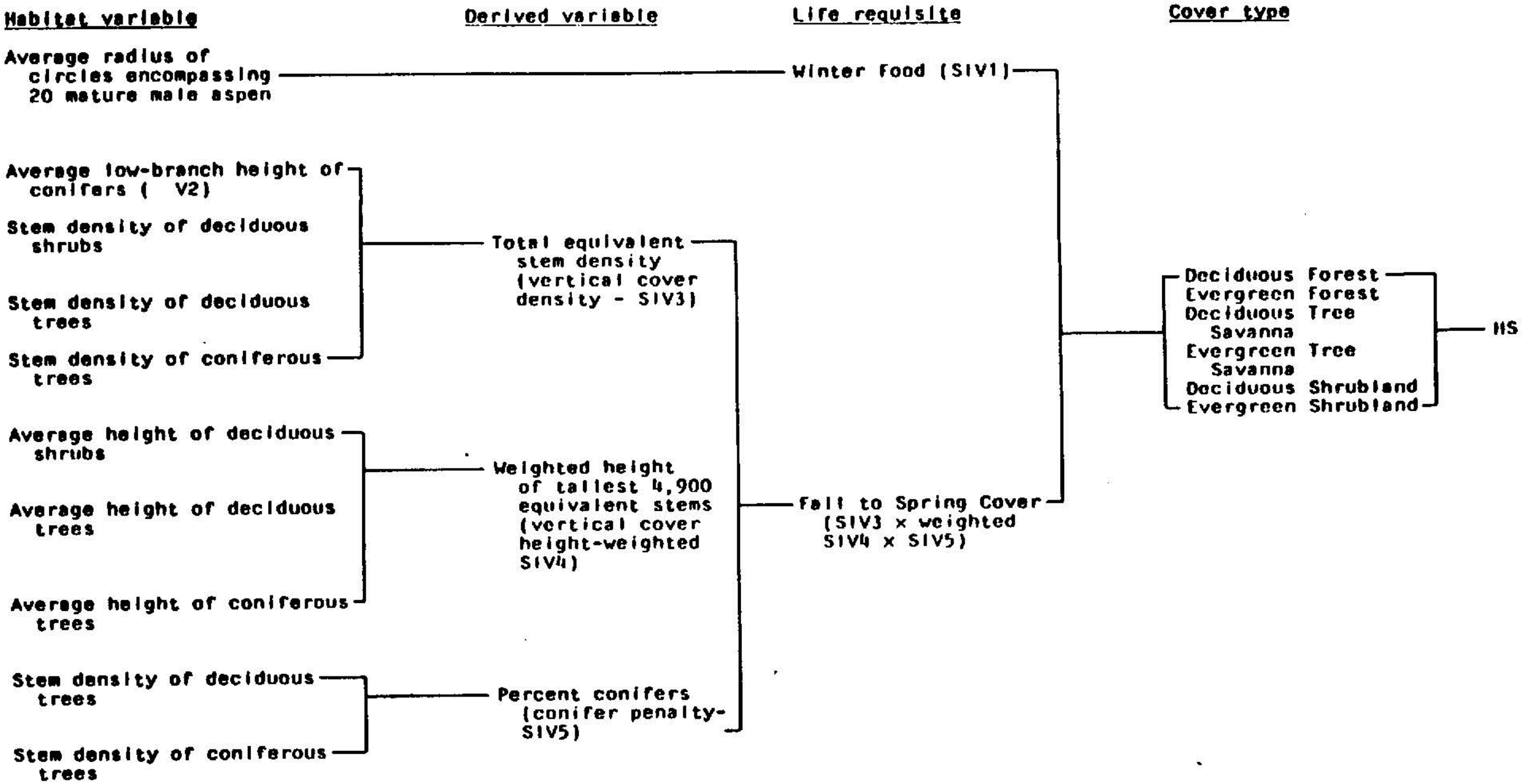

Figure 5. Relationships of habitat variables, derived variables, life requisites, and cover types to the habitat suitability index (HSI) for the ruffed grouse.

Variable (definition)	Cover types	Suggested techniques
The average radius of circles encompassing 20 mature male aspen [staminate flower producing aspen (Gullion 1984a), typically ≥ 25 years of age and 15.2 cm (6 inches) dbh].	DF,EF,DTS, ETS,DS,ES	Tape measure, optical range finder, pacing
Density of deciduous shrub stems [number/ha (2.471 acres) of deciduous woody stems ≥ 0.9 m (3.0 ft) tall growing with multiple, clumped, erect stems emanating from a common base at the ground].	DF,EF,DTS, ETS,DS,ES	
Density of deciduous trees [number/ha (2.471 acres) of deciduous woody stems ≥ 0.9 m (3.0 ft) tall growing with a single, erect stem from the ground].	DF,EF,DTS, ETS,DS,ES	Quadrat count [variable sized plots depending upon the relative density of plant growth forms (e.g., 0.004 ha for abundant growth forms and 0.04 ha for scarce growth forms)]
Density of coniferous trees [number/ha (2.471 acres) of coniferous woody stems ≥ 0.9 m (3.0 ft) tall growing with a single, erect stem from the ground].	DF,EF,DTS, ETS,DS,ES	
Average lowest-branch height above ground (measured to lowest point on bottom of branch) of conifers.	DF,EF,DTS, ETS,DS,ES	Graduated rod
Average height of woody stems (the average vertical distance from the ground to the top of woody stems, measured separately for deciduous shrubs, deciduous trees, and conifers).	DF,EF,DTS, ETS,DS,ES	Graduated rod, trigonometric hypsometry

Figure 6. Definitions of habitat variables and suggested measuring techniques.

4. Conifers provide vertical cover for ruffed grouse, but because they also provide cover for predators that prey upon grouse, the net effect of having conifers in ruffed grouse habitats is a reduction in habitat suitability.

The primary model assumption identifies winter and the spring and fall drumming periods as the limiting seasons for ruffed grouse. A corollary to this assumption is that nesting and brood rearing requirements will never be more limiting than fall to spring requirements. This assumption might be incorrect for ruffed grouse at the southern extreme of their range. Based on observed low juvenile to adult ratios (1:1) during fall, Dimmick (pers. comm.) suggests that nesting or brood rearing requirements limit fall populations of ruffed grouse in Tennessee. This hypothesis has not been substantiated, but users applying this model in the southern Appalachians should proceed with caution. Boag (pers. comm.) suggests that limiting factors change with the abundance of ruffed grouse, and density of the birds during the breeding season, through lack of space per se, is limiting for high density populations of ruffed grouse. It is important to recognize that use of this model for habitat assessment is inappropriate if conditions in the potential application area differ from those assumed limiting in this model.

If a user feels that the primary assumption is valid for an identified application, then the other three major assumptions must be addressed. Modifications of these assumptions and specific assumptions described under each component can be made if the user believes that such modification will better approximate conditions in the intended area of application. Users should be aware that output from modified models will not be directly comparable with other applications employing this model in its unmodified form. However, this has little consequence when a user desires to rank habitat suitability according to availability of habitats within a limited geographical area rather than according to availability on a continent-wide basis.

The second major assumption identifies mature male aspens as optimal winter food for ruffed grouse. The importance of aspens as winter food for ruffed grouse decreases in regions where winter snow cover is nonexistent or of short duration (Gullion and Svoboda 1972). Aspens often are unavailable to ruffed grouse in these regions. Other food items such as sumac, bittersweet, poison ivy, greenbrier, dogwood, and hophornbeam may need to be included in Variable 1 (Fig. 1) for model applications in Ohio, Indiana, and Illinois (Stoll et al. 1980; Stoll pers. comm.). Likewise, mountain laurel, Christmas fern, and honeysuckle may need to be included in Variable 1 for model applications in the southern Appalachian Mountains (Stafford and Dimmick 1979). However, the amount of these food items required to support grouse over winter has not been determined, and users will have to exercise their own discretion when incorporating other food items in the Winter Food variable. Winter food requirements of ruffed grouse in regions where winter-long snow cover does not occur are sufficiently broad that winter food may not be limiting (Gullion 1984b), and Variable 1 can appropriately be deleted from the model for some applications.

The third major assumption identifies density and height of woody stems as important components of vertical cover for ruffed grouse. However, in some ruffed grouse habitats in the southeastern states, vertical cover is provided by an understory of Japanese honeysuckle vines or a branching, evergreen canopy of mountain laurel and/or rhododendron (Rhododendron spp.) (Dimmick pers. comm.). Actual stem densities are low in pole sized timber stands and SIV3, consequently, would indicate unsuitable vertical cover. A vegetation profile board (Hays et al. 1981) may provide a better measure of cover density than stem density in habitats where vines are providing significant vertical cover. Actual calibration of the suitability curve for Variable 3 to reflect percent cover as measured by a vegetation profile board will have to be determined by individual users.

The fourth major assumption identifies conifers as having an overall negative impact on habitat suitability for ruffed grouse, because they provide concealment for predators, especially raptors. Predation on ruffed grouse is not always a significant decimating factor associated with coniferous habitats (Theberge and Gauthier 1982; Chambers pers. comm.; Dimmick pers. comm.; Keppie pers. comm.; Stoll pers. comm.). Furthermore, conifers with low-growing branches (e.g., spruce and firs) may have greater cover value for ruffed grouse than concealment value for raptors and should not be considered as detrimental as "high pine" conifers (Gullion and Marshall 1968; Boag pers. comm.; Chambers pers. comm.). Several modifications of the conifer penalty (SIV5, Fig. 4) are possible to reflect these different assumptions. A user can choose to eliminate the conifer penalty (SIV5) from the HSI equation for Fall to Spring Cover, modify the conifer penalty (Equation 3) to include only certain conifer species or growth forms (e.g., long-needled "high pines"), or modify the conifer penalty to differentially weight the detrimental impacts of conifer species or growth forms (e.g., weight spruce and fir as having 25% of the negative impact of pines).

Conifers provide important thermal cover for ruffed grouse inhabiting regions where winter snow cover is absent [e.g., Missouri (Lewis et al. 1968)] or unsuitable for snow-burrow roosting [e.g., central New York (Woehr 1974)]. Snow-burrow roosting may represent the optimal solution for thermal regulation by ruffed grouse, but wet or crusted snow conditions will prevent snow-burrow roosting (Woehr 1974), increasing winter mortality of grouse (Dorney and Kabat 1960). Roosting in conifers may be the best alternative available to ruffed grouse when snow-burrow roosting is impossible (Woehr 1974). Thus, conifers may actually have an overall positive impact on habitat suitability for ruffed grouse in regions where snow-burrow roosting is limited for extended periods, even though predation losses also are high (Chambers pers. comm.; Keppie pers. comm.). Chambers (pers. comm.) suggested that 15 to 30% conifer cover represents optimal suitability for winter cover in northeastern habitats, with suitability decreasing at either lower or higher percentages of conifers. Several clumps (0.1 to 0.2 ha in size) of conifers provide better cover than either scattered or large, contiguous stands of conifers.

SOURCES OF OTHER MODELS

A dynamic linear model developed by Steinke (1975) attempts to maximize ruffed grouse numbers per unit area by simulating optimal production of the winter food source, i.e., buds of mature male aspens. Maximum theoretical grouse populations were achieved after 40 years by clearcutting and burning hardwood forests to maintain mid-seral stages. Although cover and the interspersion of cover and food were recognized as important factors for ruffed grouse populations, they were not incorporated into Steinke's (1975) model, precluding evaluation of year-round habitat suitability for ruffed grouse.

A pattern recognition (PATREC) model developed for ruffed grouse in southeastern Idaho (Wilson 1983) uses conditional probabilities with Bayes' Theorum to relate habitat patterns to a potential for having high (7.7 grouse/100 ha) and low (0.4 grouse/100 ha) density grouse populations. Probabilities can be converted to indicate the relative number of grouse that a tract of land can potentially support. No explanation was provided as to why the selected variables might be related to habitat suitability and, thus, able to differentiate between habitats supporting high and low density grouse populations. The lack of information relating model variables to habitat requirements of the ruffed grouse will make it difficult to adapt this model for application outside of southeastern Idaho.

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BLACK-CAPPED CHICKADEE (Parus atricapillus)

HABITAT USE INFORMATION

General

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

Food

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

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

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

Water

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

Cover

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

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

Reproduction

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

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

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

Interspersion

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

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

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

HABITAT SUITABILITY INDEX (HSI) MODEL

Model Applicability

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

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

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

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

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

Model Description

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

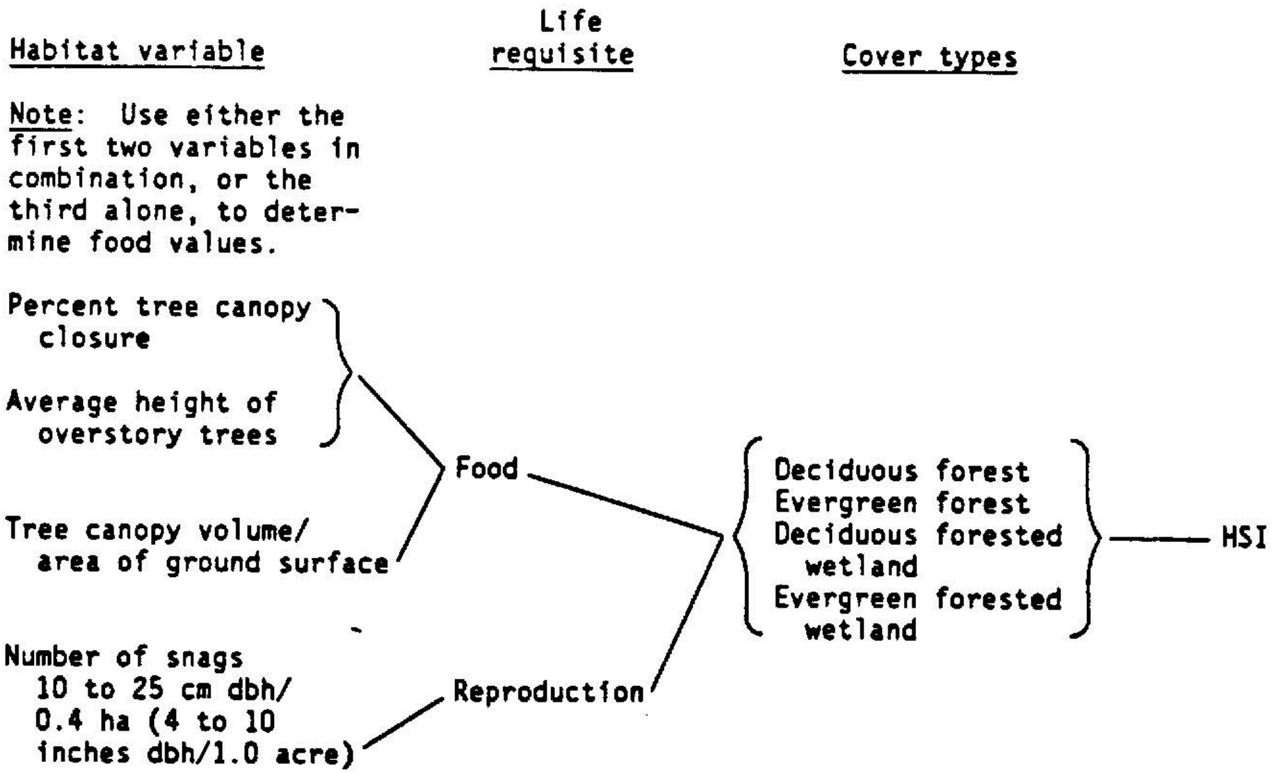


Figure 1. Relationship of habitat variables, life requisites, and cover types in the black-capped chickadee model.

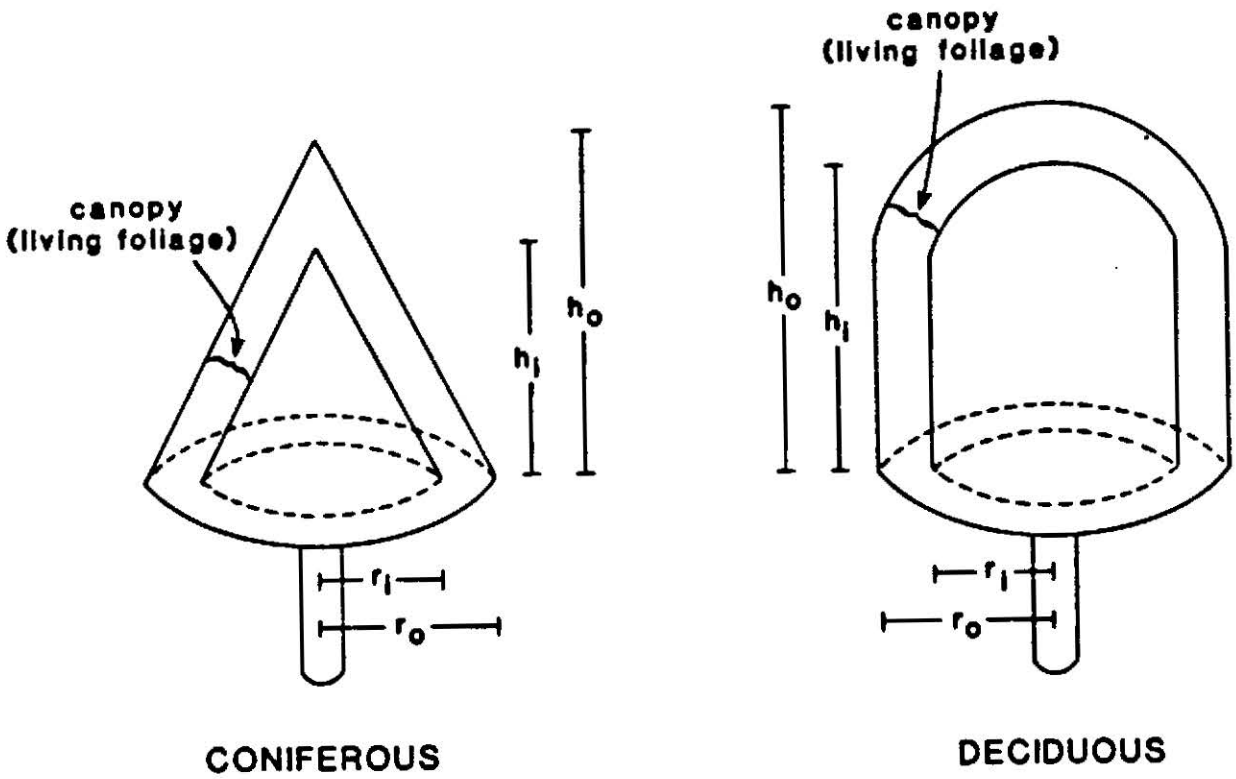
The following sections provide a written documentation of the logic and assumptions used to interpret the habitat information for the black-capped chickadee in order to explain the variables and equations that are used in the HSI model. Specifically, these sections cover the following: (1) identification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

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

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

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

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



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

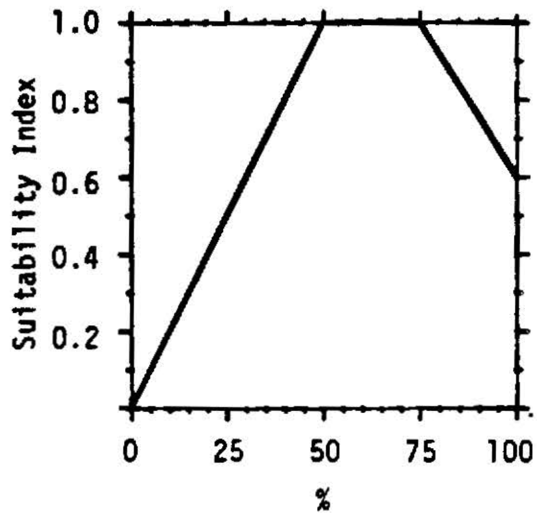
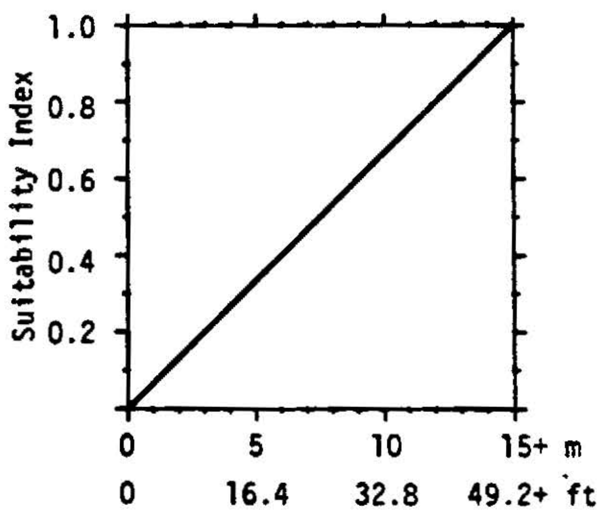
DECIDUOUS: $CV = 2\pi/3(h_o r_o^2 - h_i r_i^2)$

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

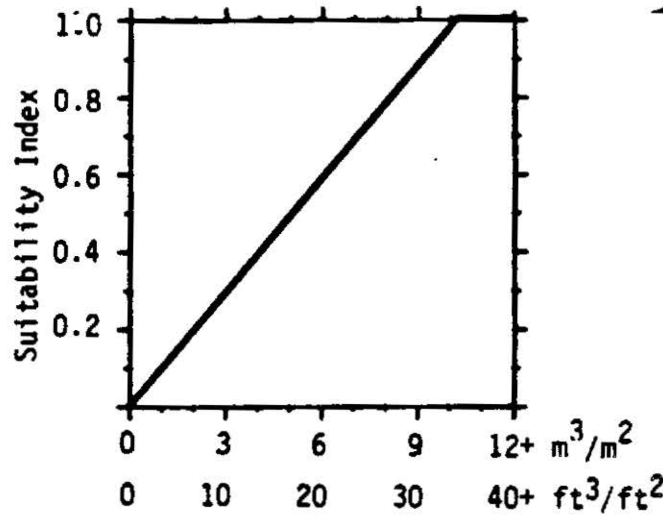
Figure 2. Tree shapes assumed and formulae used to calculate canopy volume (CV). (From Sturman 1968a).

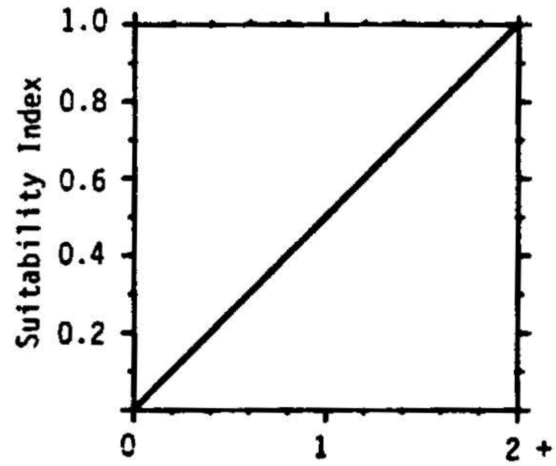
Model Relationships

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

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

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





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

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

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

Application of the Model

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

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

Figure 3. Definitions of variables and suggested measurement techniques.

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

Figure 3. (concluded).

SOURCES OF OTHER MODELS

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

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HABITAT SUITABILITY INDEX MODELS: YELLOW WARBLER

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CONTENTS

YELLOW WARBLER (*Dendroica petechia*)

HABITAT USE INFORMATION

General

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

Food

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

Water

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

Cover

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

Reproduction

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

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

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

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

Interspersion

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

Special Considerations

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

HABITAT SUITABILITY INDEX (HSI) MODEL

Model Applicability

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

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

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

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

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

Model Description

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

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

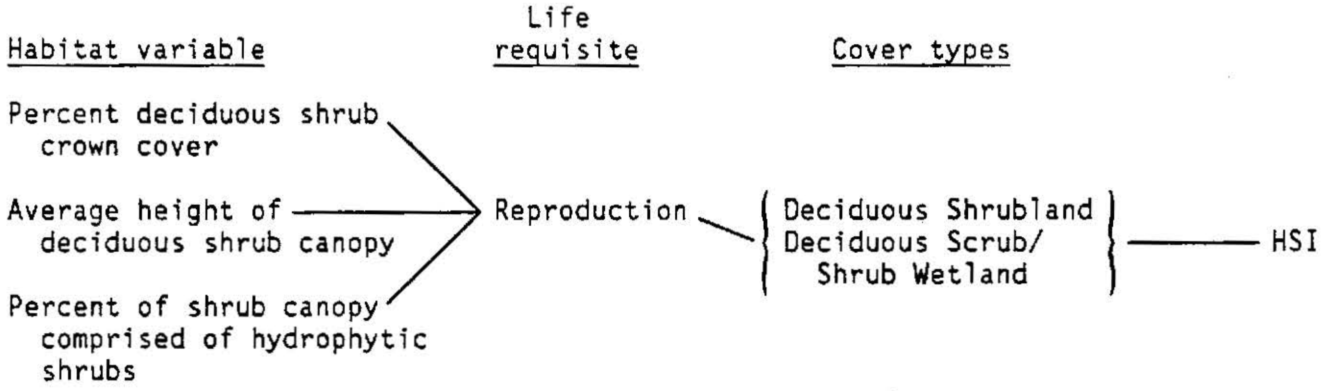


Figure 1. Relationship between habitat variables, life requisites, cover types, and the HSI for the yellow warbler.

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

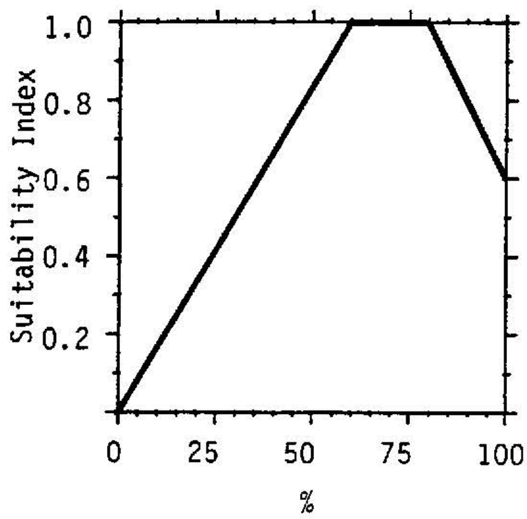
Reproduction component. Optimal nesting habitat for the yellow warbler is provided in wet areas with dense, moderately tall stands of hydrophytic deciduous shrubs. Upland shrub habitats on dry sites will provide only marginal suitability.

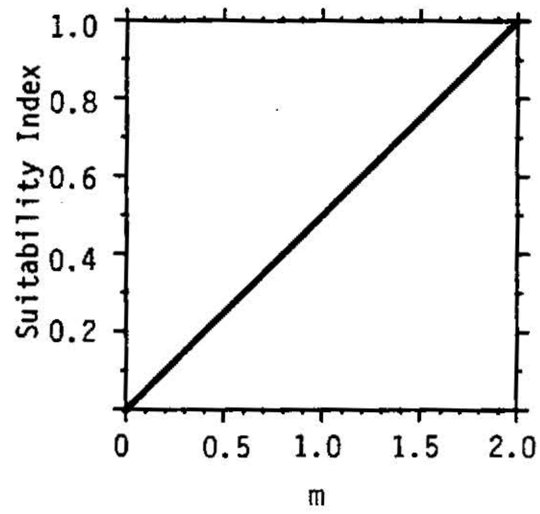
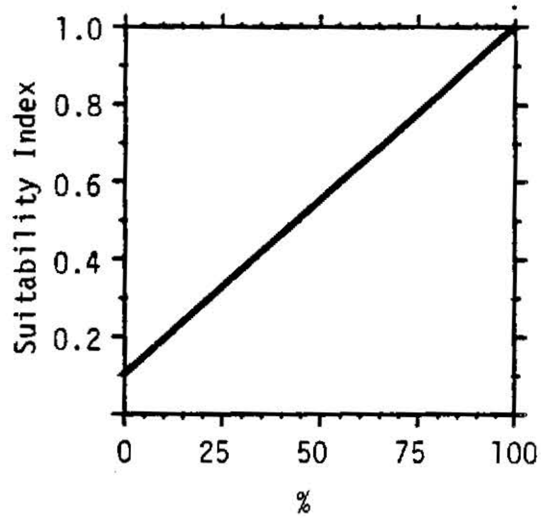
It is assumed that optimal habitats contain 100% hydrophytic deciduous shrubs and that habitats with no hydrophytic shrubs will provide marginal suitability. Shrub densities between 60 and 80% crown cover are assumed to be optimal. As shrub densities approach zero cover, suitability also approaches zero.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

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

Model Relationships

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

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

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

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

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

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

Application of the Model

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

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

Figure 2. Definitions of variables and suggested measurement techniques.

SOURCES OF OTHER MODELS

No other habitat models for the yellow warbler were located.

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DIPPER

General

The dipper ~~(Cinclus mexicanus) is a large passerine that lives along~~ swift mountain rivers and streams throughout Washington and Oregon (Larrison and Sonnenberg 1963). The species is a year-round resident where currents keep streams open during the winter. Seasonal movements to open water occur elsewhere.

Food Requirements

Dippers are opportunistic predators and take a wide variety of aquatic insects (Thut 1970). The winter diet in southwestern Washington was comprised entirely of aquatic invertebrates (Thut 1970). Prey items included midge (Chironomidae) and caddisfly (Trichoptera) larvae, stonefly (Plecoptera) and mayfly (Ephemenoptera) nymphs, beetles (Coleoptera), snails (Gastropoda), and mites (Acari). Caddisfly nymphs and fish eggs were eaten in another area of western Washington (ehinger 1930); Montana dippers foraged on stonefly, mayfly, and caddisfly larvae and nymphs (Bakus 1959a).

The spring and summer diet also includes some terrestrial insects (Thut 1970; Sullivan 1973) and occasionally amphibians (Sullivan 1973). Dippers will also take small fish 5.1 to 7.6 cm (2 to 3 in.) long (Bakus 1959a). Trout hatchlings in hatchery densities are vulnerable to dipper predation (Thut 1970).

Dippers are well adapted to diving and wading in the flowing water of rocky mountain streams (Goodge 1957; Sullivan 1973). The species picks aquatic organisms off the stream bottom and from rocks along shoreline coves (Bakus 1959a; Cogswell 1977). Most food items are obtained from pools of slow-moving water rather than from riffles (Thut 1970). The dipper will also search rock crevices on streambed rocks for prey items and may flycatch for aerial insects during the summer (Bakus 1959a).

Water Requirements

Dippers require swift-flowing open water as foraging, nesting, and wintering habitat. Dippers forage in shallow water; most dives for food were 0.2 to 0.6 m (0.5 to 2.0 ft.) deep and the deepest observed was 1.2 m (4.0 ft.) (Bakus 1959a). Nest sites are located over water from 1.2 to more than 3.0 m (4 to 10 ft.) deep (Bakus 1959a).

Cover Requirements

Little information was found on cover requirements for dippers during the breeding season. Dense riparian vegetation and rock ledges for roosting probably characterize most breeding streams. The European species (Cinclus cinclus) roosts on metal bridge girders on streams where natural rock faces are lacking (Hewson 1969).

Dippers concentrated on streams with open water, deciduous riparian vegetation, and shoreline logs and rocks in southern British Columbia during the winter(King et al. 1973). Birds were absent from areas where dense conifers came down to the stream edge and where logs and rocks were scarce. One wintertime roost in Washington was beneath an overhanging bank of sod and roots (Ehinger 1930). Vegetative cover may not be a major requirement in winter; a high concentration of dippers occurred on the barren drawdown area of the Skagit River above Ross Lake in southern British Columbia (King et al. 1973).

Reproductive Requirements

Nest sites are located in inaccessible spots over or nearly over the edge of streams (Hann 1950). Nests are often found in a rock crevice in a vertical rock face above deep, swiftly-flowing water. Such rock niches were the sites for 7 of 11 dipper nests in Colorado (Hann 1950), 9 of 14 nests in Montana (Bakus 1959a), and 2 of 4 nests in Washington (Goodge 1959). Nests were 0.9 to 4.6 m (3 to 15 ft.) above the water in Colorado (Hann 1950) and 1.5 to 6.1 m (5 to 20 ft.) high in Montana (Bakus 1959a). Other nest sites include bridge girders and other man-made constructions (Bakus 1959a; Goodge 1959), crevices behind waterfalls (Hann 1950; Bakus 1959a), and stream debris (Hann 1950). Nesting success is high (69% in Montana) because sites are generally inaccessible to predators (Sullivan 1973).

The availability of suitable nest sites may be an important limiting factor in dipper populations (Price and Bock 1973). Each breeding territory in Montana had a protected nest site (Sullivan 1973). A river in British Columbia that lacked overhangs, waterfalls, and steep banks had a breeding population of one dipper pair per 12.6 km (7.8 mi.) of stream; in winter this density increased to one bird per 0.8 km (0.5 mi.) of stream (King et al. 1973). The construction of bridges has increased the availability of nest sites (Sullivan 1973).

Breeding territories are linear and follow the stream course (Sullivan 1973). Territory length was estimated at 320 m (350 yds.) in Montana (Bakus 1959b), and up to 0.8 km (0.5 mi.) in Colorado (Hann 1950).

Food for nestlings is gathered up to 274 to 366 m (300 to 400 yds.) upstream and downstream from the nest (Hann 1950). Fledged broods remain in the breeding territory until dispersal. Young require rocks and logs for resting while being fed by the parents.

Special Requirements

None were found in the literature.

Interspersion Requirements

The dipper is found exclusively within riparian cover types. Pairs remain on their territories year-round where streams remain open (Sullivan 1973). In other areas, a fall movement downstream occurs after freeze-up at higher elevations, with a corresponding upstream movement occurring in the spring (Bakus 1959b; King et al. 1973). No information is available on the distances travelled between breeding and wintering areas.

Pre-nesting density in Montana was one bird per 0.8 km (0.48 mi.) of stream; wintering density increased to one per 0.3 km (0.2 mi.) of stream (Bakus 1959b). Winter density along the Skagit River in British Columbia was one bird per 0.8 km (0.52 mi.) along the river and one per 0.3 km (0.2 mi.) along side channels (King et al. 1973).

Special Considerations

Water quality may influence food abundance on both winter and breeding streams. Increased loads of silt in mountain streams, caused by logging operations upstream and adjacent to dipper habitat may abrade stream benthos (R. Hirschi, pers. comm.). Altered streambeds may silt in and eliminate aquatic insects that require a rocky substrate. Removal of streamside vegetation and debris and alteration of rocky ledges and other stream channel configurations eliminates nesting sites and resting areas. Streams with highly fluctuating water levels are unsuitable for nesting.

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DIPPER

Tree-dominated wetland - Riparian
Shrub-dominated wetland - Riparian

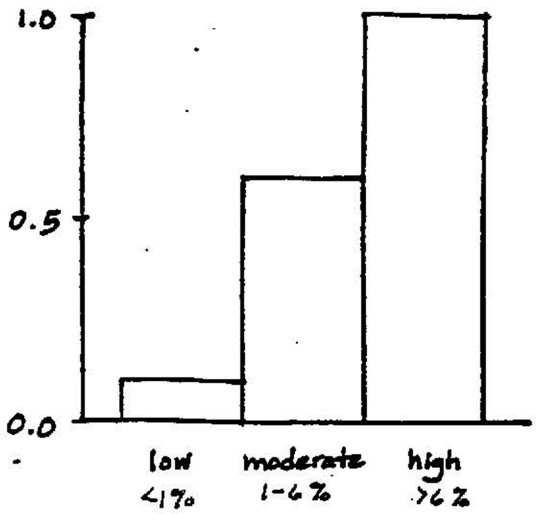
HABITAT REQUIREMENT	FIELD MEASUREMENT
Food	Stream gradient (V_1) Bottom substrate (V_2)
Water	Months of open water (V_3)
Reproduction	Relative abundance of vertical rock wall waterfalls, bridges (V_4)

Food HSI = $SI_1 + SI_2$
Water HSI = SI_3
Reproduction HSI = SI_4

HSI = lowest of the above

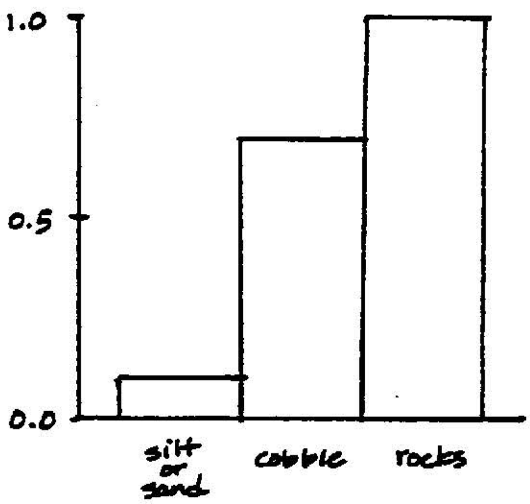
Tree-dominated wetland - riparian

1. Stream gradient = subjective estimate made along the length of a dipper's breeding territory (approximately 0.5 km, 0.3 mi of stream). Streams with a swift current and rapids or waterfalls should receive the highest suitability index.



Assumes:
- Prey species are most abundant in riffle areas (swift currents, rapids).

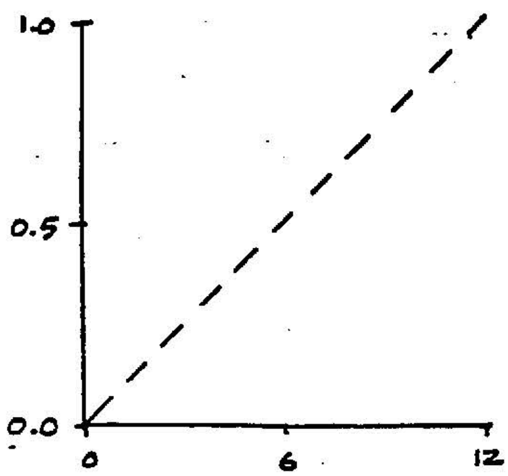
2. Bottom substrate



Assumes:
- Prey species are associated with rocky substrates.

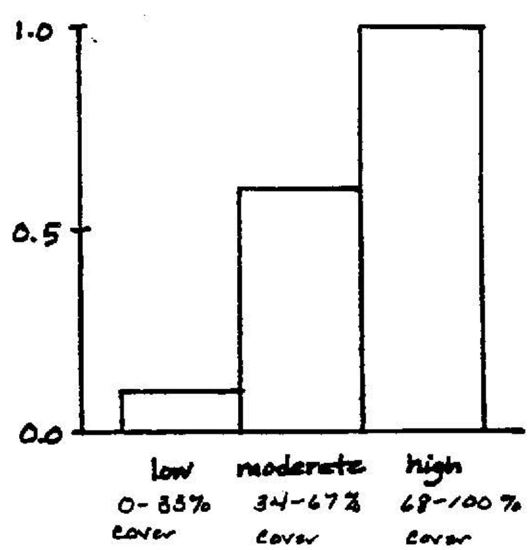
Tree - dominated wetland - riparian

3. Months of open water



Assumes:
- Habitat is less than optimal if seasonal movements are required.

4. Relative abundance of vertical rock walls, waterfalls, bridges = subjective estimate of potential nest sites made along the length of a dipper's breeding territory (approximately 0.5 km, 0.3 mi. of stream). Natural nests sites are probably preferred over man-made structures.

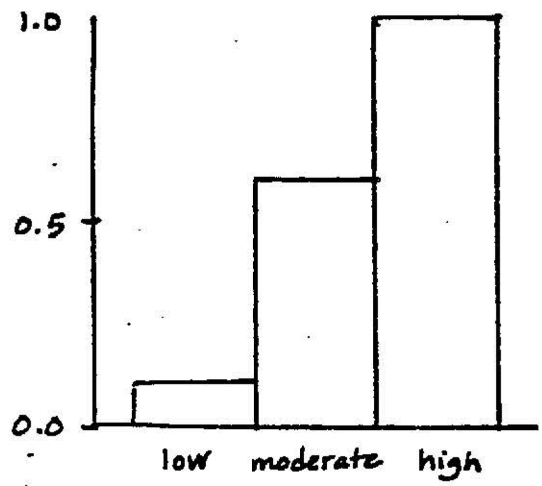


% cover of area by vertical rock walls + waterfalls

Assumes:
- Nest site requirements are an important limiting factor on dipper populations (King et al. 1973; Price and Bock 1973)

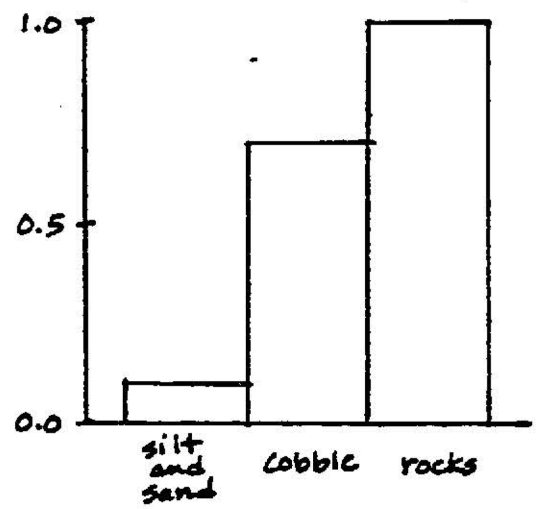
Shrub-dominated wetland - riparian

1. Stream gradient = subjective estimate made along the length of a dipper's breeding territory (approximately 0.5 km, 0.3 mi. of stream). Streams with a swift current and rapids or waterfalls should receive the highest suitability rating.



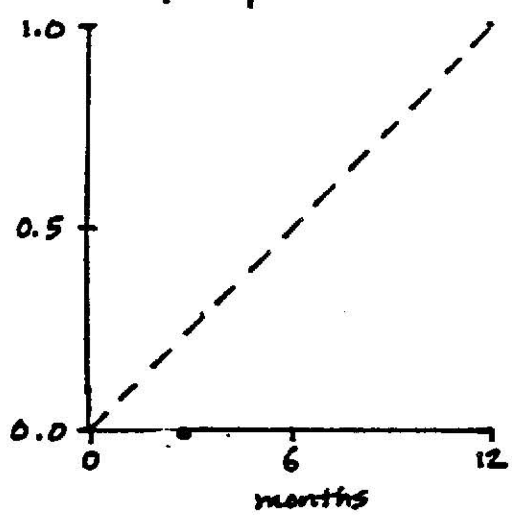
Assumes:
- Prey species are most abundant in riffle areas (swift currents, rapids)

2. Bottom substrate



Assumes:
- Prey species are associated with rocky substrates.

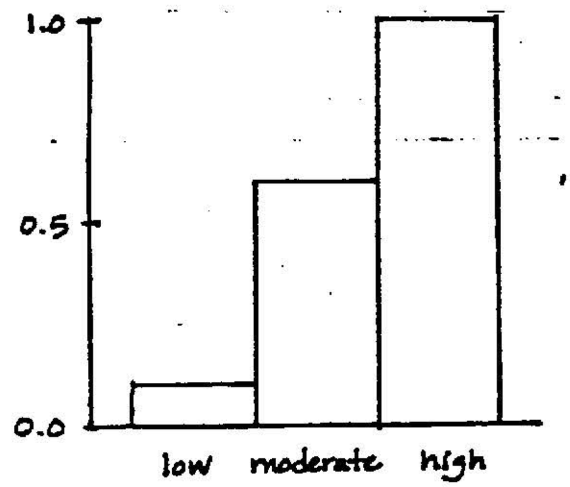
3. Months of open water



Assumes:
- ~~Habitat~~ is less than optimal if seasonal movements are required.

Shrub-dominated wetlands - riparian

4. Relative abundance of vertical rock walls, waterfalls, bridges = subjective estimate of potential nest sites made along the length of a dipper's breeding territory (approximately 0.5 km, 0.3 mi. of stream). Natural nests sites are probably preferred over man-made structures.



Assumes:

- Nest site requirements are an important limiting factor on dipper populations (King et al. 1973; Price and Bock 1973).

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HABITAT SUITABILITY INDEX MODELS: BEAVER

by

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CONTENTS

BEAVER (Castor canadensis)

HABITAT USE INFORMATION

General

The beaver (Castor canadensis) is a large, highly specialized aquatic rodent found in the immediate vicinity of aquatic habitats (Hoffman and Pattie 1968). The species occurs in streams, ponds, and the margins of large lakes throughout North America, except for peninsular Florida, the Arctic tundra, and the southwestern deserts (Jenkins and Busher 1979). Beavers construct elaborate lodges and burrows and store food for winter use. The species is active throughout the year and is usually nocturnal in its activities. Adult beavers are nonmigratory.

Food

Beavers are generalized herbivores; however, they show strong preferences for particular plant species and size classes (Jenkins 1975; Collins 1976a; Jenkins 1979). The leaves, twigs, and bark of woody plants are eaten, as well as many species of aquatic and terrestrial herbaceous vegetation. Food preferences may vary seasonally, or from year to year, as a result of variation in the nutritional value of food sources (Jenkins 1979).

Denney (1952) summarized the food preferences of beavers throughout North America and reported that, in order of preference, beavers selected aspen (Populus tremuloides), willow (Salix spp.), cottonwood (P. balsamifera), and alder (Alnus spp.). Although several tree species have often been reported to be highly preferred foods, beavers can inhabit, and often thrive in, areas where these tree species are uncommon or absent (Jenkins 1975). Aspen and willow are considered preferred beaver foods; however, these are generally riparian tree species that may be more available for beaver foraging but are not necessarily preferred over all other deciduous tree species (Jenkins 1981). Beavers have been reported to subsist in some areas by feeding on coniferous trees, generally considered a poor quality source of food (Brenner 1962; Williams 1965). Major winter foods in North Dakota consisted principally of red-osier dogwood (Cornus stolonifera), green ash (Fraxinus pennsylvanica), and willow (Hammond 1943). Rhizomes and roots of aquatic vegetation also may be an important source of winter food (Longley and Moyle 1963; Jenkins pers. comm.). The types of food species present may be less important in determining habitat quality for beavers than physiographic and hydrologic factors affecting the site (Jenkins 1981).

Tree cutting may occur during any season of the year (Jenkins 1979). However, the most intensive amount of foraging on trees or shrubs by beavers typically occurs in late fall, after green vegetation has become desiccated, and during early spring, prior to the availability of green vegetation. Woody vegetation may be consumed immediately, although the majority of the branches and stems are hauled to a cache for storage and later use as winter food.

An adequate and accessible supply of food must be present for the establishment of a beaver colony (Slough and Sadleir 1977). The actual biomass of herbaceous vegetation will probably not limit the potential of an area to support a beaver colony (Boyce 1981). However, total biomass of winter food cache plants (woody plants) may be limiting. Low marshy areas and streams flowing in and out of lakes allow the channelization and damming of water, allowing access to, and transportation of, food materials. Steep topography prevents the establishment of a food transportation system (Williams 1965; Slough and Sadleir 1977). Trees and shrubs closest to the pond or stream periphery are generally utilized first (Brenner 1962; Rue 1964). Jenkins (1980) reported that most of the trees utilized by beaver in his Massachusetts study area were within 30 m (98.4 ft) of the water's edge. However, some foraging did extend up to 100 m (328 ft). Foraging distances of up to 200 m (656 ft) have been reported (Bradt 1938). In a California study, 90% of all cutting of woody material was within 30 m (98.4 ft) of the water's edge (Hall 1970)

Woody stems cut by beavers are usually less than 7.6 to 10.1 cm (3 to 4 inches) dbh (Bradt 1947; Hodgdon and Hunt 1953; Longley and Moyle 1963; Nixon and Ely 1969). Jenkins (1980) reported a decrease in mean stem size cut and greater selectivity for size and species with increasing distance from the water's edge. Trees of all size classes were felled close to the water's edge, while only smaller diameter trees were felled farther from the shore.

Beavers rely largely on herbaceous vegetation, or on the leaves and twigs of woody vegetation, during the summer (Bradt 1938, 1947; Brenner 1962; Longley and Moyle 1963; Brenner 1967; Aleksiuk 1970; Jenkins 1981). Forbs and grasses comprised 30% of the summer diet in Wyoming (Collins 1976a). Beavers appear to prefer herbaceous vegetation over woody vegetation during all seasons of the year, if it is available (Jenkins 1981).

Aquatic vegetation, such as duck potato (Sagittaria spp.), duckweed (Lemna spp.), pondweed (Potamogeton spp.), and water weed (Elodea spp.), are preferred foods when available (Collins 1976a). Water lilies (Nymphaea spp.), with thick, fleshy rhizomes, may be used as a food source throughout the year (Jenkins 1981). If present in adequate amounts, water lily rhizomes may provide an adequate winter food source, resulting in little or no tree cutting or food caching of woody materials. Jenkins (1981) compared the rate of tree cutting by beavers adjacent to two Massachusetts ponds that contained stands of water lilies. A pond dominated by yellow water lily (N. variegatum) and white water lily (N. odorata), which have thick rhizomes, had low and constant tree cutting activity throughout the fall. Conversely, the second pond, dominated by watershield (Brasenia schreberi), which lacks thick rhizomes, had increased fall tree cutting activity by beavers. Tree cutting was particularly evident as the watershield leaves died.

Water

Beavers require a permanent supply of water and prefer a seasonably stable water level (Slough and Sadleir 1977). Beavers can usually control water depth and stability on small streams, ponds, and lakes; however, larger rivers and lakes where water depth and/or fluctuation cannot be controlled, are often partially or wholly unsuitable for the species (Murray 1961; Slough and Sadleir 1977). Beavers are absent from sizable portions of rivers in Wyoming, due to swift water and an absence of suitable dwelling sites during periods of high and low water levels (Collins 1976b).

In riverine habitats, stream gradient is the major determinant of stream morphology and the most significant factor in determining the suitability of habitat for beavers (Slough and Sadleir 1977). Retzer et al. (1956) reported that 68% of the beaver colonies recorded in Colorado were in valleys with a stream gradient of less than 6%, 28% were associated with stream gradients from 7 to 12%, and only 4% were located along streams with gradients of 13 to 14%. No beaver colonies were recorded in streams with a gradient of 15% or more. Valleys that were only as wide as the stream channel were unsuitable beaver habitat, while valleys wider than the stream channel were frequently occupied by beavers. Valley widths of 46 m (150 ft) or more were considered the most suitable. Marshes, ponds, and lakes were nearly always occupied by beavers when an adequate supply of food was available.

Cover

Lodges or burrows, or both, may be used by beavers for cover (Rue 1964). Lodges may be surrounded by water or constructed against a bank or over the entrance to a bank burrow. Water protects the lodges from predators and provides concealment for the beaver when traveling to and from food gathering areas and caches.

The lodge is the major source of escape, resting, thermal, and reproductive cover (Jenkins and Busher 1979). Mud and debarked tree stems and limbs are the major materials used in lodge construction although lesser amounts of other woody, as well as herbaceous vegetation, may be used (Rue 1964). If an unexploited food source is available, beavers will reoccupy abandoned lodges rather than build new ones (Slough and Sadleir 1977). On lakes and ponds, lodges are frequently situated in areas that provide shelter from wind, wave, and ice action. A convoluted shoreline, which prevents the buildup of large waves or provides refuge from waves, is a habitat requirement for beaver colony sites on large lakes.

Reproduction

Reproductive and cover requirements for the beaver are the same.

Interspersion

Suitable habitat for beavers must contain all of the following: (1) stable aquatic habitat providing adequate water; (2) channel gradient of less than 15%; and, (3) quality food species present in sufficient quantity (Williams 1965).

Beaver colony territories are distinct and nonoverlapping and are the fundamental units of a beaver population (Bradt 1938). A colonized area typically contains a series of ponds of various ages, sizes, and depths (Rutherford 1964). The beavers within each colony may establish and utilize several lodges or bank burrows, or both, within their territory. During periods of low population density, the territorial boundaries of one colony may expand to include the dams and lodges of adjacent vacant colony sites (Townsend 1953). During periods of low stream flows, floodplain populations of beavers reestablished dwelling sites and territories within the main river channel in Wyoming (Collins 1976b). The average distance moved was 262 m (286 yds).

The basic composition of a beaver colony is the extended family, comprised of a monogamous pair of adults, subadults (young of the previous year), and young of the year (Svendsen 1980). Dispersal of subadults occurs during the late winter or early spring of their second year and coincides with the increased runoff from snowmelt or spring rains. Subadult beavers have been reported to disperse as far as 236 stream km (147 mi) (Hibbard 1958), although average emigration distances range from 8 to 16 stream km (5 to 10 mi) (Hodgdon and Hunt 1953; Townsend 1953; Hibbard 1958; Leege 1968).

The daily movement patterns of the beaver centers around the lodge or burrow and pond (Rutherford 1964). The density of colonies in favorable habitat ranges from 0.4 to 0.8/km^2 (1 to 2/mi^2) (Lawrence 1954; Aleksiuk 1968; Voigt et al. 1976; Bergerud and Miller 1977 cited by Jenkins and Busher 1979). The mean distance between beaver colonies in an Alaskan riverine habitat was 1.59 km (1 mi) (Boyce 1981). The closest neighbor was 0.48 km (0.3 mi) away. The size of the colony's feeding range is a function of the interaction between the availability of food and water and the colony size (Brenner 1967). The average feeding range size in Pennsylvania, excluding water, was reported to be 0.56 ha (1.4 acre). The home range of beaver in the Northwest Territory was estimated as a 0.8 km (0.5 mi) radius of the lodge (Aleksiuk 1968). The maximum foraging distance from a food cache in an Alaskan riverine habitat was approximately 800 m (874 yds) upstream, 300 m (323 yds) downstream, and 600 m (656 yds) on oxbows and sloughs (Boyce 1981).

Special Considerations

Beavers will live in close proximity to man if all habitat requirements are met (Rue 1964). However, railways, roads, and land clearing often are adjacent to waterways and may be major limiting factors affecting beaver habitat suitability (Slough and Sadleir 1977).

Transplants of beaver may be successful on strip mined land or in new impoundments where water conditions are relatively stable (Nixon and Ely 1969). Highly acidic waters, which often occur in strip mined areas, are acceptable for beaver if suitable foods are present.

HABITAT SUITABILITY INDEX (HSI) MODEL

Model Applicability

Geographic area. This HSI model was developed for application throughout the range of the beaver. However, preferred foods may vary throughout the range of the species, depending on local availability. The food component of this model assumes that woody vegetation potentially may limit the ability of an area to support beavers. Herbaceous vegetation is an important component of the summer diet of beavers and is believed to be preferred over woody vegetation during all seasons, if available. Because herbaceous vegetation is generally available throughout the year in the southern portion of the beaver's range, it may have a more important influence on the annual diet than is indicated in this model.

Season. This model has been developed to evaluate the quality of year-round habitat for the beaver.

Cover types. This model has been developed to evaluate habitat quality 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).

Due to the foraging behavior of the beaver, the application of this model and determination of habitat units will vary by cover type. When evaluating beaver habitat in riverine, lacustrine, and wetland cover types, the model considers the area of the cover type plus a 200 m (656 ft) band of habitat on each side of the riverine channel or surrounding the water body or wetland. Figure 1 illustrates the relationship of cover types to the suggested evaluation area.

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 minimum habitat area for beavers was not found in the literature. However, it is assumed that a minimum of 0.8 km (0.5 mi) of stream channel and 1.3 km^2 (0.5 mi^2) of lake or marshland habitat must be available before these areas are suitable for colonization by beaver. If this minimum amount of habitat is not present, the HSI is assumed to be 0.0.

Cover type | Area for evaluation

Lacustrine [> 8 ha (20 acres)]

HSI determined only for area contained within 200 m (656ft) band around lake.

Lacustrine [≤ 8 ha (20 acres)]

HSI determined for area contained within 200 m band plus area of lake.

Riverine

HSI determined for area within 200 m band on both sides of river plus area of river.

Palustrine (herbaceous wetland, forested wetlands, or shrub wetlands)

HSI determined for area contained within cover type plus area within 200 m band around wetland cover type.

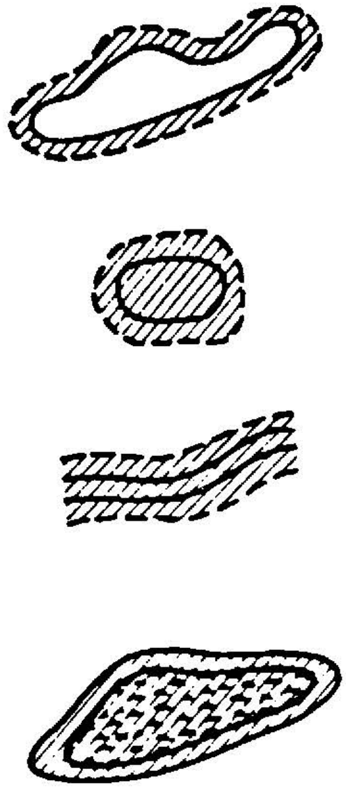


Figure 1. Guidelines for determining the area to be evaluated for beaver habitat suitability under various cover type conditions.

Special model considerations. Potential beaver habitat must contain a permanent source of surface water. Lakes and reservoirs that have extreme annual or seasonal fluctuations in the water level will be unsuitable habitat for beaver. Similarly, intermittent streams, or streams that have major fluctuations in discharge (e.g., high spring runoff) or a stream channel gradient of 15% or more, will have little year-round value as beaver habitat.

Assuming that there is an adequate food source available, small lakes [< 8 ha (20 acres) in surface area] are assumed to provide suitable habitat. Large lakes and reservoirs [> 8 ha (20 acres) in surface area] must have irregular shorelines (e.g., bays, coves, and inlets) in order to provide optimum habitat for the species.

Evaluation of potential beaver habitat must be centered in and around a suitable aquatic habitat. Therefore, the following factors must be taken into consideration in order to determine if this model is applicable to the habitat being evaluated:

If aquatic component of the cover type typically has extreme changes in water level or flow rate or has a channel gradient exceeding 15% -	Do not continue with model; HSI for beaver is assumed to be 0.0.
If aquatic component of the cover type has moderate or no fluctuation in water level or flow rate and channel gradient does not exceed 15% -	Continue with model to determine HSI values for water and food.

Verification level. This model was reviewed by Stephen H. Jenkins, Ph.D., Department of Biology, University of Nevada, and Rebecca J. Howard, Research Assistant, Department of Forestry and Wildlife Management, University of Massachusetts, Amherst. Improvements suggested by these reviewers were incorporated into this model.

Model Description

Overview. The HSI model for the beaver considers the quality of life requisites for the species in each cover type. Water and winter food are the only life requisites considered because the cover and reproductive needs of the species are assumed to be identical with water requirements. It also is assumed that all of the habitat requirements of the beaver can be provided within each cover type in which it occurs. Figure 2 illustrates how the HSI is related to cover types, life requisites, and specific habitat variables.

The following sections provide a written documentation of the logic and assumptions used to translate habitat information for the beaver to the variables and equations used in the HSI model. Specifically, these sections cover: (1) identification of the 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.

Food component. Woody and herbaceous vegetation comprise the diet of the beaver. Herbaceous vegetation is a highly preferred food source throughout the year, if it is available. Woody vegetation may be consumed during any season, although its highest utilization occurs from late fall through early spring. It is assumed that woody vegetation (trees and/or shrubs) is more limiting than herbaceous vegetation in providing an adequate food source. Therefore, this model evaluates the potential of an area to provide an adequate winter food source.

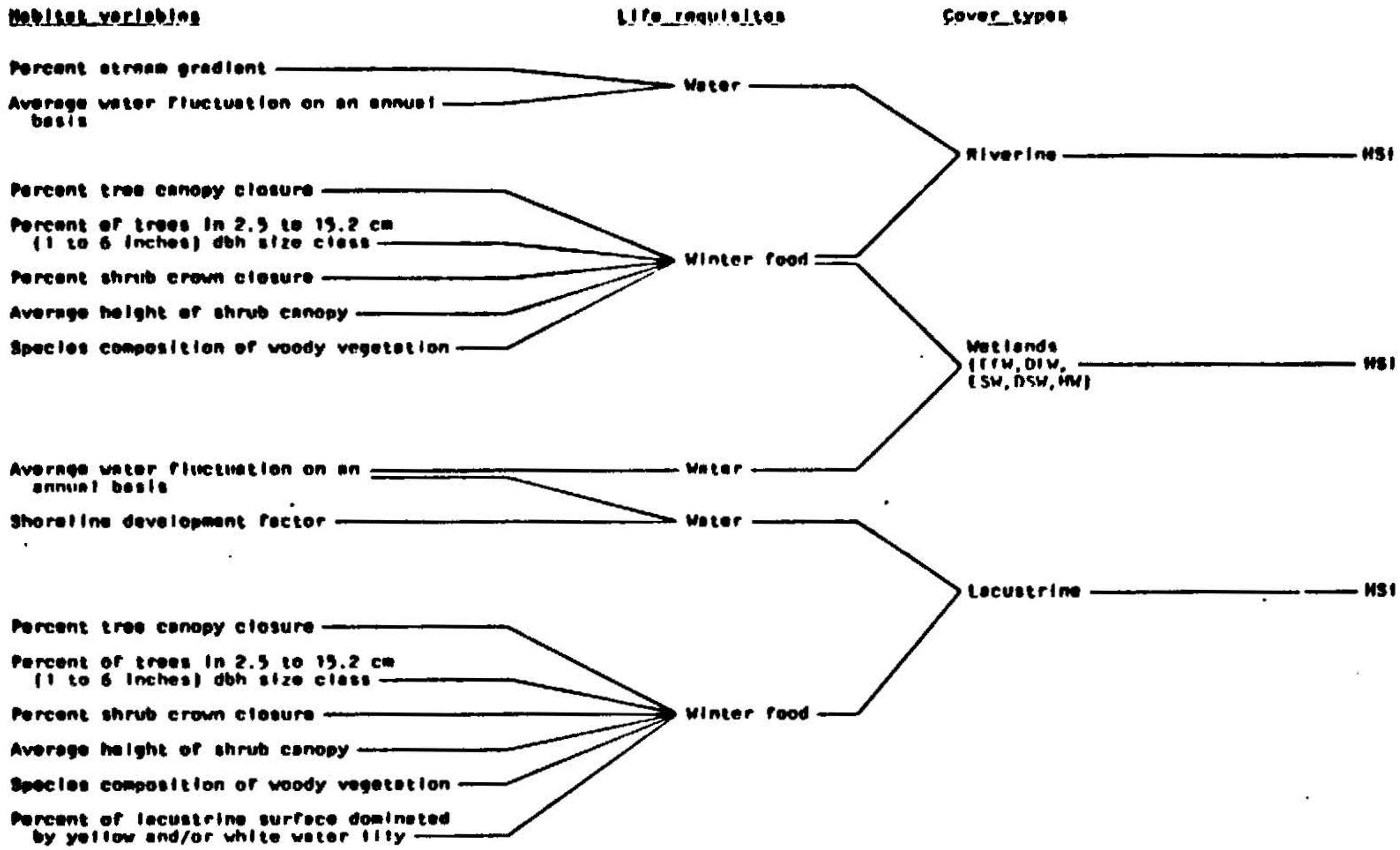


Figure 2. Tree diagram illustrating the relationships of habitat variables, life requisites, and cover types to the HSI for the beaver.

Several tree and shrub species (willow, aspen, cottonwood, and alder) have often been reported to be preferred foods; however, highly preferred species may vary in different geographic regions. Although coniferous trees and shrubs may be consumed, they are a less desirable food source for beavers than are deciduous tree species. Local variations in food preference and availability should be taken into consideration when evaluating the food component of this model.

Although beavers forage at distances up to 200 m (656 ft) from water, the majority of foraging occurs within 100 m (328 ft) of the water's edge. Even though woody vegetation may be within the optimum density and size classes, it is assumed that potential food sources farther than 100 m (328 ft) from water will be of less value than woody vegetation within 100 m (328 ft). Woody vegetation in excess of 200 m (656 ft) is assumed to have no value as a potential food source.

It is assumed that a tree and/or shrub canopy closure between 40 and 60% is an indication of optimum food availability. Tree or shrub crown closures exceeding 60% are assumed to be less suitable due to the decreased accessibility of food. Extremely dense stands result in decreased mobility and the increased likelihood of cut trees hanging up in adjacent trees. To be assigned a maximum suitability value, the dbh of trees should range from 2.5 to 15.2 cm (1 to 6 inches), and shrubs should be at least 2 m (6.6 ft) tall.

The food value in a cover type is a function of the density, size class, and species composition of woody vegetation. Optimum conditions are a stand of preferred tree and/or shrub species, of medium density, less than 15.2 cm (6 inches) dbh. An adequate food source includes some trees, or shrubs, or both. The species composition of the vegetation present influences the value obtained for density and size class. Stands of highly preferred species enhance the habitat value of the site, while foods of low preference will lower the overall food value of the site. White or yellow water lilies in lacustrine cover types may be used to supplement the winter food supply. Lakes or ponds supporting these aquatic species have a higher value as winter habitat than lacustrine cover types lacking this additional food source.

Water component. Water provides cover for the feeding and reproductive activities of the beaver. A permanent and relatively stable source of water is mandatory for suitable beaver habitat.

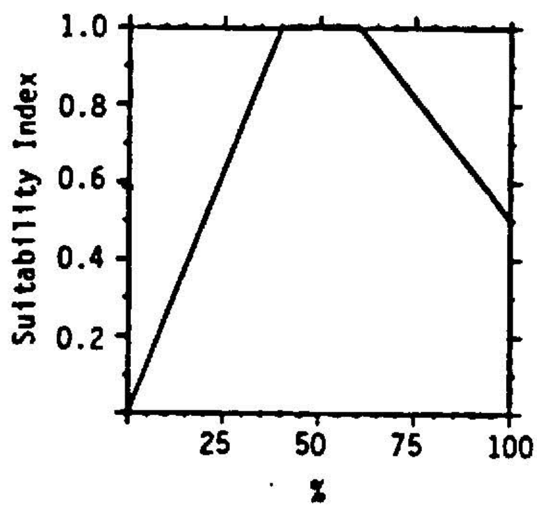
In riverine cover types, a major change in the rate of flow or a channel gradient exceeding 15% indicate poor or unsuitable habitat. Stream channel gradients of 6% or less have optimum value as beaver habitat. Stable water levels are of optimum value as beaver habitat, while major fluctuations in the water level or flow rate decrease the value of the site. Rivers or streams that are dry during some parts of the year are assumed to be unsuitable beaver habitat.

Lacustrine habitat types less than 8 ha (20 acres) in surface area are assumed to provide suitable habitat, if an adequate food source is present. Lacustrine cover types larger than 8 ha (20 acres) in surface area must provide physical diversity (e.g., bays, coves, and inlets) in the shoreline configuration in order to provide suitable beaver habitat. It is assumed that large reservoirs or lakes that are roughly circular in shape or are comprised of extensive stretches of straight shoreline provide little shelter from wind and wave action and, therefore, have little value as beaver habitat. Variation in the water level in lacustrine cover types results in less suitable habitat quality for beavers. Lakes or ponds that are dry during portions of the year are assumed to be unsuitable beaver habitat.

All wetland cover types (e.g., herbaceous wetland and deciduous forested wetland) must have a permanent source of surface water with little or no fluctuation in order to provide suitable beaver habitat.

Model Relationships

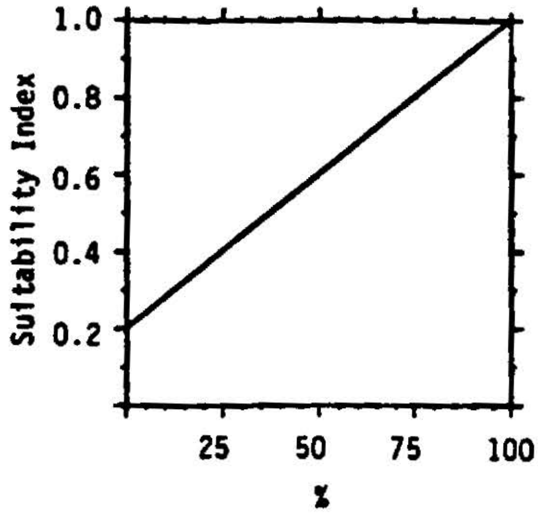
Suitability Index (SI) graphs for habitat variables. The relationships between various conditions of habitat variables and habitat suitability for the beaver are graphically represented in this section.

Cover type	Variable		
EFW,DFW, ESW,DSW, HW,R,L	V_1	Percent tree canopy closure.	

EFW,DFW,
ESW,DWS,
HW,R,L

V_2

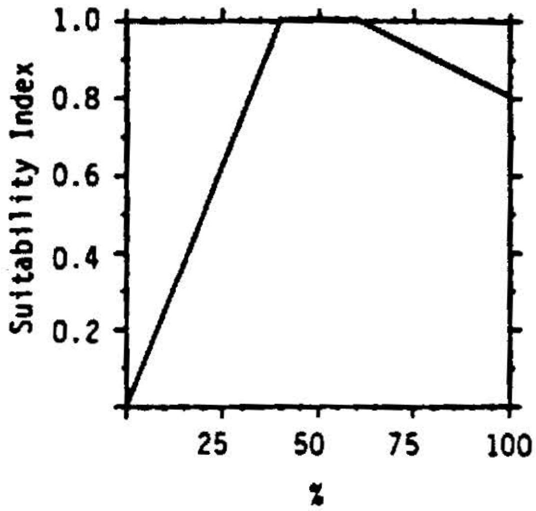
Percent of trees in 2.5 to 15.2 cm (1 to 6 inches) dbh size class.



EFW,DFW,
ESW,DSW,
HW,R,L

V_3

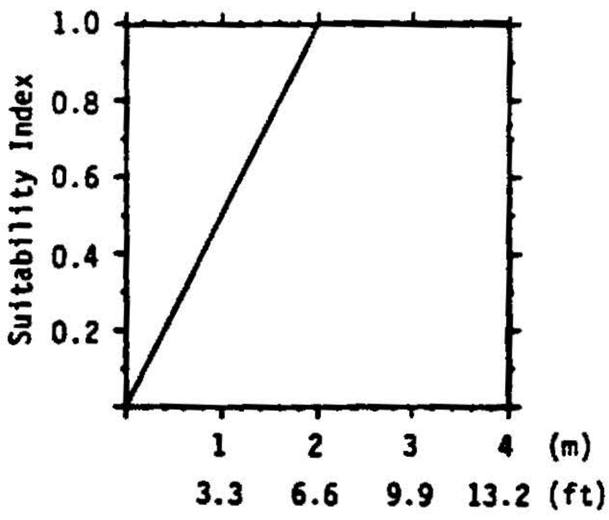
Percent shrub crown cover.

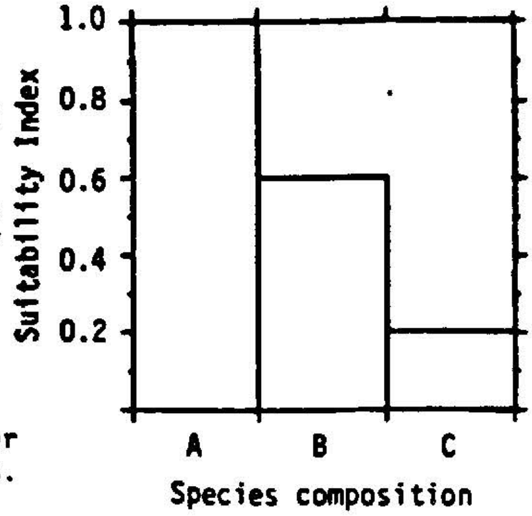
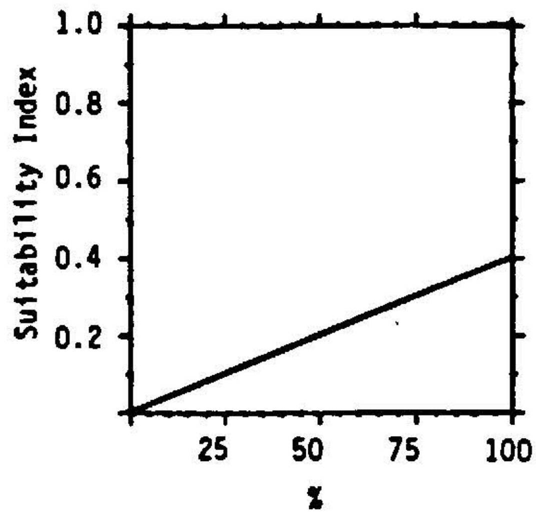
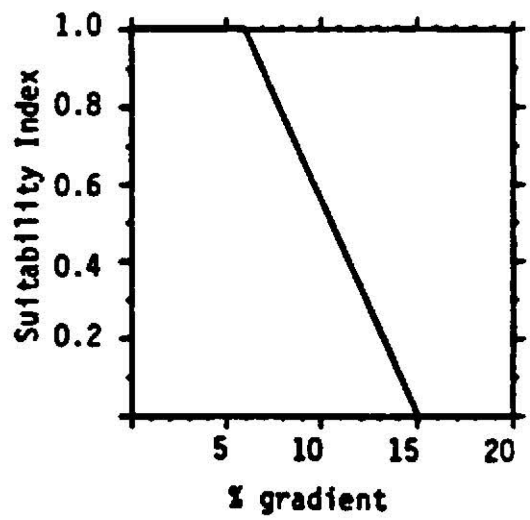


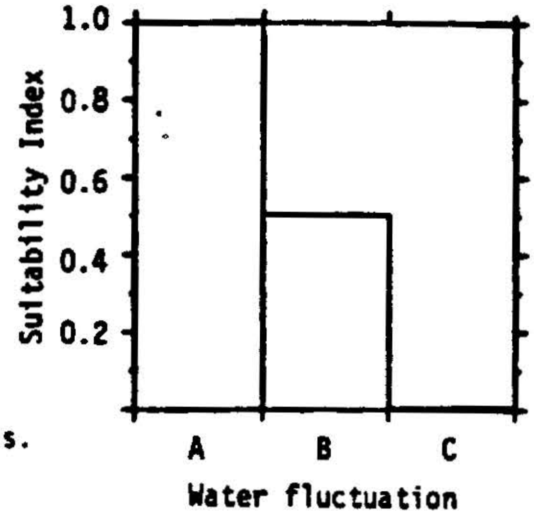
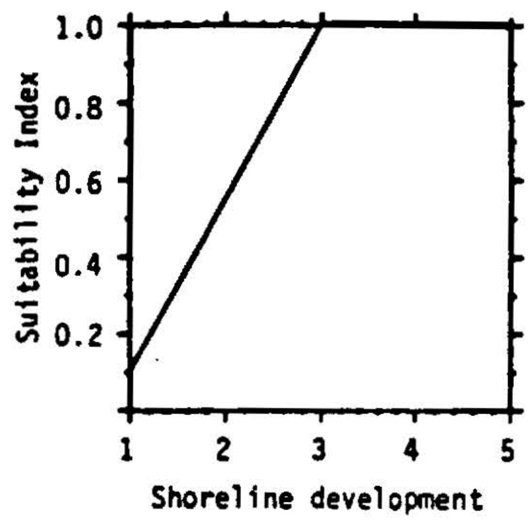
EFW,DFW,
ESW,DSW,
HW,R,L

V_4

Average height of shrub canopy.



EFW, DFW, ESW, DSW, HW, R, L	V_5	Species composition of woody vegetation (trees and/or shrubs) A) Woody vegetation dominated (≥ 50%) by one or more of the following species: aspen; willow; cottonwood; or alder. B) Woody vegetation dominated by other deciduous species. C) Woody vegetation dominated by coniferous species (e.g., fir and pine).	
L	V_6	Percent of lacustrine surface dominated by yellow and/or white water lily.	
R	V_7	Percent stream gradient.	

EFW,DFW, ESW,DSW, HW,R,L	V_8	Average water fluctuation on annual basis. A) Small fluctuations that have no effect on burrow or lodge entrances. B) Moderate fluctuations that affect burrow or lodge entrances. C) Extreme fluctuations or water absent during part of year.	
L	V_9	Shoreline development factor (see variable definition in Figure 4).	

<u>Equations</u>. In order to obtain life requisite values for the beaver, the suitability index values for appropriate variables must be combined with the use of equations. A discussion and explanation of the assumed relationships between variables was included under <u>Model Description</u>. The suggested equations for obtaining food and water values for the beaver are presented by cover type in Figure 3.

Life requisite	Cover type	Equation
Winter food	DFW, EFW, DSW, ESW, HW	$\frac{a+b+c}{2.5}$
Winter food	R	$\frac{b+c}{1.5}$
Winter food	L	$\frac{b+c}{1.5} + V_6$

where: a = woody vegetation value within actual wetland boundary. The suggested equation is:

$$[(V_1 \times V_2)^{1/2} \times V_5]^{1/2} + [(V_3 \times V_4)^{1/2} \times V_5]^{1/2}$$

b = woody vegetation value within 100 m (328 ft) from the water's edge. The suggested equation is:

$$[(V_1 \times V_2)^{1/2} \times V_5]^{1/2} + [(V_3 \times V_4)^{1/2} \times V_5]^{1/2}$$

c = woody vegetation value within 100 m (328 ft) to 200 m (656 ft) from the water's edge. The suggested equation is:

$$0.5 \quad [(V_1 \times V_2)^{1/2} \times V_5]^{1/2} + [(V_3 \times V_4)^{1/2} \times V_5]^{1/2}$$

Life requisite	Cover type	Equation
Water	R	V_7 or V_8, whichever is lowest.
Water	L	V_8 or V_9, whichever is lowest, if lacustrine area ≥ 8 ha (20 acres) in surface area. V_8, if lacustrine area is < 8 ha (20 acres) in surface area.
Water	DFW, EFW, DSW, ESW, HW	V_8

Figure 3. Equations for determining life requisite values by cover type for the beaver. If equation products exceed 1.0, they should be considered equal to 1.0.

HSI determination. Based on the limiting factor concept, the HSI is equal to the lowest life requisite value obtained for either food or water.

Application of the Model

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

SOURCES OF OTHER MODELS

Slough and Sadleir (1977) developed a land capability classification system for beaver that related habitat variables to beaver colony site density through multiple regression analysis. The model can be used for beaver population inventory because it predicts beaver colony site density.

Howard (1982) developed a land capability classification system for the identification and ranking of potential beaver habitat. Discriminant and principle components regression analysis models are used to relate habitat variables that quantify food availability and water reliability to beaver colony site selection and longevity. The models are applicable to stream habitats in typical mixed coniferous-deciduous forests of the Northeast.

Variable (definition)		Cover types	Suggested technique
V_1	Percent tree canopy closure [the percent of the ground surface shaded by a vertical projection of the canopies of woody vegetation ≥ 5.0 m (16.5 ft) in height].	R,L,DFW EFW,DSW, ESW,HW	Transect, line intercept, remote sensing
V_2	Percent of trees in 2.5 to 15.2 cm (1 to 6 inches) dbh size class [the percent of trees with a dbh of 2.5 to 15.2 cm (1 to 6 inches)].	R,L,DFW, EFW,DSW, ESW,HW	Transect, quadrat, diameter tape
V_3	Percent shrub crown cover [the percent of the ground surface shaded by a vertical projection of the canopies of woody vegetation < 5 m (16.5 ft) in height].	R,L,DFW, EFW,DSW, ESW,HW	Line intercept, quadrat, remote sensing
V_4	Average height of shrub canopy (the average height from the ground surface to the top of those shrubs that comprise the uppermost shrub canopy).	R,L,DFW, EFW,DSW, ESW,HW	Line intercept, quadrat, graduated rod
V_5	Species composition of woody vegetation (trees and/or shrubs) (refer to model page 12).	R,L,DFW, EFW,DSW, ESW,HW	Transect, line intercept
V_6	Percent of lacustrine surface dominated by yellow and/or white water lily [the percent of the surface dominated by yellow water lily (<u>Nymphaea variegatum</u>) and/or white water lily (<u>N</u>. <u>odorata</u>)].	L	Line intercept, remote sensing

Figure 4. Definitions and suggested measurement techniques of habitat variables.

Variable (definition)	Cover types	Suggested technique
V_7 Percent stream gradient (the vertical drop in meters or feet per kilometer or mile of stream or river channel). % stream gradient = $(\frac{A}{B})$ 100 where A = difference in elevation between sample points. B = distance between sample points.	R	Topographic map
V_8 Average water fluctuation on an annual basis (refer to model page 13).	R, L, HW, DFW, EFW, DSW, ESW	Local data
V_9 Shoreline development factor (a ratio relating the relative edge of a water body to its area. To obtain a value for shoreline development factor (SDF), divide the length of the shoreline by the length of the circumference of a circle with the same area as the water body. The following formula may be used: $SDF = \frac{\ell}{2\sqrt{A\pi}}$ where SDF = shoreline development factor ℓ = length of shoreline A = area of water body A circle would have a SDF equal to 1.0. The greater the deviation from a circular shape, the greater the SDF value will be. Values of 3 or more are assumed to be optimum for beavers).	L [≥ 8 ha (20 acres)]	Remote sensing, topographic map, dot grid, map wheel

Figure 4. (concluded).

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Appendix B. Habitat Use Information and HSI Model for the Red-tailed Hawk

B.1 Introduction. HSI models should be adequately documented so that the HSI estimates can be properly interpreted. This appendix provides an example red-tailed hawk model with documentation as described in 103 ESM 3.4. Section B.2 below provides documentation of habitat use information, and B.3 describes the HSI model, including model assumptions and limitations. Section B.4 contains information for applying the model.

B.2 Habitat use information

A. General. The red-tailed hawk (*Buteo jamaicensis*) inhabits all of the continental United States (Brown and Amadon 1968). In more northern parts of its range, it is quite migratory, although breeding pairs were found to be year-round residents in areas as far north as Wisconsin (Petersen 1979) and Michigan (Craighead and Craighead 1956). Commonly used habitat consists of woodlots, scattered trees, or tracts of mature woodland, often interspersed with, or adjoining, large expanses of open fields (Brown and Amadon 1968). Red-tailed hawks are rare in areas characterized by extensive unbroken forest. The red-tailed hawk has the widest ecological tolerance and geographic distribution of any buteo in North America. This species has not suffered the detrimental eggshell thinning observed in many other raptors, due to its predominantly mammalian diet (Hickey and Anderson 1968; Petersen 1979).

B. Food requirements. The red-tailed hawk is an opportunistic predator, feeding primarily on prey species which are locally common (Bohm 1978). It feeds on a variety of animals, but mostly small and medium-sized rodents, rabbits, and other mammals (Brown and Amadon 1968). Other important food items include medium-sized birds, large insects, and reptiles. Both adults and juveniles will feed on carrion (Errington and Breckenridge 1938). A winter diet of red-tailed hawks in Wisconsin averaged 44% cottontail rabbits (*Sylvilagus* spp.), 28% microtines (*Microtus* spp.), and 10% pheasants (*Phasianus colchicus*) (in percent biomass) (Petersen 1979).

Red-tailed hawks commonly hunt from perches overlooking open areas and by soaring above fields (Tyler and Saetveit 1969; Bohm 1978). Schnell (1968) found that red-tailed hawks prefer to hunt from tree perches, allowing the raptor to strike down on ground dwelling prey. Foraging sites in southern Michigan were open areas such as grassland and abandoned and cultivated fields (Craighead and Craighead 1956). In Wisconsin, lowland pastures with scattered trees were heavily used by hunting red-tailed hawks, whereas cover types without trees for hunting perches were seldom used (Petersen 1979). Results from an Ohio study suggest that red-tailed hawk productivity may be partially related to the percent of hunting territory in fallow pasture (Howell *et al*. 1978). Highly productive sites typically had over twice as much fallow pasture (69% average) around them as low productive sites. Hunting areas in New York were recently abandoned fields with matted, grassy cover (Bart 1977). Grassland and corn stubble were equally utilized as winter foraging sites in Illinois (Schnell 1968). Plowed fields were avoided. A comparison of cover types comprising home ranges of red-tailed hawks in Wisconsin suggests selection for predominantly graminoid cover of pastures and grasslands (Petersen 1979). Areas with grass less than 10 cm (4 in) high were generally preferred, but adults occasionally hunted over much taller vegetation. Pastures with abundant grasses were preferred.

Red-tailed hawks have been known to nest and hunt in woodlots (Luttich et al. 1970) and in extensive, unbroken forests (Titus and Mosher In press). Due to the lower availability of food (chipmunks, mice, and squirrels) and the natural obstacles presented by standing timber, these extensively forested regions probably cannot support as many red-tailed hawks as more open areas characterized by a woodlot-field mix (Mosher pers. comm.). Compared to random samples of surrounding habitat, red-tailed hawks nesting and feeding in extensive forests in Maryland were found on sites with a higher number of large trees [≥ 50 cm (20 in) dbh] and a lower percentage of tree canopy cover (Titus and Mosher In press).

C. Water requirements. Water does not appear to be limiting to the red-tailed hawk (Bartholomew and Cade 1962). Most water is supplied by the metabolic process of digesting food.

D. Cover requirements. Red-tailed hawks wintering in Iowa used open wooded areas along stream bottoms to satisfy cover requirements (Weller 1964). Winter perches in Illinois were in groups of trees > 9 m (30 ft) tall (Schnell 1968). Both upper and midcanopy portions of trees are used for daily activities and night roosting (Dunstan and Harrell 1973). Dense timber, particularly conifers, is frequently used for night and winter roosts (Brown and Amadon 1968). The availability of suitable cover does not appear to be limiting to the red-tailed hawk as long as suitable reproductive habitat is available.

E. Reproductive requirements. Red-tailed hawk nests are generally located in mature trees and are found more frequently in open woodlots and woodland edges rather than in closed dense woodlots or woodland interiors (Orians and Kuhlman 1956; Gates 1972; Misztal 1974 cited by Howell et al. 1978). Groves used by nesting red-tailed hawks in Wisconsin were generally less than 0.4 ha (1 ac) in size (Gates 1972). The size of the tree and the height at which the nest may be placed is more important in site selection than the degree of concealment afforded by the surrounding timber (Bailey 1918).

Nest trees in Michigan were large, averaging 23.6 ± 3.3 m (77.8 ± 10.9 ft) tall and 52.3 ± 15.0 cm (20.9 ± 6 in) dbh (Belyea 1976). The average dbh of nest trees was 58 cm (23 in) [range 41 to 71 cm (16 to 28 in)] in southeastern Minnesota (Le Duc 1970) and 64 cm

(25 in) [range 38 to 127 cm (15 to 50 in)] in Ohio (Misztal 1974 cited by Howell et al. 1978). The importance (relative frequency) of any one tree species may affect nest site selection, but appears to have no direct relationship to productivity (Howell et al. 1978). Nests are often re-used year after year (Brown and Amadon 1968).

F. Special habitat requirements. The availability of adequate perches is vital. During nonbreeding periods, red-tailed hawks commonly perch conspicuously on dead snags (Brown and Amadon 1968) and lone trees (Schnell 1968). Red-tailed hawks occasionally nest in isolated trees along fencelines and ditchbanks (Gates 1972); however, isolated trees are used mainly as hunting lookout posts.

G. Interspersion requirements. Red-tailed hawk home ranges in Wisconsin containing large amounts of woodland were larger than home ranges enclosing small, scattered woodlots (Petersen 1979). Austing (1964) concluded that red-tailed hawks occupying "fringe" habitat maintained larger home ranges in order to find sufficient prey. Data from an Ohio study suggests a correlation between the amount of woodland-forest comprising a study area and breeding density and breeding success (Howell et al. 1978). In this study, highly productive red-tailed hawk nest sites had an average of 8.1% of the home range in woodlot, whereas sites with low productivity had over twice as much (20.8%) wooded area.

While it is generally accepted that the availability of nest sites is critical to breeding red-tailed hawks, the optimum mix of habitat types needed to provide sufficient amounts of both nest sites (woodlots, forested areas, isolated trees) and hunting areas remains unclear. Data from recent population studies of red-tailed hawks suggests a correlation between habitat composition (in percent cover type) and breeding pair density. Data summarized from these studies (Table B-1) suggests that study areas comprised of large percentages of woodland-forests support lower breeding population densities than study areas that are comprised of approximately 10% woodland. Study areas that are composed of very small percentages of habitat types that provide potential nest sites also support low densities of breeding red-tailed hawks. Austing (1964) characterized a study area in Ohio composed roughly of 70% river valley (pasture-grassland-cropland) and 30% woodland as prime habitat.

Territory size is affected by the degree of interspersion of cover types (Petersen 1972, 1979). In Michigan, the size of red-tailed hawks' winter range was inversely proportional to the food supply (Craighead and Craighead 1956). Red-tailed hawks generally maintain circular or oval home ranges which vary spatially according to various habitat variables (Fitch et al. 1946). Red-tailed hawks in an area of Wisconsin with significant amounts of cropland and pasture had year-round territories averaging 119 ha (298 ac), whereas territories without these two cover types averaged 154 ha (384 ac) (Petersen 1972). The average home range size of red-tailed hawks in another Wisconsin study was 137 ha (338 ac) with the largest home range being reported in fall [390 ha (963 ac)] (Petersen 1979).

Table B-1. Comparison between habitat composition and breeding density of red-tailed hawks.

Source and Study Area	Density of Active Breeding Red-tailed Hawks in km² per pair	Composition of Study Area in Cover Type Percentage	
Gates (1972) (Wisconsin)	10.6	Cropland-Pasture	85%
		Lakes, Marshes	10%
		Forest-Woodland	.3%
Hager (1957) (New York)	7.9	Cropland-Pasture approximately	50%
		Forest-Woodland approximately	50%
McInvaille and Keith (1974) (Central Alberta)	7.6	Cropland-Pasture approximately	41%
		Forest-Woodland approximately	34%
Luttich et al. (1970) and (1971) (Central Alberta)	7.0	Cropland-Pasture	50%
		Lakes, Marshes	5%
		Forest-Woodland	45%
Petersen (1979) (Wisconsin)	4.7	Cropland-Pasture	71%
		Lakes, Marshes	16%
		Forest-Woodland	8%

Breeding territories in southeastern South Dakota and northwestern Iowa averaged 256 ha (640 ac) (Tyler and Saetveit 1969). Craighead and Craighead (1956) reported a hunting range radius of 1.19 km (0.75 mi). The average home range of nesting red-tailed hawks in southern Wisconsin was 3.75 km² (1.5 mi²) with an average maximum diameter of 3.2 km (2 mi). A maximum diameter of a red-tailed hawk's home range was reported to be 4 km (2.5 mi).

H. Special considerations. The red-tailed hawk is more tolerant of civilization than most raptor species (Jackman and Scott 1975). Nonetheless, Michigan red-tailed hawks did not nest within 370 m (411 yd) of occupied human dwellings (Belyea 1976). Nest desertion in four out of seven cases in Wisconsin was attributed to human interference (Petersen 1972).

B.3 Habitat Suitability Index (HSI) model for the red-tailed hawk (*Buteo jamaicensis*)

A. Model applicability

(1) Geographic area. This model was developed primarily for the entire eastern half of the United States, classified by Bailey (1978) as the humid temperate domain.

(2) Season. This model will produce HSI values based upon breeding habitat needs for the red-tailed hawk.

(3) Cover types. The red-tailed hawk is an adaptable, opportunistic raptor that utilizes a wide variety of cover types. Since this model is a prototype, cover type consideration has been limited to the following two types: Grassland (G) and Deciduous Forest (DF).

(4) Minimum habitat area. Minimum habitat area is defined as the minimum amount of contiguous suitable habitat that is required before an area will be occupied by a particular species. This information was not found in the literature for the red-tailed hawk. If local information is available to define the minimum habitat area, the HSI for the species will be zero if less than this amount of area is available.

(5) Verification level. This model was critiqued by James Mosher, University of Maryland, who concluded it was as reasonable as can be expected given the variety of habitat types encompassed in the applicable range. His review comments have been incorporated into the current model. No field tests have been conducted.

B. Model description

(1) Graphic overview. This HSI model for the red-tailed hawk considers the quality of the life requisites found in each cover type and interspersion of life requisites when the habitat is composed of two or more cover types. Figure B-1 shows how the HSI is related to cover types, life requisites, and specific habitat variables. Food and reproduction are the only life requisites considered in this model. It is assumed that cover needs are met by adequate reproductive habitat and that water is not limiting.

(2) Life requisite components

a) Food. Food suitability for the red-tailed hawk is related to the abundance and accessibility of suitable prey. This relationship is based upon the premise that optimum conditions for prey do not necessarily reflect optimum conditions for the predator. For this reason, coupled with the fact that many species fall into the broad category of "prey", a general approach to modeling food suitability for this predator is presented.

It is assumed that the abundance of prey in grasslands is related to the structure of the herbaceous vegetation which can be estimated by measuring the density and height of herbaceous cover. The accessibility of prey is related to the level of concealment provided for prey by herbaceous vegetation and the degree of access by the hawk to all "huntable" areas. The accessibility of prey can be estimated by measuring the height of herbaceous vegetation and the availability of suitable hunting perch sites. It is assumed that moderately high to high densities of herbaceous vegetation will support dense popualtions of prey species. It also is assumed that dense stands of herbaceous vegetation will not dramatically reduce the success rate of prey capture by this opportunistic predator. Herbaceous vegetation between 8 and 46 cm tall is considered optimum. If a large proportion of all the herbaceous vegetation present in a grassland is in this height class, conditions will be optimum. Very short vegetation will limit the abundance of prey, whereas very tall vegetation will maximize concealment for prey and thereby limit prey accessibility. It is assumed that three or more suitable perch sites per 0.4 ha will provide optimum hunting conditions. The lack of suitable perch sites will not be completely limiting since red-tailed hawks will hunt by gliding over fields.

Overall food suitability for red-tails in grassland habitats is related to the density and height of herbaceous vegetation and availability of perch sites. Herbaceous density is the most important factor in determining abundance of prey and thus, food quality. No food will be provided in habitats with either a total lack of herbaceous cover or herbaceous cover that is all too short or too tall.

Hunting strategies of the red-tailed hawk in forested areas have not been documented, and the relationships influencing the abundance of prey is unknown. It is assumed that red-tails will hunt in forests and that they feed upon both ground and canopy dwelling mammals. It is assumed that, in the forest, the most critical factor influencing food suitability for the red-tailed hawk is prey accessibility.

Dense stands of trees would likely interfere with the flight patterns of this large buteo, which is best suited for hunting from a lookout perch or soaring slowly over open fields. Conversely, an "open" forest would maximize utilization of all vegetative strata by the red-tailed hawk. It is assumed that prey accessibility can be estimated by measuring the canopy closure of trees, and that canopy closures of less than 50% provide the best prey accessibility and canopy closures of 100% provide poor accessibility (no suitability). It is further assumed that even the best forests provide limited prey availability for red-tailed hawks.

b) Reproduction. Reproductive value is related to the availability of suitable nest trees. It is assumed that the availability of suitable nest trees can be adequately assessed by measuring the density of large trees. It is assumed that a minimum of 10 trees per 0.4 ha (1.0 ac) greater than 50 cm (20 in) dbh are needed to provide optimal suitability, and that if no large trees are available, reproductive suitability will be absent. These statements are based upon the assumption that suitable cliff sites are not available for potential nest sites in the eastern United States.

Human disturbances may have a severe negative impact on nesting red-tailed hawks. The field user must assess each situation with respect to human interference during nesting and, if necessary, adjust the reproductive value accordingly.

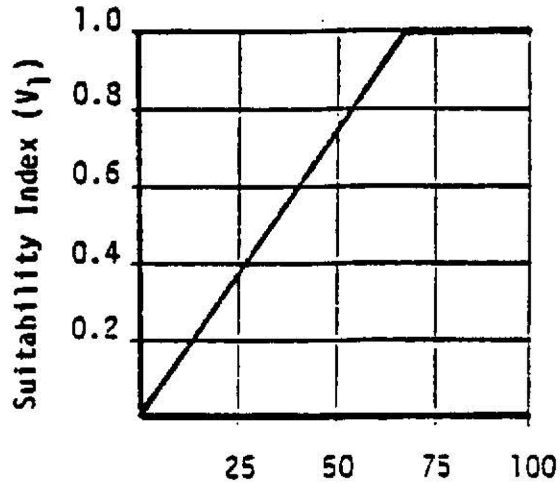
(3) Interspersion of life requisites. It is assumed that the best habitat for the red-tailed hawk contains high quality food over 70% of the habitat and high quality reproductive habitat over 15% of the area. These estimates are based upon data indicating that red-tailed hawks generally hunt over large portions of their home range but restrict reproductive activities to isolated and small woodlots and forested areas. High quality food is not required over 100% of the area because the effective hunting range is usually smaller than the home range, i.e., hunting activities are concentrated in areas where prey capture success rates are highest.

The effective amount of food and reproductive resources is determined by considering the distance between cover types which provide the resources. Since food and reproductive resources may be provided by different cover types, the distances between cover types can be used to determine the amount of useable area. It is assumed that the optimum distance between food and reproductive resources is equal to or less than 1.2 km. It is also assumed that if food and reproductive resources are distributed at three times this distance, or 3.6 km, then they exceed the distance that red-tailed hawks will fly during the breeding season to obtain them. These distance measurements were estimated using information in the literature pertaining to average home range size and maximum diameters of home ranges.

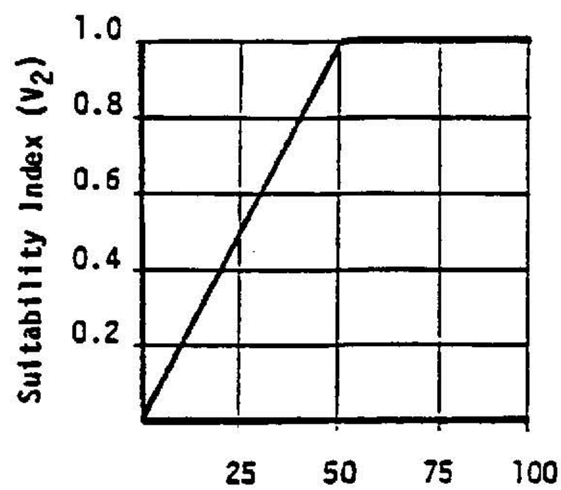
C. Model relationships. This section contains suitability index curves and equations to quantitatively describe the relationships discussed in the previous section. These curves and equations can be used to produce an HSI for the red-tailed hawk.

(1) Suitability index curves

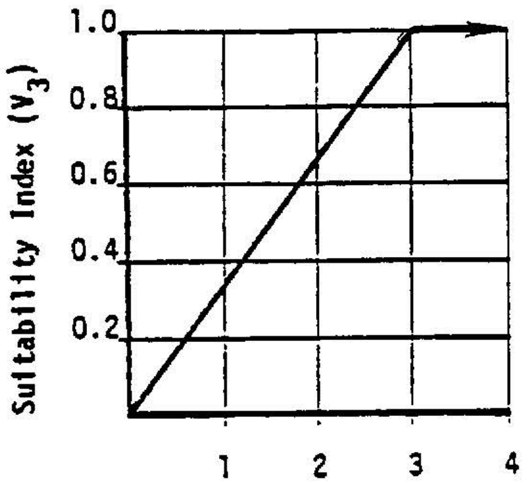
Cover Type	Variable	
Grassland	(V_1)	Percent herbaceous canopy cover.



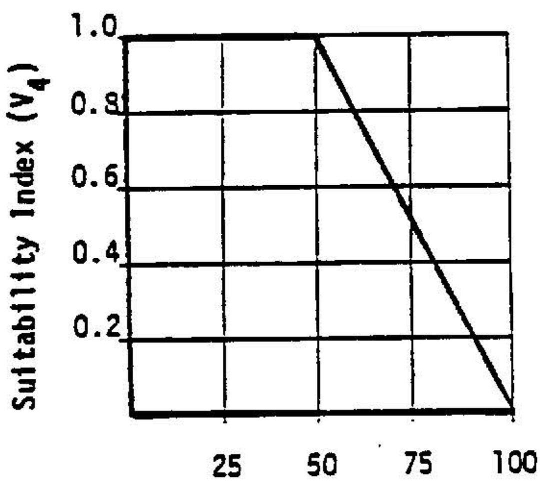
Grassland	(V_2)	Percent herbaceous canopy 8 to 46 cm (3 to 18 in) tall.



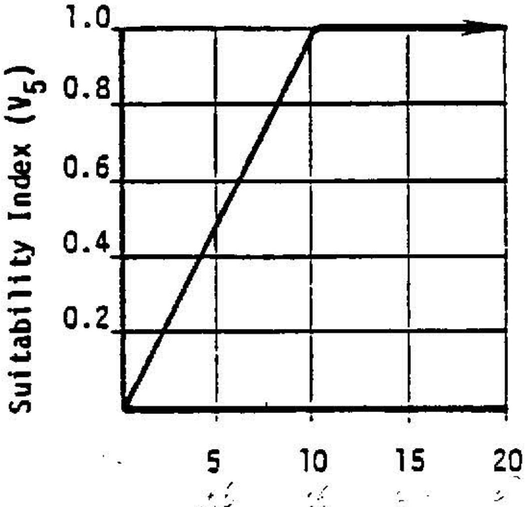
Grassland (V₃) Number of trees ≥ 25 cm (10 in) dbh per 0.4 ha (1.0 ac).



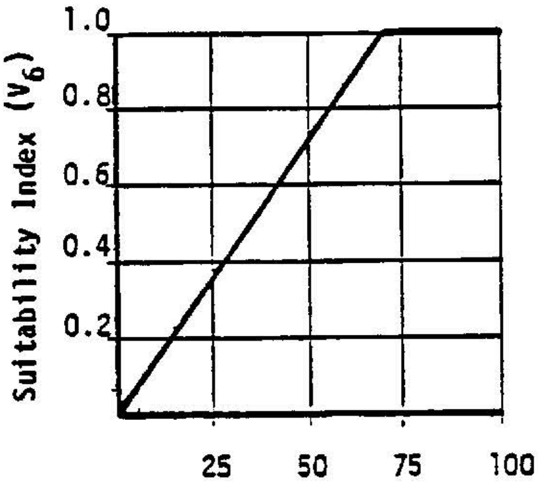
Deciduous Forest (V_4) Percent tree canopy closure.



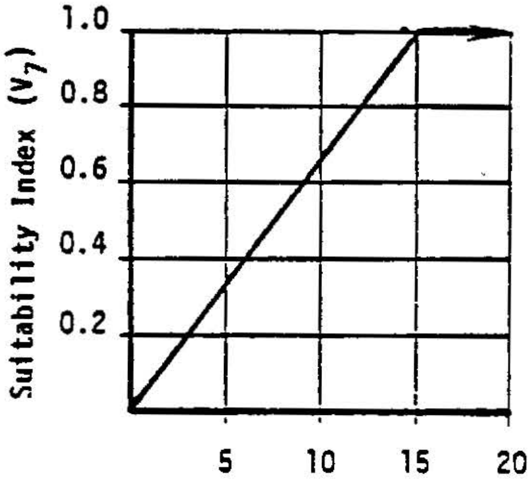
Deciduous Forest	(V_5)	Number of trees ≥ 50 cm (20 in) dbh per 0.4 ha (1.0 ac).



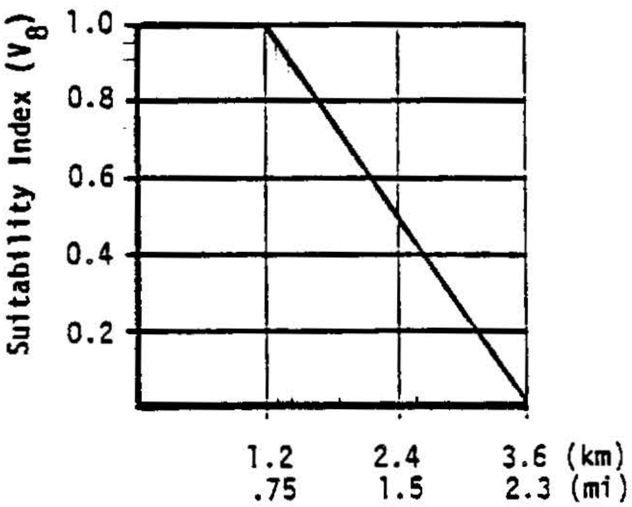
All	(V_6)	Percent area in optimum food.



All (V$_7$) Percent area in optimum reproduction.



All (V$_8$) Distance between cover types.



(2) Equations

a) Equations for food component. The following equations integrate index values for each variable to obtain a life requisite value for food in each cover type.

Cover Type	Equation
G	Food Value = $(V_1^2 \times V_2 \times V_3)^{1/4}$
DF	Food Value = $(V_4 \times 0.6)$

b) Equations for reproduction component.

Cover Type	Equation
DF	Reproductive Value = V_5

D. HSI determination. The following calculations must be made to determine an HSI.

(1) Determine if all life requisites are provided at some level greater than zero, considering all cover types under consideration. If any life requisite is not provided, the HSI will equal zero and no further calculations are necessary.

(2) Compute the life requisite values for each cover type by collecting field data for each variable and entering this data into the proper suitability index curve and using the resulting index values in the appropriate life requisite equations.

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

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

Be certain that only those cover types used by the species are considered in determining this percentage.

(4) Determine which cover types are not providing one or more life requisites. For each of these cover types, an interspersion index must be computed. This is accomplished as follows:

a) Select random points on a map in each cover type missing a life requisite and measure the distance to the edge of the nearest other cover type (or cover types, where two or more life requisites are missing) that provide(s) the missing life requisite(s).

b) Enter each of these distance measurements into the Suitability Index Curve titled "Distance between Cover Types", record the individual interspersion indices, and use these to calculate the average interspersion index for each cover type. Where two or more life requisites are missing from a cover type, use the lowest average interspersion index in the next calculation.

(5) 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 area (%) of each cover type. For those cover types that provide all life requisites the useable area (%) is the same as the relative area (%).

(6) 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 2 above). Sum the products of this multiplication across all cover types for each life requisite. This sum for each life requisite is the equivalent percent of the area that provides that life requisite at optimum 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 optimum, 1.0 value).

(7) To determine overall life requisite values, enter the percent area for each life requisite (Step 6) into the appropriate life requisite composition Suitability Index Curve. The index value obtained is the overall life requisite value.

(8) The HSI is equal to the lowest of the overall life requisite values.

B.4 <u>Application of the model</u>. The level of detail needed for a particular application of this model will depend on time, money, and accuracy constraints. Detailed field sampling of all variables will provide the most reliable and replicable HSI values. Any or all variables can be estimated, in order to reduce the amount of time required to apply the model. Increased use of subjective estimates decreases reliability and replicability, and these estimates should be accompanied by appropriate documentation to insure that decisionmakers understand both the method of HSI determination and quality of the data used in the HSI model.

The measurement techniques in Table B-2 are suggested for the variables used in this model. A field form can be developed from this list.

Table B-2. Suggested measurement techniques and definition of habitat variables.

Variable (Definition)	Cover Types	Suggested Technique
(V_1) Percent herbaceous canopy cover [the percent of the ground surface that is shaded by a vertical projection of all non-woody vegetation (grasses, forbs, sedges, etc.)]	G	Line transect and Daubenmire plot frame
(V_2) Percent of herbaceous vegetation that is 8 to 46 cm (3 to 18 in) tall (self explanatory)	G	Line transect and Daubenmire plot frame
(V_3) Number of trees ≥ 25 cm (10 in) dbh per 0.4 ha (1.0 ac) (self explanatory)	G	Line transect and dbh tape
(V_4) Percent tree canopy closure (the percent of the ground surface that is shaded by a vertical projection of the canopies of all trees)	DF	Line transect and ocular estimate
(V_5) Number of trees ≥ 50 cm (20 in) dbh per 0.4 ha (1.0 ac) (self explanatory)	DF	Line transect and dbh tape

B.5 Sources of other models. No other habitat models for the red-tail were identified during the development of this model.

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This was developed by Karen Miller of this office 916-978-4613

DRAFT HABITAT SUITABILITY INDEX MODEL
OSPREY (Pandion haliaetus)

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

September 1984

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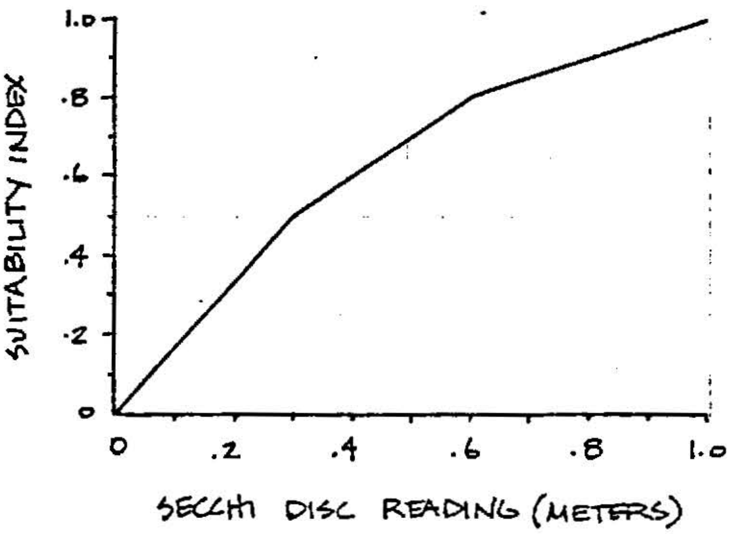
VARIABLE	COVER TYPES	SUGGESTED TECHNIQUE
(V_1) Water clarity - measured to 1 meter depth during summer	R,S	Secchi disc
(V_2) Availability of perch sites - the number of perch trees/mile of shoreline.	R,S	Ocular estimate
(V_3) Availability of pilot pilot trees - the number of pilot (perch) trees within nesting habitat.	H	Ocular estimate
(V_4) Nest tree availability - number of suitable size trees for nesting/acre	H	Ocular estimate, rangefinder, diameter tape
(V_5) Nesting/fishing habitat relationship - distance between potential nesting habitat and fishing waters	R,S,H	Measuring tape, remote sensing

Cover Type	Life Requisite	Habitat Variable
Reservoir (R)	Food	Water clarity (V_1)
		Availability of perch sites (V_2)
	Interspersion	Nesting/fishing habitat relationship (V_5)
Stream (S) (Pit River only)	Food	Water clarity (V_1)
		Availability of perch sites (V_2)
	Interspersion	Nesting/fishing habitat relationship (V_5)
Conifer-hardwood forest (H)	Reproduction	Availability of pilot trees (V_3)
		Nest tree availability (V_4)
	Interspersion	Nesting/fishing habitat relationship (V_5)

Variable 1. Water clarity - measured to a depth of one meter during summer.



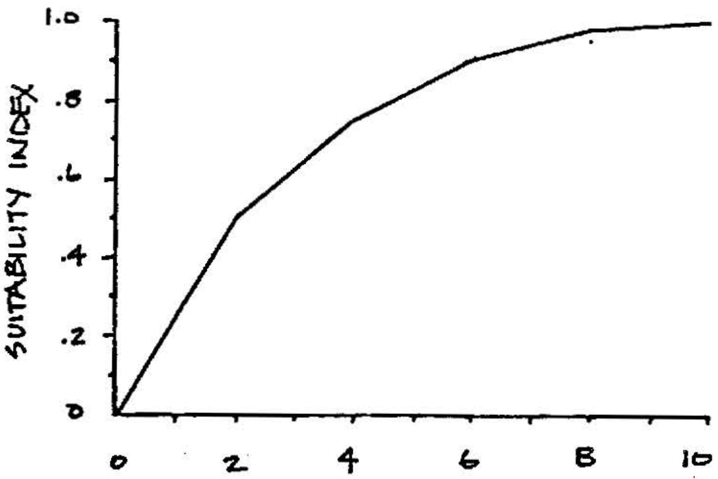
Assumes:

1) Osprey capture prey to a maximum depth of 1 meter (Beebe, 1974).

2) The availability of forage is not a limiting factor at Lake Shasta (see Bogener, 1979; and Conway and Fitch, 1982 for productivity update).

3) Osprey require clear water to capture prey.

Variable 2. Availability of perch sites - the number of perch sites per mile of shoreline (within 200 feet of water or in water).

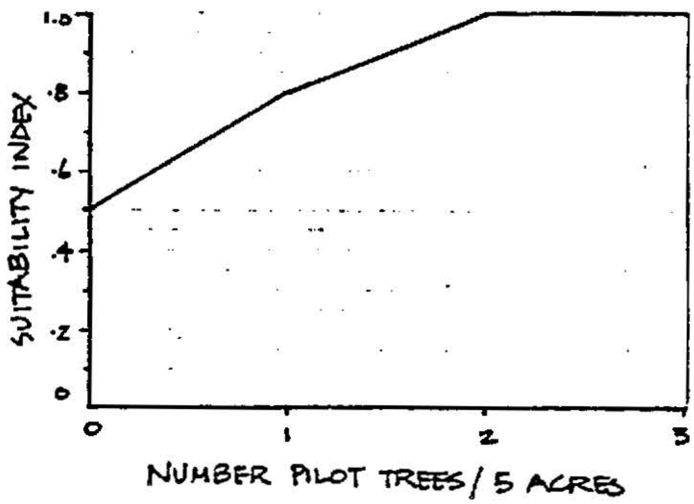


Assumes:

1) Twenty or more perch trees adjacent to fishing waters provides optimum conditions (Airola, 1983).

2) Suitable perch trees are defined as snags, dead-topped trees or open-crowned live trees that allow easy access for landing and take-off (Airola, 1983).

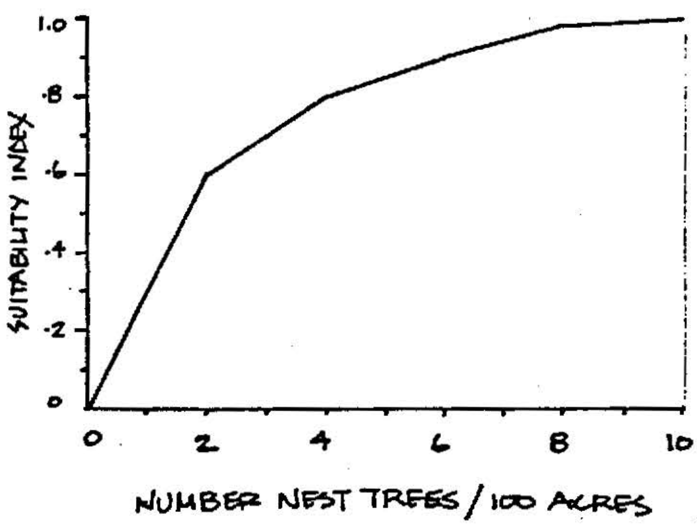
Variable 3. Availability of pilot trees - the number of "pilot" perch trees immediately surrounding nest sites and within suitable nesting habitat.



Assumes: 1) A minimum of 2 pilot trees per 5 acres of nesting habitat is optimum (Airola, 1984).

2) Pilot trees are defined as snags, dead-topped trees or open-crowned live trees that allow easy access for landing and take-off (Airola, 1983).

Variable 4. Nest tree availability - the number of suitable size trees per acre for osprey nesting.



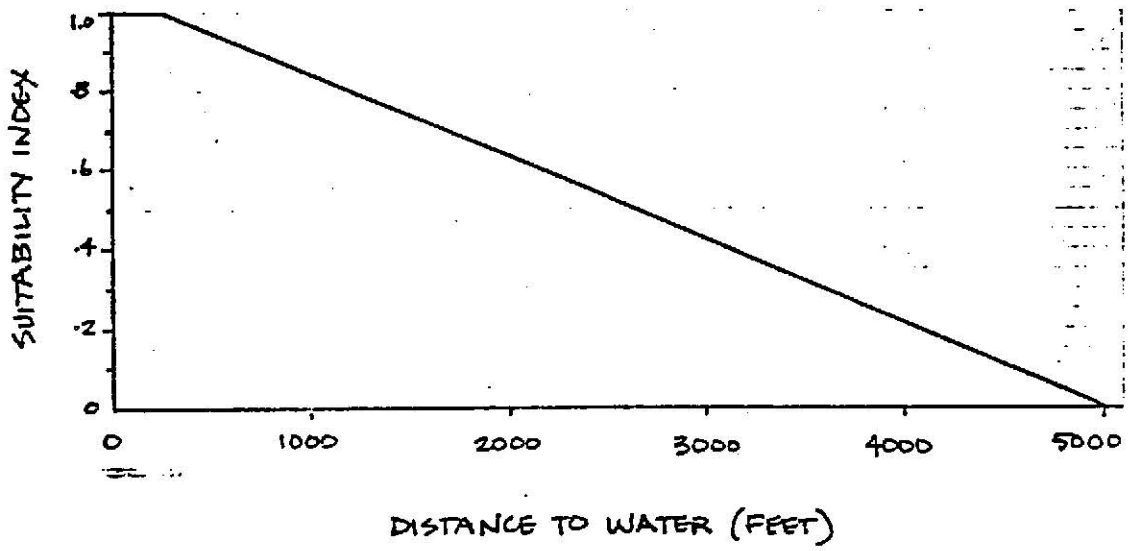
Assumes: 1) Suitable size trees for nesting have a minimum height of 75 feet and minimum dbh of 40 inches (Shimamoto and Airola, 1981).

2) Ten or more suitable size trees per 100 acres of nesting habitat are required to meet present nesting needs (Airola, 1984).

3) Suitable tree species include ponderosa pine, douglas-fir, and sugar pine (Detrich, 1978).

Variable 5. Nesting/fishing habitat relationship - the distance between potential nesting habitat and fishing waters.

Assumes: 1) At Shasta Lake, the greatest number of active nests are within 250 feet of the reservoir (Bogener, 1979).



Equations Used to Calculate Suitability Indices

a) Food

Cover Type	Equation
R,S	$(V_1 \times V_2)^{\frac{1}{2}}$

b) Reproduction

Cover Type	Equation
H	$(V_3 \times V_4)^{\frac{1}{2}}$

c) Interspersion

Cover Type	Equation
R,S,H	V_5

HSI Determination:

The HSI value equals the life requisite value calculated for each cover type multiplied by the interspersion value.

Assumptions Used in Applying the Osprey Model

V_1 - Water clarity.

The water in Lake Shasta at one meter during the summer was assumed to be clear; SI = 1.0.

V_2 - Availability of perch sites.

It was assumed that the Pit River was the only one of the tributaries suitable as osprey habitat (higher number of nutrients in the water, higher number of fish species), and that perch trees were not limiting; SI (for Pit River) = 1.0 (Dietrich, wildlife biologist, personal communication, 1984).

V_5 - Nesting/fishing habitat relationship.

It was assumed that the distance between potential nesting habitat and fishing waters was not limiting in the study area; SI = 1.0.

It was assumed that measuring the numbers of potential perch sites, pilot trees, and nest trees observed from the lake was as good as or better than measuring these variables through a random sampling scheme.

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KMiller:5/29/84:rlm
MLONG/Q
revised 10/19/84/ar
revised 11/7/84/ar

Habitat Suitability Index Model received from USFWS OBS WELUT Fort Collins, Co. in June 1982

MULE DEER

Species Narrative

General. With the exception of those cover types associated with the Artic and tropic climatic zones, the mule deer (Odocoileus hemionus) inhabits every major vegetative type in western North America (Wallmo 1978). All of the Rocky Mountain and intermountain regions are inhabited by mule deer, with scattered populations extending as far east as Minnesota and Iowa and as far north as British Columbia and Alberta.

Food Requirements. Optimal mule deer habitat in Colorado is comprised of an interspersed and diverse collection of vegetational successional stages (Loveless 1964). Areas that provide this diversity also provide mule deer the opportunity for more beneficial forage selection. Mule deer cannot be categorized simply as browsers since woody plants are not uniquely palatable, nor are they totally suited to the nutritional requirements and digestive capacity of the species (Wallmo 1967).

Palatability of deer forage is a relative factor which varies with local and seasonal availability (Hill 1956). Mule deer are highly selective feeders in that the portions of plants which contain the highest protein levels are most often selected (Schneegas and Bumstead 1977). As plants mature the protein, phosphorus and carotine levels decrease, while less digestable components such as crude fiber and legnin increase. As a result, seasonal use of specific vegetation will vary and within a few weeks time a highly preferred plant species may become completely unused.

Mule deer feed primarily upon herbs, and small shrubs (Hill 1956). Generally mule deer consume small quantities of grass, and do not feed to any great extent upon trees and large shrubs except in winter when deep snow makes other foods difficult or impossible to obtain. The number of plant species utilized by the mule deer throughout the year may be large; however, stomach analysis normally indicate that 80% or more of the contents are comprised of not more than 5 or 6 species at a feeding. Analysis of data from 99 food habits studies of the Rocky Mountain mule deer indicated that the diet of the species was comprised of at least 202 shrub and tree species, 484 forbs, 84 grasses, sedges and rushes, and 18 other plant species (Kufeld et al. 1973).

Grasses constitute a high percentage of the mule deer's diet during the spring (Hill 1956). However, dried grasses are not utilized except under unusual conditions or as a starvation ration (Einarsen 1956). Grass consumption normally decreased to 5% or less of the diet during the summer months whereas forb consumption reached its peak use (Hill 1956). New shrub growth may account for as much as 33% of the mule deer's summer diet. Fall generally marks the mule deer's transition from a diet consisting chiefly of forbs to one of shrubby vegetation, however, forbs may still comprise up to 25% of the diet. Browse (shrubs and trees) often furnishes 75% or more of the mule deer's winter diet. The availability of adequate browse is often the limiting factor for mule deer populations over much of their range (Schneegas and Bumstead 1977).

Big sagebrush (_Artemisia tridentata_) and mountain mahogany (_Cercocarpus_ spp.) were reported to be the key mule deer browse on a northeastern Utah mule deer winter range (Richens 1967). Antelope bitterbrush (_Purshia tridentata_), serviceberry (Amelanchier spp.), forbs, and grasses were important supplemental winter foods. Anderson et al. (1972) reported antelope bitterbrush as being a major food item on Colorado mule deer winter ranges.

Seasonal temperature and moisture regimes regulate the annual nutrition cycle of the mule deer (Wallmo 1978). The diet of the mule deer may fail to meet the energy requirements for body maintenance during a considerable portion of the year, with winter browse as the most limiting factor (Wallmo et al. 1977). Colorado winter range was reported to provide forage that supplied approximately 50% of the total protein or energy requirements of the mule deer (Schneegas and Bumstead 1977). High mortality was reported for California mule deer in severe winters where they were totally dependent upon browse (Leach 1956 cited by Wallmo 1978). Low winter mortality was reported for the same area in mild winters as a result of a more diversified diet that included green grasses. Snow conditions, duration of winter, and the time of initiation of spring growth are other factors which govern a range's potential to support mule deer (Schneegas and Bumstead 1977).

Water Requirements. The majority of the mule deer's water requirements are met by moisture contained in the vegetation consumed (Rue 1978). Additional moisture is obtained from dew, rain water, snow, and ice.

A study by Mackie (1970) in Montana's Missouri River Breaks revealed that the use of range by mule deer decreased sharply at distances of 1.6 km (1.0 mi) or more from standing water.

Cover Requirements. Mule deer require forest and rangelands which are comprised of a variety of successional stages (Longhurst 1961). Young brush interspersed with forbs and grasses will provide ideal feeding cover. Conversely, extensive tracts of mature brush, climax forest with little ground cover interspersed with few openings, and climax grasslands lacking forbs will not provide optimal habitat.

Stands of timber or dense shrubs 244 to 490 m (800 to 1,600 ft) across were reported to provide optimal cover for mule deer in Oregon (Thomas et al. 1976). Smaller patches of cover may satisfy the cover requirements of the mule deer depending on the topography of the area. Small evergreen trees and shrubs on winter range and deciduous trees and shrubs on spring, summer, and fall range were reported to provide excellent thermal cover for mule deer in Colorado (Loveless 1964).

Summer range capable of carrying deer in good condition through the breeding season is necessary for maximum herd productivity (Julander et al. 1961). Prime summer ranges typically occur in areas which receive a relatively high rainfall and support diverse vegetation located on a variety of topographic aspects (Schneegas and Bumstead 1977). The quantity and availablity of summer range throughout the west is believed to be adequate, and may not be a limiting factor in determining mule deer populations. However, Julander et al. (1961) reported that summer range may be critical when associated with small isolated plateaus, or mountains surrounded by arid lowlands.

Mule deer normally inhabit higher elevations in summer and descend to lower areas in response to increasing snow depths (Gilbert et al. 1970). Mass movements of mule deer onto their winter range in Utah were reported to be synchronous with snowstorms and cold weather in early to mid-November (Richens 1967).

Line intercept data on Utah mule deer winter range revealed that approximately 32% of the ground surface was covered by vegetation (Richens 1967). Important browse species comprised roughly 58% of the ground cover. Use of key browse plants was reported to be most intensive on the more accessible sites, along streams and trails and near escape cover. The heaviest use of sagebrush was generally within 0.4 km (0.25 mi) of pinyon-juniper stands or other escape cover. Browsing was evident on all exposures but was most apparent on the drier southern slopes. Loveless (1967) reported that mule deer in Colorado showed a preference for vegetative types which provided food on south and east facing slopes. Locations which provided cover, but little preferred browse, were not extensively used by mule deer. Excellent winter habitat for mule deer was characterized as areas where the surface acreage was approximtely one-half shrub types and one-half timber types. In cold, windy weather, mule deer in Utah were usually found in sheltered areas, particularly in dense stands of juniper (Richens 1967). Stormy weather in Colorado induced mule deer to seek the shelter of drainage areas or heavy timber (Loveless 1967).

Reproductive Requirements. Fawning occurs where all of the needs (water, cover, forage), of the doe are found within a relatively compact area (Einarsen 1956). Desirable fawning habitat in Oregon was reported to be comprised of low shrubs or small trees ranging from 0.6 to 1.8 m (2 to 6 ft) in height under an overstory tree canopy cover of approximately 50% (Thomas et al. 1976). Slope gradient should not exceed 15% and plentiful succulent vegetation should be available. Accessible water should be within 180 m (600 ft).

Interspersion Requirements. The abundance and availability of preferred browse and the interspersion of such areas were reported to influence the mule deer's non-random spatial distribution on a Colorado winter range (Loveless 1964). Loveless (1963) reported that winter range in Colorado was comprised of approximately 45% shrub-dominated slopes and 45% coniferous timbered slopes. The close proximity of browse covered slopes to sites dominated by open timber with a browse understory had a positive influence upon the distribution patterns of the mule deer. Optimal winter range in California had a maximum distance between feeding and bedding areas of less than 0.4 km (0.25 mi) (Leopold et al. 1951).

Mule deer are typically distributed over a much larger area on summer than winter range (Schneegas and Bumstead 1977). Concentrations of the species are not common on summer ranges despite a tendency to select and utilize preferred habitats. Leopold et al. (1951) reported that the estimated average summer and winter ranges of mule deer in California had approximate diameters of 0.8 to 1.2 km (0.5 to 0.75 mi) and 0.4 to 0.6 km (0.25 to 0.37 mi) respectively. The average activity radius for mule deer in Utah was reported to be equivalent to 0.4 km (0.24 mi) (Robinette 1966). Average density on a Utah winter range under normal winter conditions was reported to be 46 per 2.59 km^2 (46 per mi^2) (Richens 1967).

Regardless of where they locate on the summer range, mule deer return to the ancestral wintering area to which they were first taken as fawns (Zalunardo 1965). The species may move 80 km (50 mi) or more from summer to winter range (Wallmo 1978).

Special Considerations. Mule deer declines have been attributed to advancing succession resulting from increased fire suppression, intensive silvicultural prescriptions, and the reduction of animal units on grazing allotments (Schneegas and Bumstead 1977). Fire and logging are generally considered as being favorable influences on mule deer ranges as a result of the abundance and diversity of forage induced following the disturbance. Several studies have reported the successful use of prescribed burning to improve protein values for browse (Einarsen 1946; Biswell et al. 1952; Leege 1969; Vogel and Beck 1970). Such activities may result in improving habitat conditions for 25 years or more; however, the period of habitat enhancement is usually succeeded by a century or more of essentially unusable habitat if further management actions are not taken (Wallmo 1978).

High winter mortality has been reported on Rocky Mountain and intermountain deer winter ranges dominated by sagebrush (Wallmo 1978). Carpenter (1976) suggested that such winter ranges may be improved by partially supressing sagebrush and encouraging increased growth of herbaceous vegetation.

Snow has a major effect on the winter ecology of mule deer. Winter deer distribution in Middle Park, Colorado was reported to be governed primarily by snow depth (Wallmo and Gill 1971). During winters with deep snow the availability of winter range was so reduced that the carrying capacity of the range was negligible. Delineation of deer distribution indicated that snow depths exceeding 30.4 cm (12 in) were sufficient to discourage continuous occupation of an area unless the snow was extremely low in density. Loveless (1967) reported that snow depths of 30.4 cm (12 in) hampered deer locomotion and depths of 60.9 cm (24 in) or more precluded the use of an area by mule deer.

Winter nutrition in the central Rocky Mountains is directly related to winter snow cover (Wallmo and Gill 1971). During light snow accumulations nutrition is adequate since more range is accessible; however, during winters with heavy snow accumulations the winter range becomes more restricted and deer nutrition becomes inadequate. Prolonged periods of deer concentration on critical winter range where food is inadequate will result in heavy winter mortality. The concept of maintaining a stable carrying capacity of winter range for mule deer in the high valleys of the central Rockies is unrealistic.

Winter range is one of the most important components of mule deer habitat (Thomas et al. 1976). Any adverse environmental impacts on winter range are usually magnified in deer herd populations.

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Habitat Suitability Index (HSI) Model for the Mule Deer

General Information

Species Information

Species:	Mule Deer (*Ococoileus hemionus*)
Habitat Use Pattern:	Multicover type user
Status:	Resident (seasonal migrant)
Cover Types:	All
Ecoregion:	M3113
Model Type:	Uncalibrated Index Model for Winter Range

Threshold Range Size. Information on the minimum size of suitable habitat that must be present before an area will be occupied by a population of mule deer was not found in the literature.

Home Range Data. Winter home range size for mule deer has been estimated to have a radius ranging from 0.4 to 1.2 km.

Habitat Composition. Habitat composition information for species which are multicover type users is most useful when presented in terms of life requisite needs. Optimal life requisite composition may be determined by considering the composition of the habitat in terms of cover types and by considering what life requisites are provided by each cover type. The following percentages were estimated based on the assumption that food should be available over a larger area than cover to provide optimal winter habitat.

Life Requisite	Optimal Percentage Estimate
Food	60%
Water	Assumed not to be limiting on winter range.
Cover	40%

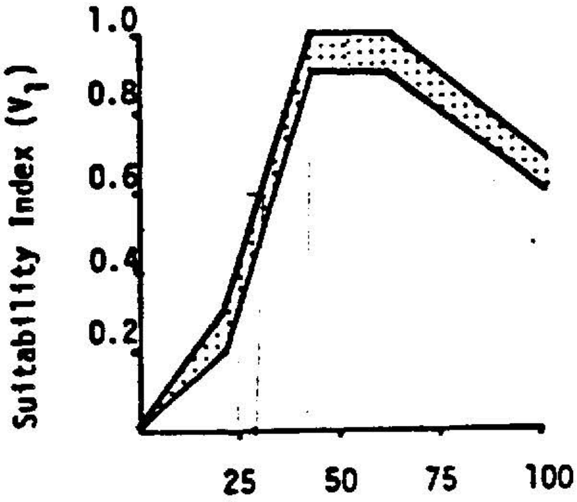
Evaluation Criteria

Winter Food Value. Browse often furnishes 75% or more of the mule deer's winter diet. Forbs and grasses are supplemental winter foods and their availability will result in an increased food value for mule deer.

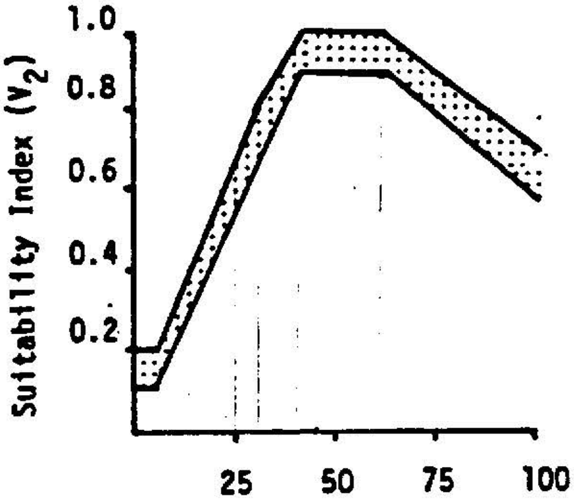
Variable

Suitability Index Curve

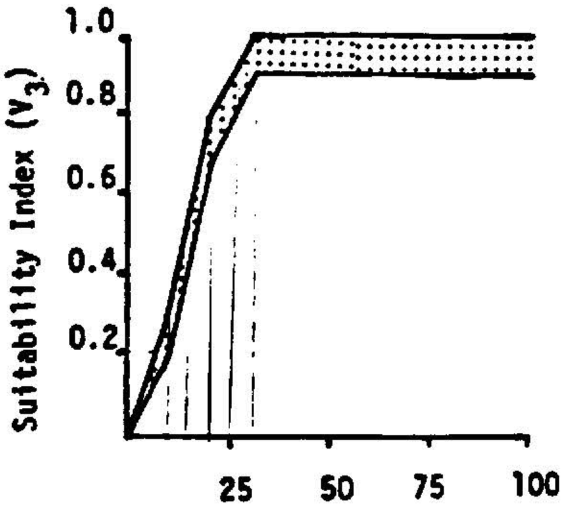
[V_1] % shrub crown cover < 1.5 m (5 ft) in height. (Do not consider small conifers as shrubs.)



[V_2] % shrub crown cover of preferred shrubs ≤ 1.5 m (5 ft) in height. (Preferred shrubs include, but are not limited to, antelope bitterbrush, mountain mahogany, ceanothus, chokecherry, and serviceberry.)



[V_3] % herbaceous canopy cover.

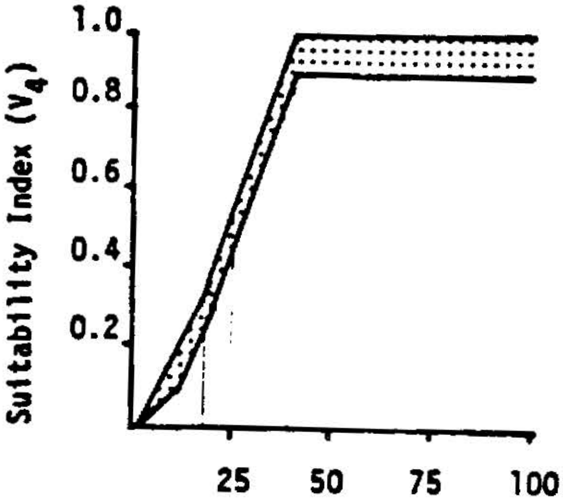


Winter Food Value in all cover types is a function of V_1, V_2, and V_3. V_1 and V_2 are interactive variables and compensations exist between them. The abundance of shrubs and the availability of preferred shrubs are the most important components of the food value for winter range and have been weighted accordingly. The suggested function is:

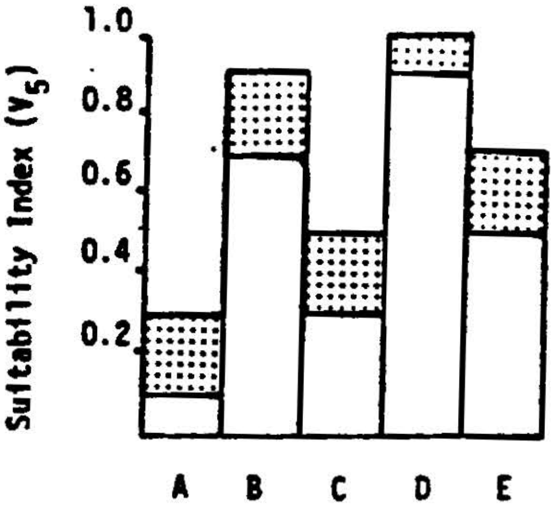
$$\frac{3(V_1 \times V_2)^{1/2} + V_3^*}{4}$$

*When evaluating food on winter range the average snow conditions for the area must be taken into consideration. If the average depth of snow on the ground exceeds 60.9 cm (24 in) for extended periods of time, the life requisite value for food should equal zero. If persistent snow cover ranges from 30.4 cm (12 in) to 60.9 cm (24 in), the life requisite value should be adjusted downward. In determining winter snow conditions consider snowfall records, slope, aspect, wind, and vegetative cover.

Cover Value. Excellent winter habitat for mule deer has been characterized as being comprised of approximately one-half shrub cover types and one-half timbered cover types.

Variable		Suitability Index Curve
[V_4]	% canopy cover of evergreen woody vegetation $\geq$ 3.0 m (10 ft) in height.	

[V_5] Topographic diversity (consider entire project area).
A) Level terrain (0-5% slope), flat or nearly so, little to no physical diversity.
B) Level terrain (0-5% slope), area broken by drainages.
C) Rolling terrain (5-25% slope).
D) Rolling terrain (5-25% slope), ridges, rims and/or drainages present.
E) Mountainous (> 25% slope).



Cover Value in all cover types is a function of V_4 and V_5. V_4 and V_5 are interactive and compensations exist between them. The life requisite value will be zero only if both variables are equal to zero. The suggested function is:

$$\frac{2V_4 + V_5}{3}$$

HSI Determination for Multicover Type Users. The following is an abbreviated step by step discussion of HSI determination for multicover type species.

Step 1 - Determine Suitability Indices for each variable based on field data.

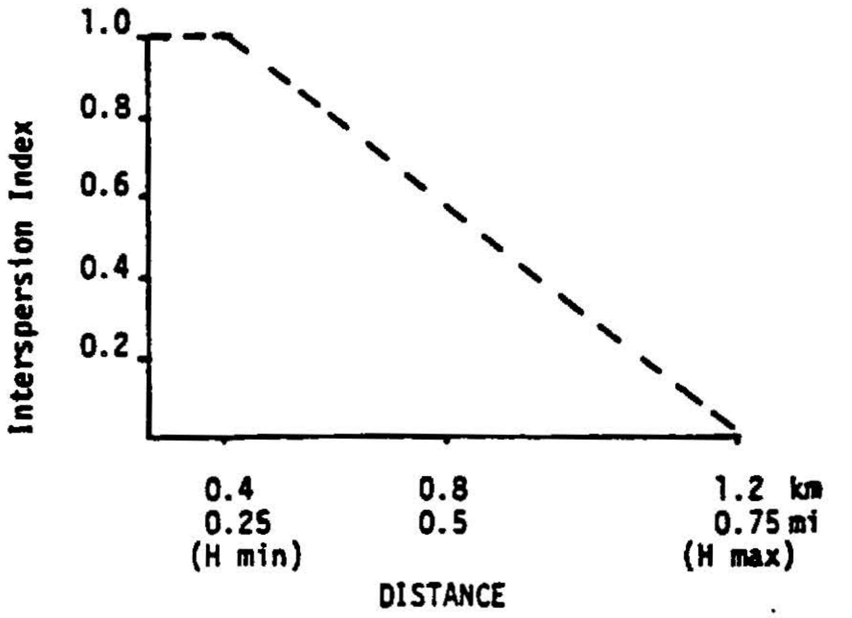
Step 2 - Compute Life Requisite Values for the indicated cover types using the suggested functions provided in the model.

Step 3 - Determine if all life requisites can be provided considering all cover types within the study area. If any life requisites are missing, the HSI will equal zero and no further evaluation is necessary.

Step 4 - Using the life requisite values computed in Step 2, the next step is to determine the spatial relationship of cover types providing various life requisites. Life requisite values may need to be adjusted to varying degrees depending on the distances separating them and how the distances compare with the species minimum and maximum home ranges. This step is accomplished as follows:

a) Determine the mean distance (measured from randomly selected points) from each cover type missing a life requisite to the edge of the next nearest cover type that provides the missing life requisite(s).

b) Incorporate the mean distance measurements from Step 4a into the x-axis of the home range-interspersion graph presented below. Determine where the mean distance measurement intercepts the graph and obtain the interspersion index by reading the corresponding value from the y-axis.



c) Multiply the interspersion index for each cover type determined in Step 4b by the life requisite values determined in Step 2. The products are the modified life requisite values.

Step 5 - Determine the relative abundance (in percent) of cover types used by the species within the study area, as follows:

$$\text{Relative Area for Cover Type A} = \frac{\text{Area of Cover Type A}}{\text{Total Area of all Cover Types used by the Species}} \times 100$$

Be certain that you consider only those cover types used by the species in determining relative area of cover types.

Step 6 - Determine the percent life requisite support provided by the available habitat as follows:

a) For each life requisite within each cover type, multiply the modified life requisite value(s) (Step 4c) by the relative area of that cover type (Step 5). The products equal the percent life requisite support provided by each cover type.

b) Sum the products from Step 6a for each life requisite. The total equals the percent life requisite support provided by the available habitat.

Step 7 - For each life requisite, divide the percent life requisite support (Step 6b) by the optimal percent life requisite estimate provided in the General Information section of the HSI Model (use the lower percentage where a range of percents are given as estimates for optimal life requisite percent). This yields the overall life requisite values for the entire study area.

Step 8 - The Habitat Suitability Index (HSI) is the lowest of the overall life requisite values.

Model Assumptions and Limitations. It is assumed in this model that the availability of free water will not be limiting on mule deer winter range. It is also assumed that average annual snowfall data will be available for the area (or immediate geographic region) under evaluation and that the influence of snow conditions can be directly related to the value calculated for food. It is assumed that the food value for the mule deer can be estimated without a precise volume measurement or assessing vegetative productivity, by estimating the approximate standing crop of vegetation. A further assumption is that the home range data can be used to assess spatial relationships of food to cover.

The major limitation in this model is that optimal life requisite composition values and the interspersion graph are best estimates derived from literature reviews. The estimates presented may not be valid in every situation.

MODIFICATIONS MADE TO THE HSI MODELS FOR THE SKAGIT DAMS ORIGINAL IMPACTS HEP

Pileated Woodpecker

none

Yellow Warbler

none

Ruffed Grouse

- o Winter food (Aspen) parameter was removed fro the model (not limiting in the Project Area)
- o Conifer penalty was dropped from the model; avian preditors are not limiting in the Project Area)

Marten

- o Used successional stages that match the software

Black-capped Chickadee

none

Mule Deer

- o All shrubs less than 2m not 1.5 were measured
- o Small conifers were included in shrub cover measures since they are a food source for deer on the Project Area.
- o Only palatable herbaceous cover was measured
- o The food HSIs for slopes between 40 and 80 percent were multiplied by 0.5 since these slopes receive less use by deer than do slopes of 0 to 39 percent. Slopes greater than 80 percent were not considered deer habitat for food or cover.

Red-tailed Hawk

- o Added a measurement of shrub canopy cover to the model for food habitat quality; graph was the same as that for tree canopy cover; SI value is multiplied in the model formula
- o Tree canopy closure in open canopy forests and the number of trees greater than 25cm dbh per ha was assumed to be 1.0 by the HEP team at the June 1987 meeting
- o interspersion distances were measured from a map.

Osprey

- o Converted to a multicover model by weighting the food and reproduction HSI by the appropriate cover type area
- o Interspersion was assigned an HSI of 1.0 by the HEP team at the November 1987 meeting

Beaver

- o Used a weighted average to calculate values for the habitat parameters for the 0 to 100m and 100 to 200m bands adjacent to riverine areas or surrounding wetlands
- o Only shrubs palatable for beaver were measured

Dipper

- o Reproduction HSI = percent of area covered by vertical rock walls
- o Food HSI = (SI of bottom substrate) * (SI of stream gradient)